Curriculum Guide
For Treatment of Shoulder Injury

Welcome to the ASES curriculum guide for treatment of shoulder injury. This guide has been developed by the ASES Education committee, with contributions by many ASES members, to be used as a reference source by residents, fellows, Orthopedic Surgeons, and others who desire a basic foundation of information on evaluation and treatment of shoulder injury and disease.

The guide is organized by pathological topic. The organization in general follows the outline of topics found in the Iannotti and Williams textbook Disorders of the Shoulder Second Edition, which is felt to be a comprehensive overview of shoulder problems. ASES gratefully acknowledges the willingness of the editors Drs Joseph Iannotti and Gerald Williams, and the publishers Lippincott Williams and Wilkins, to allow ASES to use the textbook as the organizational source.

An annotated bibliography of key references has been developed for each topic by an experienced shoulder surgeon or other expert on the specific topic. The annotations give a brief summary of the particular reference, and then place the reference in a context of its importance in the understanding of the topic. References are either a "classic" in the field, a review of the topic, or current research on the topic. It is expected that a broad background on each topic can be gained through all the references.

Each topic reference list reflects the judgment of the individual author regarding which references to include, and as such is not inclusive of all possible references. Therefore, the list should be taken as a starting point for understanding each topic. The editors have reviewed the reference lists, and believe that information relating to the broad context for each topic has been included. It is expected that the list will be periodically updated, so that the basic information will reflect current knowledge.

The editors would like to thank the many ASES members who contributed to the curriculum guide. They include Drs Jonathan Ticker, Lawrence Higgins, Gerald Williams, Tony Romeo, Patrick McMahon, Brian Cole, Ed McFarland, Mike Wiater, Jeff Abrams, Answorth Allen, Peter Millet, David Collins, Sumant Krishnan, David Dines, Jed Kuhn, Evan Flatow, Anthony Rokito, Martin Kelly, and Tim Uhl. Dr Andy Green was the co- editor and contributed many chapters and long hours of work on the project.

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Chair, ASES Education Committee
Editor, ASES Curriculum Guide

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1. Anatomy and Biomechanics of Rotator Cuff Pathophysiology

Brooks, CH; Revel, WJ; Heatley, FW. A quantitative histologic study of the vascularity of the rotator cuff tendon. Journal of Bone and Joint Surgery 74B: 151-153, 1992.

This cadaveric study evaluated the blood supply in both supraspinatus and infraspinatus tendons. The tendons were first perfused, then were evaluated in serial histologic slices for blood vessels. The study found there is an area about 15mm from the bony insertion in which there are fewer perfused blood vessels, but this area was as large in the infraspinatus as it was in the supraspinatus. It appears that hypovascularity alone is not an adequate explanation for the etiology of rotator cuff tears.

Clark, JM; Harryman, DT. Tendons, ligaments, and capsule of the rotator cuff. Journal of Bone and Joint Surgery 74: 713-725, 1992.

This cadaveric study looked at gross and microscopic anatomy of the rotator cuff muscles. This study demonstrated the cuff was composed of 5 distinct layers of tissue and that the tendons splayed out to form a common distal humeral insertion. The coracohumeral ligament was found to be a major part of the rotator interval and biceps sheath, and to reinforce the supraspinatus.

Burkhart, SS. Reconciling the paradox of rotator cuff tear versus debridement: A unified biomechanical rationale for the treatment of rotator cuff tears. Arthroscopy 10: 4-19, 1994.

This current concepts review introduces many biomechanical principles upon which treatment guidelines may be based. They include the definitions of functional and non-functional rotator cuff tears, the suspension bridge of the rotator cuff, the cable/crescent concept, and coronal and transverse plane force couples. Guidelines for treatment include restoration of the force couples by restoration of the suspension bridge, partial rotator cuff repair in massive tears to restore transverse plane force couples, debridement/repair of unstable rotator cuff edges to reduce pain, and indications for arthroscopic debridement in massive tears.

This paper should be one of the foundations for approaching, understabding, and treatment of rotator cuff disease.

Davidson, PA; Elattrache, NS; Jobe, CW et al. Rotator cuff and posterior superior glenoid labrum injury associated with increased glenohumeral motion: A new site of impingement. Journal of Shoulder and Elbow Surgery 4: 384-390, 1995.

This paper reported undersurface impingement and rotator cuff damage related to direct impact between the posterior superior labrum and the supraspinatus. Etiologic factors include anterior capsular laxity, muscle weakness, and increased scapular protraction. Direct impact/compression appeared to be the etiologic mechanism for the rotator cuff injury.

Carpenter, JE. Basic science of the rotator cuff. AAOS OKU: Shoulder and Elbow: 19-29, 1997.

This review and update highlights the clinically significant anatomy of each of the rotator cuff muscles, and discusses the etiology of cuff tears. It has a detailed discussion of the biomechanics of the rotator cuff. It describes the normal biomechanics of the rotator cuff in generating force and providing motion, and then explores how rotator cuff injury affects normal cuff function and may affect glenohumeral joint motion. If the rotator cable system is intact (supraspinatus small tear or infraspinatus/subscapularis repaired) then forces may be transmitted that allow humeral head depression and reasonable joint motion.

Carpenter, JE; Flanagan, CL; Thermopoulos, S et al. The effects of overuse combined with intrinsic or extrinsic alterations in an animal model of rotator cuff tendinosis. American Journal of Sports Medicine 26: 801-809, 1998.

This basic science study evaluated different theoretical models of rotator cuff injury. Overuse alone, or overuse plus intrinsic damage or extrinsic compressions were the models. All 3 models demonstrated some histologic changes of injury, but overuse alone did not demonstrate any change in the mechanics of the tissue. Overuse plus other injury appears to lead to the most severe injury.

Yamaguchi, K; Tetro, AM; Blam, O. Natural history of asymptomatic rotator cuff tears: A longitudinal analysis of asymptomatic tears detected sonographically. Journal of Shoulder and Elbow Surgery 10: 199-203, 2001.

This study followed patients who were found to have rotator cuff tears but who were not symptomatic. Over 5 years, 51% of those responding reported symptoms of rotator cuff disease, with increased pain and decreased activities of daily living score. Only 50% of the symptomatic patients showed progression of tear size, but no patients, symptomatic or asymptomatic, showed a decrease in tear size.

Dugas, JR; Campbell, DA; Warren, RF et al. Anatomy and dimensions of rotator cuff insertions. Journal of Shoulder and Elbow Surgery 11: 498-503, 2002.

This study evaluated the dimensions of the rotator cuff attachments to the humerus. It showed that the rotator cuff attaches very closely to the articular margin of the cartilage in the supraspinatus and the wisth of insertion is 12-14mm. The area of the insertions of all the tendons is quite large, about $6cm^2$. All the tendons attach over a broad area, except the lower portion of the subscapularis.

Mehta, S; Gimbel, GA; Soslowsky, LJ. Etiologic and pathogenetic factors for rotator cuff tendinopathy. Clinics in Sports Medicine 22: 791-812, 2003.

This is an excellent review of the gross and microscopic anatomy, the known etiologic factors, and basic science findings regarding rotator cuff disease. It highlights the complex 3-D anatomy of the cuff, the differential strain patterns (less strain tolerance capability on the articular side), and defines intrinsic, extrinsic, and overuse mechanisms of injury. In their animal model, extrinsic (compression) injury from impingement showed greater injuries when combined with overuse. Intrinsic factors, especially poor matrix and apoptosis, also appeared to be common causative factors.

Fitzpatrick, MJ; Powell, SE; Tibone, JE et al. The anatomy, pathology, and definitive treatment of rotator interval lesions. Arthroscopy 19S: 70-79, 2003.

This instructional course provides a good review of the anatomy, pathophysiology, and treatment of lesions of structures associated with the rotator interval. This is a complex area, with multiple structures. Problems with the rotator interval can be categorized as interval contractures (adhesive capsulitis) or interval laxity (GH instabilities). Biceps pathology, with or without subscapularis injury, can also occur. Pulley lesions commonly cause biceps tendinopathy or instability.

Kibler, WB; Dome, DC. Chronic shoulder injuries. In Garrick, JG (ed) OKU: Sports medicine 3: 79-88, 2004.

This review and update provides an overview of rotator cuff function relating to normal shoulder biomechanics, emphasizing the roles of humeral head compression, and depression. It also reviews the literature regarding the etiology of rotator cuff disease, and discusses both external and internal impingement of the rotator cuff. It then provides clinical implications of the basic science findings.

2. Diagnosis, Patient Selection, and Clinical Decision Making

Mallon, WJ; Herring, CL; Salley, PI et al. Use of vertebral levels to measure presumed internal rotation at the shoulder: A radiographic analysis. Journal of Shoulder and Elbow Surgery 5: 299-306, 1996.

This study used CT scans and radiographs to document the contribution of scapulothoracic motion, glenohumeral motion, and elbow flexion to the motion of shoulder internal rotation to place the hand to the vertebral spine. This vertebral level measurement is frequently used as a measure of glenohumeral internal rotation.

Glenohumeral rotation contributes at best only 2/3 of the demonstrated vertebral level motion, and vertebral level position is variable and greatly influenced by elbow flexion. The vertebral level method of estimating glenohumeral internal rotation inaccurately measures the actual motion.

Hertel, R; Ballmer, FT; Lambert, SM et al. Lag signs in the diagnosis of rotator cuff rupture. Journal of Shoulder and Elbow Surgery 5: 307-313, 1996.

This study evaluated lag signs, defined as the discrepancy between active and passive ranges of motion (when full motion is achievable) in different positions of the shoulder as indicators of injury to the rotator cuff muscles. It evaluated internal rotation lag for subscapularis injury, external rotation lag for supraspinatus and infraspinatus injury, and the drop arm lag sign for infraspinatus.

The study showed that lag signs were usually specific for muscle injury, but not uniformly sensitive. The magnitude of the lag correlated with the size of the tear. Partial supraspinatus tears were not detected by the external rotation lag sign.

Morrison, DS; Frogameni, A; Woodworth, P. Non operative treatment of subacromial impingement syndrome. Journal of Bone and Joint Surgery 79: 732-737, 1997.

This retrospective study evaluated the success of a specific treatment protocol consisting of rest, anti-inflammatory medication, and exercises designed to strengthen the humeral head depressors of the rotator cuff in relieving the symptoms of impingement.

Overall, 67% of the patients improved and 28% did not improve and required surgical treatment. Patients over 60 years of age, whose impingement was more related to degenerative cuff changes, and patients under 40 years of age, whose impingement was more frequently secondary to other glenohumeral problems, had the lowest level of success.

Deutsch, A; Altchek, DW, Veltri, DM et al. Traumatic tears of the subscapularis tendon. American Journal of Sports Medicine 25: 13-22, 1997.

This paper retrospectively reviewed clinical presentation, clinical diagnosis, MRI findings, and operative treatment. Clinical exam findings of localized pain, range of motion limited by pain, and decreased internal rotation strength were suggestive but not diagnostic of the injury. Most patients could not do the lift off test due to pain. MRI exam demonstrated the lesions in all cases. Operative repaired decreased pain and increased strength for all patients.

Hayes, K; Walton, JR; Szomor, Z et al. Reliability of 3 methods for assessing shoulder strength. Journal of Shoulder and Elbow Surgery 11: 33-39, 2002.

This study determined the inter-rater and intra-rater reliability of manual muscle testing, a hand-held dynamometer, and a spring scale dynamometer in evaluating demonstrated strength in symptomatic patients doing 4 different shoulder movements.

This study showed that manual muscle testing is not as reliable as the dynamometers for any of the tests or testing positions. Dynamometers should be used for accurate and reliable strength measurements.

Goutallier, D; Postel, J-M; Gleyze, P et al. Influence of cuff muscle fatty degeneration on anatomic and functional outcomes after simple suture of full thickness tears. Journal of Shoulder and Elbow Surgery 12: 550-554, 2003.

This retrospective multicenter report evaluates tear healing and functional scores in patients with repaired rotator cuff tears and relates these findings to pre and post operative evaluation of fatty infiltration in the muscles. The authors use the Goutallier system of classification of infiltration, MRI and CT scans for tendon healing, and constant scores for functional outcomes. The report had the deficiencies of a retrospective study.

The study showed that pre operative findings of grade 2 or higher score increased the risk for re-tear and a decreased constant score. Higher degrees of fatty infiltration are important prognostic factors in planning rotator cuff surgery.

Churchill, RS; Febringer, EV; Dubinsky, TJ et al. Rotator cuff ultrasonography: Diagnostic capabilities. Journal of the American Academy of Orthopaedic Surgeons 12: 6-11, 2004.

This perspectives article gives an overview of the technology of the ultrasound machine, a good description of the techniques used to visualize the biceps, subscapularis, supraspinatus and infraspintaus tendons, and reviews the available literature on outcomes.

Advantages include relatively low cost, in office dynamic imaging, non-invasiveness, and utility in full thickness tears and post operative follow-up. Disadvantages include a high

degree of operator dependency, low utility in partial thickness injuries, and inability to address labral and articular pathology.

Teefey, SA; Rubin, DA; Middleton, WD et al. detection and quantification of rotator cuff tears – comparison of ultrasonographic, magnetic resonance imaging, and arthroscopic findings. Journal of Bone and Joint Surgery 86: 708-716, 2004.

This Level I study prospectively evaluated the capability of ultrasound and MRI to accurately assess the presence of rotator cuff tears, whether they were partial or full thickness tears, and the tear size and amount of retraction. Arthroscopic evaluation was used as the gold standard.

There was no statistical difference between the 2 imaging methods in detecting or accurately reporting rotator cuff tears. They displayed similar high degrees of accuracy. The decision to use one method or the other may depend on factors such as operator experience, presence of incompatible devices, and necessity of imaging other structures.

Kibler, WB; Sciascia, AD, Dome, DC. Evaluation of apparent and absolute supraspinatus strength in patients with shoulder injury using the scapular retraction test. American Journal of Sports Medicine 34(10): 1643-1647, 2006.

This controlled laboratory study examined supraspinatus strength via a hand-held dynamometer in both scapular stabilized empty can (scapular retraction test) and classic (unstabilized) empty can muscle testing positions in healthy and injured subjects. Supraspinatus muscle strength increased by 13% in the healthy subjects and 24% in the injured subjects using the scapular retraction test. Pain levels did not change from one test to the other.

This study showed that demonstrated apparent supraspinatus weakness on clinical examination in injured patients may be dependent on scapular position. The weakness may be due to other factors such as a lack of a stable base in the kinetic chain or scapula.

Goldberg, SS; Bigliani, LU. Shoulder impingement revisited: Advanced concepts of pathomechanics and treatment. AAOS Instructional Course Lectures 55: 17-27, 2006.

This Instructional Course Lecture provides an overview of impingement reviewing the history, etiology, anatomy, biomechanics, biology, evaluation and treatment of the condition. The authors note that impingement syndrome has many factors contributing to its presence which justifies the need to perform a complete evaluation of the body rather than an evaluation focused at the shoulder region. Treatment of impingement should include control of inflammation, strengthening of scapular stabilizers as well as humeral movers, and, if warranted, subacromial decompression without unnecessary bone removal. The authors did not advocate the use of steroid injection due to a lack of quantitative support from the literature.

3. Management of Impingement

Neer, CS. Anterior acromioplasty for the chronic impingement syndrome in the shoulder. Journal of Bone and Joint Surgery 54: 41-50, 1972.

This classic paper established the guidelines for current thought and treatment. It focused attention on compression of the cuff against the arch as the ultimate pathomechanics, showed that the anterior, rather than lateral arch is the ultimate site of compression, and proposed anterior acromioplasty as the surgical treatment. It clarified impingement symptoms in a specific population – workers with an average age of 51.

This paper, and its conclusions, serves as an important guide, but must be integrated with further findings in other populations.

Harryman, DT; Sidles, JA; Clark, JM, et al. Translation of the humeral head on the glenoid with passive glenohumeral motion. Journal of Bone and Joint Surgery 72: 1334-1343, 1990.

This cadaver study evaluated the relation between glenohumeral rotation and translation of the humeral head on the glenoid. In "normal" capsules, translations only occurred at the end ranges of rotational motions, preserving ball and socket glenohumeral kinematics. In shoulders that were tightened in the posterior capsule, translations occurred in the mid ranges of motion, and created anterior and superior positioning of the humeral head on the glenoid.

This study demonstrates that alterations in rotation can create altered glenohumeral kinematics, and direction as well as magnitude of humeral head motion is capable of creating impingement. This altered rotation can be measured clinically, and should be evaluated in patients with impingement.

Warner, JJP; Micheli, L; Arslenian, L. Scapulothoracic motion in normal shoulders and shoulders with glenohumeral instability and impingement syndrome. Clinical Orthopaedics and Related Research 285: 199-215, 1992.

This study utilized Moire topographic analysis to study scapular position and motion in patients as they moved their arms in flexion. The topography of the contours of the back and scapulae were evaluated in 3 groups of patients. Compared to patients with no injury and "normal shoulders", patients with glenohumeral instability and impingement demonstrated asymmetrical topography consistent with alteration of scapular position and motion. This occurred in 67-100% of the injured patients.

This clinical paper was among the first studies to demonstrate altered scapular position and motion in association with shoulder injury.

Flatow, EL; Soslowsky, LJ; Ticker, JB, et al. Excursion of the rotator cuff under the acromion – patterns of subacromial contact. American Journal of Sports Medicine 22: 779-788, 1994.

This cadaver study used stereophotogrammetry to evaluate the patterns of contact between the humeral head/supraspinatus and the acromion/CA ligament/AC Joint as the arm was elevated and rotated. The acromion and rotator cuff were in closest proximity with arm elevations between 60 and 120 degrees. Conditions that decrease external rotation, arm elevation, or acromial elevation increase compression. Regions of contact are focused on the anterior inferior acromion.

This study, with the limitations of a cadaver study, provides evidence for employing an anterior acromioplasty for patients with impingement symptoms that do not respond to non-operative management, and highlights the importance of normalizing rotation to decrease impingement.

Stephens, SR; Warren, RF; Payne, LZ, et al. Arthroscopic acromioplasty: A 6 to 10 year follow up. Arthroscopy 14: 382-388, 1998.

This long term outcome study showed that, in general, short term results of patient satisfaction were maintained. However, 33% of sports participants continued to have pain and lack of power, and 19% were considered failures according to HSS scores. Most of the failures were in the younger groups. The authors felt this was mainly due to diagnostic errors or surgical errors, and emphasized the need for precise diagnosis and specific indications for subacromial decompression.

Ludewig, PM; Cook, TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Physical Therapy 80: 276-291, 2000.

This clinical study evaluated glenohumeral and scapulothoracic motion and scapulothoracic muscle activity in controls and in workers with impingement, as the arms were elevated with hand held loads. The impingement group showed decreased scapular upward rotation, increased scapular anterior tilting, and increased scapular internal rotation, along with decreased serratus anterior muscle activation. These alterations need to be considered in evaluation and treatment of these patients.

Spangehl, MJ; Hawkins, RH; McCormack, RG, et al. Arthroscopic versus open acromioplasty: a prospective randomized blinded study. Journal of Shoulder and Elbow Surgery 11: 101-108, 2002.

This level I study evaluated subjective and objective outcomes 1 year after isolated acromioplasty by open or arthroscopic techniques. There was no significant difference between open and arthroscopic techniques for pre to post operative improvement, patient

satisfaction, UCLA score, or strength. Both groups improved in reduction of pain and improvement of function, but the open technique resulted in higher levels of improvement. Good and excellent results were seen in 67% but increased to 87% in the non-worker's compensation group.

This well designed study showed that either technique is capable of generating good results, but not in every patient, highlighting the need for careful patient selection for the procedure.

McFarland EG; Selhi, HS; Keyuradan, E. Clinical evaluation of impingement: what to do and what works. Journal of Bone and Joint Surgery 88: 432-441, 2006.

This instructional course lecture provides an outstanding overview of the rationale and principles for the clinical evaluation of the patient with symptoms of shoulder impingement. It then describes and illustrates specific clinical and radiological exam tests for outlet impingement, partial or full thickness rotator cuff tears, coracoid impingement, internal impingement, and SLAP lesions.

This review will be helpful as a resource to know how to do the tests and how to interpret the results of the tests.

Goldberg, SS; Bigliani, LU. Shoulder impingement revisited: advanced concepts of pathomechanics and treatment. AAOS Instructional Course Lectures vol 55: 17-27, 2006.

This comprehensive review outlines the history, anatomic considerations, biomechanics, evaluation, and treatment of impingement. It reviews findings that establish the anterior acromion and CA ligament as the location of the impingement, reviews acromial morphology, outlines intrinsic and extrinsic biomechanics that may play etiologic roles, and reviews evaluation and treatment strategies and outcomes.

This review places impingement in a dynamic rather than static context, and shows the multiple possible causative factors that need to be considered in treatment.

Kharrazi, FD; Busfield, BT; Khorsad, DS. Acromioclavicular joint reoperation after arthroscopic subacromial decompression with and without concomitant acromioclavicular surgery. Arthroscopy 23: 804-808, 2007.

This paper reviewed results of operative intervention for impingement that involved controversial techniques that either left the AC joint alone or included the AC joint in the treatment. 1.5% of patients required AC joint re-operation in both groups. In this large study, violation of the AC joint by co-planing or distal clavicle resection did not in itself create more or less AC joint symptoms. There was a high rate of continued symptoms, mainly pain, in the re-operation group.

This study suggests that AC joint surgery is not required as a normal part of the operation in subacromial decompression.

Kibler, WB; Sciascia, AD. What went wrong and what to do about it: pitfalls in treatment of common shoulder injuries – problems in shoulder impingement treatment. AAOS Instructional Course Lectures vol 57, AAOS, Rosemont: 2008.

This ICL reviews pitfalls in treatment of impingement. It discusses pitfalls in diagnosis, treatment, and rehabilitation. In addition to intrinsic subacromial pathology, multiple extrinsic problems including glenohumeral internal derangement, AC joint injury, scapular dyskinesis, and neurological problems can create or exacerbate symptoms of impingement and must be ruled in or out in the diagnostic work-up. Pitfalls in treatment include doing the wrong operation based on an incomplete diagnosis, or doing too much or too little decompression. Pitfalls in rehabilitation include prescribing the wrong exercises at the wrong time, or omitting steps in the rehabilitation process.

This review provides a guide for a comprehensive treatment plan for impingement, and illustrates steps that may be taken if initial treatment is unsuccessful.

4. Open Rotator Cuff Repair

Gerber C, Schneeberger AG, Beck M, Schlegel U. Mechanical strength of repairs of the rotator cuff. J Bone Joint Surg Br 1994;67:371-380.

The authors report the results of a detailed study of factors related to suture type and suture placement and the strength of rotator cuff tendon fixation. Before undertaking the study they surveyed experts in shoulder surgery about their techniques for tendon grasping and tendon to bone fixation. Regarding suture type the authors found that non-absorbable braided polyester and absorbable polyglactin and polyglycolic acid sutures best combined ultimate tensile strength and stiffness. Most importantly, they found that the commonly used simple suture constructs failed at relatively low loads. A tendon grasping suture technique, a modified Mason-Allen suture, was found to have significantly greater ultimate tensile strength. Lastly, they found that the suture-bone interface was a substantial point of weakness in the overall construct of a rotator cuff repair. The findings of this study form the basis of what many consider the gold standard of rotator cuff repair; transosseous sutures with Mason-Allen tendon grasping.

Goutallier D, Postel JM, Bernageau J, Lavau L, Voisin MC. Fatty muscle degeneration in cuff ruptures. Pre- and postoperative evaluation by CT scan. Clin Orthop Relat Res. 1994;304:78-83.

The authors describe their classification of fatty muscle degeneration of the rotator cuff. They proposed a grading system with 5 stages: Stage 0 corresponds to a completely normal muscle, without any fatty streak; in Stage 1 the muscle contains some fatty streaks; in Stage 2 the there is more muscle than fat; in Stage 3 there is as much fat as muscle; and in Stage 4 more fat than muscle is present.

They studied correlations between muscle degeneration and clinical outcome and evaluated the progression of muscle degeneration after rotator cuff repair. The found that the infraspinatus muscle can degenerate in association with tearing of the anterior superior rotator cuff even if the infraspinatus is not torn. Isolated supraspinatus tears were not associated with significant infraspinatus degeneration. The post-operative CT scans rarely demonstrated reversal of fatty degeneration. Recurrent tears were associated with supraspinatus and infraspinatus fatty infiltration. Based upon their findings they concluded that it is better to operate early on larger tears before irreversible muscle deterioration occurs.

Harryman DT, Mack LA, Wang KY, Jackins SE, et al: Repairs of the rotator cuff: Correlation of functional results with integrity of the cuff. J Bone Joint Surg 1991;73-A:982-989.

In this paper the authors reported the first large study to correlate the integrity of rotator cuff repair with the functional outcome. They evaluated the functional outcome and repair integrity of 105 patients who were treated with open rotator cuff repair. Repair integrity was assessed using ultrasound examination. From a structural standpoint, they found that smaller tears had a greater rate of healing compared to larger tears.

The authors performed a detailed analysis and found a number of correlations between rotator cuff tear size and repair integrity and patient outcomes. In general, the patients' ability to perform activities of daily living and severity of pain did not correlate with the size of the tear that was repaired. Shoulders with large recurrent defects had less active shoulder elevation. Patients with an intact rotator cuff had better shoulder strength and function than those with a recurrent defect. Additionally, although there was a high rate of pain relief regardless of the integrity of the repair, patients with intact repairs had greater average scores for pain and satisfaction.

The results highlight the fact that patients with intact rotator cuff repairs have better functional outcomes. Thus, efforts to enhance healing are warranted. In addition, patients who undergo rotator cuff repair that does not result in complete healing experience significant improvement in functional outcomes.

Neer CS II. Anterior acromioplasty for the chronic impingement syndrome in the shoulder: A preliminary report. J Bone Joint Surg Am 1972;54:41-50.

In this classic article, Neer introduced the concept of subacromial impingement as a factor in the development of rotator cuff disorders. Previous authors had emphasized the lateral acromion as the source of the problem and recommended acromionectomy. In contrast, Neer emphasized the role of the anterior acromion and the coracoacromial ligament and introduced anterior acromioplasty as the surgical treatment. Anterior acromioplasty has remained a component of most rotator cuff repair techniques.

Green A. Chronic massive rotator cuff tears: Evaluation and management. J American Academy of Orthopaedic Surgeons 2003; 11:321-331.

With the increasing age and functional demands of patients large and massive rotator cuff tears are becoming a more common clinical problem. This is a review article that specifically focuses on chronic massive rotator cuff tears. Classification, clinical and radiographic evaluation, and management (non-operative and operative) are reviewed. Options for operative management include debridement, rotator cuff repair, and rotator cuff reconstruction.

Millett PJ, Wilcox RB, O'Holleran JD, Warner JJP. Rehabilitation of the rotator cuff: An evaluation-based approach. J American Academy of Orthopaedic Surgery 2006;14:599-609.

This is a current review article that discusses rehabilitation of patients after rotator cuff surgery. The authors emphasize the importance of considering patient progress and achievement of clinical goals. They describe four phases of rehabilitation that begin with maintaining and protecting the repair in the immediate post-operative period, followed by progression from early passive range of motion through return to pre-operative levels of function.

Edwards TB, Walch G, Sirveaux F, Mole D, Nove-Josserand L, et al. Repair of tears of the subscapularis. J Bone Joint Surg Am 2005;87:725-730.

The authors reported on the surgical treatment of a large series of patients with isolated subscapularis tendon tears. They treated a spectrum of pathology ranging from smaller upper to complete full thickness tears. Many of the patients had concomitant biceps tendon pathology. Seventy percent of the patients were male and two thirds reported a traumatic etiology. The surgical technique for mobilization of a retracted subscapularis tendon is described in detail.

They reported a high rate of success with significant improvements in the Constant scores. The severity of the subscapularis pathology was a major factor in determining the ultimate function of the subscapularis, with worse fatty degeneration of the muscle and more extensive tearing associated with positive post-operative lift-off and belly-press tests. The data did not demonstrate a statistically significant correlation between the severity of subscapularis pathology and the Constant score. This is most likely due to the fact that the Constant score assesses strength that is most dependent on the superior and posterior rotator cuff, as well as the deltoid. They also found that biceps tenodesis and tenotomy had a beneficial effect on a number of the outcome parameters.

Gerber C, Fuchs B, Hodler J. The results of repair of massive tears of the rotator cuff. J Bone Joint Surg 2000;82-A:505-515.

The treatment of massive rotator cuff tears remains a complex clinical challenge. More recent literature has emphasized a critical assessment of the outcome of operative treatment. In this study, the authors performed a prospective evaluation of a specific technique of rotator cuff repair that attempted to improve the initial fixation strength and healing rate of massive rotator cuff tears. The technique included transosseous tendon fixation with no. 3 braided non-absorbable suture placed in a modified Mason-Allen grasping configuration. The sutures were tied laterally over a titanium plate to reinforce the bone of the tuberosities.

The post-operative evaluations included both clinical examination as well as MRI to determine the extent of healing as well as the condition of the rotator cuff muscles. There was significant improvement in most of the clinical outcome parameters. There was no

improvement in internal or external rotation motion or in the abduction strength. The rotator cuff repair was intact in 63% of the cases. The patients with an intact repair had significantly greater strength, active range of motion, Constant, and subjective shoulder value. Despite the clinically satisfactory results fatty degeneration of the rotator cuff was observed to increase in the subscapularis, supraspinatus, and infraspinatus muscles. Successful repair only benefited the supraspinatus muscle in that this muscle showed less progression of fatty degeneration if the repair was intact. Additionally, although the post-operative degree of muscular atrophy of the infraspinatus and subscapularis did not depend upon the integrity of the repair, the integrity of a supraspinatus repair appeared to halt and possibly reverse atrophy of the supraspinatus muscle.

This study highlights the functional outcome benefits of repair of massive rotator cuff tears even in the face of incomplete healing of a repair and demonstrates that techniques that improve the healing rates may result in better long-term functional outcomes.

Klepps S, Bishop J, Lin J, Cahlon O, Strauss A, Hayes P, Flatow EL. Prospective evaluation of the effect of rotator cuff integrity on the outcome of open rotator cuff repairs. Am J Sports Med. 2004;32:1716-22.

The authors performed a prospective outcomes study of open rotator cuff repair. They specifically analyzed the effect of rotator cuff repair integrity on outcome. One year after surgery the patients underwent a clinical evaluation identical to the pre-operative assessment and had a follow-up MRI to determine the integrity of the rotator cuff. Overall, 67 percent of the repairs were intact.

The authors found that patients with re-tears had significant improvements in all clinical outcome parameters including strength. Although the patients with failed repairs had equivalent improvements in strength they had less initial and follow-up strength. The authors reported that there were no statistically significant correlations between cuff integrity and outcome. However, the sample size of the study was probably too small to detect statistically significant correlations between rotator cuff integrity and clinical outcome.

Walch G, Boulahia A, Calderone S, Robinson AH.The 'dropping' and 'hornblower's' signs in evaluation of rotator-cuff tears. J Bone Joint Surg Br. 1998 Jul;80(4):624-8.

The affect of rotator cuff tears on shoulder strength is well known. In the presence of chronic large and massive rotator cuff tears decisions regarding treatment and repairability can be based upon objective pathology such that the clinical outcome is predictable. The authors evaluated the relationship between physical exam findings of severe posterior rotator cuff pathology, the “dropping” and “hornblower’s” signs, and the objective rotator cuff pathology identified on CT scans. They found that both signs had high sensitivity and specificity for advanced fatty degeneration of the infraspinatus muscle.

5. Reparable Rotator Cuff Tears (Mini Open)

Arthroscopy. 1990;6(1):55-60. Arthroscopic assisted rotator cuff repair: preliminary results. Levy HJ, Uribe JW, Delaney LG.

This study represents the first peer-reviewed publication detailing a new technical approach to full-thickness rotator cuff repair. This arthroscopic-assisted technique to rotator cuff repair, also referred to as a mini-open or limited-open repair, is proposed as a limited deltoid-splitting approach to avoid deltoid detachment, which is required during a standard, traditional open rotator cuff repair. By performing the subacromial decompression in an arthroscopic fashion, the deltoid release is not required to approach the rotator cuff from a lateral aspect through the deltoid split

The 25 patients in this series with rotator cuff tears were treated with an arthroscopic-assisted approach, and retrospectively reviewed with a follow-up of 12-27 months (mean: 18 months). Age, arm dominance and sex represented the expected distribution of more males (72%), more dominant arms (68%) involved and average age of 57.5 years (range: 21-74 years). Using the UCLA scoring system, 80% of patient outcomes were rated as excellent or good, with significant improvement in pain, function, range-of-motion and strength. When analyzed by tear size, those patients with a small or medium sized tear (8 patients) achieved 100% satisfactory rating, while patients with large or massive tears (17 patients) had 71% satisfactory rating. All of the unsatisfactory ratings were in patients with large tears. Abduction splints were used for a variable period of time post-operatively (1-3 weeks) with passive range-of-motion initiated the first day following surgery.

The outcome rating of 80% satisfactory is within the range reported previously with standard open repair techniques. The surgical modification reported in this study has advantages over open repair, but reveals a potential weakness of this technique for repairing large and massive tears, as the diminished satisfactory rating reveals. Two patients excluded from the study group with massive tears had the arthroscopic subacromial decompression performed, but the tear edges could not be approximated with arthroscopically-placed sutures and the technique was aborted. All of the steps for tendon repair were performed through the deltoid split, including releases and tendon mobilization, in addition to fixation, which in this case utilized transosseous tunnels.

Am J Sports Med. 1994 Jan-Feb;22(1):19-25. Arthroscopically enhanced "miniapproach" to rotator cuff repair. Paulos LE, Kody MH.

This study is the second peer-reviewed publication retrospectively highlighting the mini-open approach to full-thickness rotator cuff repair, indicating the first repair was performed in April 1986 and including a longer post-operative follow-up than previously reported.

The 18 patients in this series with rotator cuff tears were treated with an arthroscopic-assisted approach with a follow-up of 36-72 months (mean: 48 months). Age represented a slightly younger average than previously reported, 57.5 years (range: 21-74 years), though arm dominance involved was 72% and there were 78% males involved. Also using the UCLA scoring system, 88% of patient outcomes were rated as excellent or good, with significant improvement in pain, function, range-of-motion and strength. Of the 17 patients with tear size reported, 6 had a 1 cm tear, 8 had a tear between 1-2 cm and 3 had a tear 3 cm or more. The two patients who reported being only slightly better or not better had pending worker's compensation cases, with the latter showing signs of progressive acromioclavicular arthritis. The glenohumeral arthroscopy allowed for the diagnosis of concomitant pathology, which the authors treated with 5 labral debridements, two biceps debridements and two chondroplasties. An abduction pillow was used post-operatively in 7 patients based on tear size, tissue quality and tension of the repair.

While small, medium and larger tears were included in this study, tear size was not correlated with the outcomes, with only 3 patients having tears 3 cm or larger. The authors did state "Acute tears, easily mobilized tears, and tears that are not retracted more than 2 cm, regardless of size, can usually be repaired through a 'miniapproach'." As previously reported, all steps for tendon repair were performed during the open stage and completed with non-absorbable Dacron sutures. Interestingly, the authors describe a "double-row" technique, with transosseous tunnels for the primary repair and anchors medially to augment the repair, particularly a delaminated portion. The advantage of the diagnostic portion of the arthroscopy to identify, and treat, additional pathology, is noteworthy, though taken for granted today.

Arthroscopy. 1994 Feb;10(1):54-60. Arthroscopically assisted rotator cuff repair: correlation of functional results with integrity of the cuff. Liu SH, Baker CL.

Reporting on rotator cuff integrity following arthroscopic-assisted rotator cuff repair, these authors also describe their technique for a deltoid-sparing approach to rotator cuff repair from a series of 48 repairs in 45 patients beginning in June 1987.

This series included 33 patients with 35 repairs retrospectively reviewed with an average follow-up of 3.7 years (range: 2.5 – 5.1 years). There were 58% women, with the dominant arm involved in 70% and an average age of 63 years (range: 35-76 years). The surgical technique used multiple 0 PDS sutures placed arthroscopically, utilized for traction through the deltoid split and utilized for transosseous repair to a trough on the greater tuberosity. An abduction splint was used post-operatively in all patients for 3 weeks, though pendulums and protected passive range-of-motion exercises were begun during that 3 week period. Again, using the UCLA scoring system, 85% of patients had excellent or good results and 93% were satisfied. "On the average, all patients improved at least one grade on manual strength testing after surgery." Single-contrast arthrography was used post-operatively in all patients. There was a 54% re-tear rate, with twelve patients (34%) having full-thickness re-tears and 7 patients (20%) having partial-thickness re-tears. Of the 13 patients with a large tear that was repaired, 10 had re-tears (77%), including 8 full-thickness re-tears (62%). Of the 22 patients with a small or medium tear that was repaired, 9 had re-tears (41%), including

4 full-thickness re-tears (18%). However, these findings could not be correlated with a significant difference in functional outcomes between groups with full-thickness re-tears, partial-thickness re-tears or no re-tears.

The re-tear rate in this series was similar to other studies, though 27% of patients and repairs, those from out of state, were lost to follow-up and not included. While, rotator cuff integrity following this mini-open repair did correlate with tear size, it did not correlate with functional outcomes. This series included repair with an absorbable suture, which would not likely be used today.

J Bone Joint Surg. 2001 May;83-A(5):764-71. Mini-open rotator cuff repair: an updated perspective. Yamaguchi K

Adapted from an instructional course lecture, this review, yet forward-thinking, article summarizes the state-of-the-art for mini-open rotator cuff repairs. The fundamentals of rotator cuff repair are highlighted. The disadvantages of the standard open repair, such as the required delay in rehabilitation to allow for deltoid healing or a 0.5% incidence for deltoid avulsion in experienced hands, are noted. All mini-open repair reports have described using the open portion for all the releases and repair. The author noted that this limited-open technique may not be advisable for all rotator cuff tear indicated to be repair. When the open portion of the approach is also used to mobilize and release the tear, the limited view laterally obstructed by the acromion may inhibit an adequate release and repair. The author suggested that this original description of the technique is better served for smaller, easily mobilized tears. The author outlines two alternative mini-open techniques, distinguishing the arthroscopically-assisted open repair (akin to the original description) from a mini-open assisted arthroscopic repair. In the latter technique, releases are performed arthroscopically to fully mobilize the tear, expanding the technique to be applicable in larger rotator cuff tears. As the majority of the procedure is performed arthroscopically, the open portion is only used for direct repair of tendon to bone, limited the time, and possibly injury, during deltoid exposure and retraction. Including the author's proposed progression to complete arthroscopic repair, the Table below demonstrates this.

TABLE 2. Comparison of Surgical Techniques

Type of Repair	Joint Inspection	Subacromial Decompression	Rotator Cuff Releases	Placement of Tagging Sutures	Tendon Gripping Stitches	Bone-Tendon Fixation
Arthroscopically assisted open repair	Arthroscopic	Arthroscopic	Open	Open	Open	Open
Mini-open assisted arthroscopic repair	Arthroscopic	Arthroscopic	Arthroscopic	Arthroscopic	Open	Open
Completely arthroscopic repair	Arthroscopic	Arthroscopic	Arthroscopic	Arthroscopic	Arthroscopic	Arthroscopic

(Reproduced with permission from Yamaguchi K: Mini-open rotator cuff repair: An Updated perspective. *Instr Course Lect* 45:53–6(2001.)

This article, as well as another with co-authors in Clinical Orthopaedics & Related Research in September 2001, suggests a progression toward "minimally invasive" rotator cuff repair, with the traditional mini-open approach followed by the mini-open arthroscopically assisted approach as the surgeon develops arthroscopic release and tendon mobilization techniques on his or her way towards an all arthroscopic repair. While a disadvantage of the traditional open repair with the deltoid released necessarily results in a delay in rehabilitation, the delay may not be mitigated with mini-open or arthroscopic repairs, nor might the full recovery time.

Arthroscopy. 2002 Jul-Aug;18(6):665-70. Mini-open rotator cuff repair using a two-row fixation technique: outcomes analysis in patients with small, moderate, and large rotator cuff tears. Fealy S, Kingham TP, Altchek DW.

As a technical note, these authors propose two rows of anchor fixation, one medial just off the articular margin and one lateral at the greater tuberosity edge, to enhance fixation of a rotator cuff repair over the prepared sulcus in larger-sized tears.

In a series of 75 consecutive patients, their double-row technique is utilized in 30 patients with large rotator cuff tears as well as 45 patients with small or moderate tears. The surgical technique includes arthroscopic releases to mobilize the tendon and then the mini-open deltoid split for anchor placement and tendon repair to bone. The medial row anchor sutures are repaired in a horizontal mattress fashion, compared with a simple, or modified Mason-Allen, suture technique laterally, which are tied first. The authors found no difference in outcome based on tear size at a minimum 24 months follow-up.

While the advancements to extend the mini-open indications to larger rotator cuff tears included a variety of arthroscopic releases, the approach presented here also seeks to improve immediate tendon fixation to bone for tears potentially under greater tension and to enhance healing of the repaired tendon over a broad surface area of the footprint. Tendon mobilization and secure fixation to bone over a wider surface are clearly important to a successful outcome.

J Shoulder Elbow Surg. 2002 Nov-Dec;11(6):605-8. Infection after mini-open rotator cuff repair. Herrera MF, Bauer G, Reynolds F, Wilk RM, Bigliani LU, Levine WN.

Over a 10 year period, 360 consecutive patients from two institutions treated with a mini-open rotator cuff repair were reviewed for the incidence of post-operative infection. Potential complications following mini-open rotator cuff repair beyond re-tear had been well-delineated.

This study finds a 1.9% incidence of deep infection (7 patients) following mini-open rotator cuff repair from two separate institutions, with 6/7 patients affected by Propionibacter acnes. Other bacteria included Staphylococcus epidermidis (1 patient), Staphylococcus aureus (1), and Pseudomonas aeruginosa (1). All surgeries were >6 months apart with no other correlating factors in the series. Patients presented an average of 24 days (range: 13-37) following surgery, and were treated with an average of 2 additional surgeries (range: 1-4).

The 4 patients with a re-tear were re-repaired. A combination of intravenous and oral antibiotics was utilized, with no recurrent infections noted after completion of treatment.

While this infection rate was higher than reports cited by these authors of 0.27% – 1.7% for traditional open repairs, it is less than the 0.5% incidence of deltoid avulsion the mini-open procedure was designed to avoid. Propionibacter acnes has been reported as the infecting agent in other studies and must be considered a culprit for infection when identified on culture. Additional complications not reported by this study, but of concern following mini-open rotator cuff repair, include pain and post-surgical stiffness.

Arthroscopy. 2003 Mar;19(3):234-8. All-arthroscopic versus mini-open rotator cuff repair: A long-term retrospective outcome comparison. Severud EL, Ruotolo C, Abbott DD, Nottage WM.

Taking repair of rotator cuff tears to the next step along the minimally-invasive continuum, these authors compare their results of mini-open repair with all-arthroscopic repair.

Over a 6 year period, 58 patients with 64 rotator cuff repairs performed by one surgeon were retrospectively reviewed, with patients with massive tears, prior rotator cuff surgery and neurologic lesions, among other criteria, excluded. The all-arthroscopic group included 35 shoulders, with anchor repairs, and the mini-open group included 29 shoulders, with transosseous repairs. The UCLA scoring system revealed 91% excellent or good results, compared with 93% excellent or good results in the mini-open group. The all-arthroscopic group had significantly greater range-of-motion at 6 weeks and 12 weeks post-operatively, but the final range-of-motion was significantly different. Of the 4 patients who had both procedures, subjective preference for the arthroscopic approach was reported "because they felt that they experienced les pain and a quicker recovery." Complications in the all-arthroscopic group included one patient with a sinus tract that required debridement and another who developed a ruptured biceps, both prior to a final good outcome. Complications in the mini-open group included 4 with stiffness, 2 treated with manipulation prior to fair final outcomes and 2 who were just observed with excellent final outcomes. There was also one patient in the mini-open group that had a re-tear and re-repair prior to a poor final outcome.

Selection criteria for each group were not indicated, however, 62% of the mini-open group had large tears compared with 26% in the all-arthroscopic group, suggesting a possible bias. Of the 4 patients who had both procedures, the outcome scores were not significantly different. The authors referred to a series published in abstract form by Stephen Weber comparing 126 arthroscopic repairs with 154 mini-open repairs, noting no difference at final outcome between the two groups, though with significantly less narcotic use in the all-arthroscopic group.

6. Arthroscopic Rotator Cuff Repair

Gartsman GM, Khan M, Hammerman SM. Arthroscopic repair of full-thickness tears of the rotator cuff. J. Bone Joint Surg. 1998; 80-A: 832-840.

This article represents one of the earliest comprehensive outcome studies of arthroscopic rotator cuff repair. The authors used a single row repair technique and evaluated the clinical outcomes at a minimum of 2 years post-operatively. The improvements and final outcomes were comparable to those reported in recent studies of double row arthroscopic repairs.

Park JY, Levine WN, Marra G, Pollock RG, Flatow EL, Bigliani LU. Portal-extension approach for the repair of small and medium rotator cuff tears. Am. J. Sports Med. 2000; 28: 312-316.

The authors evaluated the results of mini-open rotator cuff repair used to treat 110 patients with small and medium sized tears. They reported a high rate of clinical outcome success. The surgical technique included arthroscopic acromioplasty and transosseous rotator cuff repair. The portal-extension or mini-open rotator cuff repair technique represents a transition step between traditional open rotator cuff repair and all arthroscopic repair. This study establishes a standard for comparison of the results of arthroscopic rotator cuff repair.

Burkhart SS, Lo IKY. Arthroscopic rotator cuff repair. J American Academy of Orthopaedic Surgeons 2006;14: 333-346.

This review article is an in depth discussion of all aspects of arthroscopic rotator cuff repair. In addition to the usual discussion of tendon to bone fixation, the authors provide a number of technical pearls to enhance the reader's ability to perform arthroscopic rotator cuff repairs.

Cole BJ, ElAttrache NS, Anbari A. Arthroscopy 2007 ;23 :662-669.

Arthroscopic rotator cuff repair technique has evolved substantially over the past decade. Technical advances in instrumentation have facilitated the development of techniques that can replicate the tendon to bone fixation that is achieved in traditional transosseous open and mini-open rotator cuff repair techniques. This article is a current and excellent review of the most up to date understanding and thoughts about arthroscopic rotator cuff repair. In addition, there is an extensive reference list.

Yamaguchi K, Ball CM, Galatz LM. Arthroscopic rotator cuff repair: transition from mini-open to all-arthroscopic. Clin. Orthop. Sept 2001; 390: 83-94.

This review article discusses technical considerations of rotator cuff repair that are required to be able to perform to all arthroscopic repairs. The progressive incorporation of arthroscopic evaluation, preparation, and finally rotator cuff tendon repair is an ideal approach for the surgeon who desires to make the transition from open to arthroscopic repair. Current surgeons in training are more likely to develop advanced arthroscopic skills during their residency and fellowship and may primarily learn arthroscopic rotator cuff repair.

Bishop J, Kleps S, Lo IK, Bird J, et al. Cuff integrity after arthroscopic versus open rotator cuff repair: A prospective study. J Shoulder Elbow Surg 2006;15:290-299.

In this study the authors evaluated the integrity of rotator cuff repairs at greater than one year after surgery. They compared the outcomes and repair integrity of patients who were treated with open rotator cuff repair with transosseous suture fixation to patients who had arthroscopic rotator cuff with a single row technique. Repair integrity was determined with MRI.

All of the clinical outcomes were equivalent except for external rotation strength which was greater for the open repair patients. A greater percentage of the open repairs were intact, although there was no statistically significant difference with the data available. Across the entire study the outcome scores were better if the rotator cuff repair was intact. When they analyzed rotator cuff tears greater than 3 cm in dimension they found that rotator cuff tear integrity was statistically significantly better for open repair compared to arthroscopic repair.

The findings of this study suggest that the fixation achieved with earlier arthroscopic rotator cuff repair techniques is inferior to traditional transosseous open repair and is the cause of greater observed failure rates with arthroscopic repairs of larger tears. The experiences of these, as well as other authors, led to the development of arthroscopic techniques with greater fixation strength, primarily double row techniques.

Boileau P, Brassart N, Watkinson DJ, et al. Arthroscopic repair of full-thickness tears of the supraspinatus: does the tendon really heal? J Bone Joint Surg Am 2005;87:1229-1240.

In this study the authors evaluated the clinical and anatomic results of arthroscopic single row repair of isolated full-thickness tears of the supraspinatus tendon. The clinical outcomes were assessed with the Constant and UCLA scores, as well as the Simple Shoulder Test. The integrity of the repairs was determined using CT arthrography (78% of the patients) or MRI. Overall, the healing rate was 70% and about 60% of the unhealed tears were smaller than the original tears. Patients who had a healed tendon were significantly stronger and had higher Constant scores. Age, the size of the original tear, and tendon delamination extending anteriorly or posteriorly were all independent factors that were

associated with lower healing rates. Neverthelesss, healing of the repair did not appear to have an affect on pain relief, activity, mobility or patient satisfaction.

The authors concluded that the results that they achieved with their single row arthroscopic technique were equivalent to results previously reported with open and mini-open rotator cuff repair techniques.

Franceschi F, Ruzzini L, Longo UG, Martina FM, Zobel BB, Maffulli N, Denaro V. Equivalent clinical results of arthroscopic single-row and double-row suture anchor repair for rotator cuff tears: a randomized controlled trial. Am J Sport Med 2007;35:1254-1260.

The authors performed a randomized prospective study that compared single row with double row arthroscopic rotator cuff repair of large and massive tears. Post-operative integrity of the repair was assessed after 2 years with MR arthrography. The clinical outcomes were equivalent based upon the follow-up evaluation with the UCLA score and patient satisfaction. Nevertheless, the patients with double row fixation had better anatomic results.

Based upon the results of this study, single row and double row rotator cuff repair appeared to yield equivalent short term results despite differences in the cuff integrity. The issue of rotator cuff integrity may have implications for longer term functional outcome.

Lafosse L, Jost B, Reiland Y, Audebert S, Toussaint B, Gobezie R. Structural integrity and clinical outcomes after arthroscopic repair of isolated subscapularis tears. J Bone Joint Surg Am. 2007;89-A:1184-1193.

Advances in instrumentation and surgical skills have lead to expansion of the indications for arthroscopic rotator cuff repair. In this report the authors present their approach to the arthroscopic management of subscapularis tears and analyze the clinical and anatomic outcomes. The majority of the tears were traumatic and involved varying degrees of the subscapularis tendon. Four of the 17 patients had a complete subscapularis tear. Post operative imaging demonstrated that 15 of 17 repairs were healed. The clinical outcomes based upon Constant and UCLA scores were excellent. The authors demonstrated that arthroscopic repair of the subscapularis tendon is feasible and yield predictable results.

Lafosse L, Brozska R, Toussaint B, Gobezie R. The outcome and structural intergrity of arthroscopic rotator cuff repair with use of the double-row suture anchor technique. J Bone Joint Surg Am 2007;89-A:1533-1541.

Recent technical advances in arthroscopic instrumentation and implants, improved understanding of both normal and pathologic rotator cuff anatomy, and early studies of repair integrity have inspired an evolution in arthroscopic repair techniques. Arthroscopic double row techniques appear to be favored by more experienced shoulder surgeons.

The authors of this article studied the functional and anatomic outcome of rotator cuff repairs performed with a double row suture anchor technique. The structural integrity of the repairs was evaluated at a minimum of 6 months post-operatively with either arthrogram, CT arthrogram, or MR arthrogram. The authors classified the tears according to Patte, by determining the position of the lateral edge of the supraspinatus tendon on a mid coronal image. Overall, there was nearly 90% repair integrity. There were no re-tears of small tears. Not surprisingly shoulders with smaller tears had better strength than shoulders with large or massive tears. The re-tear rate for larger supraspinatus tears was less than 20%.

The authors concluded that in their experience double row arthroscopic rotator cuff repair results in greater healing rates than previously reported for arthroscopic and open repairs methods. Nevertheless, the authors did not classify tear size based upon overall dimension and did not consider fatty degeneration or muscle atrophy and thus their findings may not be comparable to other studies.

Sugaya H, Maeda K, Matsuki K, Moriishi J. Functional and structural outcome after arthroscopic full thickness rotator cuff repair: Single-row versus dual-row fixation. Arthroscopy 2005;21:1307-1316.

The authors reported on a retrospective cohort study that compared the clinical and structural outcomes of arthroscopic single and double row repairs in 39 and 41 patients respectively. They assessed clinical outcomes with the UCLA and ASES scores. There were no statistically significant difference between the clinical outcomes of single row and double row repairs. The MRI evaluations demonstrated that single row repair was associated with a greater re-tear rate than the double row repairs. The authors' reported that they prefer double row repair because improved rotator cuff integrity should result in better overall functional outcome. It is possible, but yet unproven, that the longer-term outcomes of double row repair might be superior.

7. Management of Irreparable Rotator Cuff Tears:

L'Episcopo JB. Tendon transplantation in obstetrical palsy. Am J Surg 1934; 25:122-5.

Original description of latissimus dorsi and teres major transfer to restore external rotation in children with obstetrical palsy. Pectoralis major is released to obtain access to lat dorsi and teres major. Both are released and sutured together. Tendons re-routed posterior and lateral and fixed to humerus.

Covey DC, et al. Modification of the L'Episcopo procedure for brachial plexus birth palsies. JBJS (Br). 1992;74:897-901.

Retrospective review of 19 children who underwent a new modification of the L'Episcopo procedure for obstetric brachial plexus palsy. Through an axillary approach the latissimus dorsi tendon was re-routed anteriorly to the humerus and then anastomosed to the teres major tendon routed posteriorly. At an average follow-up of four years two months, the mean increase in shoulder abduction was 26 degrees and the mean increase in external rotation was 29 degrees. Two patients had complications, and five did not gain from the procedure. The modified operation was relatively easier to perform and provided excellent cosmesis.

Gerber C, Clavert P, Millett PJ, Holovacs TF, Warner JJ. Split pectoralis major and teres major tendon transfers for reconstruction of irreparable tears of the subscapularis. Tech Shoulder Elbow Surg 2004; 5:5-12.

Detailed surgical technique of spilt pectoralis major and teres major tendon transfer for the treatment of irreparable tears of the subscapularis. Pectoralis major tendon transfer is an acceptable salvage option for irreparable subscapularis tendon ruptures. Although limited functional goals may be expected in most cases, the majority of patients obtain a good pain relief, which improves their function below chest level. Addition of the teres major component to the transfer may be beneficial in cases where both the upper and lower portion of the subscapularis muscle is irreparable.

Gerber C, Hersche O. Tendon transfers for the treatment of irreparable rotator cuff defects. Orthop Clin North Am 1997; 28:195-203.

The anatomical and physiological bases for tendon transfers in the setting of irreparable rotator cuff tears are discussed. Current clinical results after tendon transfer are discussed.

Gerber C, Maquieira G, Espinosa N. Latissimus dorsi transfer for the treatment of irreparable rotator cuff tears. JBJS Am 2006;88(1):113-120.

Retrospective review of sixty-seven patients with sixty-nine irreparable, full-thickness tears of at least two complete tendons managed with latissimus dorsi transfer. Thirteen patients also had deficient subscapularis function preoperatively. Mean Subjective Shoulder Value increased from 28% preoperatively to 66% at the time of follow-up. The mean age and gender-matched Constant and Murley score improved from 55% to 73%. Flexion increased from 104 degrees to 123 degrees , abduction increased from 101 degrees to 119 degrees , and external rotation increased from 22 degrees to 29 degrees. Abduction strength increased from 0.9 to 1.8 kg. In shoulders with poor subscapularis function, minimal improvement in these parameters was observed. The paper concludes that latissimus dorsi transfer durably and substantially improves chronically painful, dysfunctional shoulders with irreparable rotator cuff tears, especially if the subscapularis is intact.

Jost B, Gerber C. Pectoralis major transfer for subscapularis insufficiency. Tech Shoulder Elbow Surg 2004; 5:157-164.

Detailed surgical technique of pectoralis major transfer for subscapularis insufficiency. Technique consists of an attempted repair of the remaining subscapularis, the detachment of the entire pectoralis major tendon, transfer over the conjoined tendon, and transosseous fixation over a thin titanium augmentation on the medial aspect of the greater tuberosity. Pectoralis major transfer for isolated subscapularis tears results in improvement of function up to 79% of a normal shoulder. If an irreparable subscapularis tear is associated with an irreparable supraspinatus tear, the results are clearly less favorable, and pectoralis major transfer may not be warranted.

Klepps SJ, Goldfarb C, Flatow E, Galatz LM, Yamaguchi K. Anatomic evaluation of the subcoracoid pectoralis major transfer in human cadavers. JSES 2001; 110:453-9.

Anatomic exploration on 20 human cadavers in which the entire pectoralis major muscle, medial and lateral pectoral nerves, and musculocutaneous nerve were explored and quantified. The relationship between the pectoralis major and the conjoined tendon was studied in situ and after simulated transfers. The medial and lateral pectoral nerves were located far medial to the pectoralis major tendon insertion and appeared to be safe from injury as long as surgical dissection remained lateral to the pectoris minor and less than 8.5 cm from the humeral insertion. Transfer of the pectoralis major superficial to the musculocutaneous nerve created less tension than transfer deep. Split pectoralis major transfer, release of the proximal musculocutaneous branches, or debulking of the pectoralis major muscle belly is recommended in subcoracoid transfer to prevent tension on the nerve.

Magermans DJ, Chadwick EK, Veeger HE, van der Helm FC, Rozing PM. Biomechanical analysis of tendon transfers for massive rotator cuff tears. Clin Biomech 2004; 19:350-7.

Tendon transfer procedure of latissimus dorsi, teres major, or a combination of these two to the insertions of either teres minor, infraspinatus, supraspinatus, or subscapularis was simulated using a biomechanical musculoskeletal model of the upper extremity. Biomechanical analysis of the transferred muscles was performed, taking outcome variables such as moment arms, muscle length and muscle force into account. Tendon transfer of the teres major to the supraspinatus insertion produced the best functional outcome in the treatment of massive rotator cuff tears.

Warner JJ, Parsons IMT. Latissimus dorsi transfer: a comparative analysis of primary and salvage reconstruction of massive, irreparable rotator cuff tears. J Shoulder Elbow Surg 2001; 10:514-21.

Compared outcomes for 16 patients who underwent latissimus dorsi transfer as a salvage reconstruction for a failed prior rotator cuff repair with outcomes for 6 patients who underwent a primary reconstruction for an irreparable cuff defect. There was a statistically significant difference in Constant score between groups, which measured 55% for the salvage group compared with 70% for the primary group. Poor tendon quality, stage 4 muscle fatty degeneration, and detachment of the deltoid insertion each had a statistically significant effect on the Constant score. Late rupture of the tendon transfer occurred in 44% of patients in the salvage group compared with 17% in the primary group at a mean of 19 months postoperatively. Rupture had a statistically significant effect on the Constant score, which declined by a mean of 14%. Study concludes that salvage reconstruction of failed prior rotator cuff repairs yields more limited gains in satisfaction and function than primary latissimus dorsi transfer.

8. Complications of Rotator Cuff Surgery

Complications of Rotator Cuff Repair. Orthop Clin of North Amer. Vol 28 No. 2 April 1997. Pierre Mansat, MD: Robert H. Cofield, MD; Tycho E Kerstien, MD, and Charles M. Rowland MS

Complications following rotator cuff surgery are probably underreported or underappreciated. Although several authors have studied the results of operative treatment of failed rotator cuff repairs, Mansat and colleagues have published the most definitive study regarding complications following rotator cuff repair.

In their series of 116 rotator cuff repairs, the combined medical and surgical complication rate was 38% (44 shoulders). While the surgical complication rate was 33% (38 shoulders), complications that affected the final surgical outcome occurred in 16% of patients (23 complications in 19 shoulders). Complications included failure of tendon healing (17), frozen shoulder (3), deep infection (2), and anterosuperior humeral head dislocation (1). Failure of tendon healing was inferred clinically by an inability to actively flex the arm farther than 120 degrees in the absence of stiffness. The actual rate of recurrent tearing may have been higher if postoperative imaging studies had been obtained. In Mansat et al's extensive literature review, as well as their reported study, the rate of revision surgery was approximately 3.5%.

This classic article remains the most definitive study to date regarding complications of rotator cuff repair. They alert us to the fact that certain medical or surgical complications may be unreported or unappreciated. We are reminded that a host of complications exist which should be made known to patients and surgeons alike. These include complications that may or may not affect the final result, and those that lead to revision surgery.

Functional and Anatomical Results After Rotator Cuff Repair. Clin Orthop. No. 304, pp43-53, 1994. Dominique F. Gazielly, MD; Pascal Gleyze, MD; and Catherine Montagnon, MD.

The postoperative integrity of the rotator cuff, following rotator cuff repair, represents the primary surgical goal. However, recurrent or persistent rotator cuff defects have been reported to occur in 20% to 90% of cases. Persistent defects are not necessarily the sine qua non for failure, since the presence of a persistent rotator cuff defect is compatible with a good postoperative result following rotator cuff repair. The quality of the functional results, however, clearly relate to the size of the persistent defect. This has led a number of authors to study the correlation between cuff integrity and the corresponding functional results.

In their prospective series of 100 open rotator cuff repairs among 98 patients, Gazielly et al utilized ultrasonography to evaluate the anatomic condition of the rotator cuff, after a minimum of 2 years following surgery (average of 4 years). Ultrasonography

showed 65% intact cuffs, 11% thinned cuffs, and 24% recurrent defects. The incidence of recurrence after an isolated supraspinatus repair was 10%, while the recurrence of tearing in two and three tendon repairs was 41% and 89%, respectively. The chief predisposing factors for recurrence were found to be the size of the preoperative tear (57%), age (25%), and the degree of occupational use (18%). The functional results obtained (utilizing Constant's Score) were more closely related to the anatomic condition of the rotator cuff at follow-up (intact, thinned, or recurrent tear), than to the tear size as surgery. While no correlation was found between tear type and postoperative pain or satisfaction, the Constant score was inversely related to the size of the recurrent defect. They also found that the anatomic results of rotator cuff repair are stable over time between the minimum and maximum follow-up.

Rotator cuff re-tearing is a relatively endemic event following rotator cuff repair. This prospective study by Gazielly et al elaborates on previous work done by Harryman (JBJS 73A, 1991) and Calvert (JBJS 68B, 1986). They reinforce the concept that functional results of rotator cuff repair are directly correlated to the anatomic condition of the rotator cuff following surgery. Interestingly, patient satisfaction and pain relief are often ubiquitous following surgery, despite the presence of a recurrent defect. These studies have propelled further research regarding cuff integrity with the advent of arthroscopic rotator cuff repairs. Bishop (JSES May. 2006), Lee (JSES Jan. 2007), and Galatz (JBJS 86A, 2004) elaborate on the concept of postoperative rotator cuff integrity relative to arthroscopic repairs. The above-described predictive factors of tear size and age appear to play a role in the recurrent tears following both arthroscopic and open techniques.

Reoperation for failed rotator cuff repair: Analysis of fifty cases. JSES Vol 1, No. 6 pp283-286. Robert J. Nevaiser, MD; and Thomas J. Nevaiser, MD

Revision rotator cuff surgery is much more challenging than primary rotator cuff repair. In this setting, the surgeon is often faced with elements of post-operative stiffness and scarring, weakness, pain, and deltoid abnormalities. Early reports by DeOrio and Cofield (JBJS 68A, 1984), regarding the effectiveness of re-operation for failed repairs, were rather dismal. These sentiments defined the management of failed rotator cuff repairs for nearly a decade. In 1992, Nevaiser and Nevaiser studied fifty patients in an effort to delineate factors associated with success and to determine whether or not functional improvements could be achieved with revision surgery.

In their series of 50 patients, the number of previous operations varied from one to four (average 1.6). The size of the recurrent defects was small (2cm) in six cases, large (2-4cm) in twenty-three cases, and massive (>4cm) in twenty-one cases. The most common factor associated with re-tearing was the initiation of resisted strengthening exercises within the first three months (28 of 50 patients). Revision surgery was performed through a deltoid-on approach, and consisted of a revision acromioplasty, acromioclavicular arthroplasty, and repair of the rotator cuff to a cancellous trough in the anatomic neck. Five cases required either interpositional grafting or tendon transfer in order to close the defect. Forty-five patients were satisfied with their result, with significant improvements in pain (46 patients), and motion (26 patients). Factors associated with a successful result in this series were related to an adequate decompression of the subacromial space and acromioclavicular joint,

mobilization and closure of all defects with tendon-to-bone sutures, avoidance of weights in the early post-operative period (3 months), and an intact and functioning deltoid. The tear size and number of prior operations did not affect the outcome.

This important study challenged the conventional wisdom of non-operative treatment for the failed rotator cuff repair. Nevaiser and Nevaiser demonstrate that the meticulous surgical and postoperative techniques of primary rotator cuff repair can be applied to revision rotator cuff repair. While the overall results do not parallel that of primary repairs, an overall improvement in pain and function may be achieved.

Surgical Treatment of Postoperative Deltoid Origin Disruption. Clin Orthop. No. 343 pp 93-98. Jerry S. Sher, MD; Joseph P. Iannotti, MD, PhD; Jon J.P. Warner, MD; Yram Groff, MD; and Gerald R. Williams, MD

Detachment of the deltoid origin represents a potentially devastating complication of rotator cuff surgery. While injury to the deltoid is an infrequent occurrence, it is generally poorly tolerated. Deltoid detachment is frequently overlooked in the immediate post-operative period, and there is often a long delay prior to diagnosis and intervention. Although this complication is recognized as a devastating complication, little attention has been given to the management of the loss of the deltoid following rotator cuff surgery.

Sher and colleagues offer the only report on the surgical management for this problem, offering their experience with twenty-four patients who underwent either direct repair or rotational deltoidplasty reconstruction of the detached deltoid muscle. In all cases intervention was delayed, with an average duration of symptoms prior to reconstruction of 17 months. The index operation consisted of rotator cuff repair (12 patients), acromioplasty (4 patients), and lateral acromionectomy with or without repair (8 patients). Direct repair of the deltoid was performed in four patients, while the remaining twenty patients underwent a rotational deltoidplasty in order to reconstruct the chronic defect. Satisfactory results were obtained among eight patients (33%). Unsatisfactory results were noted in six of nine patients who had a deltoid reconstruction in the presence of an intact rotator cuff. Negative prognostic indicators included prior lateral acromionectomy, massive rotator cuff tearing with weakness in external rotation, and a residual postoperative deltoid defect larger than 2 cm.

Loss of the integrity of the deltoid origin following surgery is generally regarded as an operative disaster. Although there is no information in the literature regarding acute repair of deltoid disruption, prevention of this complication is clearly preferred to treatment. Sher and colleagues provide a method of reconstruction for delayed treatment of postoperative deltoid disruption. Predictive variables for a favorable result include an intact or repairable rotator cuff, early recognition and treatment, little or no middle deltoid involvement, and no acromial insufficiency.

Acromial Fracture: A Complication of Arthroscopic Subacromial Decompression
Leslie S. Matthews MD; W.Z. Burkhead, MD; Stuart Gordon, MD; John Racanelli, MD; Louis Ruland, MD. JSES Vol 1, No. 4. pp256-261

Although the reported incidence of postoperative acromial fracture following rotator cuff surgery is quite low, the overall incidence is unknown and may be underreported or undetected. The diagnosis is probably overlooked in most cases and is frequently delayed due to a low index of suspicion. While acromial fracture may occur following open acromioplasty, the advent of arthroscopic techniques to perform arthroscopic subacromial decompression may invite a higher incidence of fracture of the acromial process. The results of treatment for acromial fracture, whether acute or delayed, are unfortunately poor.

Matthews et al have reported the most extensive series of case reports involving acromial fracture following arthroscopic subacromial decompression. Six fractures of the acromion were reported to occur following arthroscopic subacromial decompression for the treatment of stage II impingement syndrome. All six patients presented with a history of pain and decreased level of function following surgery, with clinical evidence of deltoid dysfunction only evident in one patient. The diagnosis was delayed in half of the patients due to a low index of suspicion of the complication, and failure to obtain appropriate imaging studies. In all cases, the acromial fracture was evident on axillary radiographs and CT scans. Treatment of the complications included non-operative management, fragment excision, and open reduction and internal fixation. While one patient improved significantly following open excision of the fracture fragment, the overall results in the series were generally poor. Promulgated risk factors include overzealous bone resection as well as generalized osteopenia. The authors conclude that surgical correction of the fracture may not satisfactorily resolve associated pain and loss of function following this complication, and encourage appropriate preoperative planning and meticulous surgical technique during the index procedure in an effort to mitigate the risk of the complication and its resulting disability.

Iatrogenic meso-acromial fractures, whether occurring intraoperatively or post-operatively, are the result of technical error. Since the results of treatment are uniformly poor, it is incumbent on the surgeon to avoid this complication. While a discussion on technical considerations is beyond the scope of the article, the literature supports maintaining at least 50% of the thickness of the acromion following acromioplasty. Under-resection of the acromion can be assessed intra-operatively, and small corrections (feathering) can be made to perform an adequate acromioplasty. Over-resection is unfortunately not a correctable situation and may predispose to acromial fracture.

Infection after Rotator Cuff Repair. Jeffrey J. Settecerri, MD; Mark A. Pitner, MD; Mickael G. Rock, MD; Arlen D. Hanssen, MD; and Robert H. Cofield. Journal of Shoulder and Elbow Surgery. Volume 8. Number 1. pp. 1-5. 1999

Deep infection following rotator cuff surgery is relatively uncommon, but represents a potentially devastating complication in terms of functional outcome. The reported incidence of this complication has been reported to range between 0.27% and 1.9%. While it

is not particularly flattering to have one's name tied to a series of complications, the resulting bacteriologic characteristics, clinical course, treatment, and end results after rotator cuff surgery complicated by deep infection serve as a guide to future management of this complication.

Settecerri and colleagues provided the first published series of 16 patients (.27% incidence) who were treated for deep infection following open rotator cuff repair. Pre-operative risk factors associated with infection included steroid injection (4 patients), rheumatoid arthritis (1 patient), previous surgery (3 patients), and the absence of pre-operative antibiotics (8 patients). The elapsed time from the index procedure until the diagnosis of infection averaged 72 days (range 2 to 483 days). The cultured organisms included Proprionobacter (6 patients), coagulase-negative Staphylococcus (4 patients), Staphylococcus Aureus (4 patients), Peptostreptococcus (1 patient), and a combination of Proprionobacter and Staphylococcus (1 patient). An average of 3.5 surgical debridements were required (range 2 to 8 debridements), leaving the open wound packed with iodine-soaked gauze between debridements. The rotator cuff was not re-repaired until the time of final closure, while the deltoid was always re-sutured between debridements, and always repaired at the time of final closure. The duration of antibiotic treatment consisted of intravenous treatment for 2 to 4 weeks, followed by oral treatment for 2 to 4 weeks. Following eradication of the infection, satisfactory final results were obtained in 5 patients (42%).

This study highlights the fact that low-virulence organisms, such as Proprionobacter acnes, should be recognized as a pathologic entity, and should not be dismissed as a culture contaminant. The most important factors in effectively treating deep infections are a high index of suspicion, early diagnosis, aggressive serial debridements, and intravenous antibiotic treatment. There is a tendency to treat patients with post-operative wound problems (such as mild erythema, drainage, or late hematoma formation) with oral antibiotics. While these methods may occasionally be successful, the preferred management of deep, post-operative wound infection remains surgical drainage and debridement. Further work on neglected infections (Mirzayan JBJS 82A, 2000) and infection after arthroscopically assisted rotator cuff repair (Herrerra JSES 2002) reinforce the principles outlined by the above authors. Despite successful treatment of the infection, post-operative deep infection following rotator cuff repair clearly has a negative effect on the overall outcome.

Superior Humeral Dislocation. A Complication Following Decompression and Debridement for Rotator Cuff Tears. M. Wiley, M.CH., F.R.C.S. Clin. Orthop. No. 263. Feb. 1991. pp135-141

Under normal loading conditions, the static coracoacromial arch plays a limited role as a secondary passive restraint to anterosuperior subluxation, but assumes a critical role in the presence of a dysfunctional rotator cuff. In the setting of uncompensated rotator cuff dysfunction, coracoacromial insufficiency from prior surgery will severely compromise overhead function. The progression from superior humeral migration associated with large rotator cuff tears, to surgically induced superior humeral dislocation was first described by Wiley in 1989.

Wiley reports his series of 4 patients who developed superior humeral dislocation (anterosuperior escape). Surgery consisted of hemiarthroplasty for a proximal humerus fracture (2 patients), rotator cuff repair (1 patient), and debridement of an irreparable rotator cuff tear (1 patient). In all cases, subacromial decompression and resection of the coracoacromial ligament was performed in an effort to correct impingement and improve access to the rotator cuff. All patients developed severely disabling symptoms associated with anterosuperior escape of the humeral head. Corrective measures included iliac crest bone grafting (from the acromion to the coracoid process), and soft tissue transfers. While he achieved pain relief in two patients, functional results were dismal, leading to his observation that this complication may defy surgical correction. He concluded that bursal decompression for the management of large irreparable rotator cuff tears should rarely be performed. While he felt that the coracoacromial ligament needed to be divided, he recommended that the deltoid should be carefully repaired, and deltoid detachment must be avoided.

This article was the first to draw attention to the phenomenon of anterosuperior escape of the humeral head. Wiley shows that it is clearly an iatrogenic complication with devastating results. While the indications for coracoacromial ligament preservation and repair continue to evolve, there is general consensus that the complication must be prevented. Prevention of anterosuperior humeral head subluxation involves preservation of the coracoacromial arch during acromioplasty and rotator cuff repair, particularly in the presence of a large rotator cuff tear or a decreased preoperative acromiohumeral interval.

On the Disadvantages of Radical Acromionectomy. Charles S. Neer MD: Tom A. Marberry MD. JBJS Vol 63A, No. 3 March 1981 pp416-419

Subacromial impingement is recognized as a common cause of chronic shoulder pain, and partial acromionectomy (acromioplasty) represents the most common procedure performed on the shoulder. Early surgical procedures consisted of radical acromionectomy, complete acromionectomy, and lateral acromionectomy, in an effort to access the rotator cuff and relieve the impingement on the humeral head. Very few authors are able to impact the practice of surgery as Dr Neer did when he described his technique of anterior acromioplasty, as an alternative to radical acromionectomy. He was able to completely supplant the concept of radical acromioplasty and its inherent complications with the concept of anterior acromioplasty. In 1972, Neer published his preliminary report on anterior acromioplasty for the treatment of chronic impingement syndrome. In 1982, he provided a clear description of the disadvantages and complications of radical acromioplasty, which led him to advocate his newer technique.

This study includes a series of 30 consecutive patients who were referred following radical acromionectomy. Cited indications for the index surgery included rotator cuff tear (18 patients), malunion of the greater tuberosity (7 patients), bursitis, rheumatoid arthritis, and failed surgery (5 patients). All patients exhibited retraction of the middle deltoid muscle and had an average range of forward elevation of 41 degrees. Eight patients had serious postoperative wound complications. Reconstruction of the deltoid was attempted in twenty of the thirty patients with disappointing results in fourteen of the twenty surgically operated cases. Neer concluded that radical acromioplasty was not an effective procedure in any

diagnostic category, and that reconstruction following radical acromioplasty was especially difficult, resulting in generally poor outcomes.

Neer was one of the first authors to describe the operative disaster of deltoid disruption following radical acromionectomy. He clearly described a constellation of symptoms including pain, weakness, loss of function, stiffness, and wound complications that accompany loss of the deltoid origin. Numerous subsequent authors have affirmed this operative disaster. These observations by Neer led to a paradigm shift in the approach to acromial surgery that still exists today. The current arthroscopic approaches to subacromial decompression reflect a variation on Neer's anterior acromioplasty as an alternative to radical acromionectomy.

The Treatment of Stiffness of the Shoulder after Repair of the Rotator Cuff. Jon J.P. Warner MD: Patrick E. Gries MD. JBJS Instructional Course Lecture. Vol 79-A, No. 8. August 1997. pp1260-1269

Since the literature currently lacks a standardized definition of frozen shoulder in the postoperative setting, the incidence of postoperative stiffness following rotator cuff repair is unknown. However, there is widespread agreement that the hallmark of postoperative frozen shoulder involves a commensurate decrease in both active and passive arcs of motion, which can involve one or more planes of motion. Frozen shoulder that occurs following rotator cuff surgery is related to a combination of capsular contracture and extracapsular scarring, and may occur independent of rotator cuff integrity. Iatrogenic tightening of the rotator interval and overadvancement of the rotator cuff tendon are surgical factors that may lead to loss of motion by capturing the shoulder. The surgeon should understand the variables involved in loss of motion after repair of the rotator cuff in order to effectively manage these patients.

While numerous authors have described the permutations and treatment options for frozen shoulder, this review article by Warner specifically addresses stiffness following rotator cuff repair. He discourages the use of closed manipulation in the setting of rotator cuff repair in order to avoid injury to the repair. Rather, arthroscopic management allows a controlled, step-wise approach to selective capsular releases, and debridement of dense adhesions in the humeroscapular motion interface. Open releases are indicated in patients who have failed arthroscopic release or have had iatrogenic tightening of tendinous structures. Aggressive postoperative physical therapy is essential to obtain a satisfactory outcome. They recommended that revision rotator cuff repair be delayed until passive motion has been restored.

Some loss of motion following repair of a large rotator cuff tear may be inevitable due to loss of tendon tissue during local transplantation of the tendon. The acceptable amount of loss of passive motion associated with acceptable results has not been defined in the literature, but some patients may not complain of painless loss of motion, provided that pain and function have improved. The indication for treatment becomes a symptomatic loss of motion, which affects the ability of the patient to perform activities of daily living. Warner clearly defines the etiologic risk factors, evaluation, and treatment for this postoperative complication. While advances in arthroscopic surgical skill levels will lead to

subtle improvements in surgical technique, Warner's overall approach to this problem should stand the test of time.

9. Calcifying Tendinitis

Bosworth BM. Calcium deposits in the shoulder and subacromial bursitis. Journal of the American Medical Association (JAMA) 1941;116(22):2477-82

Bosworth describes, in a classic reference, the finding of calcium deposits in the rotator cuff muscles and tendons with an associated inflammatory condition in the bursa. Previously, this was known as "periarticular calcifications", "subdeltoid calcifications", "para-arthritis", "calcified bursitis", and "painful shoulder". Bosworth investigated 5,061 employees in a routing screening examination with chest radiograph; a total of 138 shoulders (2.7%) were found to have calcium deposits. Etiology was indeterminate. A total of 46 of 138 had bilateral deposits, for a total of 202 shoulders affected. More than half had the deposits in the supraspinatus tendon, 44% in the infraspinatus, and 23% in the teres minor. Only 5 shoulders had deposits in the subscapularis.

The appearance was noted on the radiographs, and 34.6% of the 202 shoulders were symptomatic at some point. Nocturnal discomfort was the number one complaint. Acute excision was recommended for an acute attack, but others were relived with heat applications, baking, diathermy or short wave frequency application. The majority of symptomatic deposits were in males. Larger deposits were more frequently symptomatic, although they may remain quiescent and symptomless for years. Excision of the deposit was recommended for acute attacks, with complete and permanent relief.

This is a landmark study from 1941 that investigate the prevalence of calcium deposits in the shoulder, and followed those that had symptoms in a large population of individuals. Large-scale studies such as this are commendable in scope, and are increasingly difficult to perform in today's research. The findings of Bosworth serve to underscore the fact that many deposits may be asymptomatic, even for years, however, the larger the deposit, the higher the chance for symptomatic inflammation at some point. The location of deposits was also delineated – the majority were in the supraspinatus, followed by the infraspinatus, with very few in the subscapularis, a finding which has not appreciably changed in over 50 years.

Litchman HM, Silver CM, Simon SD, Eshragi A. The surgical management of calcific tendonitis of the shoulder. An analysis of 100 consecutive cases. Int Surg 1968;50:474-9.

The authors reviewed 100 consecutive cases of surgically treated calcific tendinitis of the shoulder. They demonstrated that acute cases showing large, dense, and multiloculated deposits are successfully treated surgically; chronic painful calcium deposits are best managed by operative means. They also found that complete excision of the deposit is simple, with minimal associated morbidity, however, rotator cuff function was not clearly assessed in the article. In addition, if adhesive capsulitis is encountered simultaneously, the authors suggested that the both disorders be treated together. It was more frequently encountered in women.

DePalma AF, Kruper JS. Long-term study of shoulder joints afflicted with and treated for calcific tendinitis. Clin Orthop 1961;20:61-72.

The authors treated 154 cases of calcific tendinitis from 1949 to 1959 (10 years), or which 94/154 were available for follow-up. The deposits were reomoved with a 1.5 to 2 inch incision in the subacromial area. The defect was closed with side-to-side sutures after excision of the deposit. A total of 66% had complete restoration by 3 weeks, 83% by 4 weeks. Some shoulders developed frozen shoulder (2) after surgery and necessitated additional surgical intervention. A total of 53 shoulders were treated surgically, 41 conservatively. The best results were in uncomplicated cases treated conservatively (12 weeks mean to resolution). Surgical intervention also provided a predictable results. In the surgical group, 53% were fully recovered by 6 weeks, 83% by 10 weeks. Two developed adhesive capsulitis postoperatively.

Overall, they found that 90% of the lesions are in the supraspinatus region, and 52% are single lesions. Several associated conditions are encountered – intraosseous calcific deposits, bicipital tenosynovitis, and frozen shoulder, and surgical management with concomitant conditions yielded superior results to nonoperative management. Overall, surgical management produced 96% good results, but required longer convalescence than those treated conservatively.

Ark JW, Flock TJ, Flatow EL, Bigliani LU. Arthroscopic treatment of calcific tendinitis of the shoulder. Arthroscopy 1992;8(2):183-88.

Although open excision of calcium deposits have been shown to provide reliable relief, the authors present a report on 23 patients who underwent arthroscopy to treat resistant calcific tendinitis of the shoulder. The mean age was 49 years (range 33-60), and mean follow-up was greater than 2 years (12-47 months). All patients underwent a subacromial bursectomy, a coracoacromial ligament release (if inflamed, 9 patients), and a direct rotator cuff examination. Localization of the deposits was facilitated by needle and rotation of the arm during arthroscopy. Once localized, a “snowstorm-like” effect appeared on the monitor, and a small incision was made in the cuff to incise the deposit (longitudinal incision in-line with fibers).

A total of 50% had full relief of their pain, and 41% had occasional episodes of discomfort, but were satisfied with their results. Two patients (9%) had persistent pain, and had a second reoperation for retained calcium deposit excision. Range of motion was excellent. Preoperative radiographs were helpful to localize the deposits. Postoperative radiographs deemed that not all calcium was removed, and the authors felt that complete excision of the calcium was not a prerequisite for a successful result.

The authors have presented a good case-series of arthroscopically treated symptomatic calcific tendinitis. This study underscores the importance of proper patient selection (recalcitrant, steroid injections, therapy), and localization of the deposit with a combination of radiographic (5-views preoperatively) and arthroscopic methods. Overall, good/excellent results were achieved in 91% of the patients, and served to propel arthroscopy as a viable treatment alternative to recalcitrant and symptomatic calcific tendonitis.

Ebenbichler GR, Erdogmus CB, Resch KL, Funovics MA, Kainberger F, Barisani G, Aringer M, Nicolakis P, Wiesinger GF, Baghestanian M, Preisinger E, Fialka-Moser V. Ultrasound therapy for calcific tendinitis of the shoulder. N Engl J Med 1999;340:1533-8.

The authors conducted a randomized, double-blind comparison of ultrasonography and sham ultrasounding (insonation) in 61 consecutive shoulder with symptomatic rotator cuff calcific tendinits. The patients received 24 15-minute session of either pulsed ultrasound or a sham treatment (indistinguishable) over the calcification area.

After 6 weeks of treatments, calcium deposits resolved in 6 shoulders (19%) in the ultrasound group, and decreased by at least 50% in 9 shoulder (28%). The sham group had essentially no improvement. Overall, patients who had received ultrasound therapy had greater decreases in pain and greater improvement in quality of life versus those treated with a sham ultrasound wand. However, by nine months of follow-up, the differences were not as significant.

Short-term improvement with use of ultrasound was demonstrated by this study and can result in decreased calcium accumulation in the rotator cuff. Although this study was randomized, the short-term improvements are diminished by 9 months. Ultrasound has been demonstrated to be effective in the short-term, however, corticosteroid injections may be just as helpful for acute onset of symptoms, and involve less time and expense than ultrasound therapy. Additional studies regarding the use of injections versus ultrasound have yet to be documented.

Uhthoff HK, Loehr JW. Calcific tendinopathy of the rotator cuff: Pathogenesis, diagnosis, and management. JAAOS 1997;5(4): 183-191.

This is an excellent peer-reviewed article on calcific tendinitis in the rotator cuff, and lives up to the high standard of JAAOS articles. The authors start first with a description of the pathogenesis, describing the differences between degenerative calcification and reactive calcification, as well as delineating the stages-precalcific, calcific (which is subdivided into formative, resting, and resorptive phases), and postcalcific. Workup and management (both nonoperative and operative) are described.

Rowe CR. Calcific tendinitis. Instr Course Lect 1985;34:196-98.

Rowe documents the physical characteristics of calcium deposits in the shoulder – as a dry, powdery deposit, a soft putty (toothpaste), or a milky creamy collection. The clinical course is outlined – chronic, silent phase; impingement, recurrent phase; and acute phase, with recommended treatments for each phase. Overall, a concise review of the salient features of calcific tendinitis.

Faure G, Daculsi G. Calcified tendinitis: a review. Ann Rheum Dis 1983;42:Suppl 49-54.

The authors present a review of calcific tendinitis. Overall, a concise article that delineates treatment, especially a nonoperative approach from a rheumatologic perspective.

10. Biceps

Itoi, E; Kuechle, DK; Newman, SR, et al. Stabilising function of the biceps in stable and unstable shoulders. Journal of Bone and Joint Surgery 75: 546-550, 1993.

This cadaver study tested the contributions to anterior shoulder stability in normal and unstable shoulders. It found that both long and short heads functioned as anterior stabilizers with the arm in abduction and external rotation, and that their role increased in unstable shoulders. It may work by increasing compression or by secondarily tightening the ligaments.

Warner, JJP; McMahon, PJ. The role of the long head of the biceps in superior stability of the glenohumeral joint. Journal of Bone and Joint Surgery 77: 366-372, 1995.

This clinical study documented changes in superior translation of the humeral head after tear of the long head of the biceps. 2 to 6mm of superior translation occurred as the arm was abducted. The patients reported no post operative functional loss.

The increased translation suggests a role for the biceps in decreasing translations in the midranges of GH motion, but the absence of functional deficits in the presence of an intact rotator cuff would suggest adequate compensatory mechanisms to meet the demands of the low level testing activity. The increased translation may be more significant in higher demand activities.

Pagnani, MJ; Deng, XH; Warren, RF, et al. Role of the long head of the bicpes brachii in glenohumeral stability: A biomechanical study in cadavera. Journal of Shoulder and Elbow Surgery 5: 255-262, 1996.

This study determined the effect of simulated physiologic contraction of the long head of the biceps tendon on glenohumeral translation in multiple shoulder positions. Application of force through the biceps resulted in significant decreases in humeral head translation especially in the low ranges of elevation. This effect occurred both in internal and external rotation. This function helps to center the rotating humerus on the glenoid and stabilizes the fulcrum of the shoulder joint.

Eakin, CL; Faber, KJ; Hawkins, RJ, et al. Biceps tendon disorders in athletes. Journal of the American Academy of Orthopaedic Surgeons 7: 300-310, 1999.

This review discusses all aspects of biceps function and dysfunction including anatomy and function, pathology and pathogenesis, assessment, and treatment. It divides pathology into degenerative problems, origin injury, and tendon instability. Treatment

guidelines for operative and non-operative techniques are presented. It provides a well reasoned framework for the pathogenesis that includes multiple factors such as muscle imbalance, overhead mechanics, scapular dyskinesis, GH laxity, and fiber failure.

This paper provides a good framework for treatment of biceps disorders in a high demand population.

Bennett, W. Arthroscopic repair of anterosuperior (supraspinatus/subscapularis) rotator cuff tears: a prospective cohort with 2-to 4-year follow-up. Classification of biceps subluxation/instability. Arthroscopy 19: 21-33, 2003.

This paper reports on treatment of lesions of the rotator interval, including anterior supraspinatus, medial/lateral pulleys, long head of the biceps, and superior subscapularis. Primary surgical treatment was directed at the rotator cuff. The biceps was debrided if the lesion was than 50%, and tenodesed into the subscapularis if the injury was greater than 50%. Outcomes scores revealed improvement in all groups.

This paper also proposed a classification system for biceps instability that allowed a rationale for treatment based on differential injury to the subscapularis alone, the lateral pulley alone, or combined lesions of tendons and pulleys.

Habermeyer, P; Magosh, P; Pritsch, M, et al. Anterosuperior impingement of the shoulder as a result of pulley lesions: a prospective arthroscopic study. Journal of Shoulder and Elbow Surgery 13: 5-12, 2004.

This prospective study evaluated patients with pulley lesions. 4 patterns of injury were observed – isolated lesions of the superior glenohumeral ligament (SGHL), SGHL and partial supraspinatus injury, SGHL and partial subscapularis injury, and SGHL and both supraspinatus and subscapularis injury. 90% also had involvement of the biceps tendon. They concluded that pulley lesions lead to biceps tendinopathy, causing increased humeral head translation, and consequent impingement. This also indicates a need to evaluate all patients with biceps tendinopathy for rotator cuff and rotator interval injury.

Walch, G; Edwards, TB; Boulahia, A, et al. Arthroscopic tenotomy of the long head of the biceps in the treatment of rotator cuff tears. Journal of Shoulder and Elbow Surgery 14:238-246, 2005.

This paper studied outcomes in selected patients who had tenotomy as part of treatment for full thickness rotator cuff tears. The patients either had irrepairable tears or were unable to undergo rehabilitation. Constant scores improved in the follow-up period, and 87% of patients were satisfied with the result. The acromio-humeral interval decreased slightly.

Biceps tenotomy in relatively low demand patients can decrease symptoms and results in high patient satisfaction, but does not change radiographic progression of arthrosis.

Kelly, AM; Drakos, MC; Feally, S, et al. Arthroscopic release of the long head of the biceps tendon. American Journal of Sports Medicine 33: 208-213, 2005.

This reviewed outcomes of biceps tenotomy, either isolated or as part of other treatments around the shoulder. Outcome scores overall were good to excellent. 70% had a "popeye" sign. 36% reported fatigue discomfort or soreness isolated to the biceps after resisted elbow flexion.

The authors did not recommend tenotomy in heavy lifters, due to fatigue and pain, but felt it was acceptable in less vigorous individuals due to decreased biceps tenderness.

Kibler, WB (ed). The Biceps from Origin to Insertion (CD available from ISAKOS) San Diego, CA, 2007.

This CD is a compilation of papers given at an ISAKOS consensus conference on the biceps. Literature reviews and current research were both included. Topics included biceps anatomy and function, clinical presentation and evaluation, and surgical techniques. Consensus findings included: the importance of the biceps in maximizing GH kinematics at high rotational speeds; the common association of biceps symptoms and rotator cuff injury; the need to include new clinical tests such as the "bear hug" and "upper cut" in the clinical exam; and that tenodesis and tenotomy appear to have equal outcomes in most patients.

Barber, FA; Field, LD; Ryu, RKN. Biceps tendon and superior labral injuries: Decision making. Journal of Bone and Joint Surgery 89: 1844-1855, 2007.

This instructional course lecture reviews pertinent aspects of anatomy and function, pathology, relation to superior labral (SLAP) tears, and treatment. It details the intricate overlap of biceps function with rotator cuff and labral function. It points out that biceps injury or symptoms rarely occur in the absence of rotator cuff, especially subscapularis, injury. It discusses the various treatment techniques, including non-operative treatment and discusses the operative treatments including subacromial decompression, tenodesis, and tenotomy.

11. SLAP Lesions

Andrews JR, Carson WG, McLeod WD. Glenoid labrum tears related to the long head of the biceps. Am J Sports Med. 1985 Sep-Oct;13(5):337-41.

This is an early, if not the first description of superior labrum injury in the shoulder. Until the time of this report, labral tears known to cause symptoms were located anteroinferior (e. g. the Bankart lesion) resulting in anterior instability and located posteroinferior resulting in posterior instability.

Tears of the glenoid labrum were observed in 73 baseball pitchers and other throwing athletes who underwent arthroscopic examination of the dominant shoulder. Most of the tears were located over the anterosuperior portion of the glenoid labrum near the origin of the tendon of the long head of the biceps muscle into the glenoid. At arthroscopy, the tendon of the long head of the biceps appeared to originate through and be continuous with the superior portion of the glenoid labrum. In many cases it appeared to have pulled the anterosuperior portion of the labrum off the glenoid. Detachment of the biceps anchor was implicated as the etiology of the lesion through arthroscopic viewing of the biceps tendon as the muscle was electrically stimulated. With stimulation of the muscle, the tendinous portion became quite taut, particularly near its attachment to the glenoid labrum, and lifted the labrum off the glenoid. Three-dimensional high-speed cinematography with computer analysis and the biceps being a muscle that traverses both the elbow joint and the shoulder joint also implicated the biceps.

The authors of this study indentified a new lesion from repetitive activity in a select group of elite baseball pitchers and studied a possible etiology. This lesion is now known to occur in many others including laborers, individuals with a rotator cuff tear, and overhead athletes, and to be the result of both trauma and normal degenerative processes.

Snyder SJ, Karzel RP, Del Pizzo W, Ferkel RD, Friedman MJ. SLAP lesions of the shoulder. Arthroscopy 1990;6(4):274-9.

The classification of superior labrum lesions described in this manuscript became widely accepted and, the authors coined the acronym SLAP as Superior Labrum Anterior and Posterior.

A specific pattern of injury to the superior labrum of the shoulder was identified in 27 individuals with shoulder arthroscopy. The injury of the superior labrum was described as beginning posterior and extends anterior, stopping before or at the mid-glenoid notch and including the "anchor" of the biceps tendon to the labrum. The most common mechanism of injury was a compression force to the shoulder, usually as the result of a fall onto an outstretched arm, with the shoulder positioned in abduction and slight forward flexion at the time of the impact. The most common clinical complaints were pain, greater with overhead

activity, and a painful "catching" or "popping" in the shoulder. Standard imaging tests were done but did not identify the lesion preoperatively.

MR arthrograms were not done. The SLAP lesions were classified into four distinct types, fraying of the superior labrum (type I), detachment from the superior glenoid (type II), a bucket-handle tear (type III) or a tear that extended into the biceps tendon (type IV). Treatment was individualized for the type of SLAP lesion.

The diagnosis of the SLAP lesion was made with arthroscopy and was found to occur in individuals other than baseball players. It could also be classified and treated with arthroscopic techniques.

Iannotti JP Ramsey ML. Arthroscopic decompression of a ganglion cyst causing suprascapular nerve compression. Arthroscopy. 1996 Dec;12(6):739-45.

Cysts of the spinoglenoid notch were known to be a cause of suprascapular nerve compression that resulted in infraspinatus muscle atrophy and manifested as weakness of shoulder external rotation. Magnetic resonance imaging (MRI) of the shoulder had improved clinician's ability to diagnose these cystic lesions and confirmed them to be ganglion cysts that communicated with the glenohumeral joint from a SLAP tear. Traditionally, treatment of suprascapular nerve compression by a ganglion cyst had required open cyst excision through either a deltoid and infraspinatus muscle takedown or a muscle splitting approach.

These authors present three cases of symptomatic suprascapular nerve compression by a ganglion cyst in which the cyst was decompressed arthroscopically. In each case the patient's symptoms resolved and a postoperative MRI confirmed the cyst to be gone.

Arthroscopic ganglion cyst decompression is effective and avoids the morbidity of an open surgical procedure. Current treatments of decompression and/or repair of the SLAP lesion, when possible, continue to yield durable success.

Bencardino JT, Beltran J, Rosenberg, ZS, Rokito A, Schmahmann, Mota J, Mellado JM, Zuckerman J, Cuomo F, Rose D. Superior labrum anterior-posterior lesions: diagnosis with MR arthrography of the shoulder. 2000 Jan;214(1):267-71.

To aid in decision-making and preoperative planning, clinicians were in need of a means to diagnose SLAP lesions before surgery. Arthroscopic procedures were available to treat shoulder pain resulting from mechanical symptoms and mild shoulder instability. Improved physical examination techniques had aided clinicians in diagnosis of milder labral lesions that the severe lesions known to result from shoulder dislocation. The purpose of this study was to determine the accuracy of magnetic resonance (MR) arthrography in the diagnosis of SLAP lesions of the shoulder.

MR arthrography of the shoulder was performed in 159 patients with a history of chronic shoulder pain or instability. Fifty-two patients underwent arthroscopy or open surgery 12 days to 5 months after MR arthrography and SLAP lesions were classified. Surgical findings were correlated with those from MR arthrography. SLAP injuries were diagnosed at surgery in 19 of the 52 patients (37%). Six of the 19 lesions (32%) were

classified as type I, nine (47%) as type II, one (5%) as type III, and three (16%) as type IV. MR arthrography had a sensitivity of 89% (17 of 19 patients), a specificity of 91% (30 of 33 patients), and an accuracy of 90% (47 of 52 patients). The MR arthrographic classification showed correlation with the arthroscopic or surgical classification in 13 of 17 patients (76%) in whom SLAP lesions were diagnosed at MR arthrography.

MR arthrography was shown to be a useful and accurate technique in the diagnosis of SLAP lesions of the shoulder. MR arthrography provides pertinent preoperative information with regard to the exact location of tears and grade of involvement of the biceps tendon.

Kim TK, Queale WS, Cosgarea AJ, McFarland EG. Clinical features of the different types of SLAP lesions: an analysis of one hundred and thirty-nine cases. Superior labrum anterior posterior.J Bone Joint Surg. 2003 Jan;85-A(1):66-71.

The goals of this study were to define the prevalence, associated pathological findings, and clinical features of the different types of SLAP lesions.

Five hundred and forty-four patients undergoing shoulder arthroscopy for a variety of diagnoses were prospectively included in this consecutive case series. Of these, 139 (26%) had a SLAP lesion at arthroscopy. Demographic data, clinical data, and arthroscopic findings in those with a SLAP lesion were compared with those in a control group with no SLAP lesion. One hundred and three (74%) of the SLAP lesions were Type I, twenty-nine (21%) were Type II, one (0.7%) was Type III, and six (4%) were Type IV. Most (123) of the SLAP lesions were found to be associated with other intra-articular lesions. Multivariate analysis revealed that a positive Speed test and a supraspinatus tear were significantly associated with Type-I lesions ($p = 0.012$ and $p = 0.001$, respectively). The findings associated with Type-II lesions differed according to the patient's age: Type-II lesions in patients who were forty years of age or younger were associated only with a Bankart lesion, whereas those in patients older than forty years of age were associated with a supraspinatus tear and osteoarthritis of the humeral head. Type-III and Type-IV lesions were associated with a high-demand occupation and a Bankart lesion.

This case-control study demonstrated that the prevalence, associated pathological findings, and clinical features of the different types of SLAP lesions vary with the patient population that is studied. Also, the clinical features and pathological findings associated with the different types of SLAP lesions often overlap. Isolated SLAP lesions with no associated pathological findings are uncommon, and care must be taken when ascribing symptoms to a SLAP lesion when other lesions are present.

Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology Part I: pathoanatomy and biomechanics. Arthroscopy. 2003 Apr;19(4):404-20.

For years, shoulder pain in the overhead athlete was attributed to mild shoulder instability (e. g. microinstability). The authors proposed that posteroinferior capsular tightness was an important etiology of shoulder pain in the overhead athlete. Resulting in diminished internal rotation of the abducted shoulder, it could be diagnosed with comparison

to the contralateral side. With overhead throwing, this resulted in posteosuperior translation of the humeral head, accompanied by pain in the cocking phase of throwing and demonstrated on clinical examination by pain in the posterior shoulder when placed in the apprehension position of abduction and external rotation. A peel-back mechanism was responsible for the SLAP lesion. Mild anterior shoulder instability occurred last and was due to these alterations in the glenohumeral joint and aberrations of scapulothoracic motion.

The authors introduced a new method of stretching the posterior capsule to prevent and treat shoulder pain in the overhead athlete, the "sleeper" stretch.

Nam EK, Synder SJ. The diagnosis and treatment of superior labrum, anterior and posterior (SLAP) lesions. Am J Sports Med. 2003 Sep-Oct;31(5):798-810.

This article reviews the anatomy, biomechanics, classification, diagnosis, and the authors' suggested treatments for SLAP lesions.

Shoulder arthroscopy and improved understanding of shoulder anatomy and biomechanics, led to the identification of SLAP lesions. Although the history, physical examination, and imaging specifically magnetic resonance arthrography, are extremely important in the diagnosis of SLAP lesions, definitive diagnosis is best made with diagnostic arthroscopy. Treatment of these lesions is directed according to its type. In general, type I and III lesions are debrided, whereas type II and many type IV lesions are repaired.

Excellent schematics detail the classification and the authors' step-by-step method for repair of a type II SLAP lesion. The manuscript also includes a concise review of the results of treatment.

McMahon PJ, Burkhart A, Musahl V, Debski RE. Glenohumeral translations are increased after a type II superior labrum anterior-posterior lesion: a cadaveric study of severity of passive stabilizer injury. J Shoulder Elbow Surg. 2004 Jan-Feb;13(1):39-44.

Clinicians have long thought SLAP lesions to cause shoulder pain both from mechanical symptoms and mild shoulder instability. This biomechanical study of simulated type II SLAP lesions determined the effects on glenohumeral joint translations. Study of cadaver shoulders allowed precise measurement of two lesions of different severity.

A robotic/universal force-moment sensor testing system was used to simulate load-and-shift tests by applying an anterior or posterior load to each shoulder. This same loading protocol was repeated after creating two type II SLAP lesions of different severity. In the first the superior labrum and the biceps anchor were elevated subperiosteally from the glenoid bone (SLAP-II-1), and in the second the biceps anchor was completely detached (SLAP-II-2). Statistical analysis was performed with a 2-factor repeated-measures analysis of variance followed by multiple contrasts, and the significance level was set at $P < .05$. At 30 degrees of abduction, anterior translation of the vented joint from anterior loading was 18.5 +/- 8.5 mm. It was significantly increased (26.2 +/- 6.5 mm, $P = .03$), after the SLAP-II-2 lesion and compared with the SLAP-II-1 lesion (25.0 +/- 6.8 mm, $P = .03$). Increases in anterior translations at 60 degrees of abduction were not significantly differ in comparison to

the two SLAP lesions. Inferior translation also resulted from anterior loading. At 30 degrees of abduction in the vented joint, it was 3.8 +/- 4.0 mm and was significantly increased (8.5 +/- 5.4 mm, P =.05) after the SLAP-II-2 lesion, no different than that after the SLAP-II-1 lesion (7.8 +/- 4.9 mm).

Glenohumeral translations were increased, regardless of severity, after simulation of type II SLAP lesions. Since translations increased despite the long head of the biceps tendon not being loaded, the superior capsulolabrum as well as passive effects of the biceps tendon may be responsible for the instability. During stabilizing surgical interventions, passive stabilizers that are injured in the type II SLAP lesion should be considered as well as dynamic activity in the tendon of the long head of the biceps brachii.

Waldt S, Metz S, Burkart A, Mueller D, Bruegel M, Rummeny EJ, Woertler K. Variants of the superior labrum and labro-bicipital complex: a comparative study of shoulder specimens using MR arthrography, multi-slice CT arthrography and anatomical dissection. Eur Radiol 2006 Feb;16(2):451-8.

The purpose of this study was to evaluate the anatomical variability of the superior labrum and to compare MR arthrography and multi-slice CT arthrography in the diagnosis of variants of the labro-bicipital complex.

Forty-three elderly human shoulder specimens were examined with the use of MR arthrography and multi-slice CT arthrography prior to joint exploration and macroscopic inspection of the superior labrum and labro-bicipital complex. Two radiologists evaluated MR and CT arthrograms, and the results were compared with macroscopic assessments. Anatomical dissection of all shoulder specimens revealed a sublabral recess in 32/43 (74%) cases. The attachment of the superior labrum was categorized according to De Maeseneer and associates (De Maeseneer M, Van Roy R, Lenchik L, Shahabpour M, Jacobson J, Ryu KN, Handelberg F, Osteaux M. CT and MR Arthrography of the Normal and Pathologic Anterosuperior Labrum and Labral-Bicipital Complex. Radiographics 2000, 20, S 67-S81) as type 1 in ten (23%) cases, as type 2 in eight (19%), as type 3 in ten (23%), and as type 4 in 14 (33%) cases. One superior labrum showed detachment consistent with a type 3 SLAP lesion. On MR arthrography and CT arthrography the attachment of the superior labrum was categorized in concordance with macroscopic assessments in 79% and 84% of cases, respectively. The anteroposterior extension of sublabral recesses was accurately determined with MR and CT arthrography in 59% and 81% of cases, respectively.

The normal attachment of the superior labrum was shown to have considerable variability. Knowledge of variants is essential to avoid false positive diagnosis of a SLAP lesion. Both, MR arthrography and multi-slice CT arthrography are effective in the detection and classification of a normal sublabral recesses.

Jones GL, Galluch DB. Clinical assessment of superior glenoid labral lesions: a systematic review. Clin Orthop Relat Res. 2007;455:45-51.

SLAP lesions are difficult to diagnose with physical examination despite efforts to develop specific tests. The authors reported a review of the literature through Medline and Embase database searches.. All studies with level of evidence of III or better that reported diagnostic accuracy of SLAP-specific physical examination tests were included. Each instance of independent evaluation of a SLAP-specific examination showed poorer examination performance than in the original study that reported it. Considerable variability existed between independent evaluations of a given SLAP-specific physical examination test as well.

The authors concluded that there was no SLAP-specific physical examination test that could be used solely, in the diagnosis of a SLAP lesion. Differences in patient populations between studies and the accompanying differences in SLAP lesion prevalence and comorbid conditions played the greatest role in variance of results.

12. Traumatic Muscle Ruptures

Ulmer TW, Simonian PT. Muscle ruptures affecting the shoulder girdle, in Rockwood CA, Matsen FA, Wirth MA, Lippitt SB (eds): The Shoulder, vol 2. Philadelphia: WB Saunders, 2004, pp1173-1187.

Review of different muscle and tendon injuries about the shoulder girdle. Diagnosis and treatment options discussed.

Haupt HA: Overuse injuries in the upper extremity: Upper extremity injuries associated with strength training. Clin Sports Med 2001;20:481–490.

Discusses tendon ruptures of the pectoralis major, biceps, and triceps. Links improperly performed strength training exercise with these injuries. Explores association of anabolic steroid use and musculotendinous injuries.

Bak K, Cameron EA, Henderson IJ: Rupture of the pectoralis major: A meta-analysis of 112 cases. Knee Surg Sports Traumatol Arthrosc 2000;8:113–119.

Meta-analysis of 112 cases of pectoralis major rupture. Rupture occurred most commonly in sports during weight training, weight lifting, or wrestling when the arm is externally rotated and abducted. Most reported ruptures are complete and are located at the insertion to the humerus. Work-related injuries occur more often at the musculo-tendinous junction. The prognosis is related neither to the age of the patient nor to the location of the rupture. Surgical treatment, preferably within the first 8 weeks after the injury, has a significantly better outcome than conservative treatment or delayed repair.

Garrett WE Jr: Muscle strain injuries: Clinical and basic aspects. Med Sci Sports Exerc 1990;22:436–443.

Review of muscle injuries covering basic science and physiology while tying in clinical relevance.

Kragh JF Jr, Basamania CJ: Surgical repair of acute traumatic closed transaction of the biceps brachii. J Bone Joint Surg Am 2002;84:992–998.

Comparison of nine patients who underwent surgical repair of complete transaction of the biceps brachii and three patients treated non-operatively. Muscle fibers and epimysium

were sutured with use of running interlocked stitches as well as modified Mason-Allen stitches. Patients who had surgical repair had better results than did those who had nonoperative treatment, with respect to supination torque, appearance, and satisfaction.

Menetrey J, Kasemkijwattana C, Fu FH, Moreland MS, Huard J: Suturing versus immobilization of a muscle laceration: A morphological and functional study in a mouse model. Am J Sports Med 1999;27:222–229.

Compared the effect of a surgical repair versus a short period of immobilization (5 days) on muscle healing in lacerated gastrocnemius muscle in mice. Suturing the lacerated muscle immediately after injury promoted better healing of the injured muscle and prevented the development of deep scar tissue in the lacerated muscle. Immobilization resulted in slower muscle regeneration and the development of a large area of scar tissue. Tetanus strength 1 month after injury was 81% of control muscles for the sutured muscles, 35% for the lacerated muscles with no treatment, and 18% for the immobilized muscles.

Petilon J, et al. Pectoralis Major Muscle Injuries: Evaluation and Management. JAAOS. Jan/Feb. 2005; 13:59-68.

Review of anatomy, function, pathogenesis, diagnosis, imaging, and management options of pectoralis major injuries.

Morrey BF. Tendon injuries about the elbow, in Morrey BF (ed): The Elbow and its Disorders, 3r^{d} ed. Philadelphia: WB Saunders, 2000, pp468-84.

Comprehensive review of evaluation and management options of tendon injuries about the elbow. Detailed description of surgical techniques.

Ramsey ML. Distal Biceps Tendon Injuries: Diagnosis and Management. JAAOS. May 1999; 7:199-207.

Review of anatomy, function biomechanics, etiology, clinical evaluation, classification, and treatment options of partial and complete rupture of the distal biceps tendon. Discusses clinical results and potential complications and limitations of non-operative and operative treatment.

Caughey M, Welsh P. Muscle ruptures affecting the shoulder girdle. In: Rockwood C, Matsen F (eds). The Shoulder. WB Saunders: Philadelphia, 1990:863-73.

Review of different muscle and tendon injuries about the shoulder girdle. Diagnosis and treatment options discussed.

D'Alessandro D, Shields C. Biceps rupture and triceps avulsion. In Jobe F (ed). Operative Techniques in Upper Extremity Sports Injuries. CV Mosby: St. Louis, 1996:506-17.

Detailed overview of evaluation and management options of bicep and tricep muscle injuries. Covers treatment from conservative to operative intervention. Surgical techniques illustrated.

Kelley J, ElAttrache N. Muscle ruptures of the shoulder girdle. In Jobe F (ed). Operative Techniques in Upper Extremity Sports Injuries. CV Mosby: St. Louis, 1996:360-72.

Detailed overview of evaluation and management options of various muscle injuries about the shoulder girdle. Covers treatment from conservative to operative intervention. Surgical techniques illustrated.

Hunter M, Shybut G, Nuber G. The effect of anabolic steroid hormones on the mechanical properties of tendons and ligaments. Trans Orthop Res Soc. 1986; 11:240.

Illustrated anabolic steroid use weakens mechanical properties of tendons and ligaments and predisposes to injury.

Miles JW, Grana WA, Egle D, Min KW, Chitwood J. The effect of anabolic steroids on the biomechanical and histological properties of rat tendon. J Bone Joint Surg Am. 1992:Mar;74(3):411-22.

Animal study in which twenty-four male rats were divided into four groups, with anabolic steroids and exercise as variables. Biomechanical tests suggested that anabolic steroids produce a stiffer tendon, which fails with less elongation. The energy at the time when the tendon failed, the toe-limit elongation, and the elongation at the time of the first failure were all affected significantly. No alterations of structure were noted when the specimens were viewed with light microscopy. Alterations of the sizes of the collagen fibrils were noted on electron microscopy.

13. Anatomy, Biomechanics, and Pathophysiology of Glenohumeral Instability

Turkel SJ, Panio MW, Marshall JL, Girgis FG. Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. J Bone Joint Surg – Am Vol 1981;63-A(8):1208-1217.

The authors were one of the first to comprehensively study the stabilizing mechanism of the glenohumeral joint as well as the biomechanical properties of the glenohumeral ligaments during various joint positions. Previously, several authors had studied the effect of an anterior dislocation on the inferior capsule (Thomas, 1909; Symeonides 1972); damage to the inferior capsule was noted in the specimens. Turkel and colleagues sought to identify what each of the periarticular structures contributes to stability of the glenohumeral joint, and determining the relative importance of the capsular structures in limiting external rotation in various positions.

A total of 36 cadaveric specimens were dissected and ligaments of the anterior capsule of the shoulder identified with radiopaque suture markers. Selective cutting was performed of the anterior structures – subscapularis, shoulder capsule, and superior, middle, and inferior glenohumeral ligaments. Radiographic analysis of the markers was utilized to demonstrate anatomic position and relative tightness of each structure during zero, 45, and 90 degrees abduction. The authors found the following were predominant stabilizers: at zero degrees abduction (subscapularis), 45 degrees abduction (subscapularis, MGHL, and superior IGHL), and at 90 degrees abduction (IGHL).

Little was known about the relative contributions of the anterior structures to shoulder stability prior to this study. DePalma in 1949 felt that the IGHL was absent from up to 25% of specimens, and the subscapularis was deemed to be the primary stabilizer. Moseley and Overgaard studied the anterior capsular mechanism of the shoulder in 1962, however, the study of Turkel was the first to provide some biomechanical evidence to the relative contributions of the anterior shoulder structures. The biomechanical concepts of shoulder stability and mechanisms of anterior shoulder dislocation were in their infancy in 1981, and this was one of the first to describe the complex behavior of the IGHL in various degrees of abduction. Turkel et al. hypothesized that imbrication of the subscapularis tendon to the greater tuberosity may provide exceptional stability, however, it would considerably restrict external rotation. The authors correct surmised that if the subscapularis is left alone, a plication of the underlying capsule and IGHL repair may be all that is necessary in the provocative position of anterior shoulder instability.

O'Brien SJ, Neves MC, Arnoczky SP, Rozbruck SR, DiCarlo EF, Warren RF, Schwartz R, Wickiewicz TL. The anatomy and histology of the inferior glenohumeral ligament complex of the shoulder. American Journal of Sports Medicine 1990;18(5):449-456.

This study investigated the gross and histologic anatomy of the IGHL in cadaveric specimens. The complex anatomy of the IGHL was investigated in a contemporary abstract by the authors, which had demonstrated that the IGHL was the primary checkrein against

both anterior and posterior dislocation of the humeral head. The anatomy of the IGHL was investigated to determine the complex nature of this structure to act as both an anterior and posterior stabilizer of the shoulder joint.

An arthroscopic examination was performed on 11 cadaveric specimens, and the glenohumeral ligaments (anterior and posterior) identified. The joint capsule was then opened and topographical arrangement of the ligaments described. The authors found that the IGHL was a complex of structures consisting of an anterior band, a posterior band, and a diffuse thickening of the capsule between these bands termed the axillary pouch. It was noted that in internal rotation, the posterior band provided support for the humeral head posteriorly; whereas, in external rotation the opposite occurred. The origins of the IGHL complex was also described, ranging from 2 to 4 o'clock for anterior IGHL, and 7 to 9 o'clock for posterior IGHL. Microscopic anatomy was also described – the inner and middle layers of the capsule were found to be the thickest and most prominent, and well-organized coarse collagen bundles.

This study elucidated the complex anatomy of the IGHL, by correlating with arthroscopic examination both gross and histologic findings. Three discreet areas of the IGHL were identified, and hypothesized that each would function as a separate, but concomitant role in shoulder stability. The findings of this study were truly landmark and served as a springboard for a multitude of soon to follow biomechanical studies on the function of this ligamentous complex in shoulder instability.

Lippitt S, Matsen F. Mechanisms of Glenohumeral Joint Stability. Clinical Orthopaedics and Related Research 1993;291:20-28.

The study by Lippitt and Matsen summarizes some of the excellent work on shoulder instability that was performed at the University of Washington in the late 1980's and early 1990's. These findings were initially presented at an ASES meeting and published in the current article on the concepts of concavity-compression and scapulohumeral balance to maintain stability of the glenohumeral joint. Concavity-compression is a term to describe the effect of placing a convex object (humerus) into a concave surface (glenoid); compressing the convex object with a greater force into the concave object enhances stability. In order for the shoulder to effectively provide static restraint, a functional labrum must be intact to increase the depth of the concavity of the glenoid.

By altering the load and compressive force into the glenoid, the maximum translation force to move the humeral head out of the concave surface is increased in all directions, especially inferiorly and superiorly. These findings served to emphasize the coordinated efforts of the dynamic and static stabilizers of the shoulder joint. Without an adequately functioning rotator cuff, the humeral head easily subluxates off the glenoid surface, even in the setting of good glenoid depth provided by the static restraint of the labrum. The authors described scapulohumeral balance, to maintain the humeral head centered in the glenoid.

The authors introduced the term concavity-compression and truly elevated the coordinated function and importance of the dynamic and static stabilizers of the glenohumeral joint. They have since expanded on this principle to investigate what happens

to the concavity-compressive kinematics after labral tears and chondral defects, truly elevating our understanding of the biomechanics of shoulder stability.

Matsen FA III, Chebli C, Lippitt S. Principles for the evaluation and management of shoulder instability. Journal Bone and Joint Surgery – American Volume 2006;88-A:648-69.

This review paper, derived from an AAOS Instructional Course Lecture, is an excellent compilation of much of the work from the University of Washington on shoulder instability in a well-organized and beautifully illustrated publication that highlights the biomechanical principles of shoulder instability.

The concept of concavity-compression is reviewed, followed by the dynamic importance and balance of stability provided by the rotator cuff musculature. The plane of the scapula is identified. Stability ratios are defined which is defined as the ratio of force necessary to displace the humeral head from the glenoid center divided by the load compressing the humeral head into the glenoid. Negative intraarticular pressure and the importance of the static ligamentous stabilizers are also reviewed.

In summary, this is an excellent and well-illustrated article that explains in sufficient detail many of the biomechanical concepts of shoulder instability.

Levine WN, Flatow EL. The pathophysiology of shoulder instability. American Journal of Sports Medicine 2000;28(6):910-17.

Levine and Flatow have provided an outstanding review on the biomechanical principles of shoulder instability. The major focus of the article is on the static and dynamic stabilizer of the glenohumeral joint. It starts first with the labrum, describing several normal variants (that should not be repaired), pathologic findings in the ligaments, and the capsular injury in anterior shoulder instability. The latter part discusses the importance of dynamic factors in shoulder stability, including the rotator cuff and biceps tendon. The authors also include an important section on proprioception of the shoulder, which has been shown to be an important (and possibly overlooked) principle in maintaining stability of the shoulder.

In summary, Levine and Flatow have provided an excellent review on the static and dynamic contributions to shoulder stability.

Cole BJ, Millett PJ, Romeo AA, Burkhart SS, Andrews JR, Dugas JR, Warner JJP. Arthroscopic treatment of anterior glenohumeral instability: Indications and Techniques. AAOS Instructional Course Lectures – Shoulder and Elbow.

This first part of this article is a good review on the anatomy of shoulder stability, and goes onto describe the pathoanatomy of anterior shoulder instability. The article highlights many of the additional areas of injury that are important to assess in anterior shoulder instability, and serves to highlight the complex pathophysiology of a shoulder dislocation or instability event. This includes ligaments (static restraints), rotator cuff (dynamic), bony

anatomy (static), especially glenoid erosion and Hill-Sachs injuries, and the importance of instability in the setting of an inverted pear glenoid.

Overall, the authors present a comprehensive review on the biomechanics and anatomy of shoulder instability.

Wang VM, Flatow EL. Pathomechanics of acquired shoulder instability: A basic science perspective. Journal Shoulder Elbow Surgery 2005;14(1S):2-S to 11-S.

Written from a basic scientist perspective, this is an excellent review of the biomechanics of shoulder instability and serves as an excellent foundation to understand the complex interplay of factors associated with shoulder instability. Very comprehensive, the article describes the static restraints, causes of failure, and tensile loads on ligaments, and subfailure loads to the IGHL. This is a great reference for both orthopaedic surgeons and basic science researchers.

Bankart ASB. The pathology and treatment of recurrent dislocation of the shoulder-joint. British Journal of Surgery 1938;26:23-29.

This is a classic reference, which briefly describes the pathology that Bankart encountered in 27 consecutive cases of shoulder dislocations. He described an abnormal laxity of the capsule and to weakness of the surrounding muscles, due to stretching or imperfect healing after the reduction of an ordinary traumatic dislocation. He found this to occur in extreme abduction, and a rent in the capsule is formed, frequently shearing off the fibrous glenoid ligament from its attachment to bone, over nearly the entire anterior half of the glenoid surface. Bankart identified the typical lesion of recurrent dislocation in these 27 cases – detachment of the glenoid ligament from the anterior margin of the glenoid.

Speer KP, Deng X, Borrero S, Torzilli PA, Altchek DA, Warren RF. Biomechanical evaluation of a simulated Bankart lesion. Journal of Bone and Joint Surgery – American Volume 1994;76-A(12):1819-26.

The authors performed an excellent biomechanical study on the stability effect of the shoulder with a simulated Bankart lesion. They were one of the first to delineate that capsular injury is also necessary to produce obligate translations necessary for a shoulder dislocation to occur. The authors found that injury to the anterior part of the IGHL at the level of the glenoid is not solely responsible for the increased anterior glenohumeral translation to produce and anterior dislocation. Their study was important in that it emphasized the capsular injury that occurs in a dislocation event; it is this capsular injury that needs to be addressed in surgical repair, along with any labral damage.

Bigliani LU, Kelkar R, Flatow EL, Pollock RG, Mow VC. Glenohumeral stability. Biomechanical properties of passive and active stabilizers. Clinical Orthopaedics and Related Research 1996;338:13-30.

The authors have provided an excellent summary of their work performed at the Columbia Shoulder Service in New York. This study was one of the first to investigate the tensile properties of the IGHL, from a pure biomechanical and histological analysis. Altered kinematics of the glenohumeral joint was also delineated.

Blasier RB, Guldberg RE, Rothman ED. Anterior shoulder stability: Contributions of rotator cuff forces and the capsular ligaments in a cadaver model. Journal Shoulder and Elbow Surgery 1992;1(3): 140-50.

This study quantified biomechanically the contributions to stability of the shoulder joint made by tensions of the rotator cuff muscles. It also investigated the biomechanical contributions of the glenohumeral ligaments, while dynamically loading the cadaveric model. This model allowed for direct measurement of the relative contributions of the rotator cuff tendons and static resistance of the anterior capsular structures.

Lazarus MD, Sidles JA, Harryman DT, Matsen FA III. Effect of a chondral-labral defect on glenoid concavity and glenohumeral stability. Journal of Bone and Joint Surgery – American Volume 1996;78-A(1):94-102.

A chondral-labral defect was created in the anteroinferior aspect of the glenoid and the glenohumeral stability ratio was determined. The intact, incised, and reconstructed conditions were tested; it was found that the reconstructed chondral-labral height sufficiently restored the stability ratio back to the intact state. This supports the concept of concavity-compression, and the importance of a chondral-labral repair (as well as capsular imbrication) as part of the preferred anterior shoulder stability repair procedure.

14. Overhead Throwing Athlete

Inman VT , Saunders JB, Abbott LC. Observations on the function of the shoulder joint. J Bone Joint Surg Am 1944; 26:1-30

This classic article introduces the basic functional anatomy and complex relationship between the four joints that comprise the shoulder i.e. the glenohumeral, scapulo-thoracic, the acromio-clavicular and the sterno-clavicular. The article also analyses the muscle forces about the shoulder and the function of the different muscles.

This article discusses the force couple between the deltoid and the rotator cuff and the force couple between the trapezius and serratus anterior. It emphasizes the importance of the scapula in proper elevation of the shoulder joint. The article established the fact that elevation of the shoulder is a complex motion which occurs at all four articulations about the shoulder. The article also established the ratio of 2 to 1 between glenohumeral motion, scapular thoracic motion and elevation of the arm.

This is the classic article of motion and function of the shoulder joint that describes in detail the comparative anatomy, force and function of the muscles, and biomechanics of the joints that allow a smooth elevation of the arm. The concept of force couple of the shoulder was established and is still used today. The importance of the scapular muscles and proper scapular motion is emphasized which is crucial for proper mechanics of overhead activity.

Saha AK. Mechanics of elevation of the glenohumeral joint. Acta Orthop Scan 1973; 44:668-678

This is a classic article on the anatomy and biomechanics of the shoulder joint. The article presents the different motions of the humerus on the glenoid. It discusses the concepts of rolling motion versus spinning motion and translation of the humerus on the glenoid. The article establishes the concept of dynamic stability of the glenohumeral joint being established by the muscle forces imparted on it. The article presents the requirements that would be ideal for a prosthetic replacement of the proximal humerus, and was the first to study the muscles of the shoulder with EMG.

This article establishes the basic anatomy of the proximal humerus and glenoid and lays the foundation for analyzing the different motions of the proximal humerus on the glenoid. It also introduces the concept of dynamic stability which is important in the shoulder in the midranges of motion when the ligaments are laxe. This dynamic stability has important consequences in the overhead athlete.

Glousman RE, Jobe FW, Tibone JE, Moynes D, Antonelli D, Perry J. Dynamic electromyographic analysis of the throwing shoulder with glenohumeral instability. J Bone Joint Surg Am 1988;70(2): 220-6

This article analyzes the throwing athlete, with shoulder symptoms presumable due to anterior instability, with dynamic EMG while pitching a baseball.

Fifteen skilled pitchers were analyzed using high speed photography in conjunction with EMG analysis. The muscles studied were biceps, middle deltoid, supraspinatus, infraspinatus, pec major, subscapularis, latissimus dorsi and serratus anterior. These symptomatic pitchers were compared to a previous study of twelve asymptomatic pitchers. The symptomatic pitchers had mildly increased activity in their biceps and supraspinatus. They also had diminished activity of the serratus anterior and the subscapularis.

This study shows that there is a neuromuscular imbalance in the symptomatic throwing athlete. These athletes were thought to have symptoms secondary to instability but may have had symptoms secondary to internal impingement. Whether the muscle imbalance is primary or a secondary phenomenon cannot be determined from this study. A rehabilitation program with subscapularis and serratus anterior strengthening would be advisable in the symptomatic throwing athlete.

Turkel SJ, Panio MW, Marshall JL, Girgis FG. Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. J Bone Joint Surg Am 1981; 63 (8): 1208-17.

This study did an anatomic dissection of the subscapularis and shoulder capsule, including the glenohumeral ligaments, in cadaveric shoulders to determine the different structures responsible for providing anterior stabilization of the shoulder.

This cadaveric study used radiographic markers to demonstrate the position, tightness and laxity of the subscapularis muscle, middle and inferior glenohumeral ligaments during external rotation of the shoulder in different degrees (0, 45 and 90 degrees) of abduction. A sequential cutting study was performed. The study showed that with the arm at the side the subscapularis muscle stabilized the joint. At 45 degrees of abduction the subscapularis, middle glenohumeral ligament and anterior superior fibers of the inferior glenohumeral ligament provide the stability; and as the shoulder approaches 90 degrees of abduction, the inferior glenohumeral ligament provides stability during external rotation.

This is a classic study which showed that the inferior glenohumeral complex is the primary restraint for preventing anterior dislocation of the glenohumeral joint in the apprehension position. The structures that are being stressed at lower levels of abduction and at the side are the subscapularis muscle, middle and superior glenohumeral ligaments.

Pagnani MJ, Deng X-H, Warren RF, Torzilli PA, O'Brien SJ. Role of the long head of the biceps brachii in glenohumeral stability; a biomechanical study in cadavera. J Shoulder Elbow Surg 1196; 5:255-262

The purpose of this study was to determine if the long head of the biceps plays a role in providing stability to the glenohumeral joint.

Cadaveric shoulders had a force applied to simulate a muscle contraction of the long head of the biceps to study the effect on glenohumeral translations. Application of forces on the long head of the biceps resulted in a significant decrease in humeral head translation. The effect of the long head of the biceps was more pronounced at lower elevation angles.

The function of the long head of the biceps in the shoulder is controversial and dynamically does not contract significantly during overhead activities. However with low forces applied to it, it may apply stability to the glenohumeral joint. Whether the muscle tendon unit or the tenodesis effect is responsible, in either case, the long head of the biceps should not be a sacrificed in the overhead athlete. It may play a role in providing some stability to the shoulder joint.

Grossman MG, Tibone JE, McGarry MH, Schneider DJ, Veneziani S, Lee TQ. A Cadaveric Model of the Throwing Shoulder: A Possible Etiology of Superior Labrum Anterior-to-Posterior Lesions. American J Sports Medicine 824-831, 2005

This laboratory model created in cadavers was used to model the thrower's shoulder by creating increased external rotation with decreased internal rotation. This was done by stretching the anterior capsule and tightening the posterior capsule respectively. The effect on the translations and the motion of the humerus on the glenoid was then studied.

Ten cadaveric shoulders were used to measure humeral rotation range of motion, the position of the humerus at maximum external rotation, and translations measured in 90 degrees of abduction and 90 degrees external rotation. After stretching the anterior capsule there was a significant increase in external rotation and after a simulated posterior capsular contraction there was a significant decrease in internal rotation. The humeral head translated posterior inferiorly when the humerus was rotated from neutral to maximum external rotation. This did not change with anterior capsule stretching; however following a simulated posterior capsular contraction there was a trend toward a more posterior superior position of the humeral head with the humerus in maximum external rotation in comparison to the position in the stretched condition. If the posterior capsule is contracted, the humeral head is forced posterior superiorly which may explain the etiology of type II slap lesion in the overhead athlete.

This cadaveric study confirms clinical observations of the pathologic changes that we often see in the shoulder of the throwing athlete. It supports the concept of a posterior capsular contraction being more important than anterior laxity in causing pathologic changes about the shoulder.

Rodosky MW, Harner CD, Fu FH. The role of the long head of the biceps muscle and superior glenoid labrum in anterior stability of the shoulder. Am J Sports Med 1994;22(1): 121-30

This cadaveric study was used to determine if the long head of the biceps muscle and attachment of the superior labrum play a role in shoulder stability in the overhead athlete.

The data suggests that the long head of the biceps muscle contributes to anterior stability of the glenohumeral joint by increasing the shoulder resistance to translational forces in the vulnerable abducted and externally rotated position. The biceps muscle also helps diminish the stress placed on the inferior glenohumeral ligament.

The detachment of the superior glenoid ligament is detrimental to anterior shoulder stability as it decreases the shoulder resistance to torsion and places an increased amount of strain on the inferior glenohumeral ligament. It explains why overhead athletes with SLAP lesions have increased anterior laxity of their shoulder.

Townsend H, Jobe FW, Pink M, Perry J. Electromyographic analysis of the glenohumeral muscles during a baseball rehabilitation program. Am J Sports Med 1991;19(3): 264-72

This article analyzed exercises that are most efficient in a glenohumeral rehabilitation program for throwing athletes.

These exercises were carried out in 15 males, performing 17 different shoulder exercises commonly used in a shoulder rehabilitation program by profession baseball teams. The four rotator cuff muscles as well as the deltoid, pec major and latissimus dorsi were studied. Some exercises consistently were found to be the more challenging exercises for all muscles. These shoulder exercises consisted of elevation in the scapular plane, shoulder flexion, horizontal abduction with the arm externally rotated and a press up.

The study documents the minimum exercises needed for an effective rehabilitation program for the glenohumeral muscles. This includes just four exercises. While other exercises are certainly important these four exercises should be included in any rehabilitation program for the overhead athlete.

Burkhart SS, Morgan CD, Kibler WB. The disabled throwing shoulder: spectrum of pathology: Part I pathoanatomy and biomechanics. Arthroscopy 2003; 19(4): 404-420

This is a review article which discusses the pathoanatomy and biomechanics of the throwing shoulder and presents the concept of the peel back mechanism versus internal impingement as causing the pathoanatomy in the overhead athlete. Anterior instability which leads to internal impingement has been cited previously as a major cause of shoulder problems in the throwing athlete. This article questions this concept presenting the peel back mechanism associated with a posterior capsule contracture and pseudo anterior laxity which leads to problems such as SLAP lesions and rotator cuff pathology. They present the biomechanics to help explain their theory.

This is a comprehensive review article of the different mechanisms that can cause pathology in the thrower's shoulder. It encompasses biomechanics and pathoanatomy that have been proven on a clinical basis. They use these principles in their rehabilitation and surgical treatment of the throwing athlete.

15. Diagnosis of Instability and Non-operative Treatment

The Pathology and Treatment of Recurrent Shoulder Dislocation of the Shoulder-Joint. AS Blundell Bankart. Br J Surg, 26:p23-29. 1938.

This classic article Dr Bankart seeks to dispel some of the beliefs about the etiology of shoulder dislocations, to describe detachment of the labrum seen in recurrent dislocations and to describe a method of repair of the detached labrum. Prior to this publication the etiology of recurrent shoulder instability was believed to be primarily due to capsular tearing alone, to lack of bone support or to loss of muscle support. As a result, the operations described prior to this report included capsular plication alone, muscle transfers anterior to the shoulder, bone blocks to the anterior glenoid or sling operations where tissues such as the biceps tendon were woven through the humeral head to suspend the proximal humerus.

Dr Bankart reported upon 27 patients who had detachment of the labrum from the anterior and inferior glenoid as the result of recurrent shoulder dislocation. He also described detachment of the capsule from the scapular neck, bony lesions of the anterior glenoid rim and stripping of the periosteum and capsule from the scapular neck. His surgical technique consisted of an extended deltopectoral approach, osteotomy of the coroacoid and release of the subscapularis tendon near its attachment. He recommended a vertical arthrotomy of the capsule and repair of the labrum to the glenoid rim using sutures through drill holes.

An Evaluation of the Apprehension, Relocation and Surprise Tests for Anterior Shoulder Instability. Lo IKY, Nonweiler B, Woolfrey M, Litchfield R, Kirkley A AJSM 2004, 32:301-307.

This study was one of the first to evaluate the most commonly utilized examination tests used to make the diagnosis of anterior shoulder instability. While the cornerstone of making the diagnosis of anterior shoulder instability is a history of an injury with the arm in an abducted and externally rotated position accompanied by a subluxation or dislocation of the shoulder, many patients do not present with this classic history. In these cases the physical examination can be helpful in confirming the diagnosis.

The authors prospectively studied these three examination methods in 46 patients who had a variety of diagnosis, but only 17 had a diagnosis of traumatic anterior instability. The apprehension maneuver was performed with the patient supine and the arm was placed in abduction and external rotation. A positive test was if the patient reported apprehension or pain. The relocation maneuver was performed by stabilizing the humeral head using posterior pressure on the proximal humerus once the patient reported apprehension or pain in the apprehension maneuver. For the relocation test to be positive the patient should have relief of the pain or apprehension. The surprise test was performed after the relocation test by quickly removing the hand that was stabilizing the proximal humerus. For the test to be positive the patient had to again report suddenly a sense of apprehension or pain.

The surprise test was the most accurate with a specificity of 99%, but a sensitivity of only 64%. The apprehension maneuver provided the next best clinical usefulness with a specificity of 99% and a sensitivity of 52%. The relocation test was the least useful especially when utilizing pain as a criterion of instability. The location of pain with these maneuvers was found to be varied and not helpful in determining the diagnosis of instability. These tests were found to also produce pain in patients with a variety of diagnosis, such as rotator cuff tears, osteoarthritis and multidirectional instability. These three examination techniques for evaluating patients with anterior shoulder instability are recommended but have to be utilized with an appreciation of the limitations of the tests.

Recurrent Transient Subluxation of the Shoulder. CR Rowe and B Zarins. Journal of Bone and Joint Surgery. 63-A: 863-872, 1981

This study was the first to describe the "dead arm syndrome" and to introduce the concept that it might be caused by subluxation of the shoulder when the arm is in abduction and external rotation in active patients. They postulated that when the arm is in this position the shoulder will either overtly or covertly subluxate, causing the symptoms of pain, fatigue and decreasing performance.

They reported upon 60 shoulders in 58 patients which included 26 patients who felt that the shoulder would transiently subluxate and another 32 who were unaware that the shoulder was subluxating as a cause of their symptoms. The mechanism of injury in most patients was either a traumatic injury or repetitive trauma with the arm in an abducted and externally rotated position. All patients demonstrated a positive anterior apprehension test which produced pain or a sense of instability.

All patients were initially treated with rehabilitation and only eight patients were successfully treated with this program. The others underwent a standard Bankart procedure or a modified Bankart procedure with a capsulorraphy (capsular shift with no labrum repair). If there was a large rotator cuff interval then this was closed. 64% of the patients had a Bankart lesions and 26% had capsular laxity alone and 20 patients also had placation of the rotator cuff interval.

The results were reported with the Rowe score and demonstrated that 70% were excellent, 24% good and 6% fair. In the patients who had the dominant arm operated upon, only 64% were able to return to "forceful throwing" or sports, whereas of those patients who had the non-dominant arm operated upon 87% were able to return to athletics or work with no limitations.

This is a provocative article that demonstrates the difficulty in defining the pathology in the throwing shoulder and the challenge of returning them to active athletics. This article also discusses the potential role of the rotator cuff interval in the etiology of shoulder laxity and instability.

Treatment of instability of the shoulder with an exercise program. Burkhead WZ and Rockwood CA. JBJS Am 1992, 74:890-896.

This is an important study that demonstrates the effectiveness of a rehabilitation program for patients with atraumatic or "multidirectional" shoulder instability, and it reinforced the impression that a rehabilitation program is less effective for patients with traumatic subluxations or dislocations. One hundred and forty shoulders in 115 patients were given a rehabilitation program that was uniform and described in detail in this publication. The patients were divided into four groups: Type I those with traumatic subluxation without dislocation, Type II those with a traumatic subluxation after dislocation, Type III atraumatic voluntary subluxations and Type IV those with involuntary subluxations. The patients were followed for 2 to 6 years. Of those patients with traumatic subluxations only 16% had a good or excellent result, whereas 80% of those patients with atraumatic subluxuations had a good or excellent result. In each subgroup they found that patients with posterior instability had better response to an exercise program than those with anterior instability. The authors emphasize that this information is of great value when counseling patients about the effectiveness of rehabilitation for their particular type of instability. This study also supports the concept that dynamic stability of the glenohumeral joint can be improved through rehabilitation.

Voluntary dislocation of the shoulder: A preliminary report on a clinical, electromyographic and psychiatric study of 26 patients. Rowe CR, Pierce DS and Clark JG. JBJS Am 1973, 55:445-460.

This classic study of a series of patients with the ability to voluntarily subluxate their shoulders over the glenoid rim. This study evaluated the authors experience with a series of 26 patients, and they divided the patients into those who were psychologically suspect (Group I, N=8) and those who were judged to be psychologically normal (Group II, N=18). The authors performed electromyography in some patients and found that the subluxation of the shoulder was performed by activating some muscles and relaxing other muscles. The patients also had to utilize some muscles to stabilize the scapula in order to position the joint so that it could be subluxated. The authors presented a strengthening program which they recommended as the definitive treatment. They characterized this syndrome by noting that (1) this syndrome beings usually in childhood or early adolescence, (2) subluxation regardless of direction is produced by muscle activation patterns for that type of subluxation, (3) that there is rarely any intra-articular pathology present, (4) that radiographic abnormalities are rare, (5) that there was a significant difference in response to treatment between groups I and II. Of the patients in group I the results were generally poor regardless of whether the treatment was non-operative or surgical. The five patients in group I had 9 shoulders which underwent a total of 37 operations, and most continued to have symptoms as a final result. In Group II, patients generally responded positively to rehabilitation, and of the 3 who underwent surgical intervention, the results were good. This study emphasized the importance of a careful assessment of these patients, consideration of their psychological

status and the use of a structured rehabilitation program which will be successful in most cases.

Voluntary subluxation of the shoulder in children. A long-term follow-up study of 36 shoulders. Huber H and Gerber C. JBJS Br 1994, 76B:118-122.

The ability of some children to subluxate their humeral head out of the glenoid has been called by a variety of names including voluntary, demonstrable, habitual and muscular instability. Many children learn how to do this and can demonstrate it at will, and most have no history of trauma or injury. The authors reviewed 36 shoulders in 25 children with open growth plates who ranged in age from 6 to 16 years of age (average 12). 26 shoulders in 19 patients were treated non-operatively and followed for 6 to 26 years (average 11 years). All patients in this group ceased performing the maneuver by age 16 years of age, had no limitations in employment and no arthritic changes. Five patients in this group had some symptoms with sports activities, and two sustained traumatic disclocations which responded to surgical intervention. The second group of 10 shoulders in 7 patients who underwent surgery were evaluated at an average follow up of 14 years. All the patients continued to have signs of ligamentous shoulder laxity, and only 5 of the operated shoulders had a good result. None of the shoulders showed signs of osteoarthritis in this operative group. The authors conclude that in this group of patients “skillful neglect” is the best course of treatment, but they admit this was not a randomized study. They also concluded that voluntary instability in children does not generally result in arthritis, but the follow up was relatively short.

Inferior capsular shift for involuntary inferior and multidirectional instability of the shoulder: A preliminary report, Neer CS, Foster CR, JBJS Am, 1980, 62:897-908.

This landmark article describes a group of patients with “instability” in a variety of directions, the evaluation of these patients and a potential surgical solution. This article defined the criteria that Dr Neer used for making the diagnosis of multidirectional instability in this populatation. All of the patients had “uncontrollable and involuntary inferior subluxation or dislocation” of the shoulder. This instability was also associated with both anterior and posterior subluxations or dislocations. All of the patients were judged to be psychologically normal and all had generalized ligamentous hyperlaxity of their other joints. The pathology at the time of surgery was excessive capsular laxity in all cases.Excluded from the study were any patients with Bankart lesions or bony lesions.

The diagnosis of inferior instability was made with a sulcus sign or traction radiographs. Traction radiographs showed that the humeral head subluxated further inferiorly than the opposite shoulder unless the patient had pain and could not relax for the examination. The examination under anesthesia was felt to especially important to determine the direction and degree of capsular laxity.

The authors emphasized four important considerations in their study. First, all of the patients were judged to be psychologically normal, and patients who could volitionally

subluxate the shoulder were excluded. Secondly, inferior instability was not always symptomatic and other lesions could be the cause of discomfort in these patients. Third, inferior subluxation that is mildly symptomatic can often be controlled by activity modification and an exercise program to strengthen the rotator cuff and scapular muscles. Lastly, determining accurately the direction of instability was critical to surgical planning in this complicated and challenging group of patients.

The effect of variation in the definition on the diagnosis of multidirectional instability of the shoulder. McFarland EG, Kim TK, Park HB, Niera CA and Gutierrez MI. JBJS Am 2003, 85: 2138-2144.

This study examined the criteria for making the diagnosis of multidirectional instability of the shoulder and the effect of using shoulder laxity testing as a diagnostic criterion influences the number of patients who would have this diagnosis. Shoulder laxity tests that were used to measure translation of the humeral head upon the glenoid rim included an anterior and posterior drawer test and the sulcus sign. Since many individuals can be subluxated over the glenoid rim and have no history of shoulder instability, the use of laxity testing which did not produce symptoms of instability would tend to over-diagnose instability in multiple directions. This is important since the diagnosis of multidirectional instability can influence what type of non-operative and operative treatment the patient will receive.

In this study the authors applied different combinations of diagnostic criteria to a cohort of 168 patients who had been operated upon for shoulder instability. The diagnosis of instability and the direction of instability had been verified by examination under anesthesia and diagnostic arthroscopy. Translation of the humeral head upon the glenoid was described as grade I (humeral head does not subluxate over the glenoid rim), type II (humeral head can subluxate over the glenoid rim but spontaneously reduces) or type III (humeral head locks out when subluxated and the examiners hands released). The sulcus sign was graded as I (less than 1.0 cm translation), grade II (1.0 to 2.0 cm translation) or grade III (over 2.0 cm translation). In this cohort there were 14 (8.3%) of the patients with a diagnosis of multidirectional instability.

If the in the same group of patients, if a grade II or III sulcus sign was used to diagnose multidirectional instability, then 100 patients (59.5%) would have multidirectional instability. If a grade II or III anterior or posterior drawer test then 139 (82.7%) of the patients would meet the criteria for multidirectional instability.

This study demonstrated that using laxity testing of the shoulder can significantly influence which patients are believed to have multidirectional instability. Laxity testing should be considered a diagnostic sign of instability only when it reproduces the patients symptom of instability, and studies of multidirectional instability should be carefully scrutinized for the criteria used for making the diagnosis.

Posterior shoulder instability. Petersen S Orthopedic Clinics of N America 2000, 31:263-274

This review article is an excellent summary of the classification, biomechanics, examination and non-operative treatment of posterior shoulder instabilities. The major categories of posterior instability include acute posterior disclocations, chronic fixed posterior dislocations and recurrent posterior shoulder subluxations. The latter can be divided into recurrent post-traumatic subluxations or dislocations, recurrent atraumatic posterior subluxations or disclocations and lastly recurrent demonstrable subluxations. The demonstrable types can be subdivided into those where the subluxations occur willfully (voluntary) or are positional only (involuntary).

The clinical approach to each of these subtypes of posterior shoulder instability varies and is outlined in the article. The treatment of posterior dislocations is determined by whether the dislocation is acute or chronic. The radiographic findings of these types of posterior instabilities is concisely reviewed. The treatment of the recurrent posterior shoulder instabilities depends upon the diagnosis, and the critical factors in arriving at a diagnosis are discussed in this article. The other major emphasis of this article is upon non-operative treatments for recurrent posterior shoulder instabilities and it provides a good review of the options available for the clinician.

Other Recommended Readings:

Clinical Evaluation of Shoulder Problems. Krishnan SG, Hawkins RJ, Bokor DJ in The Shoulder, eds Rockwood CA, Matsen FA, Wirth MA and Lippitt SB. 3rd Edition 2004, WB Saunders, Philadelphia PA

Clinical Evaluation of the Overhead Athlete: The "Differential-Directed" Approach. eds Tokish JM, Krishnan SG, Hawkins RJ. In The Shoulder in the Overhead Athlete, 2004, Lippincott Williams and Wilkins, Philadelphia PA

Clinical Evaluation of the Unstable Shoulder. Allen AA In The Unstable Shoulder eds Warren RF, Craig EV, Altchek. 1999, Lippincott, Philadelphia PA

Examination of the Shoulder: A Complete Guide. McFarland EG. Thieme Medical Publishers, 2005. New York NY

16. Anterior-Inferior Instability: Open

Neer, CS; Foster, CR. Inferior capsular shift for involuntary inferior and multi-directional instability of the shoulder. Journal of Bone and Joint Surgery 67: 897-908, 1980.

This classic paper introduced the concept and technique of reducing capsular and ligamentous redundancy to achieve stability of the shoulder. The open capsular shift restored ligamentous balance without over tightening. Only 1 patient out of 40 had a recurrence.

This technique remains the framework for all operations that attempt to reduce capsular volume as part of the treatment of instability.

Turkel, SJ; Panio, MW; Marshall, JL, et al. Stabilizing mechanisms preventing anterior dislocation of the glenohumeral joint. Journal of Bone and Joint Surgery 63: 1208-1217, 1981.

This classic article evaluated the restraints to anterior translation, using cutting studies and radiographic analysis. They found that the inferior glenohumeral ligament was the primary restraint to increased translation at arm elevation angles above 45 degrees, and rotation angles approaching 90 degrees.

This study is the basis upon which all other cutting studies are developed and was the first to demonstrate differential contributions to stability from different parts of the capsule.

Matsen, FA; Harryman, DT; Sidles, JA. Mechanics of glenohumeral instability. Clinics in Sports Medicine 10: 783-788, 1991.

This classic article summarizes the mechanical aspects of shoulder instability. It describes the mechanisms by which the joint maintains its stability, including limited joint volume, concavity-compression, and balanced ligamentous and capsular constraints. It then shows how these mechanical factors relate to the production of instability.

This paper also describes the 2 ends of the spectrum of instability, the TUBS traumatic injury and the AMBRI non-traumatic instability.

Arciero, RA; Wheeler, JH; Ryan, JB, et al. Arthroscopic bankart repair versus non operative treatment for acute, initial anterior shoulder dislocations. American Journal of Sports Medicine 22: 589-594, 1994.

This prospective non randomized short term study compared arthroscopic and non-operative treatments for first time dislocators. The surgically treated group had significantly less re-dislocations than the non-operative group, and had a high rate of stability. Only 50% of the non-operative group required surgical stabilization.

If the anticipated activity demands on the shoulder are high, and the adverse affects of a recurrent dislocation are large, early stabilization can be advocated.

Hovelius, L; Augustine, BG; Fredin, OH, et al. Primary anterior dislocation of the shoulder in young patients: A 10 year prospective study. Journal of Bone and Joint Surgery 78:1677-1684, 1996.

This prospective multi-center study followed a large cohort of patients who had 3 non-operative treatment protocols after shoulder dislocation – sling for comfort, immobilized for 4 weeks, or immobilization for varying times. At 10 year follow-up, 52% had no further dislocations. Operations for recurrent dislocations occurred in 23%. There was a higher rate of operation in younger age groups. The type and duration of initial treatment did not affect the rate of reoccurrence.

This data suggests that in the average population of patients who sustain a shoulder dislocation, routine operative treatment to prevent further episodes of dislocation cannot be recommended.

Taylor, DC; Arciero, RA. Pathologic changes associated with shoulder dislocations. American Journal of Sports Medicine 25:306-311, 1997.

This prospective observational study reviewed the pathologic findings in young athletes with anterior shoulder dislocations. All patients were in the early post injury period. 97% were found to have Bankart lesions, with no gross evidence of intracapsular injury. Other lesions were seen with less frequency.

This study establishes early confirmation of what is seen in more chronic or recurrent injuries – the Bankart lesion is the major pathologic entity that needs to be restored for stability.

Burkhart, SS; Debeer, JF. Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic bankart repairs: Significance of the inverted pear glenoid and the humeral engaging Hill-Sachs lesion. Arthroscopy 16: 677-694, 2000.

Failure of arthroscopic repairs highlighted 2 significant reasons for failure. A large bony lesion in the anterior inferior glenoid, comprising greater than 25% of the width, or a Hill-Sachs lesion that engaged the anterior glenoid rim were associated with a high failure rate. These lesions were more effectively treated by open correction of the bony defects by coracoid transfer and bone grafting.

This paper showed that many contact athletes without bony lesions can be treated by arthroscopic methods, but that there were some lesions that were best approached by open means. It provided specific guidelines for evaluation of patients to determine the nature of the lesions responsible for the instability.

Cole, BJ; Millett, PJ; Romeo, AA, et al. Arthroscopic treatment of anterior glenohumeral instability: Indications and technique. AAOS Instructional Course Lectures 53: 345-358, 2004.

This ICL reviews current methods of evaluation before surgery, surgical preparation, surgical repair techniques, and post-operative care. Emphasis is placed on adequate utilization of all of the pathoanatomy, adequate and accurate fixation of tissue, and limitations of arthroscopic repair.

This review provides extensive knowledge of pertinent anatomy as it relates to instability, a good discussion of various types of instrumentation, and techniques of anchor placement and tissue repair.

Lo, IKY; Bishop, JY; Miniaci, A, et al. Multidirectional instability: surgical decision making. AAOS Instructional Course Lectures 53: 565-572, 2004.

This ICL reviews the history of the difficulty in making the diagnosis of multidirectional instability and presents treatment options. It reviews both open and arthroscopic treatment methods. Open reconstructions may lead to better outcomes due to humeral based volume reduction and more extensive mobilization, although early results from arthroscopic procedures also show reduction in symptoms. Thermal capsulorraphy has not shown good outcomes and can be associated with capsular necrosis.

Fabbriciani, C; Milano, G; Demontis, A. et al Arthroscopic versus open treatment of Bankart lesion of shoulder: a prospective randomized study. Arthroscopy 20: 456-462, 2004.

This study presented mid term (2 year) follow-up of patients treated with open or arthroscopic methods using the same equipment and post operative protocols. There were no redislocations in either group. Outcomes measures were not significantly different except for range of motion criteria, with the open group showing decreased range of motion.

This level I study, using current surgical techniques, showed that comparable results may be obtained with either operative approach, and that arthroscopic techniques should have priority when full post operative range of motion is required.

Kirkley, A; Werstine, R; Ratjek, A, et al. Prospective randomized clinical trial comparing the effectiveness of immediate arthroscopic stabilization versus immobilization and rehabilitation in first time traumatic anterior dislocations of the shoulder: long term evaluation. Arthroscopy 21: 55-63, 2005.

This prospective clinical trial followed 2 groups of patients with dislocations to see if either treatment produced significant changes in outcomes. The non-operative group had a higher rate of redislocation. There was a small but significant difference favoring early

operative intervention on the WOSI score, but no difference in shoulder function on ASES or DASH scores.

This long term level I study did not give an unequivocal answer to the question of whether to acutely stabilize the first time dislocator. Less than half of the patients in the non-operative group eventually had surgery.

Mazzocca, AD; Brown, FM; Carreira, DS, et al. Arthroscopic anterior shoulder stabilization of collision and contact athletes. American Journal of Sports Medicine 33:52-63, 2005.

This study evaluated arthroscopic treatment of dislocations in high impact athletes. Although all returned to organized contact/collision sports, 15% has a recurrence of the dislocation. No surgeries were performed for recurrence. Even though this procedure can be used in contact/collision athletes, there may be a high rate of occurrence.

Millett, PJ; Clavert, P; Warner, JJP. Open operative treatment for anterior shoulder instability: when and why. Journal of Bone and Joint Surgery 87: 419-432, 2005.

This current concepts review describes the methods of open operative treatment and the indications for their use. Open treatment is a preferred method of treatment for many revision cases, cases in which humeral or glenoid bone loss is a major concern, capsular deficiency, and irreparable rotator cuff or subscapularis deficiency.

Decision making regarding methods of achieving stability in instability cases should take these issues into account as well as surgeon's experience and the relevant pathology.

Farber, AJ; Castillo, R; Clough, M, et al. Clinical assessment of 3 common tests for traumatic anterior shoulder instability. Journal of Bone and Joint Surgery 88:1467-1474, 2006.

This clinical review studied the anterior apprehension test, the relocation test, and the anterior drawer test to determine the overall clinical utility of these tests in the clinical examination. Documentation of anterior instability by arthroscopy or radiology was the standard. The 3 tests were found to be specific but not sensitive. Apprehension was a better end point than pain for a positive or negative test. The likelihood ratio of the apprehension test is high.

These tests are helpful in the diagnosis of anterior instability, especially when reproduction of the actual symptoms (sliding or apprehension) is the end point.

17. Anterior and Anteroinferior Instability: Arthroscopic

Stein DA, Jazrawi L, Bartolozzi AR: Arthroscopic stabilization of anterior shoulder instability: A review of the literature. Arthroscopy 2002; 18: 912-924.

This paper is an excellent review of anterior shoulder instability. The authors provide the background for a discussion of shoulder instability, describing the anatomy, pathophysiology, and natural history, before reviewing the history of the development of arthroscopic techniques for treatment of anterior shoulder instability, including staple capsulorrhaphy, transglenoid suture, bioabsorbable tacks, and suture anchors.

The "essential lesion" of anterior shoulder instability is the classic Bankart lesion, which is a detachment of the anteroinferior glenoid labrum with the inferior glenohumeral ligament from the rim of the glenoid. However, the clinician must realize that anterior instability can occur in the absence of a true Bankart lesion. Pathology such as anterior capsular stretching or tearing, anterior labral periosteal sleeve avulsion (ALPSA), humeral avulsion of the glenohumeral ligaments (HAGL), superior labral anterior-posterior (SLAP) tears, and bony defects of the glenoid (bony Bankart) or humeral head (Hill-Sachs lesion) can all contribute to anterior shoulder instability. The clinician must be able to recognize normal anatomic variants at arthroscopy without confusing them for pathologic lesions. While early reports of arthoscopic anterior instability repairs showed higher failure rates compared to open repairs, more recent evidence suggests equivalent results, even in high demand athletes. Reasons for this success include better patient selection and better arthroscopic techniques, implants, and instrumentation. The authors present technical pearls.

Arthroscopy has revolutionized the treatment of anterior shoulder instability, without some of the morbidity associated with open surgery. Level I evidence exists that shows equal success between modern arthroscopic techniques and open surgery. As experience with these techniques has grown, investigators have identified risk factors for failure of an arthroscopic anterior instability repair including large bony defects, attenuated capsulolabral structures, rotator interval lesions, collision athletes, HAGL lesions, inadequate post-operative immobilization, and failure to address all pathology encountered at surgery.

Stokes DA, Savoie FH III, Field LD, Ramsey JR: Arthroscopic repair of anterior glenohumeral instability and rotator interval lesions. Orthop Clinics North Am, 2003; 34: 529-538.

The authors present a nice review of arthroscopic repair of anterior instability and include a discussion of the role of rotator interval lesions. The evolution of arthroscopic techniques is reviewed. With current techniques, the authors feel that the entire spectrum of instability patterns can be treated with success by arthroscopic means.

The rotator interval between the anterior border of the supraspinatus tendon and the superior border of the subscapularis tendon has been shown to contribute to shoulder stability in clinical and laboratory studies. Closure of the rotator interval to supplement an arthroscopic instability repair can be helpful in cases of inferior laxity or thin, patulous tissue. The authors describe their indications and technique for arthroscopic anterior instability using suture anchors, as well as their technique for rotator interval closure. Their results in 662 patients have been previously published, with a 97% success rate that the authors feel is partly due to their treatment of the rotator interval at the time of Bankart repair.

Guidelines regarding the management of the rotator interval at the time of arthroscopic instability repair continue to evolve. While Stokes and coauthors have had success tightening the rotator interval and view it as an important adjunct, other authors have had success with arthroscopic instability repairs that did not involve tightening of the rotator interval. Treatment of the rotator interval must be individualized and is most often utilized for patients with excessive soft tissue laxity and a significant inferior instability component.

Morgan CD, Bodenstab AB: Arthroscopic Bankart suture repair: Technique and early results. Arthroscopy 1987; 3: 111-122.

In the 1980's, arthroscopy of the shoulder was in its infancy. Pioneers like Johnson and Matthews were the first to attempt to repair unstable shoulders arthroscopically. These early techniques involved the use of metallic staples. Unfortunately, failure rates of 15-20% and complications related to the implants including loosening, breakage, and migration, occurred. Morgan and Bodenstab developed a transglenoid suturing technique to avoid the complications seen with metallic hardware.

The authors review the then-current schools of thought regarding the anatomy and pathophysiology of recurrent anterior shoulder instability. At that time, open anatomic repairs of the Bankart lesion were becoming popular, while nonanatomic repairs like the Magnuson-Stack were falling out of favor. Open repair of a Bankart lesion using transglenoid drilling with Prolene pull-out sutures was described by Reider and Inglis and modified by the authors for arthroscopic use. Their technique involved use of knee instrumentation and a modified Beath pin. Via an anterior portal, a Beath pin was used to skewer the anteroinferior labrum. The pin was drilled posteriorly through the glenoid, loaded with a #1 PDS suture, then pulled out posteriorly. with a second pin was similarly placed1.5 cm superior to the first. The sutures were tied together, tensioned to reduce the labrum, and tied over the posterior deltoid fascia. In 25 cases with 12 to 30 month follow-up, all patients has full range of motion, excellent results according to the Rowe score, and no recurrences.

Morgan and Bodenstab's report is the first documenting excellent results with an all-arthroscopic repair of recurrent anterior shoulder instability. Interestingly, the editors saw fit to include a disclaimer at the beginning of the article, warning that no one but an experienced arthroscopist should attempt an arthroscopic Bankart repair, as serious complications could occur. The transglenoid drilling technique has largely fallen out of favor as the use of suture anchors has become more popular.

Wolf EM, Wilk RM, Richmond JC: Arthroscopic Bankart repair using suture anchors. Op Tech Orthop 1991; 1:184-191.

This classic reference by Wolf et al is the first description of the use of suture anchors during an arthroscopic Bankart repair. While previous investigators had described transglenoid drilling, removable rivets, and metallic staples used during an arthroscopic stabilization procedure, high rates of complications and inferior results compared to open surgery were seen. Wolf's technique has become the preferred technique for arthroscopic anterior instability repairs.

Traditionally, anterior labral tears were repaired during open surgery using bone tunnels in the anteroinferior rim of the glenoid. The Mitek suture anchor was developed in order to simplify the soft tissue to bone fixation. Wolf adapted use of the Mitek suture anchor to arthroscopic repairs, using many of the same principles from the open technique. This paper is essentially a description of his technique, which uses two anterior and two posterior portals. He describes the identification of the Bankart lesion, preparation of the glenoid rim and neck, placement of the anchors, passage of suture through the tissue, and arthroscopic knot tying. Results in 20 patients treated between 1989 and 1991 are presented. No recurrences and no complications were seen.

Since Wolf's description of the use of suture anchors for arthroscopic Bankart repair in 1991, tremendous advances in surgical technique, suture anchor design, and instrumentation have occurred. However, despite these advances, contemporary technique is remarkably similar to that described by Wolf almost 20 years ago, allowing surgeons to treat anterior instability in a minimally invasive fashion with consistently satisfactory results. His technique has withstood the test of time and is currently the most popular method of repairing Bankart lesions arthroscopically.

Burkhart SS, De Beer JF: Traumatic glenohumeral bone defects and their relationship to failure of arthroscopic Bankart repairs: Significance of the inverted-pear glenoid and the humeral engaging Hill-Sachs lesion. Arthroscopy, 2000; 16: 677-694.

Results of 194 consecutive arthroscopic Bankart repairs were analyzed to identify specific factors related to recurrence of instability. The authors believe that the debate over open versus arthroscopic techniques has focused on the success rates of soft tissue procedures, and that the some of the failures seen arthroscopically have been the result of unaddressed traumatic bone defects.

Overall, a 10.8% recurrence rate was seen. Of the 21 failures, 67% had significant bone defects (either an inverted pear glenoid or an engaging Hill-Sachs lesion) that were not addressed at surgery. Of the patients without significant bone defects, 4% had recurrent instability. Of the patients with significant bone defects, 67% had recurrent instability. Of the 101 contact athletes, 9 had significant bone defects and those had an 89% recurrence rate. The recurrence rate for contact athletes without bone defects was 6.5%.

Burkhart and De Beer emphasize many important points in this paper. The labrum should be mobilized laterally and repaired to the rim or even onto the face of the glenoid to restore normal anatomy. Arthroscopic transglenoid drilling and staple capsulorrhaphy had

high failure rates because they repaired the labrum medially, not because arthroscopic repairs are inherently inferior. Patients with large engaging Hill-Sachs lesions are not good candidates for arthroscopic repair and are more reliably treated with an open inferior capsular shift, osteoarticular bone graft to restore the humeral articular surface, or rotational humeral osteotomy. Patients with a glenoid whose inferior half is narrower than the superior half (the inverted pear glenoid) due to bony Bankart fracture or compression and erosion of the glenoid rim are not good candidates for an arthroscopic repair and are more reliably treated with a Laterjet coracoid transfer to restore the arc length of the glenoid. Contact athletes without significant bone defects do as well as nonathletes when treated arthroscopically. The authors caution against using adjunctive measures to overtighten the soft tissues (thermal capsular shrinkage, capsular plication, rotator interval closure) in order to reduce the failure rate, when attention should instead be focused on identifying patients with significant bone defects and treating them accordingly.

Gartsman GM, Roddey TS, Hammeran SM: Arthroscopic treatment of anterior-inferior glenohumeral instability: Two to five-year follow-up. J Bone Joint Surg, 2000; 82-A: 991-1003.

Gartsman and coauthors state that the high reported failure rates with early instability repairs were due to technical factors, such as the medial repair of the labrum, and failure to treat other lesions that contribute to the instability besides the Bankart lesion, such as superior or inferior labral tears, capsular stretch, and rotator interval widening. The purpose of this study was to determine the results of arthroscopic treatment of anterior-inferior instability with a surgical approach that attempted to address all components contributing to the instability.

Fifty-three patients with a mean 33 months follow-up were treated. The surgical technique involved debridement of minor labral flap tears, followed by labral repair and capsular tensioning. If the shoulder displayed persistent instability, the rotator interval was tightened. If that failed, the next step was a laser thermal capsulorrhaphy directed at the tissue in the direction of the persistent instability. With this stepwise approach, 92% had good or excellent Rowe scores, 34 of 38 patients returned to their desired level of sports participation, and 4 patients had persistent instability. The authors analyzed their results according to several independent variables and found that degree of instability, number of preoperative dislocations, age at time of operation, gender, arm dominance, and patient compliance did not significantly influence the results, while etiology (traumatic versus nontraumatic), chronicity, and degree of ligamentous laxity did.

This paper illustrates the fact that many factors contribute to anterior-inferior instability including capsular laxity or stretch, superior or inferior labral tearing, or rotator interval widening in addition to the classic anteroinferior labral tear. The surgeon should be sufficiently skilled and the operative approach flexible enough to address all the pathophysiology at the time of surgery.

Fabbriciani C, Milano G, Demontis A, Fadda S, Ziranu F, Mulas PD: Arthroscopic versus open treatment of Bankart lesion of the shoulder: A prospective randomized study. Arthroscopy, 2004; 20: 456-462.

The authors designed a prospective, randomized study to compare results of open versus arthroscopic repair of isolated Bankart lesions using metallic suture anchors.

One hundred and four patients underwent shoulder arthroscopy for evaluation of traumatic anterior shoulder instability. After the diagnostic arthroscopy, 44 patients were excluded from the study because of the presence of additional pathology besides the Bankart lesion, including capsular elongation, labral detachment to the inferior glenoid, ALPSA lesion, rotator interval tear, middle glenohumeral ligament tear, SLAP tear, glenoid bone defect, and rotator cuff tear. Patients with isolated Bankart lesions were randomized into two groups of 30 patients each. Patient characteristics were identical between the groups. Surgical technique involved an identical labral repair using three metallic suture anchors in each group. With a minimum two-year follow-up, no recurrence of dislocation was reported in either group. Although slightly better Rowe and Constant scores were seen in the arthroscopic group, the differences were not significant, except for mean ROM value in the Constant score which was significantly better in the arthroscopic group.

Of the three Level I evidence studies in the literature comparing open versus arthroscopic repair of anterior shoulder instability in a prospective, randomized fashion (Fabbriciani 2004, Sperber 2001, Jorgensen 1999), this study is the only one to compare identical suture anchor repair techniques in both groups. This study suggests that arthroscopic Bankart repair using suture anchors is as good as the open technique.

Kirkley A, Werstine R, Ratjek A, Griffin S: Prospective randomized clinical trial comparing the effectiveness of immediate arthroscopic stabilization versus immobilization and rehabilitation in first traumatic anterior dislocations of the shoulder: Long-term evaluation. Arthroscopy, 2005; 21: 55-63.

The risk of recurrent instability in young active patients has been reported to be as high as 96% with nonoperative treatment. As a result, some investigators have advocated immediate arthroscopic stabilization in this high risk patient population. The authors sought to compare results of traditional immobilization with immediate arthroscopic stabilization in patients under 30 years of age with a traumatic first time anterior dislocation.

Kirkley et al previously reported the early results of immediate arthroscopic stabilization versus immobilization in 40 young patients who were randomized into two groups in an earlier study. Fifteen patients were immobilized and sixteen underwent surgery. The current study is a long- term evaluation of the same study groups, with an average follow-up of 75 months. There was a significant reduction in the recurrence rate with surgical stabilization, as 3 patients redislocated in the surgery group and 9 redislocated in the nonoperative group. There was no significant difference in the ASES or DASH outcome measures between the groups at latest follow-up. The WOSI score showed a small difference between the two groups that the authors felt was clinically significant.

This study provides Level II evidence that immediate arthroscopic stabilization results in lower recurrence rates in selected subsets of patients. Ideal candidates are typically younger than 30 years of age and are high level athletes.

Alberta FG, ElAttrache NS, Mihata T, McGarry MH, Tibone JE, Lee TQ: Arthroscopic anteroinferior suture plication resulting in decreased glenohumeral translation and external rotation. J Bone Joint Surg, 2006; 88-A: 179-187.

Arthroscopic capsular plication has been described to treat anteroinferior shoulder instability. The purpose of this study was to evaluate the effects of a glenoid based suture capsulorrhaphy on glenohumeral range of motion, translation, and center of rotation in a biomechanical model.

Six fresh frozen cadaver shoulders were tested in a six degree of freedom testing apparatus under the following conditions: intact, after 20% anterior capsular stretching, after creation of arthroscopic portals, and after a 10 mm anteroinferior arthroscopic suture plication using two metallic suture anchors in the rim of the glenoid. After plication, external rotation was decreased by 12.6°, anterior translation was reduced >60%, and the center of rotation shifted posteriorly and inferiorly throughout the arc of motion. Following plication, the depth of the capsulolabral bumper was increased from a mean of 2.9 mm to 6.4 mm.

Alberta and coauthors have shown that in a cadaver model, anteroinferior capsular plication can decrease anterior translation and external rotation on par with results reported following laboratory evaluation of open capsulorrhaphy techniques. However, a drawback of this study is that the investigators did not evaluate the effects of shifting the capsule in an inferior to superior direction as others have advocated in the clinical setting, but instead only looked at the effects of a medial to lateral capsular plication. As a result, their technique had a minimal effect on inferior translation, decreasing it only 3.2%. As anteroinferior capsular plication is indicated in cases of capsulolabral stretching and redundancy resulting in anteroinferior translation, it would be useful to examine the effects of plication in a medial to lateral and inferior to superior direction.

Boileau P, Villalba M, Hery J-Y, Balg F, Ahrens P, Neyton L: Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. J Bone Joint Surg, 2006; 88-A: 1755-1763.

Early reports of arthroscopic stabilization techniques for treatment of anterior traumatic shoulder instability had failure rates that were higher than reported for open Bankart procedures. By the late 1990's, several authors had reported results of arthroscopic Bankart repair that equaled the results of open surgery, using the suture anchor technique described by Wolf in 1991. Boileau and coauthors retrospectively reviewed their series of arthroscopic Bankart repair using suture anchors to identify risk factors for the recurrence of instability postoperatively.

Ninety-one patients with recurrent traumatic anterior instability with a mean follow-up of 36 months were evaluated. Fourteen patients (15%) had recurrent instability. The

authors identified risk factors for failure. Glenoid bone loss due to compression or erosion of the glenoid, a large Hill-Sachs lesion, a stretched inferior glenohumeral ligament, anterior hyperlaxity, and the use of three or less anchors were associated with recurrent instability. Interestingly, a glenoid fracture was not associated with recurrent instability. On multivariate analysis, a stretched inferior glenohumeral ligament and a glenoid compression fracture had a 75% chance of recurrence. In patients with that combination of pathology, the authors advise against arthroscopic repair.

This study confirms the findings of Burkhart et al that significant bone defects of the glenoid and/or humeral head cannot be corrected by an arthroscopic soft tissue repair. In addition, this study identifies another subset of patients at higher risk for failure, those with excessive soft tissue laxity. The patients that do the best with arthroscopic Bankart repair are those with an isolated Bankart lesion. Unfortunately, most patients have more complex pathology than that, with bone defects or additional soft tissue injury, and it is incumbent upon the orthopaedic surgeon to accurately identify the pathology and rigorously select patients who are appropriate for an arthroscopic procedure.

18. Posterior Instability

Antoniou J, Duckworth DT, Harryman DT II. Capsulolabral augmentation for the management of posteroinferior instability of the shoulder. J Bone Joint Surg Am 2000;82(9):1220-1230.

Forty-one patients with posteroinferior shoulder instability were treated with arthroscopic shift of the redundant capsule. Patients with multidirectional instability underwent an additional rotator interval closure. Distinctions between workmen's compensation cases and non workmen's compensation results, primary and revision surgery results, and subjective versus objective impression of laxity or stiffness following surgery were presented.

This group was equally split amongst men and women, mostly traumatic etiology, and included ten patients with multidirectional instability. All patients had a positive jerk test and failed an organized rehabilitation program. Traumatic etiology was common, and labral pathology included a reverse Bankart lesion, chondral abrasion, capsular stripping, and labral splits. The purpose of the repair was to reduce capsular laxity and augment the glenolabral concavity. Workmen's compensation patients did not reflect improvement of the simple shoulder test and SF-36. Objective testing of stability was achieved in 85%, but subjectively 59% of patients felt they were stable and 68% of patients felt they were stiff. Revision surgery was successful in two of nine cases, with six returning to work.

A series of patients with capsular plication is presented. The rotator interval closure was a technique to incorporate articular and bursal layers in a side-to-side technique of patients with MDI. Clinical stability was achieved in most cases, but many patients perceived a difference in range of motion. Restriction was not measurable and may reflect an adaptive problem in some of the patients. Most patients with recurrent subluxation can be treated by arthroscopic soft tissue plication.

Hawkins RJ, Koppert G, Johnston G. Recurrent posterior instability (subluxation) of the shoulder. J Bone Joint Surg Am 1984;66(2):169-174.

Fifty shoulders with recurrent posterior subluxation were treated nonoperatively and surgically. The authors clarify the distinction between dislocation and subluxation, voluntary versus involuntary, and significant failure and complications that can result from surgical treatment.

This group of patients is defined by episodic posterior subluxation often with physical activity. The group is subdivided into habitual or willful, demonstrable with arm position (flexion, adduction, and internal rotation), demonstrable with select muscle contraction, and occult with symptoms reproduced with posterior load-and-shift exam. Seventy percent of patients had symptoms during daily activities, and 75% were unable to play sports or were significantly modified. Surgical treatment was a variety of open procedures including a reverse Putti-Platt, biceps tendon transfer, and glenoid osteotomy.

There was 50% recurrence in the surgical group, five of six with soft tissue alone, and serious complications in the glenoid osteotomy 5/17 including degenerative arthritis in two patients.

The authors point out difficulty in making the diagnosis and providing the best initial treatment. Seven of the patients had anterior repairs, four of which were misdiagnosed, and three were MDI. The nonoperative group accepted the limitations, and many returned to reduced activities. The surgical group had mixed results with Putti-Platt, biceps Boyd-Sisk transfer, and glenoid osteotomy. Patients can have disability, even with the ability to demonstrate their subluxation, and this should not be considered "volitional or willful."

Hawkins RJ, Neer CS II, Pianta RM, Mendoza FX. Locked posterior dislocation of the shoulder. J Bone Joint Surg Am 1987;69(1):9-18.

Forty-one shoulders were treated with locked posterior dislocation of the shoulder. The authors present a schemata for patient selection based on patient's level of activity, duration of dislocation prior to reduction (weeks, months), and articular evaluation on axillary radiograph or CT scan.

Patients presented were considered missed diagnosis following a multiple trauma or seizure event. Delay in diagnosis is associated with enlarging reverse Hill-Sachs lesions. Closed reduction in the initial six weeks with less than 20% articular loss requires bracing in external rotation. Dislocation with 20-45% loss requires either reduction followed by subscapularis transfer or McLaughlin lesser tuberosity transfer, or in shoulders with over six months history and/or 45% loss of humeral head, hemi or total arthroplasty is suggested.

The importance of an axillary radiograph or CT scan in these patients not only provides an early diagnosis, but assists in quantifying the articular surface of the humeral head and glenoid. Stabilization of seizure history and early surgical reduction makes soft tissue repair a viable option. Advanced articular changes can be treated nonoperatively in inactive elderly patients or surgically with humeral component in reduced retroversion with the addition of posterior plication sutures.

Kim S, Ha K, Park J. Arthroscopic posterior labral repair and capsule shift for traumatic unidirectional posterior subluxation of the shoulder. J Bone Joint Surg Am 2003;85(A):1479-1487.

Twenty-seven patients with unidirectional posterior instability were treated with arthroscopic labral repair and capsule plication. All patients had a positive jerk test and failed conservative treatment. Labral pathology was better defined on contrast imaging studies and confirmed arthroscopically.

This select group of traumatic-onset athletes was evaluated and treated with a suture anchor repair. These patients did not have sulcus signs or clinical evidence of increased translation inferiorly. Labral lesions arthroscopy included incomplete stripping, marginal cracks, erosion, and SLAP tears. Labral lesions on contrast MRI included nondisplaced

tears, incomplete lesion, and loss of contour – all associated with an enlarged posterior capsule. Enlarging the glenoid-labral defect and placing suture anchors repaired the labrum and plicated the capsule. All but one returned to sports, six patients had slight pain and minimal changes in measured range of motion.

This is a select group of traumatic-onset, unidirectional posterior subluxations involved in sports. A labral lesion with a small crack but subarticular cyst is described radiographically similar to the Perthes lesion anteriorly. Converting this lesion to a reverse Bankart, and repairing with suture anchors reestablished stability. Soft tissue tensioning of the posterior band of inferior glenohumeral ligament was created using permanent braided sutures. Mild changes to the rotator cuff and anterior humeral head did not require additional treatment.

Pollock RG, Bigliani LU. Recurrent posterior shoulder instability. Diagnosis and treatment. Clin Orthop 1993;291:85-96.

The authors reflect on their experience establishing the diagnosis of posterior subluxation. A classification system is introduced and includes posterior unidirectional, posteroinferior bidirectional, and multidirectional instability. The open posterior capsule shift was presented, as well as nonoperative and other surgical repair techniques.

The diagnosis of instability can be confused and lead to incorrect choice of treatment. Sulcus recognition and MDI need additional treatment to avoid failure. Acquired instability or overuse may share characteristics of both the traumatic and atraumatic etiologies. The jerk test and posterior stress tests are used to reproduce patients' symptoms. Bone abnormalities (i.e. retroverted glenoid or hypoplasia) were rare. Contrast studies provided a small improvement in diagnosis when compared to arthroscopy. A posterior capsular shift had 11% recurrence and an 80% satisfaction. Failure following a previously failed surgery occurred in five of six shoulders. Bone grafts were felt to be helpful in cases of hypoplasia or insufficient soft tissues.

This group represents a subset of patients with recurrent posterior subluxation with loose symptomatic shoulders and posterior symptoms and findings. Addressing multiple quadrants directly or indirectly has had better success than unidirectional treatment. The reduction of a sulcus and capsular pouch can be an important component of treatment. Treatment rarely requires bone augmentation and success is good in primary repairs.

Wolf EM, Eakin CL. Arthroscopic capsular plication for posterior shoulder instability. Arthroscopy 1998;14(2):153-163.

Fourteen patients with recurrent posterior instability were treated and reviewed following arthroscopic posterior capsule plication and suture anchors if the labrum was torn. The arthroscopic and clinical findings were presented, and a scoring system reflecting a return-to-sports was given.

Of these patients, nine were traumatic and 12 had labral pathology (86%). Nine of ten returned to sports, one patient had a traumatic recurrence, and none of the patients had surgical complications. Two patients had anterior labral tears treated with anchors as well. The jerk test sitting and on the side (EUA) were positive in all patients undergoing treatment. Six patients had pain with strenuous or moderate activity, and overall 86% had good or excellent results, and 93% were stable.

Jerk and posterior stress test, capsular laxity, poor definition of the posterior band of the inferior glenohumeral ligament, and labral tears or detachment were common findings in this group. A suture anchor repair combined with capsular shift was helpful to returning patients to sports, eliminating the posterior stress test and jerk test, and avoiding complications. Noteworthy was the additional articular findings including anterior labral tears. The arthroscope allows for defining articular pathology and addressing multiple quadrants when indicated.

19. Multidirectional Instability

C.S. Neer II and C.R. Foster, Inferior capsular shift for involuntary inferior and multidirectional instability of the shoulder A preliminary report, J Bone Joint Surg Am 62 (1980), pp. 897–908.

This landmark article presents successful outcomes after inferior capsular shift for patients with refractory multidirectional instability. In thirty-six patients (forty shoulders) with involuntary inferior and multidirectional instability and failed prior operative stabilization, an inferior capsular shift was performed. The procedure utilizes a flap of the capsule reinforced by overlying tendon to reduce capsular and ligamentous redundancy on all three sides. Seventeen shoulders were followed for more than two years with no residual instability and satisfactory outcomes. One shoulder began subluxating again within seven months after operation.

T.J. Schenk and J.J. Brems, Multidirectional instability of the shoulder: Pathophysiology, diagnosis, and management, J Am Acad Orthop Surg 6 (1998), pp. 65–72.

A review article summarizing the current literature on the pathophysiology, diagnosis, and management of multidirectional instability.

W.Z. Burkhead Jr and C.A. Rockwood Jr, Treatment of instability of the shoulder with an exercise program, J Bone Joint Surg Am 74 (1992), pp. 890–896.

This landmark article demonstrates the importance of identifying the etiology of instability in developing a treatment plan. One hundred and forty shoulders in 115 patients that had a diagnosis of traumatic or atraumatic recurrent anterior, posterior, or multidirectional subluxation were treated with a specific set of muscle-strengthening exercises. Only twelve (16%) of the seventy-four shoulders (sixty-eight patients) that had traumatic subluxation had a good or excellent result from the exercises, compared with fifty-three (80%) of the sixty-six shoulders that had atraumatic subluxation.

D.T. Harryman II, J.A. Sidles, S.L. Harris and F.A. Matsen III, The role of the rotator interval capsule in passive motion and stability of the shoulder, J Bone Joint Surg Am 74 (1992), pp. 53–66.

Landmark biomechanical article demonstrating the critical effect of the integrity of the rotator interval capsule on shoulder stability. A six-degrees-of-freedom position-sensor and a six-degrees-of-freedom force and torque-transducer was used to determine the glenohumoral rotations and translations that resulted from applied loads in eight cadaver

shoulders. Instability and occasional frank dislocation of the glenohumeral joint occurred inferiorly and posteriorly after section of the rotator interval capsule. Imbrication of this part of the capsule increased the resistance to inferior and posterior translation

A.D. Morris, G.J. Kemp and S.P. Frostick, Shoulder electromyography in multidirectional instability, J Shoulder Elbow Surg 13 (2004), pp. 24–29.

Electromyographic study demonstrating that altered patterns deltoid activity and imbalances in muscle forces are involved in the etiology of MDI. In subjects with MDI, compared with normal subjects, activity patterns of the anterior deltoid were different during rotation in neutral and 90 degrees of abduction, whereas those of the middle and posterior deltoid were different during rotation in 90 degrees of abduction. In subjects with MDI, the posterior deltoid showed increased activity compared with normal subjects during adduction.

R.A. Cooper and J.J. Brems, The inferior capsular-shift procedure for multidirectional instability of the shoulder, J Bone Joint Surg Am 74 (1992), pp. 1516–1521.

Landmark article reporting satisfactory objective and subjective outcomes after inferior capsular-shift procedure for multidirectional shoulder instability that is refractory to nonoperative management. Thirty-eight patients (forty-three shoulders) who had disabling multidirectional instability of the shoulder were managed with an inferior capsular-shift procedure through an anterior approach. Four patients (four shoulders) had recurrence of symptomatic and disabling multidirectional instability, but thirty-nine (91%) of the shoulders continued to function well with no instability. Nine patients (24%) continued to have episodes of apprehension, which correlated with the residual inferior and posterior translations found at the postoperative physical examination. Thirty-four patients (thirty-nine shoulders) stated that they were subjectively satisfied with the status of the shoulder, but four patients, in whom the instability had recurred, were not satisfied. Thirty-seven (86%) of the shoulders were judged to have been improved by the procedure.

R.G. Pollock, J.M. Owens, E.L. Flatow and L.U. Bigliani, Operative results of the inferior capsular shift procedure for multidirectional instability of the shoulder, J Bone Joint Surg Am 82 (2000), pp. 919–928.

Series demonstrating the efficacy and the durability of the results of the inferior capsular shift procedure for the treatment of shoulders with multidirectional instability. The operative approach (anterior or posterior) was based on the major direction of the instability. At an average of sixty-one months (range, twenty-four to 132 months), results were available for fourty-nine of fifty-two shoulders. Thirty shoulders (61%) had excellent overall result, sixteen (33%) had a good result, one (2%) had a fair result, and two (4%) had a poor result. Forty-seven (96%) of the forty-nine shoulders remained stable at the time of follow-up.

D.W. Altchek, R.F. Warren, M.J. Skyhar and G. Ortiz, T-plasty modification of the Bankart procedure for multidirectional instability of the anterior and inferior types, J Bone Joint Surg Am 73 (1991), pp. 105–112.

Series reporting excellent outcomes using novel technique for stabilization of athletic patients with anterior and inferior multidirectional instability. Forty patients who had a diagnosis of multidirectional instability of forty-two shoulders had a modified Bankart operation in which a T-shaped incision was made in the anterior portion of the capsule, with advancement of the inferior flap superiorly and of the superior flap medially. The patients were followed for an average of three years. Four patients had episodes of instability after the operation. Satisfaction of the patient was rated excellent for forty (95%) of the shoulders, good for one shoulder, and fair for one shoulder.

FG Alberta, NS Elattrache, T. Mihata, MH McGarry, JE Tibone, and TQ Lee. Arthroscopic anteroinferior suture plication resulting in decreased glenohumeral translation and external rotation: Study of a cadaver model. J. Bone and Joint Surg Am 88 (2006) pp. 179-187.

Biomechanical study evaluating the effects of arthroscopic plication on glenohumeral translation, the rotational range of motion, and the positions of the glenohumeral center of rotation. Six cadaver shoulders were tested in the intact state, after simulation of anterior instability by anterior capsular stretching, after creation of arthroscopic portals, and following a 10-mm anteroinferior arthroscopic suture plication. Arthroscopic anteroinferior plication effectively reduced anterior translation and external rotation. Plication resulted in a shift of the glenohumeral center of rotation posteriorly and inferiorly.

D.F. D'Alessandro, J.P. Bradley, J.E. Fleischli and P.M. Connor, Prospective evaluation of thermal capsulorrhaphy for shoulder instability: Indications and results, two- to five-year follow-up, Am J Sports Med 32 (2004), pp. 21–33.

Landmark article reporting significant failure rate of thermal capsulorrhaphy to address shoulder instability. This nonrandomized prospective study evaluated the indications and results of thermal capsulorrhaphy in 84 shoulders with an average follow-up of 38 months. Overall results by ASES assessment score were excellent in 33 participants (39%), satisfactory in 20 (24%), and unsatisfactory in 31 (37%).

20. Complications of Instability Surgery-References

Boardman N.D. III, Cofield RH: "Neurological complications of shoulder surgery." Clin Orthop 368:44-53, 1999.

Article discusses the regional anatomy and nerves "at-risk" during shoulder surgery. Nerve injuries are reported to occur in 1% to 2% of patients undergoing rotator cuff surgery, 1% to 8% of patients undergoing surgery for anterior instability, and 1% to 4% of patients undergoing prosthetic arthroplasty. Surgical techniques for the shoulder are improving and nerves seldom are injured by direct laceration or incorporation in suture repair. Commonly, the nerve injuries occur secondary to traction or contusion.

Boileau P., Villalba M. Hery J.Y., Balg F., Ahrens P., Neyton L.: "Risk factors for recurrence of shoulder instability after arthroscopic Bankart repair. J. Bone Joint Surg 88A (8):1755-1763, 2006.

Landmark series demonstrating increased risk of arthroscopic Bankart failure and recurrent instability in patients with bone loss or with shoulder hyperlaxity. Ninety-one consecutive patients underwent arthroscopic stabilization for recurrent anterior traumatic shoulder instability. At a mean follow-up of thirty-six months, fourteen patients (15%) experienced recurrent instability. The risk of postoperative recurrence was significantly related to the presence of a bone defect, either on the glenoid side (a glenoid compression-fracture; $p = 0.01$) or on the humeral side (a large Hill-Sachs lesion; $p = 0.05$). Recurrence of instability was significantly higher in patients with inferior shoulder hyperlaxity ($p = 0.03$) and/or anterior shoulder hyperlaxity ($p = 0.01$).

Buhler M., Gerber C.: "Shoulder instability related to epileptic seizures". J. Shoulder and Elbow Surg 11(4):339-344, 2002.

Landmark article defining hallmark pattern of large bony lesions in patients with shoulder instability related to epileptic seizures. Thirty-four shoulders in 26 patients in whom the initial dislocation had been caused by an epileptic seizure were studied for a mean of 10 years after treatment. Skeletal reconstruction was often necessary to obtain clinical stability, especially in the more difficult-to-treat anterior instability.

McFarland E.G., Kim T.K. Park H.B., Neira C.A. Guitierrez MI: "The effect of the variation in definition on the diagnosis of multidirectional instability of the shoulder".J. Bone and Joint Surg. 85A(11):2138-2144, 2003.

Study demonstrating that variations in the criteria used for the diagnosis of multidirectional instability significantly affect the distribution of patients with that diagnosis. The use of laxity testing tends to result in an overestimation of the number of patients with this condition.

Park, H.B., Yokota A, Gill H.S., El Rassi G., McFarland E.G.: "Revision surgery for failed thermal capsulorraphy". Am. J. of Sports Med 33(9):1321-1326, 2005.

Recurrent capsular laxity after failed thermal capsular shrinkage is common and frequently associated with capsular thinning. Fourteen patients underwent arthroscopic evaluation and open reconstruction for a failed thermal capsulorrhaphy. The origin of the instability was traumatic (n = 6) or atraumatic (n = 8). At revision surgery in the traumatic group, 4 patients sustained failure of the Bankart repair with capsular laxity, and the others experienced capsular laxity alone. In the atraumatic group, all patients experienced capsular laxity as the cause of failure. Of the 14 patients, the capsule quality was judged to be thin in 5 patients and ablated in 1 patient. A glenoid-based capsular shift could be accomplished in all 14 patients. At follow-up (mean, 35.4 months), 1 patient underwent revision surgery and 1 patient had a subluxation, resulting in a failure rate of 14%.

Sachs, R.A., Williams, B., Stone M.L., Paxton L., Kuney M. "Open Bankart repair: correlation of results with postoperative subscapularis function." Am.J Sports Med 33(10):1458-1462, 2005.

Important study documenting that postoperative subscapularis function was the most critical factor in determining the patient's perception of surgical success after open Bankart repair for instability. A total of 30 patients with traumatic anterior instability had an open Bankart repair by a single surgeon. These patients were observed for a mean of 4 years. Of the patients, 23% had an incompetent subscapularis with a mean of 27% strength as compared with the opposite side. These patients had a positive lift-off test result and reported 57% good and excellent results; only 57% would have the surgery again. Of the patients, 77% had a normal functioning subscapularis with at least 80% strength as compared with the opposite side. These patients had a negative lift-off test result and had 91% good and excellent results; 100% would have the surgery again.

Sperling, J.W., Antuna, S.A., Sanchez-Sotelo, J., Schleck C., Cofield RH: "Shoulder arthroplasty for arthritis after instability surgery". J.Bone and Joint Surg. 84A(10):1775-1781, 2002.

Clinical series of shoulder arthroplasty for the treatment of osteoarthritis of the glenohumeral joint following instability surgery demonstrating effective pain relief and improved motion, but high associated rates of revision surgery and unsatisfactory results due to component failure, instability, and pain due to glenoid arthritis. Thirty-three patients (thirty-three shoulders) with glenohumeral arthritis after instability surgery were treated with a shoulder arthroplasty. Shoulder arthroplasty was associated with significant pain relief ($p < 0.001$) as well as significant improvement in external rotation (from 4 degrees to 43 degrees; $p < 0.001$) and active abduction (from 94 degrees to 141 degrees; $p < 0.001$). Three patients in the hemiarthroplasty group and eight patients in the total shoulder arthroplasty group underwent revision surgery.

Tauber, M. Resch H, Forstner R. Raffl. M., Schauer, J.: "Reasons for failure after surgical repair of anterior shoulder instability." J. Shoulder and Elbow Surg. 13(3):279-285, 2004.

Series presenting etiology and management of failure after surgical repairs of anterior shoulder instability. A total of 41 patients presenting with recurrent anterior instability of the shoulder after surgical repair were followed up after a mean period of 49 months. At revision surgery, the findings were a defect of the anterior bony glenoid rim in 23 patients (56%), a large capsule in 9 (22%), and a laterally torn capsule in 2 (5%). In 7 patients (17%) a typical Bankart lesion with good capsule quality was found. At revision surgery, these lesions were addressed by a bone graft procedure in 21 cases and fixation of the rim fragment with screws in 2 cases. In the 9 patients with a large capsule, a T-shift operation was performed in 6 and a Bankart repair with capsulorrhaphy was performed in the remaining 3. In the 7 patients with a typical Bankart lesion, a Bankart repair was performed, and in the 2 patients with a laterally torn capsule, an open suturing technique was used. At follow-up, none of the patients had had further redislocation or subluxation.

Yel, M., Arazi M., Seneran H:"Complications following surgical treatment of shoulder instability and revision interventions for stabilization." Acta Orthopaedics et Traumatologica Turcica 39 Suppl 1:119-125, 2005.

Review article (in Turkish) discussing the appropriate work-up and management of glenohumeral instability.

Sachs, RA, Lin, D, Stone ML, Paxton, E, "Can the need for future surgery for acute traumatic anterior shoulder dislocation be predicted?" JBJS Am 2007;89(8) 1665-74.

Important natural history study demonstrating an inability to predict need for future stabilization surgery based on index injury evaluation. One hundred and thirty-one patients were followed for an average of four years after their first shoulder dislocation. Younger patients involved in contact or collision sports or who require overhead occupational use of the arm are more likely to have a redislocation of the shoulder than are their less active peers or older persons. However, even in the highest-risk groups, only approximately half of patients with shoulder redislocation requested surgery within the follow-up period. Early surgery based on the presumption of future dislocations, unhappiness, and disability cannot be justified.

21. Adhesive Capsulitis

Warner JJ. Frozen shoulder: diagnosis and management. J Am Acad Orthop Surg. 1997 May;5(3):130-140.

This article gives a thorough overview over the epidemiology, pathology and treatment options for this disease. The author points out that the treatment of motion loss depends on the initial recognition of the causative disorder and its natural history. Possible causes for the idiopathic, primary form of adhesive capsulitis include immunologic, inflammatory, biochemical, and endocrine alterations. Diabetic patients especially are at a greater risk for limited ROM through the thickening and the contracture of the glenohumeral joint capsule. Typically these patients are also more difficult to treat.

The secondary or acquired shoulder stiffness develops for example from post surgical or posttraumatic events. Therefore time of immobilization plays an important role.Usually physical therapy can be a successful approach in the treatment of early stages of adhesive capsulitis, but physical therapy may fail in patients whose problem is due to surgery or trauma.

Manipulation under anesthesia (MUA) can be considered as well, but MUA should not be used in the setting of post surgical motion loss because of a higher rate of complications due to previously formed scar tissue. When conservative treatment fails, arthroscopic capsular release can be used to allow a precise and controlled release of contractures in primary and secondary forms of adhesive capsulitis. When extra- articular components contribute to motion loss, an open approach should be utilized. The postoperative treatment must emphasize pain control and the maintenance of motion gains.

This should be considered a classic review paper for frozen shoulder because the author described the natural history, the wide range of pathology, the diagnostic findings, and the operative and non operative management in a very well-structured and thorough way.

Gerber C, Espinosa N, Perren TG. Arthroscopic treatment of shoulder stiffness. Clin Orthop Relat Res. 2001 Sep;(390):119-28.

The authors' purpose was to review the outcome of arthroscopic capsular release in patients with idiopathic frozen shoulder, postoperative stiffness, and posttraumatic stiffness to determine whether different etiologies have different prognoses.

This retrospective analysis showed that the best outcomes were found in those with idiopathic stiffness. Those with postoperative stiffness also had favorable results while those with posttraumatic stiffness had the worst results. All groups improved significantly and to a similar degree but the final outcomes were related to the initial degree of disability. The authors concluded that arthroscopic release was an effective method for treatment of shoulder stiffness and that the ultimate outcome was directly related to the severity of stiffness regardless of the etiology.

This information is useful to the clinician as it shows the effects of the different etiologies of frozen shoulder on the outcome after arthroscopic treatment.

Beaufils P, Prevot N, Boyer T, Allard M, Dorfmann H, Frank A, Kelberine F, Kempf J, Mole D, Walch. Arthroscopic release of the glenohumeral joint in shoulder stiffness: a review of 26 cases. Arthroscopy. 1999 Jan-Feb;15(1):49-55.

The purpose of this review was to evaluate the technical feasibility of arthroscopic treatment and to correlate the results of treatment with the causes of the stiffness.

Anterior or anterior inferior capsular releases were performed at the anterior rim of the glenoid fossa. There were no intraoperative complications. The ROM gains were independent from the cause of shoulder stiffness, but global results were better in the primary group in terms of pain and strength.

The authors stated that arthroscopic capsular release is a feasible, safe and less traumatic alternative to MUA. Arthroscopic evaluation also allows the surgeon to treat concomitant lesions. While ROM is improved in cases of postsurgical stiffness, the shoulder often remains painful.

This paper details where and how the patient can improve after treatment and demonstrates this graphically.

Uhthoff HK, Boileau P. Primary frozen shoulder: global capsular stiffness versus localized contracture. Clin Orthop Relat Res. 2006 Dec 14;79-84.

The authors of this article focused on the pathology of primary frozen shoulder, looking specifically at the occurrence of vimentin and fibroplasia, which are also present in other contracture diseases, in certain areas of the capsule.

When tissues were removed from the capsule, their first hypothesis was confirmed: that vimentin, a cytocontractile protein, is only present in the anterior capsule, whereas fibroplasia was present in the entire capsule. The conclusion was that in patients with primary frozen shoulder, the process of fibroplasia and the process of contracture through vimentin are distinct processes.

This selective expression of vimentin in the anterior structures merits more experimental investigation and can probably lead to a better understanding of the pathology of this disease.

Loew M, Heichel TO, Lehner B. Intraarticular lesions in primary frozen shoulder after manipulation under general anesthesia. J Shoulder Elbow Surg. 2005 Jan-Feb;14(1):16-21.

The goal of this study was to describe the pattern of intraarticular lesions after MUA in patients with primary frozen shoulder.

After the diagnosis of primary frozen shoulder was established, the patients underwent MUA, followed by arthroscopy. During MUA significant improvement of ROM

was achieved. However, labral tears, labral detachments, and rotator cuff tendon ruptures were noted as a result of the treatment.

Even though MUA is an effective treatment for joint mobilization, it can also cause iatrogenic intraarticular damage and therefore its use is called into question.
This paper should be considered in regards to patient safety with this procedure.

Scarlat MM, Harryman DT 2nd. Management of the diabetic stiff shoulder. Instr Course Lect. 2000;49:283-94.

The authors of this paper point out that frozen shoulder is more common in diabetic patients and that treatment of these patients can be more challenging than the typical frozen shoulder. The paper also discusses the current understanding of how diabetes mellitus affects the shoulder and the treatments available for those affected by this condition.

Because diabetic frozen shoulder is more often bilateral and recurrent, a prophylactic stretching program is recommended. Manipulation is only partially effective for those patients with Type 1 diabetes, and the authors state that MUA should only be considered for those who have a shorter duration of symptoms. For those diabetic patients with a longer duration of symptoms, arthroscopic capsular release is recommended. Typically patients with Type 1 diabetes maintain a better functional level than do those with Type 2 diabetes, but there were no differences after arthroscopic capsular release.

This article describes in detail all issues with the treatment of the diabetic stiff shoulder and is very helpful for the understanding of this pathology.

Hatch GF, Gobezie R, Millett PJ. Stiffness after rotator cuff repair. Complications in orthopedics. AAOS Monograph, 2006;13-29.

This article focuses on stiffness after rotator cuff repair and the decision making that I involved in managing patients with this problem.
The authors discuss the risk factors for stiffness, the causes of symptomatic motion loss, the surgical and non- surgical treatment options, the postoperative management, and the best ways to prevent this problem. This article discusses a specific case and how it was managed, instructing with a concrete example and explaining the whole topic very well.

The management dilemma of the patient with stiffness and a rotator cuff tear is also discussed.

Harryman DT 2nd, Sidles JA, Harris SL, Matsen FA 3rd. The role of the rotator interval capsule in passive motion and stability of the shoulder. J Bone Joint Surg Am. 1992 Jan; 74(1):53-66.

This is the classic cadaveric study which characterized the role of the rotator interval capsule with respect to glenohumeral motion, translation and stability.

The range of motion (ROM) was measured with the rotator interval tissue intact, with the tissue sectioned, and then after it had been imbricated. Alterations in the rotator interval tissue affected the mechanics of the humerus with respect to the scapula. The results of this study suggested that the capsule in the rotator interval plays an important role in glenohumeral motion and stability and that its release may improve ROM in patients with limited flexion and external rotation. Conversely, the authors proposed that imbrication of the rotator interval capsule could help control posterior and inferior instability. This has affected the surgical treatment strategies for patients with both stiffness and instability.

This landmark anatomical cadaveric study defined the biomechanical role of the rotator interval capsule and helped not only our understanding of the pathologic frozen shoulder but also our surgical treatment strategies.

Mengiardi B, Pfirrmann CW, Gerber C, Hodler J, Zanetti M. Frozen shoulder: MR arthrographic findings. Radiology. 2004 Nov;233(2):486-92.

The authors of this article focused on specific MR arthrographic findings in frozen shoulders.

They compared the preoperative MR arthrograms from a group of patients with severe frozen shoulder (due to trauma, surgery, and idiopathic shoulder treated first conservatively, followed by arthroscopic capsulotomy,) with a sex- and age- matched control group who underwent arthroscopy and MR arthrography (due to other pathologies) with no clinical or arthroscopic findings of frozen shoulder. The thicknesses of the coracohumeral ligament and the joint capsule, and the volume of the axillary recess were measured. Abnormalities in the CHL, subcoracoid fat, superior glenohumeral ligament, and superior border of the subscapularis tendon, long biceps tendon, and subscapularis recess were analyzed in consensus by two blinded radiologists.

The blinded quantitative analysis showed a significantly thicker CHL and thicker capsule in the rotator cuff interval. There was no significant difference in capsular thickness in the axillary recess either on the humerus or glenoid side. However, the volume of the axillary recess was significantly smaller in patients with frozen shoulders.
The blinded qualitative analyses lead to a more frequent obliteration of the fat triangle under the coracoid and also to a more frequent synovitis- like abnormality on the superior border of the subscapularis tendon. These analyses show the characteristic MR findings in patients with frozen shoulder.

22. Pathophysiology Glenohumeral Arthritis

Apple AS, Pedowitz RA, Speer KP. The weighted abduction Grashey shoulder method. Radiol Technol 1997;69(2):151–156

Imaging is a significant part of the evaluation of a patient with glenohumeral arthritis and in most instances, sufficient clues are available from the plain films to diagnose the disease process. A prominent radiographic manifestation of arthritis is diminution of the thickness of the "joint space", representative of the articular cartilage loss. This is very apparent in the lower extremities when the joints are imaged with the patient in the standing position (loaded) or excessively loaded position (e.g. single leg, bent knee) and often less apparent if the joints are imaged with the patient in the supine position (unloaded). The diagnosis and extent of glenohumeral arthritis can be more accurately determined utilizing the same principal.

The authors call attention to the fact that alterations of the articular cartilage of the glenohumeral joint can be difficult to detect on the routine anterior-posterior (AP) view of the shoulder due the overlapping of many osseous radiographic silhouettes. The Grashey (true AP of the glenohumeral joint) and the axillary views offer better opportunities for joint assessment but are not weight-bearing views that meet the standards of similar lower extremity views. For the creation of a similar scenario in the shoulder, the authors positioned the patient thirty-five to forty-five degrees from the radiology cassette so that the body of the scapula was as parallel as possible to the cassette. With the arm at ninety degrees of abduction and the elbow fully extended, a force nearly equal to the body weight transgresses the glenohumeral joint. Additionally, a one pound weight (felt to be manageable by most patients) is held in hand to contribute further to the load and is especially helpful for patients who can only reach forty-five degrees (the minimum required for this technique). Many examples of the successful demonstration of the discrepancy of joint space thickness with the unweighted Grashey view versus the weighted abduction Grashey view are presented.

This is a superb, inexpensive plain radiographic technique that should be incorporated into the imaging protocol for every patient assessed for glenohumeral arthritis. Truly remarkable differences in the apparent joint space thickness and the actual joint space thickness can be observed when this technique is employed. An additional benefit of the weighted abduction Grashey view is the detection of the shoulder with an unstable center of rotation, with tendencies for superior subluxation of the humeral head on the glenoid when the rotator cuff is functionally deficient.

Cruess RL. Steroid-induced avascular necrosis of the head of the humerus. Natural history and management. J Bone Joint Surg Br 1976;58:313–317.

The etiology of osteonecrosis of the humeral head may be categorized as either traumatic or atraumatic. The relationship to displaced proximal humeral fractures and

glenohumeral fracture-dislocations is well-known and perhaps more clearly understood than the atraumatic causes, for which there are many. The most significant risk factor for the development of atraumatic osteonecrosis of bone is corticosteroid ingestion, a relationship first brought to attention nearly four decades ago. At that time, joint involvement was limited to the hip and until the author's manuscript, little was known about osteonecrosis of the humeral head.

Eighteen patients received steroid therapy for conditions such as renal transplantation, lupus erythematosis, asthma, glomerulonephritis, hypopituitarism and Gillien-Barre syndrome. In all but two cases, other bones were affected, most commonly the hip. Symptoms appeared between six and eighteen months after the commencement of steroid therapy. The most common clinical manifestation was pain, especially with movement and often associated with a click later in the disease course. Gradual diminution of range of motion, attributable mostly to pain, was observed. Stiffness, or loss of passive range of motion, was a late finding. The pattern of progression in the humeral head was similar to that seen in the hip. The characteristic radiographic lesion was focal subchondral bone resorption (radiolucency) followed later by collapse of the underlying bone. With time the radiolucent zone expanded, indicative of further demarcation between the subchondral bone and the collapsed bone. Living articular cartilage was weakly supported by necrotic subchondral bone, beneath which was an empty space, necrotic bone fibrous marrow, resorbing bone and new bone in formation. Humeral articular cartilage separation was a late phenomenon. Persistently incongruent joint surfaces eventually led to typical degenerative arthritis. An excellent response to treatment with hemiarthroplasty in the most extreme cases may have been attributable to the presence of normal glenoid articular cartilage.

The mechanism for steroid-induced osteonecrosis remains unknown. Cruess continued to study the disease throughout his career and published additional important manuscripts throughout the 1980s. He proposed a classification for osteonecrosis of the humeral head based upon one used by Ficat and Arlet for the hip. The symptoms can be well-tolerated, in most instances, with conservative care until the disease is in its latest stages.

Hirooka A, Wakitani S, Yoneda M, Ochi T. Shoulder destruction in rheumatoid arthritis. Classification and prognostic signs in 83 patients followed 5-23 years. Acta Orthop Scand 1996;67(3):258–263

With its three diarthrodial joints, multiple bursae, a synovial sheath-enshrouded intra-articular tendon and a musculotendinous cuff, the shoulder is, at some point, affected in patients with rheumatoid arthritis (RA). However, there is extreme variability with regard to the extent of shoulder pathology depending upon the duration of the disease, the systemic severity of the disease and the timing of presentation for evaluation of symptoms attributable to the shoulder. It is not uncommon that the optimum time for optimum treatment of the shoulder pathology eludes recognition, either by the patient or the practitioner. The unintentional oversight often further compromises the opportunities for the adequate treatment of pain and dysfunction.

One hundred sixty-six shoulders in 83 patients with a mean age of 56 (25-83) with rheumatoid arthritis for a mean duration of 15 (5-39) years were followed with consecutive anteroposterior radiographs for a mean of 14 (5-23) years. Indices for upward migration (UI) and medial displacement (MI) of the humeral head were created to radiographically characterize shoulder destruction. Five types were recognized: non-progressive (N), n=74, normal or no progression; erosive (E), n=22, marginal erosion with disease progression, slow progression of joint destruction after 10 years; collapse (C), n=34, rapid progression of osteoporosis, cyst formation leading to humeral head collapse with advanced destruction; arthrosis-like (A), n=12, djd-like; and mutilating (M), n=14, extensive osteopenia of head and glenoid with resorption and mutilating changes. Correlations with the indices were performed. From the their review of radiographic findings and determination of the indices 5-10 years after the onset of RA, the authors were able to not only classify the type of shoulder destruction but predict the subsequent degree of shoulder destruction. Treatment options were suggested by the estimated rates of progression. Acute upward migration (implying degradation of the rotator cuff) foretold serious shoulder joint destruction (type M).

The classification scheme and serial measurement of humeral head migration helps predict shoulder joint destruction and may help to avert over or under treatment of a given shoulder. A classification by Neer and another by Larsen, while meaningful, serve to evaluate the present status of the disease. In Larsen's classification, the status might change during the period of observation, e.g. low grade to higher grade. When the fate of the shoulder is known as early as 5-10 years after the onset of disease, attention can be focused on both properly timed and properly performed treatment.

McCarty DJ Jr, Halverson P, Carrera G, Brewer B, Kozin F. Milwaukee shoulder: association of microspheroids containing hydroxyapatite crystals, active collagenase and neutral protease with rotator cuff deficits. 1. Clinical aspects. Arthritis Rheum 1981;24:464–491.

The discipline of Rheumatology has made significant contributions to advancements in the understanding of the mechanisms of crystal-induced arthritis. The process of the disease may evolve insidiously to an advanced stage whereby joints or their surrounding structures suffer irreversible damage before the patient senses the need for medical attention. One such structure is the rotator cuff. While it is widely appreciated that the intact cuff may fall victim to acute injury and as well as chronic attrition, other associations have been observed. The most prominent of these is the relationship of rotator cuff tears with the appearance of crystals and activated enzymes within the glenohumeral joint.

Four patients were observed to have an abnormal shoulder with manifestations of complete rotator cuff rupture (weakness, motion loss, atrophy), swelling and to some degree, though not in every case, an element of discomfort. Their radiographs consistently showed erosions of the cortical bone at the rotator cuff insertion site, cystic degeneration of the greater tuberosity, degenerative changes of the humeral head and glenoid and calcifications of the rotator cuff. Synovial fluid analysis revealed the presence of microspheroids

(originating from the matrices from altered capsule, synovium or articular cartilage) laden with hydroxyapatite crystals, activated collagenase and neutral protease. Distinctly absent from the fluid were polymorphonucleocytes. The authors theorized the formation of hydroxyapatite mineral phase in the altered tissue, its release in the form of a microspheroid into the joint and its consumption by macrophage-like synovial cells. Enzyme release ensues with a chemical assault on the surrounding tissues, including the rotator cuff. The process cascades with further tissue damage, increased joint instability and recurrent cycles of mineral phase formation.

More than twenty-five years after the publication of this article, the initiating event that results in Milwaukee shoulder is unknown, just as these authors surmised. Is it, as they stated, "a unique syndrome"? Were the four patients "more florid examples of a very common condition or … merely interesting rarities"? Respect must be given to the proposed theory; examples in other joints leading to arthropathy are documented, the result of response to hydroxyapatite and other crystals including calcium pyrophosphate. Unraveling the mechanical and chemical interplay into separate and distinct pathways poses a significant challenge.

Neer CS II. Degenerative lesions of the proximal humeral articular surface. Clin Orthop 1961;20:116–125

It would appear that an extensive range of motion, an absence of intrinsic stability and complex muscle actions, all in the presence of extreme leverage forces, might render the glenohumeral (GH) joint susceptible to premature demise. However, compared to the hip and the knee, it is relatively spared with regard to degenerative disease, especially osteoarthritis. Major contributions to the body of knowledge of GH arthritis must be attributed to the author, who, at an early stage in his career, acquired a keen interest in the shoulder. Long before he presented the concept of total shoulder arthroplasty, he investigated conditions of the shoulder that that might potentially benefit from its application.

In one hundred five cadaver shoulders, the glenoid articular surface revealed more substantial primary degenerative changes than the humeral head, seemingly proportionate to their respective contact areas. While humeral articular cartilage changes were observed in 28%, underscoring the association of these changes with increasing age, clinical manifestations were deemed infrequent. Despite this, painful, restricted motion accompanying radiographic GH joint space narrowing and humeral head irregularity could sometimes be explained only by a primary degenerative lesion. From his clinical experiences, the author observed that secondary degenerative lesions resulted from trauma, rheumatoid arthritis, metabolic abnormalities of cartilage, avascular necrosis of the humeral head, and response to crystal deposition. The author appreciated the fact that trauma from extra-articular fractures or subcoracoid dislocations was potentially more damaging to the articular surface than previously realized. Active and "burned out" phases of rheumatoid arthritis were described and on this basis, treatment selected carefully. Young individuals with degenerative arthritis should raise suspicion for metabolic or crystal deposition disorders. Primary disease processes or irradiation may result in necrosis of bone.

Degenerative conditions can be mimicked by neurotrophic disorder, early malignancies and infectious processes such as tuberculosis or low-grade bacterial arthritis. Radiographic findings of degenerative arthritis are often observed in patients with painful, decreased shoulder motion but may be incidental to other, more frequent causes of shoulder pain and stiffness. While it is tempting to conclude that it is the process of primary degenerative disease, careful thought should be given to the differential diagnosis. Reasonable exclusion of other intrinsic and extrinsic sources of shoulder pain is essential to establishing the diagnosis of degenerative arthritis, either primary or secondary.

Neer CS II, Craig EV, Fukuda H. Cuff tear arthropathy. J Bone Joint Surg Am 1983;65:1232–1244.

Disorders of the rotator cuff, in one form or another are probably the most common cause of adult shoulder pain. Tears of varying sizes are frequently encountered in active populations while massive, irreparable tears associated with disorganization of the glenohumeral joint are typically seen in the elderly, especially females. This lesion, unique to the shoulder, captivated the senior author (CSN,II) enabling him to develop a theory as to its genesis, characterize the pathology and speculate with regard to the best options for treatment based upon the pathological anatomy.

Over a period of eight years, the authors treated more than fifty patients with cuff-tear arthropathy, twenty-six, each suffering from intractable pain not responding to conservative measures, with anatomic total shoulder arthroplasty. Patients exhibited diminished motion, weakness, swelling, atrophy and crepitus. A radiographic feature of all patients (in fact, a requirement for the diagnosis of cuff-tear arthropathy) was collapse of the proximal aspect of the humeral head. Other prominent findings were a paucity of osteophytes, instability, patterns of osseous wear and reduction of the acromiohumeral distance. Pathological findings at the time of operation included a large, complete rotator-cuff tear, collapse of the articular surface leading to the loss of articular cartilage and eburnation of the exposed subchondral bone. The remainder of the humeral head was unusually soft. The authors hypothesized that a combination of mechanical and nutritional factors and their sequelae resulted in cuff tear arthropathy of the shoulder and the pathological features that rendered treatment uniquely difficult.

This landmark manuscript offers the most complete and detailed report of the clinical and pathological findings of cuff tear arthropathy ever published. The authors' account of the effects of alterations in glenohumeral biomechanics resulting from massive rotator cuff tears, however, has been challenged by those who support the theory of a crystal-induced disorder of the joint. The direction taken by more recent investigations has been toward a clearer understanding of the pathomechanics leading to a more precise mechanical solution, as sought by the authors, as opposed to a pharmacological solution.

Samilson RL, Preito V. Dislocation arthropathy of the shoulder. J Bone Joint Surg Am 1983;65:456–460.

There is a relationship between dislocation of the shoulder and glenohumeral arthropathy, a phenomenon recognized and discussed as early as 1861 and infrequently mentioned in the orthopaedic literature until the publication of this manuscript. Just as multiple factors may contribute to shoulder instability, so it is for dislocation arthropathy. There is a general belief that the direction of dislocation, frequency of dislocation, age at the onset of dislocation, the mechanism of dislocation, osseous defects and the treatment of dislocation may substantially impact the development of dislocation arthropathy of the shoulder.

The authors reviewed the history, clinical findings and bilateral radiographs of seventy-four shoulder dislocations in seventy patients and characterized arthrosis as either 1)mild - an inferior exostosis less than three millimeters in height on either the humeral head or glenoid or both 2)moderate – similar exostosis but three to seven millimeters in height with slight glenohumeral joint irregularity or 3)severe – similar exostosis more than seven millimeters with narrowing of the glenohumeral joint and sclerosis. Forty-five (61%) shoulders had mild, fourteen (19%) moderate and fifteen (20%) severe glenohumeral arthrosis. Pain, crepitus and motion limitations were present in those with moderate or severe arthrosis. Posterior dislocations were more apt to have moderate or severe arthrosis, perhaps due to delays in treatment.. A shoulder with one dislocation was more likely to have moderate or severe arthrosis than one with recurrent dislocations. Severity of arthrosis correlated with a younger age at the time of the initial dislocation. In this study, bone defects or the severity of the initial trauma did not correlate with the severity of the arthrosis. The choice of treatment did not appear to influence the development of arthrosis unless the joint was violated by internal fixation devices.

The natural history of shoulder dislocation is not benign; even a single dislocation event treated nonoperatively may develop dislocation arthropathy. The presentation is usually decades after the initial event or after definitive treatment has been successfully rendered. It is difficult to arrive at a precise number but the incidence of glenohumeral arthrosis, in some form, after any type of shoulder dislocations is probably about twenty per cent. It should be kept in mind that the most common cause of dislocation arthropathy may be iatrogenic, hence the designation – capsulorrhaphy arthropathy. While the manuscript provides very important data, what remains unknown is not only the fate of those shoulders followed for a longer period of time but the natural history of those shoulders with mild arthrosis.

Walch G, Badet R, Boulahia A, Khoury A. Morphologic study of the glenoid in primary glenohumeral osteoarthritis. J Arthroplasty. 1999 Sep;14(6):756-60.

Primary glenohumeral osteoarthritis is the leading indication for shoulder arthroplasty. Most of the published evidence points to the fact that the glenoid is the anatomic structure having the greatest impact upon its durability and outcome. Aspects of quantity and quality of this prosthetic-supporting structure render the joint either suitable for

total arthroplasty or hemiarthroplasty reconstruction. Historically, plain radiographs provided the only opportunity to estimate glenoid orientation to guide surgical reconstruction toward deformity correction and anatomic reconstruction. Just over two decades ago, computed tomography (CT) scanning emerged as a more advanced imaging tool that facilitated the radiographic analysis of the osteoarthritic glenoid.

One hundred thirteen CT scans of the shoulders of patients with primary osteoarthritis were reviewed by the authors. Retroversion was measured, erosion characterized as either posterior or central, and an index of subluxation was determined for each shoulder (normal = 45% - 55%). Mean glenoid retroversion was 16 (-12 to 50) degrees. The glenoid morphology was characterized as one of three types: A) 59%; retroversion - 11.5 degrees; centered; even loading pattern; A1 - 43%, minor erosion; A2 - 16%, major erosion B) 32%; retroversion - 18 degrees; posterior subluxation (subluxation index 59% [56.8% - 61.7%]); uneven loading pattern; B1 - 17%, retroversion - 14.9 degrees, narrowing of posterior joint space, subchondral sclerosis, osteophytes; B2 - 15%, retroversion - 23.4 degrees, biconcave glenoid C) 9%; retroversion - 35.7 degrees; retroversion of dysphasic origin; head well-centered or slight posterior subluxation (subluxation index 55% [35% - 75%]). The authors believed that the posterior subluxation of the humeral head accounted for the posterior erosion more so than the degree of retroversion of the glenoid. Age significantly correlated with more advanced erosion. Distinctions between posterior erosion and dysplasia are possible and may have therapeutic implications.

This informative manuscript reiterates the importance of accurate assessment of the skeletal architecture as a component of assessment of the glenohumeral joint under consideration for prosthetic reconstruction. The authors have clearly determined that the severity of posterior glenoid erosion increases over time suggesting that, due to greater technical difficulties, deliberate delays in prosthetic treatment are probably unwise. The excessively retroverted glenoid of dysplastic origin deserves more careful considerations with regard to implant selection and positioning.

Wiater JM and Flatow EL: Posttraumatic arthritis. Orthop Clin North Am 2000; 31 63-76.

Fundamental to the development of posttraumatic glenohumeral (GH) arthritis is irreversible damage to articular chondrocytes and their surrounding matrix. In rare instances, it is a traumatic insult only the GH articular cartilage. More often, it directly or indirectly affects the supporting bone and surrounding soft tissues leading not only to altered architecture but also to altered mechanical properties that further compound the adverse effect of trauma. As such, the precise cause of posttraumatic arthritis can be difficult to determine. There are numerous publications that detail the natural history of a specific traumatic lesion or the adverse sequelae to its non-surgical or surgical treatment by one method or another. Taking into account the complexity of shoulder degeneration subsequent to trauma facilitates the development of potentially successful strategies for treatment.

Posttraumatic arthritis may result from articular surface incongruities seen with intraarticular fractures and the later stages of traumatic humeral head osteonecrosis. Disturbances in normal GH mechanics can accelerate the development and progression of

posttraumatic arthritis and is often recognized when there is a proximal humeral or less often glenoid malunion, nonunion of the tuberosities or the surgical neck of the humerus as well as GH dislocation, both unreduced and recurrent. The rotator cuff, deltoid muscle, GH joint capsule and motion interfaces fall victim to the same trauma that creates the osteoarticular damage. The brachial plexus or peripheral nerves are susceptible to injury. Further complicating the traumatic scenario is the development of scar tissue, heterotopic ossification and limb pain syndromes. Primary surgical treatment risks include damage to the rotator cuff and deltoid, induction of further scar tissue, interruption of osseous blood supply, infection and unsuccessful osteosynthesis. Recognizing the challenges imposed by the pathoanatomy and significantly higher risks and complications with surgical treatment, the authors provide their recommendations for the care of patients with posttraumatic arthritis.

Most traumatic conditions of the shoulder do not result in GH arthritis. The ability of the GH joint to withstand minor alterations of surface imperfection depends on the severity of the injury, the load-bearing characteristics (normal and altered) and the integrity and functional preservation of the surrounding soft tissues. This excellent review details the pathoanatomy of posttraumatic arthritis with emphasis on the challenges that are faced in the process of surgical treatment.

Zuckerman JD, Matsen FA. Complications about the glenohumeral joint related to the use of screws and staples. J Bone Joint Surg Am 1984;66:175–180

Other than suture, metal has been the material of choice for orthopaedic surgeons attempting to achieve soft tissue fixation as a component of reconstructive shoulder procedures around the glenohumeral joint for instability, rotator cuff tears and fractures. Successful use of the metallic implant depends upon its correct placement, its security within the bone and its ability to resist fatigue and deformation force. Implant mishaps not only place adjacent musculotendinous and neurovascular structures at risk, but may result in failure of the reconstructive procedure due to unintended loss of tissue fixation. In the event of violation of the glenohumeral joint space by the metallic implant, the cartilage surfaces of humeral head and the glenoid are immediately at risk for damage from direct contact with the metal.

The authors, in collaboration with additional case contributors, analyzed thirty-seven patients with complications from the use of screws and staples around the glenohumeral joint. Thirty-five of the thirty seven patients were treated for recurrent anterior glenohumeral instability, most often a modified Bristow procedure that incorporated screw fixation of the tip of the coracoid process to the anterior glenoid. Two of the thirty-seven had undergone rotator cuff repair. Presenting symptoms indicative of implant related complication included pain (36/37), stiffness (19/37), crepitus with glenohumeral motion (16/37) and radiating parasthesias (4/37) and manifest anywhere from four weeks to ten years after placement of the implant. Thirty-four of the thirty-seven patients required surgical removal of the implant. Permanent joint damage was sustained by fourteen patients (41%), a regrettable consequence given the mean age of 27 years for these fourteen patients. If screws and staples are selected for use around the glenohumeral joint, the authors advise the importance of ample surgical exposure, the use of intraoperative axillary radiographs and, for patients with unexpected

postoperative pain, stiffness or parasthesias, assumption that the complication originates with the metallic implant until proven otherwise.

The use of metallic implants around the shoulder seems to be declining for several reasons; most importantly, perhaps, is the author's informative manuscript. Surgeons are more aware of the favor of anatomic reconstructions that do not require screws or staples and the options for soft tissue fixation to bone have expanded. Metallic suture anchors which have proven to be just as problematic as screws and staples are being replaced by absorbable anchors. Whether a reconstructive procedure is performed with open or arthroscopic technique, the surgeon must maintain high regard for the integrity of the glenohumeral joint and be certain that implants are sufficiently durable and well-fixed to achieve the goals of the procedure without the risk of a complication due to the presence or failure of the implant.

23. Alternatives to Arthroplasty

Baer WS. Arthroplasty with the aid of animal membrane. Am J Orthop Surg 1918;16.
Baer in 1918 published his experience with chromacized animal membrane in interposition arthroplasty for a variety of joints and for a variety of etiologies.

This was a retrospective review by a single surgeon. Joints ranging from the temporomandibular joint to the hip were reviewed. Etiologies were equally varied ranging from trauma to gonoccocal infection. The author reported good results particularly in the temporomandibular and hip joints.

This classic article is the first documented report of a "biologic" resurfacing or interposition arthroplasty for a human joint. Xenograft tissue was used in each case, and subjectively successful results were reported in weightbearing and high-load joints.

Blair B, Rokito AS, Cuomo F, Jarolem K, Zuckerman JD. Efficacy of injections of corticosteroids for subacromial impingement syndrome. J Bone Joint Surg Am 1996;78:1685–1689.

The use of corticosteroid injections for shoulder pain and pathology has remained a controversial practice. This article reports the results of a Level 1 study dedicated to determining the efficacy of steroid injections for subacromial pathology.

Prospective, double-blind, randomized, controlled study of the efficacy of subacromial corticosteroid injection for the treatment of subacromial impingement. Forty patients were randomized to either injection with local anesthetic alone (21 patients) or local anesthetic with corticosteroid (19 patients). The members of the control group were assessed at a mean of 28 weeks later. The corticosteroid group assessed at a mean of thirty-three weeks later. Three of the nineteen patients in the corticosteroid group had moderate to severe pain at follow-up. Fifteen of the twenty-one patients in the control group had moderate to severe pain at follow-up. Improvement in forward elevation and external rotation were better in the corticosteroid group when compared to the control group.

This is an important reference as patients with glenohumeral arthritis often demonstrate concomitant subacromial pain symptoms. The judicious use of steroid injections may be a beneficial adjunctive treatment.

Buchbinder R, Green S, Youd JM. Corticosteroid injections for shoulder pain. Cochrane Database Syst Rev 2003;1:CD004016.

This study provides a meta-analysis of all studies reporting results with the use of steroid injections to treat shoulder pain of variable etiopathology.

Randomized and pseudo-randomized studies comparing corticosteroid injection to placebo or some other intervention in the literature prior to June 2002 were reviewed for a meta-analysis. After review 26 studies met inclusion criteria. There was variability in the number of injections, sites of injections and injection dosage. The author's found that or rotator cuff disease did show a small benefit over placebo however was no different from treatment with NSAID. For adhesive capsulitis, two studies had results suggestive of benefit over placebo when intra-articular corticosteroid injections were performed early. Another study suggested benefit over the short-term of intra-articular steroid over physiotherapy.

While difficult to extrapolate to all shoulder disorders, there appears to be some benefit to judicious use of steroid injections (either subacromial or glenohumeral) for shoulder pain. The arthritic patient may derive some benefit from this treatment modality in carefully selected clinical situations.

Burkhead WZ Jr, Hutton KS. Biologic resurfacing of the glenoid with hemiarthroplasty of the shoulder. J Shoulder Elbow Surg 1995;4:263–270.

The authors report the results of glenoid interposition arthroplasty combined with humeral hemiarthroplasty.

Results of six patients treated with shoulder hemiarthroplasty combined with biologic resurfacing with 2 year follow-up were reviewed. Biologic resurfacing was performed with either autogenous fascia lata or anterior shoulder capsule. All patients had pain relief and functionally on a Neer rating scale there were 5 excellent results and 1 satisfactory result.

This classic reference is the first reported use of an interposition graft in the glenohumeral joint. The authors utilize autogenous tissue to resurface the arthritic glenoid in combination with standard humeral hemiarthroplasty, and establish the basis for biologic glenohumeral interposition arthroplasty.

Chou MM, Vergnolle N, McDougall JJ, et al. Effects of chondroitin and glucosamine sulfate in a dietary bar formulation on inflammation, interleukin-1(beta), matrix metalloprotease-9, and cartilage damage in arthritis. Exp Biol Med 2005;230:255–262.

Glucosamine and chondroitin have been utilized in the treatment of arthritis. This article reviews the chemical basis for these substances.

The effects of dietary chondroitin sulfate, chondroitin sulfate and glucosamine sulfate on arthritis in a rat model were studied. After establishing the different diets in separate groups, the rat subjects were then challenged with an injection of Freund's complete adjuvant to simulate rheumatoid arthritis in the rat. The production of the inflammatory mediators IL-1ß and MMP-9 were then assessed and compared across groups. Rats were also assessed clinically and then sacrificed for histological assessment of the joint. There were controls for both diet (rats fed neither chondroitin sulfate nor glucosamine sulfate) as well as controls for adjuvant injection (rats who were sham injected with saline only).

The investigators reported better clinical scores, decreased inflammatory mediators and decreased histological evidence of arthritis in those rats given chondroitin sulfate plus glucosamine sulfate when compared to controls. Rats given chondroitin sulfate alone showed benefit in some parameters but not all.

This article provides chemical support for the use of glucosamine and chondroitin in combination as an anti-inflammatory medication. While the comparative benefit with respect to other anti-inflammatory medications cannot be evaluated, glucosamine/chondroitin supplements may aid in reducing the inflammation and pain associated with arthritic joints.

Krishnan SG, Nowinski RJ, Harrison D, Burkhead WZ. Humeral hemiarthroplasty with biologic resurfacing of the glenoid for glenohumeral arthritis. Two to fifteen-year outcomes. J Bone Joint Surg Am 2007;89:727–734.

The authors report the intermediate- to long-term results of humeral hemiarthroplasty and biologic glenoid resurfacing with autogenous and allograft tissue for young patients with arthritic glenohumeral joints.

Thirty-four patients (thirty-six shoulders) who were managed with biologic glenoid resurfacing and humeral head replacement either with cement (ten shoulders) or without cement (twenty-six shoulders) were followed prospectively. The study group included thirty men and four women with an average age of fifty-one years.

The mean American Shoulder and Elbow Surgeons score was 39 points preoperatively and 91 points at the time of the most recent follow-up. According to Neer's criteria, the result was excellent for eighteen shoulders, satisfactory for thirteen, and unsatisfactory for five. Glenoid erosion averaged 7.2 mm and appeared to stabilize at five years. There were no revisions for humeral component loosening. Complications included infection (two patients), instability (three patients), brachial plexitis (one patient), and deep-vein thrombosis (one patient). Factors that appeared to be associated with unsatisfactory results were the use of capsular tissue as the resurfacing material and infection.

This reference documents the longest followup for biologic glenoid resurfacing in combination with a standard humeral hemiarthroplasty. Biologic resurfacing of the glenoid appears to provide pain relief similar to total shoulder arthroplasty, with allograft Achilles tendon as the preferred resurfacing material.

Mitchell N, Shepard N. The effect of synovectomy on synovium and cartilage in early rheumatoid arthritis. Clin Orthop 1972;89:178.

Synovectomy has been reported as a treatment for inflammatory arthritis. This article reports the histological basis for that treatment.

Tissue samples of 20 patients at index synovectomy were compared to tissue samples taken anywhere between 3 weeks and 6 years later. Investigators found that cell populations within the joint after synovectomy were closer to normal than cell populations found in the pre-synovectomy biopsy samples. Histologically, biopsies of the cartilage likewise appeared at least morphologically more normal over time.

For patients with inflammatory arthritis, synovectomy (either chemical or arthroscopic) may be beneficial for both symptom reduction and for retarding the destruction of normal joint cellular tissue.

Samilson RL, Prieto V. Dislocation arthropathy of the shoulder. J Bone Joint Surg Am 1983;65:456–460.

The authors document the radiographic findings associated with post-instability arthritis.

Review of seventy-four shoulders with histories of either single or multiple dislocations evaluated for radiographic evidence of glenohumeral arthropathy. Authors describe a radiographic grading system based on osteophyte formation and size and appearance of the glenohumeral articulation. They found that posterior dislocations were associated with a higher incidence of moderate and severe arthritis. This was attributed to delay in diagnosis and therefore delay in reduction. Number of dislocations and the presence of bony defects did not seem to correlate with severity of arthritis.

This classic reference is the only reported radiographic grading system for glenohumeral arthritis. By utilizing the 3-grade criteria described here, objective radiographic assessment of glenohumeral arthritis can be documented.

Simpson NS, Kelley IG. Extra-glenohumeral joint shoulder surgery in rheumatoid arthritis: the role of bursectomy, acromioplasty, and distal clavicle excision. J Shoulder Elbow Surg 1994;3:66–69.

Joint preservation surgery for rheumatoid arthritis has often involved symptom relief. This article reports the results of such an operation.

Results of extra-glenohumeral joint shoulder surgery for the treatment of rheumatoids with shoulder pain were reviewed. Localization of the patient's pain was performed with the aid of local anesthetic. Surgery (including subacromial bursectomy, anterior acromioplasty and/or excision distal clavicle) was tailored to the source of the patient's pain based upon this injection. Patients were reassessed at an average of 30 months post-op. Nineteen of twenty-two shoulders had minimal pain and both flexion and external rotation improved from 68° and 23° to 121º and 52º respectively.

While the definitive destructive mechanism in the rheumatoid shoulder is the synovial pannus, reduction of pain and restoration of motion can be obtained by addressing the subacromial space and acromioclavicular joint. This article provides the basis for extraarticular combined operations improving motion at the acromiohumeral and scapulothoracic articulations, when the glenohumeral joint is inflamed and possibly contracted.

Weinstein D, Bucchieri J, Pollock R, et al. Arthroscopic débridement of the shoulder for osteoarthritis. Arthroscopy 1993;9:366.

The authors report the results of arthroscopic glenohumeral joint debridement for the treatment of glenohumeral osteoarthritis.

Results of arthroscopic débridement for the treatment of osteoarthritis of the shoulder were reviewed in 27 patients. Procedure included lavage, loose body removal, débridement and subacromial bursectomy. Average follow-up was 30 months. While there was no improvement in range of motion, pain relief was significant with all patients experiencing some pain relief. At average follow-up of 30 months there were 78% satisfactory results (excellent or good) and 22% unsatisfactory results. Those with unsatisfactory results had had at least 8 months of pain relief before deterioration.

This is one of the earliest reported references demonstrating potential benefit for arthroscopic treatments in glenohumeral arthritis. While not appropriate for all stages of disease, this may be a beneficial treatment if the joint is still concentric.

24. Prosthetic Arthroplasty for Arthritis with Intact or Repairable Rotator Cuff

Neer CS II, Watson KC, Stanton FJ. Recent experience in total shoulder replacement. J Bone Joint Surg Am 1982;64:319-337.

The authors report the first large series describing their early experience with unconstrained total shoulder arthroplasty. Earlier disappointing results with fixed fulcrum implants led to the design of a polyethylene glenoid component to articulate with an anatomically designed humeral head component that was previously developed by the senior author to treat proximal humerus fractures and glenohumeral arthritis. The design principles were to: "(1) provide a near-normal anatomical design to permit the maximum return of motion, (2) permit minimum removal of bone, thus preserving soft-tissue attachments and allowing salvage by arthrodesis if necessary, (3) avoid mechanical blocking of prosthetic motion that might lead to mechanical failure, and (4) emphasize the importance of the reconstruction and rehabilitation of the soft tissues around the implant." They emphasized the importance of the status of the rotator cuff and the effect of the specific etiologies of the glenohumeral arthritis on the results.

Boileau P, Walch G. The three dimensional geometry of the proximal humerus. Implications for surgical technique and prosthetic design. J Bone Joint Surg British. 1997;79-B:857-865.

The authors report the results of their study of the three dimensional geometry of the proximal humerus using digitized surface mapping. They noted that there was a great deal of variation among individuals. The articular surface varied in its orientation including the inclination and retroversion as well as the offset of the center of rotation of the humeral head relative to the humeral axis. They noted that the current contemporary humeral components could not reliably restore normal anatomic relationships. In response to their findings, they designed a modular humeral prosthesis that could correct the pathologic anatomy by restoring humeral head inclination, version, and offset. This design concept is the basis for most of the modular humeral prosthetic systems that are current available.

Iannotti JP, Gabriel JP, Schneck SL, et al. The normal glenohumeral relationships. An anatomical study of one hundred and forty shoulders. J Bone Joint Surg Am 1992;74-A:491-500.

The authors reported a detailed evaluation of anatomic parameters of the proximal humerus and glenoid. They used embalmed non arthritic cadaver shoulders and MRIs from patients. They found a number of consistent patterns in the anatomy. The central portion of the humeral head is spherical while the periphery is ellipitical. There was a consistent ratio of the humeral head radius of curvature and the humeral neck height. There was also a direct correlation between the humeral head size and the patient height, as well as a strong

correlation between the lateral offset of the humerus and size of the humeral head. These parameters in normal shoulders provide a reference for assessing the anatomic reconstruction of shoulder arthroplasty. In addition, the findings provide justification for modular humeral prosthetic components with a variety of head sizes and neck heights.

Chin PY, Sperling JW, Cofield RH, Schleck C. Complications of total shoulder arthroplasty: are they fewer or different? J Shoulder Elbow Surg 2006;15:19-22.

The authors reviewed their own experience with over 400 total shoulder arthroplasties performed for a variety of indications and specifically reported on the complications. The most common complication was glenohumeral instability, followed by post-operative rotator cuff tear (including subscapularis tears), periprosthetic fracture, and brachial plexopathy. The cumulative probability of having a complication was 12 percent after 5 years. Thirty-two of the 53 complications were considered major with 17 requiring reoperation. Thirty-two complications occurred early and 21 were late. Component loosening, a major concern of surgeons, was relatively uncommon

Levy O, Copeland SA. Cementless surface replacement arthroplasty (Copeland CSRA) for osteoarthritis of the shoulder. J Shoulder Elbow Surg. 2004;13:266-271.

Traditional contemporary shoulder arthroplasty involves reconstructing the humerus with a stemmed implant. The senior author of this publication developed a surface replacement humeral component that can be used for humeral head resurfacing as well as total shoulder replacement. The authors report their experience with the Copeland surface replacement arthroplasty for the treatment of osteoarthritis of the shoulder. They included patients treated with hemiarthroplasty and total shoulder replacement. The results were felt to be comparable to results that have been reported by other authors for shoulder arthroplasty performed with stemmed humeral implants.

Edwards TB, Boulahia A, Kempf JF, et al. The influence of rotator cuff disease on the results of shoulder arthroplasty for primary osteoarthritis: results of a multicenter study. J Bone Joint Surg Am 2002;84-A:2240-2248.

The effect of rotator cuff pathology on the outcome of total shoulder arthroplasty was recognized early on by Neer. Patients with large rotator cuff tears are often managed with a limited goals approach with the expectation of inferior functional outcome. In most cases shoulders with primary glenohumeral osteoarthritis have no or minimal rotator cuff pathology. These authors studied a large series of patients who had total shoulder replacement to treat primary glenohumeral osteoarthritis in order to determine the effect of rotator cuff tendon tear and muscle degeneration. They found that minimally or non-retracted tears of the supraspinatus had no appreciable affect on the outcome as assessed by total Constant Score, active mobility, subjective satisfaction, radiographic outcome, and rate

of complications. In contrast, patients with fatty degeneration of the infraspinatus and subscapularis muscles had inferior outcomes.

Gartsman GM, Roddey TS, Hammerman SM. Shoulder arthroplasty with or without resurfacing of the glenoid in patients who have osteoarthritis. J Bone Joint Surg Am 2000;82-A:26-34.

The decision to use a prosthetic glenoid replacement to treat glenohumeral arthritis remains somewhat controversial. Gartsman, and co-authors, reported their findings of a randomized prospective study of shoulder arthroplasty performed with or without glenoid replacement for osteoarthritis. They only included patients with concentric glenoids. There was statistically better pain relief and internal rotation with total shoulder replacement. Although the differences were not statistically different, the UCLA and ASES outcome scores for total shoulder were also better than for hemiarthroplasty. In addition, 3 of the 24 hemiarthroplasty patients underwent revision to total shoulder replacement. The authors clear outline the issues related to decision making but did not make specific recommendations for either treatment.

Goldberg BA, Smith K, Jackins S, et al. The magnitude and duration of functional improvement after total shoulder arthroplasty for degenerative joint disease. J Shoulder Elbow Surg 2001;10:464-469.

Despite the wide spread use of total shoulder arthroplasty to treat glenohumeral arthritis there are only a limited number of well done published outcomes studies that document the improvement and durability of patient self-assessed outcome. Goldberg and co-authors prospectively studied 124 shoulders with the Simple Shoulder Test and the SF-36. They documented significant improvements in the mean SST scores as well as the comfort, physical role function, vitality, and emotional role function components of the SF-36. They also noted that the outcomes were durable over longer follow-up durations.

Ponce BA, Ahluwalia RS, Mazzocca AD, et al. Biomechanical and clinical evaluation of a novel lesser tuberosity repair technique in total shoulder arthroplasty. J Bone Joint Surg Am. 2005;87-A suppl 2:1-8.

There has been recent discussion about the handling of the subscapularis during shoulder arthroplasty. Recognition of internal rotation weakness has led to the development of new techniques to improve the fixation strength of the subscapularis tendon. In this paper the authors describe a method of lesser tuberosity osteotomy. In addition, they compared the fixation strength of transosseous subscapularis repair, soft tissue repair, and lesser tuberosity osteotomy. They found that lesser tuberosity osteotomy had the least displacement and greatest load to failure. Nevertheless, the difference in displacement after 3000 cycles was approximately 2 mm. In their clinical experience, only 10 percent of the patients that they

evaluated after total shoulder arthroplasty with lesser tuberosity osteotomy had subscapularis dysfunction.

Bishop JY, Flatow EL. Humeral head replacement versus total shoulder arthroplasty: Clinical outcomes- a review. J Shoulder Elbow Surg. 2005;14(1 Suppl S):141S-146S.

This is a review article that discusses the controversy regarding the use of glenoid replacement in shoulder arthroplasty. The authors review the literature and make a strong case for preferring total shoulder arthroplasty over humeral head replacement.

Bohsali KI, Wirth MA, Rockwood CA Jr. Complications of total shoulder arthroplasty. J Bone Joint Surg Am. 2006;88-A:2279-92

The authors report the findings of meta-analysis of 33 published studies of total shoulder arthroplasty. The most common complications in order of frequency were component loosening, instability, periprosthetic fracture, rotator cuff tears, neural injury, infection, and deltoid muscle dysfunction. They emphasized the importance of long-term follow-up to “clearly elucidate the short comings of total shoulder arthroplasty”. Overall, this is an excellent review of the pitfalls and complications of total shoulder arthroplasty.

25. Cuff Deficiency Arthropathy: Conventional Arthroplasty Techniques

Neer, CS, Craig, EV, Fukeda H, Cuff tear arthropathy, JBJS Am, 1983: 65; 1232-1244

This is a classic review article and the first major publication on rotator cuff tear arthropathy. Until this point, there had only been brief descriptions in the literature by Neer regarding this particular pathology. The appropriate diagnosis, pathogenesis, and treatment of cuff tear arthropathy were largely uncertain prior to this article.

In this review, the authors describe the clinical findings, pathology, pathomechanics, differential diagnosis, and treatment options of this entity. They detail the physical and roentographic findings found specifically in these patients. The pathologic descriptions include detailed gross and histologic specimens from patients with rotator cuff tear arthropathy and discuss the factors differentiating them from other causes of shoulder arthropathy. They illustrate their understanding of the pathomechanical cause including the nutritional and mechanical factors. The important mechanical factors include the instability and proximal migration of the humeral head from rotator cuff tear and biceps rupture. The nutritional status is altered secondary to a loss of a closed joint space and normal glenohumeral motion. Perhaps most interesting, the authors discuss the surgical treatment of cuff tear arthropathy with unconstrained total shoulder replacement proving most effective compared to arthrodesis or fixed-fulcrum prosthesis. They detailed some of the surgical decision making and difficulties encountered as well.

Overall, this is an excellent landmark review article which introduced the concept of rotator cuff tear arthropathy in large circulation print. Neer writes an enlightening report of their current understanding of this disease as well as their experiences on how it can best be differentiated from other forms of arthropathy and treated appropriately. His progressive work was a huge motivating factor for the design of new treatment methods for newly described pathology.

Franklin, JL, Barnett, WP, Jackins, SE, Matsen, FA, III, Glenoid loosening in the total shoulder arthroplasty, Journal of Arthroplasty, 1988; (3); 39-46

When total shoulder arthroplasty was developed, it was designed without much thought to the competency of the rotator cuff. Glenoid loosening was a complication that was found in various percentages for each study and we had little understanding prior to this study. This is a classic article which analyzed the patients with glenoid loosening and sought to determine its cause.

The author's retrospectively evaluated three groups of patients: group I had rotator cuff deficiency and a loose glenoid component; group II had rotator cuff deficiency and no clinical glenoid component loosening; and group III had no rotator cuff deficiency. They developed their own novel system for reading radiographic loosening of the glenoid. The authors demonstrated that the superior migration of the humeral head (glenohumeral center to center distance) was largest in groups I and II, which led to glenoid component loosening.

They introduce this concept as the "rocking horse phenomenon", in which component failure, in the face of a deficient rotator cuff, occurs by the superior migration of the humeral head eccentrically loading the superior glenoid, tipping it superiorly.

This is a classic article in which the authors' demonstration of glenoid loosening in the face of rotator cuff deficiency identifies this patient population as a high risk group for total shoulder arthroplasty. This finding along with the "rocking horse" concept has led many surgeons to perform a hemiarthroplasty in an arthritic cuff deficient shoulder as well as develop newer techniques (i.e. reverse-ball prosthesis) in an attempt to combat this problem. This article is very important to our current understanding to the biomechanics of the glenohumeral joint, the rotator cuff, and component loosening.

Jensen, KL, Williams GR, Jr., Russell KJ, Rockwood, CA, Jr, Current concepts review: Rotator cuff tear arthropathy, JBJS Am, 1999; 81: 1312-24

Rotator cuff tear arthropathy appears to be the result of a spectrum of degenerative changes associated with rotator cuff deficiency and has been called many different names in the past. This has led to much confusion with regard to its etiology. In addition, various forms of shoulder arthropathy have been described in a manner that overlaps with and augments confusion surrounding this specific entity. This article is an attempt to decipher and simplify some of the confusion.

In this article, Jensen describes a histologic analysis of crystalline-induced arthritis of the shoulder and discuss the association of basic calcium-phosphate crystals found in degenerative diseases of the shoulder. As glenohumeral arthritis and instability progress, these crystals are generated which further enhances the destruction of articular cartilage in the shoulder. The authors describe the Cuff Tear Theory which leads to this degenerative state. In addition, Jensen provides a detailed review of the clinical presentation and radiographic findings in diagnosing cuff tear arthropathy. They discuss the literature which describes radiographic and biomechanical evidence to suggest that the rotator cuff tear leads to mechanical alterations which result in the arthropathy prior to the formation of crystals and histologic changes. They further describe treatment options with consideration of both nonoperative and operative methods including use of constrained, semiconstrained, and unconstrained total shoulder arthroplasty, as well as the use of a hemiarthroplasty and bipolar total shoulder arthroplasty. The authors describe many of the surgical difficulties encountered with each prosthetic design and progression to newer designs. They go on to discuss the more recent articles comparing hemiarthroplasty with total shoulder replacement of different designs.

This article generates an excellent discussion with regard to the etiology of cuff tear arthropathy in an attempt to answer the question of "which came first" the histologic or biomechanical changes. They explain this complicated topic very well and further give an excellent review of the surgical options which gives the reader insight into why some of the different surgical methods were developed.

Vistosky, JL, Basamania, C, Seebauer, L, Rockwood, CA, Jr, Jensen, KL, Cuff tear arthropathy: Pathogenesis, classification, and algorithm for treatment, JBJS Am, 2004; 86: 35-40

The treatment of cuff tear arthropathy presents a unique surgical challenge. Many procedures have been used including the unconstrained, semiconstrained, and constrained total shoulder prosthesis as well as hemiarthroplasty. The purpose of this study was to design a surgical treatment algorithm for cuff tear arthropathy based on the extent of disease and instability. This would further the need for an accurate classification system, which was popularized by Seebauer.

The authors first provide background for the reader in an attempt to clarify the pathomechanical concepts by summarizing the crystal-mediated theory, cuff tear theory, and force couple theory. They then describe the classification of cuff tear arthropathy that was proposed by the Seebauer which is based on the degree of superior migration from the center of rotation and the amount of instability. The authors describe their surgical results on sixty patients with cuff tear arthropathy without anterior superior escape (Type I-A, I-B, and II-A). These patients all underwent shoulder hemiarthroplasty with an extended humeral head prosthesis. At an average follow-up of 32.4 months, the patients showed improvement in pain, range of motion and the American Shoulder and Elbow Society score. These results give the surgeon an algorithm for treatment; those without evidence of anterior escape may acceptably undergo hemiarthroplasty with an extended humeral head prosthesis while those with evidence escape (Type II-B) may benefit from other surgical methods.

This article is important because establishes the classification system by Seebauer which allows the surgeon to decide upon a treatment method based not solely on pathology, but on severity as well. The authors provide an excellent basis with which to help decision making when treating cuff tear arthropathy with and without evidence of instability.

Zeman, CA, Arcand MA, Cantrell, JS, Skedros, JG, Burkhead, WZ, Jr, The rotator cuff deficient shoulder: Diagnosis and surgical management, JAAOS, 1998; 6: 337-348

The treatment of the symptomatic rotator cuff-deficient, arthritic glenohumeral joint is a complex problem. The surgical treatment differs and may be directed based on its etiology. This is a review paper that is directed at diagnosing and differentiating rotator cuff-tear arthropathy (CTA), rheumatoid arthritic (RA) shoulder with cuff deficiency, and degenerative osteoarthritis (OA) with a deficient rotator cuff.

The article begins with a description of each type of rotator cuff problem in arthritic shoulders including the mechanical, nutritional, and inflammatory factors of cuff-tear arthropathy. They then detail some of the history, physical exam and imaging findings with which to differentiate each entity. The authors give a comprehensive review of the different surgical methods and literature concerning arthrodesis, resection arthroplasty, constrained and nonconstrained shoulder replacement, bipolar arthroplasty, and hemiarthroplasty. Arthrodesis is recommended as a salvage in patients with CTA and deficient deltoid after having failed multiple procedures whereas resection arthroplasty is not recommended in this population at all. The use of constrained prosthesis was once considered a viable solution,

however is no longer recommended because of the high rate of complications (loosening, dissociation, and fracture). The bipolar prosthesis has proven most effective on patients with RA and a massive cuff tear. They then review the studies on the use of hemiarthroplasty and nonconstrained total shoulder arthroplasty with both showing good results however hemiarthroplasty being recommended in patients with superior migration because of the high incidence of glenoid loosening. The authors also provide a detailed explanation of surgical options with regard to the status of the subscapularis tendon including different surgical approaches, transfers and repairs based on its function.

This article provides the reader with a comprehensive review of the different aspects of rotator cuff deficient arthritic shoulders and the treatment options for them. It most importantly is not limited to cuff-tear arthropathy, providing an excellent review of the literature and surgical techniques for CTA, RA, and OA with rotator cuff tears.

Field, LD, Dines, DM, Zabinski, SJ, Warren, RF, Hemiarthroplasty of the shoulder for rotator cuff arthropathy, Journal of Shoulder and Elbow Surgery, 1997; 6: 18-23

Rotator cuff tear arthropathy poses a complicated surgical problem for the orthopaedic surgeon. Attempts at treatment with total shoulder replacement in the past resulted in a high incidence of glenoid loosening secondary to increased eccentric loading of the glenoid component due to humeral head superior migration. The use of hemiarthroplasty is an alternative which allows good function with fewer complications.

This is a retrospective review of sixteen patients with cuff tear arthropathy who underwent a hemiarthroplasty with a modular head prosthesis. The humeral heads used were oversized in an effort to allow articulation with the coracoacromial arch, but not so large as to “overstuff” the joint and prevent the 50% of humeral head translation that is typically sought. The coracoacromial arch was left intact as much as possible. The patients were followed an average of 33 months. Of the sixteen patients, ten reported successful results based on the Neer “limited goals” criteria with no operative or postoperative complications. Of the patients with unsuccessful outcomes, four had undergone previous acromioplasty and attempted rotator cuff repair and one of them was a patient with Parkinson’s disease with moderately painful persistent subluxation. Even though considered unsuccessful, each patient showed improvement in range of motion. No patients showed evidence of component loosening.

This is an important article with regard to surgical treatment of rotator cuff arthropathy. It establishes hemiarthroplasty as a successful treatment option and also stresses the importance of maintenance of the coracoacromial arch and deltoid. It teaches us that treatment of a shoulder with an irreparable rotator cuff tear should make attempts at maintaining the coracoacromial arch as this is the last restraint to superior and anterior translation, a philosophy that subsequently becomes widely followed.

Sanchez-Sotelo, J, Coefield, RH, Roland, CM, Shoulder hemiarthroplasty for glenohumeral arthritis associated with severe rotator cuff deficiency, JBJS Am, 2001; 12: 1814-22

This study is an attempt at determining the radiographic and clinical results of hemiarthroplasty for cuff tear arthropathy with a larger patient population than studied in the past and an effort to determine which pathologic or technical factors affected the outcome the surgery.

Thirty three shoulders were evaluated after undergoing hemiarthroplasty for glenohumeral arthritis with a deficient rotator cuff. The results showed significant improvement in pain scores and range of motion. Approximately 73% had no or mild postoperative pain and 67% of patients were found with a successful result (No/slight pain at rest, moderate pain with vigorous activity only, external rotation >20°, and active abduction > 70°). At an average follow-up of 3.4 years, radiographic analysis showed superior erosion of the glenoid in eight patients and erosion of the acromion in fourteen patients. Loosening was not a problem. Analysis of associated findings showed two factors to be associated with a worse outcome: subacromial decompression performed prior to the hemiarthroplasty and superior migration. A prior subacromial decompression was statistically associated with clinical instability. Superior migration resulted in pain, decreased range or motion and strength, and further bone loss at the acromion.

This is an important article because, while the authors have validated a hemiarthroplasty as a good operation for glenohumeral arthritis with rotator cuff deficiency, they have also demonstrated the likely factors that are associated with a poor result. This is vital to the operating surgeon when considering which patients to indicate for a hemiarthroplasty and in discussing the expected outcome with the patients.

Sarris, IK, Papadimitriou, NG, Sotereanos, DG, Bipolar hemiarthroplasty for chronic rotator cuff tear arthropathy; Journal of Arthroplasty, 2003; 18: 169-173

The use of bipolar hemiarthroplasty has a few theoretical advantages; the birotational nature of the implant provides stability and decreases wear, which leads to decreased pain at the acromion. The lateralized offset decreases the likelihood of impingement of the greater tuberosity and also increases the moment arm of the deltoid insertion. Prior studies on the bipolar implant had treated patients who had prior surgeries and different diagnosis (i.e. rheumatoid arthritis, avascular necrosis, etc) This study was designed to evaluate the use of bipolar hemiarthroplasty in patients with cuff tear arthropathy only, who had never undergone prior surgeries.

Fourteen patients with a diagnosis of cuff tear arthropathy underwent a bipolar hemiarthroplasty by one surgeon. The implant was seated higher than the greater tuberosity to avoid impingement and the humeral head was sized to the sum of the radius of the glenoid and subacromial space. The coracoacromial arch was preserved in all patients. The average follow-up was 27.8 months. Forward flexion improved from 30° to 88°. External rotation increased on average from 10° to 37°. The American Shoulder and Elbow Society score improved from 25 to 80. Twelve out of 14 patients reported no pain with daily activities.

Based on the results from this study, the use of bipolar hemiarthroplasty appears to be a feasible surgical alternative for cuff tear arthropathy. There have unfortunately not been many studies to follow and the use of the bipolar implant has remained infrequent to date. There will need to be more comparison studies to determine the preferred surgical options.

26. Reverse Total Shoulder Arthroplasty

Rittmeister, M; Kershbaumer, F. Grammont reverse total shoulder arthroplasty in patients with rheumatoid arthritis and non-reconstructible rotator cuff lesions. Journal of Shoulder and Elbow Surgery 10: 17-22, 2001.

This paper evaluated the reverse total shoulder in rheumatoid arthritis patients. There was decreased pain and increased outcomes scores. The major problems were associated with poor bone stock (loosening).

Sirveaux, F; favard, L; Oudet, D et al. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthristis with massive rupture of the cuff. Journal of Bone and Joint Surgery 86B: 388-395, 2004.

This multi-center study evaluated short term results of the reverse arthroplasty in patients with arthritis and cuff tear. They reported significant relief of pain, increased range of motion, and increased functional outcomes scores. They emphasized the importance of the teres minor to allow external rotation and recommended that the operation should be reserved for elderly patients. There was a concern using survivorship analysis that the predicted failure rate after seven years would be high.

Werner, CML; Steinman, PA; Gilbart, M et al. Treatment of painful pseudoparalysis due to irrepairable rotator cuff dysfunction with the Delta III reverse ball and socket total shoulder prosthesis. Journal of Bone and Joint Surgery 87: 1476-1486, 2005.

This paper reviewed primary and revision usage of the reverse total shoulder prosthesis. Subjective and objective outcomes scores were improved on average, in both primary and revision cases. There was a high rate of complications, and the re-operation rate was 33%. If the prosthesis was retained, good results were not influenced by the complications once they were addressed. It is recommended as a salvage procedure if acceptable clinical outcome can't be expected with other treatments.

Frankle, M; Levy, JC; Pupello, D et al. The reverse shoulder prosthesis for glenohumeral arthritis associated with severe rotator cuff deficiency. Journal of Bone and Joint Surgery 88S part 2: 178-190, 2006.

This surgical technique article gives an overview of the pathophysiology and indications for the procedure, and then gives a detailed explanation of the surgical technique for the procedure.

Boileau, P; Watkinson, D; Hatzidakis, AM et al. The Grammont reverse shoulder prosthesis: results in cuff tear arthritis, fracture sequelae, and revision arthroplasty. Journal of Shoulder and Elbow Surgery 15: 527-540, 2006.

This clinical study reviewed mid term results of the reverse shoulder prosthesis in different groups of patients. Forward elevation was improved in all groups. The outcomes results were higher in the cuff tear arthritis group, and the complication and re-operation rate were much higher in the revision group. Special emphasis was placed on awareness of low grade infection in the revision group. Teres minor function is key to allowing some control of external rotation.

Matsen, FA; Boileau, P; Walch, G et al. The reverse total shoulder arthroplasty. Journal of Bone and Joint Surgery 89: 660-667, 2007.

This instructional course provides a comprehensive overview of the indications for the operation, the components of the arthroplasty system, surgical technique, and complications associated with the operation. The early functional results were good, but tended to worsen from 3 to 6 years after the operation.

Simovitch, RW; Zumstein, MA; Lottri, E et al. Predictors of scapular notching in patients managed with the Delta III reverse total shoulder replacement. Journal of Bone and Joint Surgery 89: 588-600, 2007.

This paper reviewed the incidence and possible etiologic factors for notching of the inferior scapular neck. Notching appears to be associated with poorer clinical outcomes, polyethylene wear, and local osteolysis. Review of the patients showed notching in almost half. It developed several radiographic measurement tools that will allow determination of the proper position of the glenosphere, more inferior and distal depending on the glenoid/scapular neck angle. Notching was associated with inferior functional results, either subjective scores, strength, or range of motion.

27. Complications of Shoulder Arthroplasty

Bohsali KI, Wirth MA, Rockwood CA. Complications of Total Shoulder Arthroplasty. J Bone Joint Surg Am. 2006;88:2279-2292.

In this current review article the subject of total shoulder arthroplasty is looked at as it relates to the complication type and rate in recent experience. Historically there has been a high complication rate associated with total shoulder arthroplasty relative to hip and knee arthroplasty. Overall the total number of shoulder arthroplasties being performed has increased at a rate comparable to that of hip and knee replacement. The complex nature of shoulder arthroplasty revision and historically high incidence of complications makes a review of the rate and type of complications leading to failure a relevant topic.

In this review article Bohsali et al retrospectively look at all articles between 1996 and 2005 that have reference to shoulder arthroplasty or replacement. This review included thirty-nine clinical studies encompassing 2810 total shoulder replacements. The analysis of these procedures revealed 414 complications (14.7%). Reverse total shoulder arthroplasty is discussed but not included in this analysis. The etiologies of the complications are multifactorial and were further stratified into failure modes. Glenoid component loosening was responsible for the highest percentage of all complications with 32% followed by instability at 30% with periprosthetic fractures representing 11% of the total number of complications. Rotator cuff tears, neural injury, infection, and deltoid detachment had contributions as well at 7.7, 4.8, 4.6, and 0.5% respectively. The review goes on to subcategorize the complications so that statistical comparison can be made between all poly glenoid versus metal backed glenoid loosening for example.

It is a necessity that we look at the body of literature to validate the methods currently in use so that we can offer our patients the most effective and long lasting surgical options. The goal of this type of assessment is to reduce morbitity for our patients as well as give us the knowledge by which to discuss the options with our patients in an educated manner. This review helps us accomplish both of these goals. The fact that this ten-year review follows a similar review by same authors allows for an analysis of the progress made in reducing the complications associated with total shoulder arthroplasty.

Chin PYK, Sperling JW, Cofield RH, Schlek C. Complications of Total Shoulder Arthroplasty: Are they Fewer or Different? J Shoulder Elbow Surg 2006; 15: 19-22.

A number of review articles have looked at shoulder arthroplasty through the last quarter century. A select few have specifically looked at complications of total shoulder arthroplasty. Chin et al, in this review look at the difference in the results between the reviews of the 1970's and 1980's and the results of the 1990's. They combine a review of the literature with a retrospective review of 431 total shoulders performed by the senior author between 1990 and 2000. The increased survivorship overall and the decrease in

component loosening are analyzed. The stated purpose of the article was to look specifically at whether implant design and surgical technique have decreased complication rates or whether the complications have changed with the overall rate of complication remaining about the same.

Evolution of prosthetic design and surgical technique over the last 25 years has contributed to increased function and patient satisfaction. Relating this directly to a decrease in complications both minor and major, requiring revision has been neglected. The purpose of this study was to look at the mode of current complications and their frequency. This is accomplished through a review of the literature and a case series of 431 total shoulders done by the senior auther with the same prosthesis over a 10 year time frame from December of 1990 to December of 2000. The review consists of 22 published patient series from 1980 until the writing of the article. The series included 1183 shoulder arthroplasties with 123 complications (10.4%). Twenty-three different types of complications are noted in this review series. The authors compare this to a series of 419 unconstrained total shoulder replacements that they reported on in 1999. These were performed between 1975 and 1989 and had 130 (31%) major complications with 95 requiring reoperation (23%). The results of their current series revealed 53 complications (12%) with a 3.9% reoperation rate. It is noted that there were 12 intraoperative complications all of which were fractures that were dealt with at the time of operation. Rotator cuff tearing was the most common complication with 17 symptomatic cases, 6 of these underwent reoperation for rotator cuff repair. The series of the authors patients revealed only one patient with glenoid loosening. This marked and over all trend for a decrease in prosthesis loosening and failure overall. Conversely, the rate of perprosthetic fractures increased. This is thought to be as a result of a deltoid sparing approach that created more torque on the humerus for exposure. Overall the rate of complications has decreased in the last decade of the twentieth century.

This article evaluates the authors series of total shoulder arthroplasty from 1990 to 2000 and then reviews the literature from 1980 to the time of the writing of the series. The results of the author's series are very promising. Using an unconstrained total shoulder prosthesis with a cemented all polyethelene glenoid consistently through his series the rate of major complication leading to reoperation was very low (3.9%). This consistency at a higher volume center demonstrates the quality that resulted. The review of the literature demonstrating complication rates from 10.4% to 31% major complications in one study, also shows decreases in the overall rate of complication and reoperation in the last 25 years. However, the review of the literature and the case series cannot be directly compared secondary to the more current case series and the differences in the prosthesis and surgical techniques used throughout the 1980's. Individually both are of great value.

Neer CS, Kirby RM. Revision of Humeral Head and Total Shoulder Arthroplasties. Clin Orthop 1982; 170: 189-195.

The evaluation of the complications leading to revision shoulder arthroplasty help develop a better understanding of the common mechanisms of failure in primary arthroplasty of the shoulder. Preoperative, surgical and postoperative considerations all play a role in the success or failure of shoulder arthroplasty. Traditionally, the survivorship of shoulder

arthroplasty has not been as high as with hip and knee arthroplasty. Prosthetic design, surgical technique, infection, rotator cuff deficiency, and neurological injury have all been identified as causes of failed prosthetic replacement of the shoulder.

This classic reference by Neer et al is important as it attempts to define the mode of failure of some of the early modern humeral and glenoid prosthesis. The mechanism of failure and the treatment with revision of either hemiarthroplasty or total shoulder arthroplasty are analyzed. Several modes of failure are discussed including design and technique errors. Early attempts at a semi-constrained fixed fulcrum glenoid and the thought that it eliminated the need for a rotator cuff failed either because of lack of external rotation or glenoid loosening. The amount of glenoid bone stock available is finite and it is difficult to reconstruct once it has been lost and the need for a functional rotator cuff is imperative for upper extremity motion especially external rotation. The mechanism of humeral component failure is discussed and related mostly to humeral height. Soft tissue balancing in the shoulder is a challenge, as a shortened or weak deltoid can inhibit active forward elevation and abduction, and a deficient capsule and rotator cuff can lead to instability. The surgical release of the deltoid from the anterior acromion with anterior or radical acromionectomy caused deteriorated deltoid function postoperatively. Neurological injury in this study was most often transitory, however it can lead to a dysfunctional upper extremity and subsequent failure.

This reference gives us insight into the factors that have caused past failures in shoulder arthroplasty. These failures are a direct reflection on the surgical technique that is used today and the evolution of prosthetic design. Increased understanding of the biomechanics of the shoulder prosthesis and the preservation of anatomic structure and function have lead to a increased survivorship with increased functionality and patient satisfaction.

Barrett WP, Franklin JL, Jackins SE, Wyss CR, Matsen FA. Total Shoulder Arthroplasty. J Bone Joint Surg Am. 1987;69: 865-872.

The first prosthetic shoulder is credited to Pean in 1893 and was made with platinum and rubber. The procedure was performed for a patient with tuberculosis of the glenohumeral joint. Neer began to use a metal hemiarthroplasty for fractures of the proximal humerus in 1955. The results were promising and in the 1970's Neer introduced the polyethelene glenoid. Thus, the modern total shoulder arthroplasty was born. The Neer unconstrained total shoulder had good results for pain control, and satisfactory functional results. The complication rates of the total shoulder arthroplasty in the 1970's and 1980's led to the need for well done prospective studies to analyze modes of failure and reasons for complications.

From 1976 to 1983 Barrett et al prospectively looked at 50 Neer II unconstrained total shoulders with a non-metal backed glenoid component. The average length of follow-up was 3.5 years. The average age of the patient at the time of surgery was 59 years. Osteoarthritis was the preoperative diagnosis in 66%, rheumatoid arthritis in 22%, and humeral head fracture in 12%. Nine (18%) of the shoulders had a rotator cuff tear at the time of the primary surgery. Attempt was made to fix all torn rotator cuffs however in the 6 massive

cuff tears none of the repairs were considered strong. Of interest is that the average hospital stay was 10-14 days, and the patient was kept in the hospital until they had achieved 40 degrees of external rotation and 140 degrees of active forward elevation. The American Shoulder and Elbow Surgeons Shoulder Evaluation was used to evaluate the postoperative results. Complications were defined in this series as either intraoperative, early postoperative, or long term. Intraoperative and early postoperative complications occurred in 16% of the 50 shoulders. All complications were 12 of the 50 shoulders (24%). This included two intraoperative fractures, one postoperative periprosthetic fracture that required open reduction and internal fixation, one axillary nerve injury, one patient with posterior humeral subluxation that resolved with therapy, one patient with extrusion of cement posterior to the glenoid neck that was later resected through a posterior approach, one patient with impingement secondary to the humeral component being placed below the greater tuberosity, and four painful shoulders that had developed loosening of the glenoid that were revised. There was a clear correlation between glenoid loosening and massive rotator cuff tear at the time of surgery as all shoulders with glenoid loosening had this finding.

As prosthetic design evolved and a standard Neer II non-constrained total shoulder with an all polyethelene glenoid was used the results of shoulder arthroplasty became more consistent. A correlation became evident that non-constrained total shoulder replacement had a high failure rate in people with massive irreparable rotator cuff tears. Four out of five patients with glenoid loosening in this series had this at the time of surgery. Although the ASES scoring system is used the data derived from that is presented in an individual manner. Continued moderate or severe pain was seen in 12 % of the cases. The average active forward elevation improved by 29 degrees to an average 100 degrees. Activities of daily living all improved. As shoulder arthroplasty has become more common and the complications have decreased, the functional scores have increased and patient expectations have become higher. Patient satisfaction has become a common evaluation tool that was not addressed in early clinical reports. The work of early investigators laid the groundwork for a successful modern total shoulder arthroplasty.

Moeckle BH, Altchek DW, Warren RF, Wickiewicz TL, Dines DM. Istability of the Shoulder After Arthroplasty. J Bone Joint Surg Am. 1993;75:492-497.

Instability of the shoulder after total shoulder arthroplasty is a relatively rare complication. If superior instability, which is caused by a massive rotator cuff tear and inferior instability, which is caused by lack of humeral length are removed from the equation, the incidence of anterior and posterior instability are surprisingly low. It is this subset of patients that are retrospectively reviewed in this series. The etiology of anterior instability after shoulder arthroplasty most often is associated with rupture of the subscapularis repair. Posterior instability, which is the less common of the two, is usually attributed to increased retroversion of the glenoid or humeral component. Preoperative posterior capsular laxity not address at the time of surgery often accompanied by over tightening of the anterior structures can also be responsible for posterior instability.

Moeckel et al performed a retrospective review of 236 total shoulder arthroplasties performed between 1984 and 1989. Ten shoulders that had anterior or posterior instability at the time of follow-up were identified and included in this study. The age of the patients at the time of surgery ranged from fifty-six to seventy-nine years. Posterior instability was found in three shoulders and anterior instability in seven. All seven of the patients with anterior instability were diagnosed with rupture of the subscapularis repair and underwent secondary mobilization and repair. Three of the seven continued to have anterior instability and underwent achilles allograft reconstruction of failed subscapularis repair, which was a success in all three. Multiple factors contributed to the shoulders with posterior instability and all three underwent correction of any soft tissue imbalance with or without correction of the glenoid or humeral components for increased retroversion. One shoulder was approached posteriorly and a posterior capsular plication was performed while the other two both had the components revised. Three modes of anterior instability were found. One patient was noted to have an acute postoperative anterior dislocation in the recovery room and was taken back for repair of the subscapularis within one week. Four patients sustained a dislocation while in physical therapy three to seven weeks after the surgery. All while performing external rotation passively. In the third group painful anterior subluxation became apparent between ten and twenty weeks postoperatively. The mode of posterior instability was found to be dislocation in one patient and painful posterior subluxation in the other two. All of these patients lost range of motion at the expense of stability with reoperation.

Thorough review of the cause of anterior and posterior instability after total shoulder arthroplasty is challenging secondary its relative scarcity in the literature. This case series by Moeckel et al makes a strong case for the etiology of both anterior and posterior instability. By recognizing the fundamental differences of superior, inferior, posterior, and anterior instability in the total shoulder arthroplasty the authors are able to define a strategy for the successful treatment of both types illustrated in this case series.

Franta AK, Lenters TR, Mounce D, Neradilek B, Matsen FA. The Complex Characteristics of 282 Unsatisfactory Shoulder Arthroplasties. J Shoulder Elbow Surg 2007; 16: 555-562.

As total shoulder arthroplasty has evolved so has the methodology of evaluating the results that have been realized. Originally the importance was focused on the shoulder itself and how the surgeon felt at final follow-up. More recent literature has transitioned to patient satisfaction and functional improvement. What has been absent in the literature is evaluation of the lower volume shoulder surgeon's shoulder arthroplasties secondary to the fact that most published studies are at large institutions with high volume shoulder surgeons. Evaluating patients that have been referred to a higher volume center gives insight into the mode of complications that lead to revision in the shoulder arthroplasty originally performed in the community hospital.

Franta et al established the Shoulder Arthroplasty Failure Experience (S.A.F.E.) project to evaluate modes of failure in patients dissatisfied after shoulder arthroplasty. From 1994 to 2004, 353 patients were enrolled in the study. Of this number 282 of the patients met the inclusion criteria for the study. Of the patients enrolled in the study 136 (48%) were total shoulder arthroplasties with the remainder being hemiarthroplasties. The patients that were

excluded were on the bases of poor quality radiographs or incomplete data for analysis. Of the 282 patients enrolled 237 (84%) underwent revision shoulder arthroplasty. Clinical exam, radiographic exam, and intraoperative findings were used to develop a list of failure mechanisms. It was found that pain was the most common reason to seek evaluation (85%). Among the total shoulder replacements the most common finding was component malalignment in 64% of the shoulders. This was followed at 63% by glenoid loosening. Stiffness and polyethelene wear both were recorded in 58% of the cases. Subscapularis failure was seen in 20% of all cases as a reason for failure. Infection was seen in 11% of the failures. Among the hemiarthroplasty group, glenoid erosion was seen in 64% of the cases. Tuberosity nonunion was seen in 41% and mal-union in 51%. The Simple Shoulder Test (SST) was used to evaluate all patients preoperatively and found an average of 2.6 of the 12 functions of the SST could be performed at presentation. The patients presented at a mean of 48.7 months from the index arthroplasty.

The authors of this study take an interesting look at a series of patients and the factors associated with failure of their shoulder arthroplasties. Instead of a traditional case series with a single surgeon and prosthesis, Franta et al take a group of patients referred to a larger volume surgeon for failed shoulder arthroplasty and derive conclusions based on the trends associated with clinical, radiographic and intraoperative findings. So all of the patients in this series had low patient satisfaction. This type of study has its limitations secondary to variations in patient selection, operative technique, and rehabilitation protocols of the original surgeon. However, several conclusions can be drawn. First of all, patient satisfaction is an important independent variable the results of shoulder arthroplasty. Secondly, standard errors in surgical technique and rehabilitation protocol stand out as common factors in the failures seen in shoulder replacement.

Tytherleigh-Strong GM, Levy O, Sforza G, Copeland SA. The Role of Arthroscopy for the Problem Shoulder Arthroplasty. J Shoulder Elbow Surg 2002;11:230-4.

Shoulder arthroplasty has gained acceptance as a safe reliable procedure in the properly selected patient. Complications are known to occur and sometimes lead to failure. When a patient presents with pain, stiffness, or weakness after shoulder arthroplasty and the standard diagnostic protocol does not give an answer a diagnostic arthroscopy can be performed. Arthroscopy offers a minimally invasive method of diagnosis and often treatment of the source of the painful shoulder. The shoulder with a successful arthroplasty is capable of developing the same conditions that a native shoulder can develop. Rotator cuff tear, impingement, AC joint arthritis, and capsular fibrosis are examples that can develop in the face of a successful shoulder arthroplasty. In these cases arthroscopy becomes a valuable tool for treating the painful or stiff shoulder arthroplasty. Secondarily, arthroscopy can be used as a diagnostic tool for complications associated with the arthroplasty. Component malalignment or loosening, loose bodies, glenoid wear, and capsular imbalance are all examples of the issues that can be diagnosed and some treated with arthroscopy.

Between 1995 and 2000 Tytherleigh-Strong et al performed arthroscopy on 29 shoulders that had developed excessive pain or stiffness after shoulder arthroplasty. Impingement was diagnosed in 34% of these patients and they underwent arthroscopic

subacromial decomression. A large rotator cuff tear was repaired in one patient. A cement loose body was removed in one. More than 50% (15) of the patients had no specific diagnosis other than pain and stiffness. Of these, 7 were found to have capsular fibrosis and underwent arthroscopic capsular release. Loose or worn prosthesis were found in 4 shoulders. These were revised as a separate procedure. With the seven cases that went on to further surgery none were included in the constant scoring. The mean preoperative constant score was 23 and improved to 63 points the the time of the most recent follow-up. The patients that underwent capsular release improved their constant score from a preoperative mean of 21 points to 59 points. Active forward elevation improved from a mean of 32 degrees to 76 degrees at the most recent follow-up.

Arthroscopic diagnosis and treatment after shoulder arthroplasty has a definite role as the shoulder develops conditions such as tearing of the rotator cuff after undergoing arthroplasty. Repair of the cuff or treatment of other conditions associated with the shoulder can be effectively rendered with arthroscopic surgery. This series shows a trend especially for treatment of impingement that supports arthroscopic treatment. Of note in this series is that in 13 of the arthroplasties were with the Copeland resurfacing hemiarthroplasty and 5 had Copeland resurfacing total shoulder arthroplasty. Although this series does not deal exclusively with total shoulder arthroplasty, the principles shown lead us to believe that arthroscopy has a place in the treatment of the painful shoulder arthroplasty.

Coste JS, Trojani C, Berg M, Walch G, Boileau P. The Management of Infection in Arthroplasty of the Shoulder. J Bone Joint Surg [Br] 2004;86-B:65-9.

Infection in the shoulder after arthroplasty is a devastating complication that leads to pain, decreased function, and decreased patient satisfaction. Arthroplasty in general has used different strategies to deal with infection. The strategies of irrigation, debridement, and antibiotic therapy are typically used together for eradication of an infection. Perioperative antibiotic prophylaxis has become standard protocol in arthroplasty. This, among other things, is responsible for decreasing the number of acute infections. Subacute and chronic infection is often difficult to diagnose which often leads to a delay in treatment. Hemotogenous spread of bacteria is thought to be responsible for chronic infection. The understanding of prophylaxis and a consistent methodology of diagnosis and treatment is crucial for the outcome to be optimal. This study evaluates the methods of diagnosis and treatment in a multicenter study that looks at the outcome of acute, subacute, and chronic infections.

Coste et al reviewed 2343 shoulder arthroplasties between 1991 and 1999 in a multicenter retrospective review. They found 49 shoulder infections (2.1%) in 42 patients (1.7%). Analysis was done of primary diagnosis, delay between diagnosis of infection and treatment, and the type of treatment. The patients with the highest rate of infection had undergone radiotherapy and had developed AVN (25%). It was found that 4% of revision shoulder arthroplasties developed infection. Patients that had been treated late for sequelae of a fracture were similar to revision at 3.6%. There were 9 of 766 (1.2%) shoulder arthroplasties for primary OA that became infected. All infected patients had pain and decreased range of motion on initial presentation. Only 57% of patients had a blood profile

drawn. The mean white blood cell count was 7.9, ESR was 55 mm/hr, and CRP of 45 mg/l. Preoperative aspiration was performed in 8 shoulders and bacteria were found in 4. They found the delay from diagnosis of infection to definitive management with revision to be quite long in every group. Acute infection saw a delay of nine months, subacute ten months, and chronic infection saw a delay of 33 months on average before surgical intervention. Persistence of infection at final follow-up was found in 16.6% of acute infections and 33% of both subacute and chronic infections. Overall treatment was considered successful in 71% of patients. Constant scores were obtained and showed a mean of 20 points before revision and 38 points at the latest follow-up. They found the length of antibiotic therapy varied widely. In 50% of the cases the antibiotic chosen had no relationship to the bacteria isolated or the bone penetrating properties of the drug. Overall they found that prosthetic revision in one or two stages with a short delay from diagnosis of infection was the most effective way to eradicate the infection.

When evaluating a multicenter study variance in technique and protocol can be a hindrance to the final outcome of the study. This variance allows the reader to see what works and what does not. What is clear in this paper is that debridement alone or antibiotics alone do not eradicate the infection around a prosthesis. Delay of treatment in this series may be responsible for relatively low constant scores and the high percentage of persistent infections. What did work was recognition of the infection early with proper diagnostic work-up and minimal delay to revision surgery with or without two-staged reconstruction. The treatment algorithm also varied markedly from center to center. Duration of antibiotic therapy varied widely as did the use of culture and sensitivity to adjust the class of antibiotics to fit the bacteria. With a consistent protocol for diagnosis, minimal delay to surgical treatment, and a multidisciplinary approach to postoperative antibiotic treatment the rate of success in the eradication of infection can be optimized.

Kumar S, Sperling JW, Haidukewych GH, Cofield RH. Periprosthetic Humeral Fractures After Shoulder Arthroplasty. J Bone Joint Surg [Am]. 2004; 86:680-689.

Periprosthetic humeral fracture after shoulder arthroplasty is a challenging condition. Although this complication is relatively rare, the periprosthetic humeral fracture is a growing subset secondary to the increase in humeral resurfacing, hemiarthroplasty, total shoulder arthroplasty, and reverse total shoulder arthroplasty. These fractures are classified as Type A when the fracture occurs at the tip of the prosthesis and extends proximally, Type B when the fracture is at the tip and extends distally, and finally type C fractures which occur distal to the prosthesis and extend to the distal metaphysis of the humerus. There is not an abundance of literature concerning periprosthetic fractures of the humerus and their treatment. This review elucidates the types of fractures and the treatment that can be used to obtain solid union and good function of the shoulder.

Kumar et al reviewed 3091 patients that had undergone a shoulder arthroplasty between 1976 and 2001 retrospectively. Postoperative periprosthetic fracture was found in 19 patients (0.6%). The prevalence has been reported between 1.6% and 2.4% in the past. Of the nineteen patients sixteen were available with full radiographic follow-up. Average age at the time of arthroplasty was 63 years. None of the patients had an ipsilateral elbow

arthroplasty. Of the sixteen patients ten had a total shoulder arthroplasty and six had hemiarthroplasty performed. The average time from arthroplasty to fracture was 49 months. One of the fractures was iatrogenic, caused during a manipulation under anesthesia six weeks after surgery. The average follow-up duration was 6.7 years. All patients were graded at the final follow-up for function and pain relief. The result was excellent if there was no or slight pain, had external rotation of at least 45 degrees, and active abduction of at least 140 degrees. A satisfactory result was had if the patient had no to moderate pain, had external rotation of at least 20 degrees, and could abduct to 90 degrees. Anything less was considered unsatisfactory. There were three excellent, four satisfactory, and nine unsatisfactory results at the time of latest follow-up. All of the fractures united. Six patients were treated non-operatively. These healed at an average of 180 days. Five patients underwent immediate operative treatment and five patients underwent delayed operative treatment after conservative management failed. These took an average of 278 days to heal after surgery. At the time of latest follow-up 67 months after fracture on average, the mean active abduction was 107 degrees and the mean external rotation was 43 degrees. The location of the fracture had an important relationship to outcome. Type C fractures responded favorably to non-operative treatment. However, fractures that were type B required surgical fixation in four out of five of the cases. The type A fractures healed without surgery in three out of four cases. With the above results the recommendation was made to attempt non-operative treatment in type C fractures and well aligned type B fractures with a well fixed humeral component. Type B fractures with a loose humeral prosthesis should be revised with a long stem and iliac crest bone grafting. Similarly, a non-operative trial is recommended for type A fractures that have a well-fixed implant. Loose components should be revised to a cemented long stem implant that goes well beyond the fracture site with autograft to augment healing.

Periprosthetic fracture of the humerus after shoulder arthroplasty is a difficult problem that will continue to be seen in the future as the number of shoulder arthroplasties is increased. Unlike periprosthetic fractures around a knee or hip arthroplasty, a trial of non-operative treatment with a well-fixed humeral prosthesis is a reasonable approach. Recognition of the patients that need revision to a long stemmed prosthesis and those in need of open reduction and internal fixation and appropriate treatment will likely optimize the outcomes in these patients.

Antuna SA, Sperling JW, Cofield RH, Rowland CM. Glenoid Revision Surgery After Total Shoulder Arthroplasty. J Shoulder Elbow Surg. 2001; 10: 217-224.

The history of Total shoulder arthroplasty and its complications has often involved loosening of the glenoid. Most often the reason for failure is multifactorial. The implant design and surgical technique play an important role in longevity of the glenoid component. The design of the glenoid component has changed over the years and the surgical technique for its implantation remains variable. Cemented all polyethylene and metal backed bone in-growth models have been used in pegged and keeled models. Evaluating the glenoid component and its contribution to the failure of a total should arthroplasty allow insight into reasons for failure and the solution.

Antuna et al reviewed 48 shoulders that underwent glenoid component revision between 1986 and 1996. The indications for surgery and inclusion in this review were glenoid component loosening in 29 (60%), glenoid material failure in 14 (30%), and glenoid component malposition or wear leading to instability in 5 (10%) shoulders. Eighteen (38%) had the glenoid component removed with insufficient bone stock for reimplantation, while 30 (62%) had revision to a new glenoid component. There was significant improvement in pain relief and range of motion in those having revision to a new glenoid component. Those without reimplantation of a glenoid were significantly less satisfied than those with. Pain was a factor as only 66% of patients in the group converted to a hemiarthroplasty had satisfactory pain relief versus 88% in the group of reimplanted glenoid components. Posterior capsular shift was performed in 9 shoulders for posterior subluxation. Twelve shoulders had over 25% posterior subluxation on the preoperative radiographs. Radiolucent lines were present in 29 (60%) of the glenoids on the preoperative radiographs. Of the 48 shoulder arthroplasties revised for glenoid failure, 25% required further surgical intervention after the index revision. Overall the average function of the group improved significantly. Active elevation improved from a mean of 96 degrees to 112 degrees postoperatively. External rotation improved from 36 degrees to 49 degrees. Internal rotation was also improved from L4 to L2. The functional gains and pain relief mad this a worthwhile operation.

The incidence of revision in the TSA has been shown to be up to 12.5%. Revision of the glenoid is the most challenging aspect of shoulder arthroplasty. Bone loss and instability pose a problem even for the experienced shoulder reconstruction surgeon. Soft tissue balancing, careful management of the glenoid bone stock, and alignment of the glenoid component are all aspects of a successful revision.

Lynch NM, Cofield RH, Silbert PL, Herman RC. Neurologic Complications After Total Shoulder Arthroplasty. J Shoulder Elbow Surg 1996;5:53-61.

Neurological deficit after shoulder arthroplasty ranges from a temporary low grade paresthesia to devastating motor and sensory brachial plexopathy. The mechanism of injury during the deltopectoral approach and subsequent total shoulder arthroplasty is controversial and has been reviewed in the literature in only a few clear review series and mostly with case reports. Direct nerve injury has been reported most often to the axillary nerve, while indirect injury has been reported from traction to the brachial plexus and even as edema in the forearm leading to median nerve compression. As minimally invasive approach has been used more frequently to theoretically imporove cosmesis and aid in the speed of recovery, the soft tissue releases and exposure has become smaller and the need for knowledge of the surrounding anatomy and management of surgical exposure has grown. Identification of the risk factors that lead to neurological deficit after shoulder arthroplasty are important if the risk is to be reduced.

Lynch et al reviewed 417 total shoulder arthroplasties in 368 patients between 1975 and 1989. Eighteen shoulders (4.3%) in 17 patients had neurological compromise after surgery. Seventy-two percent (13 of 18) of the deficits were localized to the brachial plexus. Only 1% had deficits that interfered with their rehabilitation. Three of the patients developed idiopathic brachial plexopathy which were included in this case series, and one patient had an

exacerbation of a preexisting dysesthesia. Finally, one patient has an acute carpal tunnel syndrome with deficits in the media nerve from edema of the forearm after surgery. The average age of the patients with a neurological deficit was 54 years. While rheumatoid arthritis was not found to correlate with developing a deficit, taking methotraxate was significant for the development of a neurological complication. Three of the five patients taking it developed deficits, one who had bilateral total should replacement developed brachial plexopathy in both upper extremities. There were no axillary nerve injuries. At one year 11 shoulders were graded as good while 5 were graded as fair. The long deltopectoral approach was implicated as statistically significant in the development of this complication as there were none in the posterior approach patients or those where the deltoid was taken down from the anterior acromion. Maximum improvement was realized in eight shoulders within 3 months, four shoulders in the 3-6 month time frame, and one patient between 6 and 12 months. All three patients with idiopathic brachial plexopathy took greater than 12 months for maximal recovery.

Before this review, most of the literature about neurological deficit after arthroplasty centered around the knee and hip. The shoulder presents a unique set of challenges, while there are some similarities. Traction injury is presumed to be the mechanism of injury in the majority of neurological complications after shoulder arthroplasty. Direct injury from laceration of a nerve seems to be rare. There were none reported in this series. It is clear that revision or post fracture cases where scar tissue has obscured the native anatomy increase the risk of direct injury and indirect traction injury. Of note is the realization that methotrexate had a high correlation with neurolical deficit in these patient. This will have to be studied further to have a definitive answer.

Knowledge of anatomy and of shoulder arthroplasty technique with care taken to avoid traction injury to the brachial plexus will continue to keep the incidence of this complication low. Fortunately, the recovery from neurological deficit after shoulder arthroplasty is quite good and most often full.

28. Fractures of the Scapula: Diagnosis and Treatment

Ideberg R, Grevsten S, Larsson S. Epidemiology of scapular fractures. Incidence and classification of 338 fractures. Acta Orthop Scan 1995 Oct;66(5):395-7.

Introduction
This large series of 338 scapula fractures in 322 patients collected over 10 years in two Swedish counties provides much of what we know about the epidemiology of fractures of the scapula.

Important Points
-30% of scapula fractures involve the glenoid cavity
-The most common scapula fracture was an anterior glenoid chip (bony Bankart) associated with a dislocation.
-55% of intra-articular glenoid fractures occurred in males.
-Males with scapula fractures tend to be younger (average age 49 years) than females (average age 64).

Commentary
This extremely large series provides prevalence data and describes the frequency of fracture patters in a Swedish population.

Ada JR, Miller ME. Scapular fractures. Analysis of 113 cases. Clin Orthop Relat Res. 1991 Aug;(269):174-80.

Introduction
This is a large series of 148 fractures of the scapula in 113 patients.

Important Points
-In this series, 80% of the fractures of the scapula were seen in males.
-The majority of fractures occur after motor vehicle accidents. Falls represented a distant second
-96% of patients with scapula fractures have associated injuries including pulmonary injury (37%), hemopneumothoraci (29%), head injury (34%).
-Associated vascular injuries are extremely rare.
-The body of the scapula was fractured 35% of the time, the glenoid neck 27%, the acromion 12%, the scapular spine 11%, and the glenoid 10%.
-Of the 24 patients with displaced fractures of the scapular spine and glenoid neck, pain and weakness were more common at follow up.
-Recommended surgical indications were displaced scapular spine fractures and glenoid neck fractures.

Commentary
While flawed by a limited follow up, this is a large series that demonstrated prevalence in the United States. In this population, males and scapular body fractures predominate. Like others, these authors suggest surgery should be considered for displaced scapular spine and displaced glenoid neck fractures.

Outstanding Reviews (1 or 2)
Zlowodzki M, Bhandari M, Zelle BA, Kregor PJ, Cole PA. Treatment of scapula fractures: systematic review of 520 fractures in 22 case series. J Orthop Trauma 2006 Mar;20(3):230-3.

Introduction
Scapula fractures are rare. As such most of the literature consists of case reports or case series with limited numbers of patients. This manuscript is a systematic review which compiles 520 fractures from 22 case series from which attempts at conclusions are derived.

Important Points
-Overall 82% (427/520) of the fractures had good results.
-In this series, 80% of glenoid fractures, 83% of glenoid neck fractures, and 52% of acromion and/or coracoid fractures were treated surgically, whereas 99% of isolated scapular body fractures were treated nonoperatively.
-When surgery was performed, reoperation was required in 16.5% of patients.
-80% of all fractures with involvement of the glenoid were treated surgically.
-Isolated glenoid fractures treated surgically have good to excellent outcomes 82% of the time.
-99% of isolated scapula body fractures were treated nonoperatively yielding 86% good to excellent results.
-83% of all glenoid neck fractures with our without associated other fracture types excluding glenoid fractures were treated nonoperatively, with 77% good to excellent results.
-The floating shoulder (ipsilateral clavicle and glenoid neck fractures) can be treated nonoperatively in 94% of cases.

Commentary
Although this manuscript is a review performed systematically, it nonetheless represents a low level of evidence (Level-4) as most manuscripts were case series and as such are subject to recall bias, selection bias, and publication bias. Nevertheless, pooling data like this is helpful to identify trends and place the surgical approach for these fractures in perspective.

Goss TP. Scapular fractures and dislocations: Diagnosis and treatment. J Am Acad Orthop Surg 1995 Jan;3(1):22-23.

Introduction
Scapula fractures are uncommon representing approximately 1% of all fractures, 3% of shoulder girdle fractures, and 5% of all shoulder fractures. This manuscript is a review of scapula fractures with an emphasis on the author's concept of the superior shoulder suspensory complex, which is a soft tissue and bony ring which maintains the normal stable relationship between the axial skeleton and the upper extremity.

Important Points
-90% of scapula fractures are minimally or acceptably displaced and as such are treated nonoperatively
-The superior shoulder suspensory complex is composed of the glenoid process, the coracoid process, the coracoclavicular ligaments, the distal clavicle, the acromioclavicular joint and the acromion process.
-Traumatic disruptions of one of the components of the superior shoulder suspensory complex are common, minor, and do not significantly compromise the overall integrity of the complex.
-When the ring that constitutes the superior shoulder suspensory complex fails in two or more areas ("a double disruption), significant displacements at both sites and compromise of the superior shoulder suspensory complex occurs leading to adverse complications when treated nonoperatively
-Operative indications for fractures of the scapula include the rare severely displaced fractures of the glenoid cavity, glenoid neck, and the double disruption of the superior shoulder suspensory complex with significant displacement.

Commentary
This manuscript reviews scapula fractures from an interesting and functional perspective. It assists the treating physician in deciding when surgery may be indicated.

Other References with Important Concepts
Schanderlmaier P, Blauth M, Schneider C, Krettek C. Fractures of the glenoid treated by operation . A 5- to 23- year follow-up of 22 cases. J Bone Joint Surg Br. 2002 Mar;84(2):173-7.

Introduction
Surgical intervention has been recommended for displaced intra-articular fractures of the glenoid. This manuscript reviews 22 cases with follow up of 10 years.

Important Points
-Computed tomography assists in defining the fracture type and with the surgical approach.
-An anterior approach is recommended for Type II fractures (a transverse glenoid fracture with inferior displacement of the lower part of the glenoid.

-A posterior approach is recommended for all other types of glenoid fracture, so that extension into the scapula body and axillary border can be addressed.
-Anatomic reduction was still difficult, and was achieved in 18/22 patients (82%).
-Most patients to well with Constant scores approaching 94% of the uninjured side.
-The presence of an additional injury (e.g. brachial plexus injury) profoundly influences the outcome.
-Five patients demonstrated late degenerative changes or progression of early degenerative changes (23%).

Commentary
Displaced intra-articular glenoid fractures are an indication for open reduction and internal fixation of scapula fractures. An anterior approach is recommended if the fracture does not extend into the scapular body or axillary border. A posterior approach is used for those fractures that do. Most fractures heal, however the risk of late degenerative changes is significant.

vanNoort A, te Slaa RL, Marti RK, van der Werken C. The floating shoulder. A multicentre study. J Bone Joint Surg Br. 2001 Aug;83(6):795-8.

Introduction
The floating shoulder, defined as a clavicle fracture and ipsilateral glenoid neck fracture is thought to be an unstable construct requiring open reduction and internal fixation, however biomechanical data suggests that fractures must be accompanied by acromioclavicular and/or coracoclavicular ligament disruption to be unstable. This is a retrospective study of 49 floating shoulders with follow up on 35 patients (71%).

Important Points
-31 patients were treated nonoperatively, four had immediate clavicle plate fixation. Of the 31 treated nonoperatively, 3 required later surgery for nonunion or malunion of the clavicle.
-28 patients completed nonoperative treatment and were available for follow-up
-Of the 28 patients treated nonoperatively, 6 had pain at rest (21%), whereas 3/7 treated surgically had pain at rest (43%)
-Comparing those treated surgically to those treated nonoperatively, Constant scores were similar.
-Poor constant scores were correlated with a “drooped” shoulder, or with caudal displacement of the glenoid.

Commentary
Many floating shoulders can be treated nonoperatively. Surgical intervention should be considered if there is a “drooping” of the shoulder or if the glenoid is caudally displaced, both of which ligamentous as well as bony injury.

Ogawa K, Yoshida A, Takahashi M, Ui M. Fractures of the coracoid process. J bone Joint Surg Br. 1997 Jan;79(1):17-9.

Introduction
This manuscript is a review of coracoid process fractures in 67 patients and offers a simple classification system: Type I fractures are behind the coracoclavicular ligaments, Type II fractures are anterior to the coracoclavicular ligaments.

Important Points
-Acromioclavicular dislocation was seen in 60/67 (90%) of patients with coracoid fractures.
-Other associated injuries include lacerations, and clavicle fractures of which most involved the lateral third of the clavicle.
-Fractures anterior to the coracoclavicular ligaments that were stable can be managed nonoperatively.
-Displaced fractures anterior to the coracoclavicular ligaments and all fractures posterior to the coracoclavicular ligaments were treated surgically in this series.
-87% of patients with coracoid fractures approached this way had excellent results.

Commentary
Coracoid fractures are rarely seen in isolation. Displaced avulsions of the tip of the coracoid, and unstable fractures of the base of the coracoid should be considered candidates for open reduction and internal fixation and reasonably good outcomes can be expected.

Wang KC, Hsu KY, Shih CH. Coracoid process fracture combined with acromioclavicular dislocation and coracoclavicular ligament rupture. A case report and review of the literature. Clin Orthop Relat Res 1994 Mar;(300):120-2.

Introduction
Acromioclavicular joint injuries are fairly common, however on rare occasions the coracoid is fractured near its base and the coracoclavicular ligaments remain intact. This manuscript presents a case of this and reviews the literature.

Important Points
-In most patients, the sequence of acute acromioclavicular joint injuries is the acromioclavicular ligaments, the coracoclavicular ligaments, then the detachment of the deltoid and trapezius fascia
-In some cases the epiphysis at the base of the coracoid will be disrupted leaving intact the coracoclavicular ligaments.
-In very rare cases the coracoid will fracture and the coracoclavicular ligaments will be disrupted concurrently.
-If the coracoid fracture is not displaced, a nonoperative approach may be considered.
-Surgical repair or reconstruction should include open reduction and internal fixation of the displaced coracoid process when these injuries are identified.

Commentary
Clinicians should be aware of this unusual injury pattern and should be prepared to perform open reduction and internal fixation of displaced coracoid fractures when encountered with an acromioclavicular joint injury.

Kuhn JE, Blasier RB, Carpenter JE. Fractures of the acromion process: a proposed classification system. J Orthop Trauma 1994;8(1):6-13.

Introduction
The acromion is an attachment site for the deltoid and trapezius muscles and has been implicated in the development of rotator cuff disease. This is a retrospective review of 27 fractures of the acromion process.

Important Points
-Most fractures of the acromion process are minimally displaced and treated successfully without surgery.
-Stress fractures are rare and treated nonoperatively.
-Displaced fractures without compromise of the subacromial space generally do well with nonoperative treatment.
-Displaced fractures with compromise of the subacromial space or with associated superior displacement of a concomitant glenoid neck fracture had late sequellae and pain. In this group surgical intervention may be considered.

Commentary
Acromion fractures are rare. Most can be treated nonoperatively. If the subacromial space is narrowed, surgical intervention should be considered.

Nordqvist A, Petersson C. Fracture of the body, neck, or spine of the scapula. A long-term follow-up study. Clin Orthop Relat Res 1992 Oct;(283):139-44.

Introduction
This is a relatively large series of scapula body fractures treated nonoperatively with follow up of 14 years.

Important Points
-Scapula body fractures with less than 1cm displacement had 85% good to excellent results. If displacement was greater than 1cm, good to excellent results dropped to 43%.
-Glenoid neck fractures with less than 1cm displacement had 74% good to excellent results, which dropped to 33% if the displacement was greater than 1cm.
-All scapular spine fractures in this series were displaced less than 1cm and had 80% good to excellent results.
-Residual deformity after healing was correlated statistically with continued pain.

Commentary
Although most scapular body fractures are treated nonoperatively, late deformity is associated with pain and poorer outcomes. Indications for surgery on scapula fractures are not clear, however this study suggests that surgical intervention may be indicated for substantially displaced fractures of the scapular body, scapular spine, or glenoid neck as nonoperative care is associated with poorer outcomes.

Hardegger FH, Simpson LA, Weber BG. The operative treatment of scapular fractures. J Bone Joint Surg Br 1984 Nov;66(5):725-31.

Introduction
This is a series of 37 patients with a variety of scapula fractures all treated surgically. Indications for surgery were "when bone and soft tissue damage are such that with conservative measures alone function will not be restored and post-traumatic osteoarthritis will develop."

Important Points
-This series represents a variety of fracture types: 4 apophyseal (coracoid, acromion, spine), 11 glenoid rim, 12 glenoid fossa, 3 surgical neck, 2 anatomic neck, 5 combined.
-Overall the results of surgery were moderately successful with 64% achieving full motion, 76% pain free, 67% with normal strength.
-39% of patients had complications including infections, hematomas, instability and stiffness requiring surgery.

Commentary
Indications for surgery of scapular fractures are not precise. The fractures in this series are presumably displaced, and likely associated with other injuries from high energy trauma. Nevertheless, surgical treatment can help many patients for severe fractures, yet 25-33% of patients will have pain or limited function and 39% of patients may experience complications.

29. Fractures of the Proximal Humerus Classification and Diagnosis

Gerber C, Schneeberger A, Vinh, T.S. The arterial vascularization of the humeral head: An anatomical study. J Bone Joint Surg Am 72:1486-1494, 1990.

The authors performed an anatomic study of the arterial vascularity of the proximal humerus in cadaveric shoulders. The entire articular segment of the humeral head was perfused by the ascending branch of the anterior humeral circumflex artery which runs parallel to the lateral aspect of the biceps groove. The posterior circumflex artery only perfused the posterior portion of the greater tuberosity and a small part of the posterior inferior aspect of the humeral head. Based upon their findings, they recommended that particular care be taken to preserve the anterior lateral ascending branch during surgical treatment of proximal humerus fractures.

Hawkins RJ, Neer CS II, Pianta RM, Mendoza FX. Locked posterior dislocation of the shoulder. J Bone Joint Surg Am 69:9-18, 1987.

Hawkins and co-authors reported their experience with the evaluation and treatment of locked posterior dislocations of the shoulder. Most importantly, they found that approximately 50 percent of cases were missed during the initial evaluation.

Neer CS II. Displaced proximal humeral fractures: I. Classification and evaluation. J Bone Joint Surg Am 52:1077-1089, 1970.
Neer CS II. Displaced proximal humeral fractures: II: Treatment of three-part and four-part displacement. J Bone Joint Surg Am 52:1090-1103, 1970.

In this classic paper Neer presented a classification system for proximal humerus fractures that was based upon Codman's earlier observations that proximal humerus fractures typically occur along the lines of the physeal scars of the tuberosities, articular segment, and surgical neck of the humerus. Neer devised the 4 part classification that remains the standard for evaluating proximal humerus fractures. Displacement was defined as 1 cm of bone displacement or 45 degrees of angulation. Displacement was also recognized to represent degrees of involvement of the rotator cuff as well as compromise of the vascularity to the articular segment of the humeral head.

The second part of this publication reported the results of treatment of displaced proximal humerus fractures and noted that non-operative treatment of more severe fractures had worse results. In addition, the results of ORIF of four part fractures were thought to be sufficiently poor that humeral head replacement was recommended.

Orthopaedic Trauma Association Committee for Coding and Classfication: Fracture and Dislocation Compendium. J Ortho Trauma 1996;10 (suppl 1):1-155.

The Orthopaedic Trauma Association published a comprehensive fracture classification system that was based upon the original AO/ASIF fracture classification that was developed by Maurice Muller and associates in Switzerland.

Bernstein J, Adler LM, Blank JE, et al. Evaluation of the Neer system of classification of proximal humerus fractures with computerized tomographic scans and plain radiographs. J Bone Joint Surg Am 78:1371-1375, 1996.

The purpose of this study was to determine if the addition of CT scanning of proximal humerus fractures improved the intraobserver reliability and interobserver reproducibility of the Neer classification of proximal humerus fractures. While there was a slight improvement in the intraobserver reliability there was no improvement in the interobserver reproducibility.

Hertel R, Hempfing A, Stiehler M, Leunig M. Predictors of humeral head ischemia after intracapsular fracture of the proximal humerus. J Shoulder Elbow Surg. 13:427-433, 2004.

In this study the authors classified fractures according to the Neer four-part system and performed intraoperative evaluation of the vascularity of the humeral head using laser Doppler and humeral head drilling. The findings relative to the vasularity confirmed the points of Neer classification. They also concluded that the integrity of the medial hinge and length of the metaphyseal extension of the articular segment of less than 8 mm, both signs of medial capsular integrity, predicted humeral head ischemia.

Shrader MW, et al. Understanding proximal humerus fractures: image analysis, classification, and treatment. J Shoulder Elbow Surg 14:497-505, 2005.

Shrader and co-authors studied the affect of specific training in the use of the Neer classification system upon interobserver reliability. In contrast to other studies that demonstrated low reliability, this study demonstrated that the problem with proximal humerus fracture classification my lie with the observers understanding and experience as opposed to flaws in the system.

Sidor ML, Zuckerman JD, Lyon T, et al. The Neer classification system for proximal humerus fractures: An assessment of interobserver reliability and intraobserver reproducibility. J Bone Joint Surg Am 75:1745-1750, 1993.

In this study the authors evaluated the interobserve reliability and intraobserver reproducibility for the classification of proximal humerus fractures using the Neer system. The five observers agreed on the final classification in only 32 and 30 percent of the fractures on the first and second readings respectively. The shoulder surgeon had the best reproducibility while the skeletal radiologist had the worst.

Siebenrock KA, Gerber C. The reproducibility of classification of fractures of the proximal end of the humerus. J Bone Joint Surg Am 75:1751-1755, 1993.

The authors evaluated the intra and interobserver reliability of five orthopaedic surgeons with a special interest in shoulder disorders who used the Neer and ASIF/AO proximal humerus fracture classifications for 95 fractures. The intra and interobserver reliability were found to be fair or poor for both classifications. They concluded that classification of fractures with theses systems was not sufficiently reproducible to allow comparison of similarly classified fractures in different studies.

30. ORIF 3 and 4 Part Fractures

Neer CS 2nd. Displaced proximal humerus fractures. II. Treatment of three and four part-part displacement. J Bone Joint Surg Am. 1970; 52: 1090-103.

This classic article presents the results of various treatments, including nonoperative and operative management, of three- and four-part proximal humerus fractures.

117 patients with three- and four-part fractures or fracture dislocations were followed for 1 year after either closed reduction and nonoperative treatment or surgical management. Closed treatment of displaced three- and four-part proximal humeral fractures was found to yield acceptable results in only 3 of 77 (4%) patients. Conversely, operative management of three-part fractures yielded satisfactory results in 19/33 (58%) patients, but was dependent upon the technique used. Isolated vertical fixation, such as intramedullary rods, without control of the tuberosities yielded inferior results compared to combined vertical and cuff-tension band constructs. Four-part fractures managed with ORIF resulted in poor outcome in all 13 patients, with many developing avascular necrosis. As a result the author concluded that nonoperative management of displaced three- and four-part fractures was inadequate for active patients, and recommended surgical management for these injuries: ORIF for most three-part fractures, and prosthetic replacement for some three-part and all four-part fractures.

Neer's classic article delineates a reliable rationale for management of displaced three- and four-part proximal humerus fractures. Many of the salient points in his article continue to guide management decisions.

Jakob RP, Miniaci A, Anson PS, Jaberg H, Osterwalder A, Ganz R. Four-Part Valgus Impacted Fractures of the Proximal Humerus. J Bone Joint Surg Br. 1991; 73: 295-8.

The authors identify the valgus impacted four-part fracture as a distinct pattern of proximal humerus fracture. This fracture pattern may allow for preserved blood supply to the humeral head, and unlike classic four-part fractures which are often managed with hemiarthroplasty due to concerns of avascular necrosis (AVN), the valgus impacted four-part may be amenable to open reduction internal fixation.

18 patients followed a minimum of two years were found to have a 26% rate of avascular necrosis after ORIF utilizing minimal internal fixation, including percutaneous techniques in 5 cases. All fractures went on to union, and 74% of patients had good to excellent results. The valgus impacted four-part fracture pattern may preserve the medial soft tissues along the calcar, maintaining the main blood supply to the articular segment. As such, these fractures may be amenable to ORIF with acceptable results and a lower rate of AVN than is described for other four-part fractures.

This classic article is the first to present a series of patients with four-part valgus impacted fractures, previously not well described. The 26% rate of AVN described is much lower then previously presented for four-part fractures. As a result of this series, this fracture

pattern is better appreciated and understood, and may be managed with ORIF, frequently utilizing minimal fixation and percutaneous techniques.

Iannotti JP, Ramsey ML, Williams GR, Warner JJP. Nonprosthetic Management of Proximal Humerus Fractures. Instructional Course Lecture. J Bone Joint Surg Am. 2003; 85: 1578-93.

This article reviews treatment options currently used to manage displaced proximal humerus, including three- and four-part fractures. Various surgical techniques and their results, including percutaneous pinning, ORIF with sutures, plates, and intramedullary rods are reviewed.

Surgical management of displaced three-part and valgus impacted four-part fractures requires anatomic reduction and a construct that maintains fragment position and neutralizes deforming forces. Tension band constructs have yielded acceptable results in three-part fractures, as has percutaneous pinning, although percutaneous techniques are technically demanding. Plate and screw fixation has yielded mixed results in the literature, especially in elderly, osteoporotic patients, although newer locking plates may allow improved fixation. Valgus impacted four-part fractures are amenable to percutaneous techniques when addressed acutely (within 7-10 days from injury), and has yielded good results. ORIF is recommended in patients with fractures which are not reducible via closed means, older fractures (> 10 days), or those with extensive comminution or osteopenic bone.

This Instructional Course Lecture offers an excellent review along with detailed surgical techniques and pearls aiding in the management of displaced proximal humerus fractures.

Resch H, Povacz P, Frolich R, Wambacher M. Percutaneous Fixation of three- and four-part fractures of the proximal humerus. J Bone Joint Surg Br. 1997; 79:295-300.

This series presents the results of management of displaced three-part and valgus impacted four-part proximal humerus fractures with percutaneous reduction and pinning.

All fractures went on to union. At 2 years follow-up, Constant scores were 91% (three-part) and 87% (four-part), with an 11% rate of avascular necrosis of four-part fractures. Technical aspects and pearls of percutaneous pinning are presented.

Although earlier series had demonstrated results of percutaneous pinning in management of a variety of proximal humerus fractures, this is the first to present the outcome of isolated three- and four-part fractures, and demonstrates the successful outcome available utilizing this technique in these fractures.

Gerber C, Hersche O, Berberat C. The Clinical Relevance of Posttraumatic Avascular Necrosis of the Humeral Head. J Shoulder Elbow Surg. 1998; 7:586-590.

This study examines the effect of avascular necrosis in patients treated for proximal humerus fractures. The clinical outcome and subjective satisfaction of the patients are reported, and are stratified by degree of AVN involvement.

25 patients with AVN following management of proximal humerus fractures were evaluated at an average of 7.5 years (minimum 2 years) after surgery. Only 40% of patients were rated as having a good or excellent result by subjective criteria. Patients with complete humeral head collapse fared worse than those with partial articular collapse. Analyzing the effect of malunion, patients were stratified into two groups, those with near-anatomic fracture alignment or those with malunion. Patients with malunion had worse outcomes, with poorer range of motion, and lower subjective satisfaction.

This series shows that AVN of the proximal humerus, especially when complete collapse occurs, may result in poor outcome. However, AVN may be better tolerated and have better outcomes in patients with anatomic reduction versus malunited fractures. Based on this series, if ORIF is indicated for patients with complex fractures with a risk for AVN, anatomic reduction is critical, and if not possible, hemiarthroplasty may be preferred.

Wijgman AJ, Rookler W, Patt TW, Raaymakers ELFB, Marti RK. Open Reduction and Internal Fixation of Three- and Four-Part Fractures of the Proximal Part of the Humerus. J Bone Joint Surg Am. 2002; 84: 1919-1925.

This series retrospectively reviews the results of ORIF of three- and four-part proximal humerus fractures managed with tension band or plate fixation. Intermediate to long-term results are presented.

60 patients were reviewed at a minimum of four years postoperatively with all fractures going on to union. 39 patients were managed with cerclage cuff tension banding and in the other 21 T-plates were used. 87% of patients had good-excellent results based on Constant score. 13% had poor results, most commonly associated with the development of avascular necrosis. 37% of patients developed avascular necrosis, seen more commonly following fracture dislocations, either three- (39%), or four-part (89%), versus fractures without dislocation. Of the patients with AVN, 77% had a good-excellent Constant score. No difference in AVN was observed between fixation methods.

This series highlights a few important points. The authors stress the importance of minimal stripping of soft tissues to maintain articular blood supply, to minimize the likelihood of AVN. Although the authors demonstrate that some patients may tolerate AVN well at intermediate follow-up, the high rate of AVN observed in three- and four-part fracture dislocations may warrant the use of prosthetic replacement in some of these fractures, especially in elderly patients.

Bjorkenheim JM, Pajarinen J, Savolainen V. Internal Fixation of Proximal Humeral Fractures With a Locking Compression Plate: A Retrospective Evaluation of 72 Patients Followed for a Minimum of 1 Year. Acta Orthop Scand. 2004; 72: 741-5.

This series presents the results of ORIF of proximal humeral fractures utilizing a locking plate. An innovation in the management of fractures in all aspects of orthopaedics, locking plate fixation has similarly led to a shift in the role of ORIF in the management of proximal humerus fractures.

This article presents a large series of proximal humeral fractures managed with a locking plate with multiple proximal fixed angled screws, including many three- and four-part fractures. 67 fractures healed (93%), and three patients developed AVN in a series of 72 patients with an average age of 67 years. Average Constant score at 1 year was 77, with three-part fractures having a better outcome compared to four-part. Of note, all fractures in elderly patients went on to union, with good acceptable results.

Locking plate technology is a significant advance in the management of complex proximal humerus fractures, especially in patients with comminuted, osteoporotic bone. This series highlights the good results obtainable in patients with three- and some four-part fractures using locking plate technology, including 100% union rate in elderly patients.

Keener JD, Parsons BO, Flatow EL, Rogers K, Williams GR, Galatz LM. Outcomes After Percutaneous Reduction and Fixation of Proximal Humerus Fractures. J Shoulder Elbow Surg. 2007; 16:330-338.

Results of a large series of patients with displaced proximal humerus fractures managed by percutaneous techniques are presented. 27 patients, including 8 three-part and 12 valgus impacted four-part fractures were managed with percutaneous pinning and followed an average of 35 months. All fractures went on to union. Four malunions occurred, and only one patient developed AVN. Mean Constant score was 79 for three-part fractures and 67 for four-part fractures.

Minimally invasive reduction and percutaneous fixation can yield excellent results, even in displaced three- and four-part fractures, when anatomic reduction is obtained. Additionally, by avoiding soft tissue stripping, AVN rates may be substantially lower then previously reported with traditional approaches to ORIF. As such, percutaneous pinning currently is a reliable technique for managing complex fractures in the acute setting.

31. Arthroplasty for Fracture

Neer, CS, 2nd. Displaced proximal humeral fractures: Classification and evaluation. Journal of Bone and Joint Surgery 52: 1077-1089, 1970.

Neer, CS, 2nd. Displaced proximal humeral fractures II: Treatment of three-part and four part displacement. Journal of Bone and Joint Surgery 52: 1090-1103, 1970.

Palvanen, M; Kannus, P; Niemi, S; Parkkari, J. Update in the epidemiology of proximal humeral fractures. Clinical Orthopedics and Related Research 442:87-92, 2006.

The article reports the epidemiologic data collected from the Finnish National Register from 1970 to 2002 concerning proximal humeral fractures. It shows that the overall incidence and the age adjusted incidence increased during the last three decades. The increase was especially high for elderly women. If this trend continues in the future, the number of proximal humeral fractures will triple during the next three decades.

Boileau, P; Krishnan, SG; Tinsi, L; Walch, G; Coste, JS; Mole, D. Tuberosity malposition and migration: Reasons for poor outcomes after hemiarthroplasty for displaced fractures of the proximal humerus. Journal of Shoulder and Elbow Surgery 11(5): 401-412, 2002.

Kralinger, F; Schwaiger, R; Wambacher, M; Farrell, E; Menth-Chiari, W; Lajtai, G; Hubner, C; Resch, H. Outcome after primary hemiarthroplasty for fracture of the head of the humerus: A retrospective mutlicentre study of 167 patients. Journal of Bone and Joint Surgery (Br) 86(2): 217-219, 2004.

This article reports a large multicentre retrospective study of 167 hemiarthroplasties for fracture from 12 hospitals. Different types of prosthesis had been compared. At mean follow up of 29 months, 79% of the patients had mild or no pain and the mean overall Constant Score was 55 points. The authors found that the tuberosity healing was influenced by age of patient, design of the prosthesis, and the number of hemiarthroplasties performed in the institution.

Prakash, U; McGurty, DW; Dent, JA. Hemiarthroplasty for severe fractures of the proximal humerus. Journal of Shoulder and Elbow Surgery 11(5): 428-430, 2002.

DeFranco, MJ; Brems, JJ; Williams, GR; Iannotti, JP. Evaluation and management of valgus impacted four-part proximal humerus fractures. Clinical Orthopedics and Related Research 442: 109-114, 2006.

The authors of this article have analyzed the literature about the valgus impacted fractures. They describe specifically the pathoanatomy and the prognostic factors. They highlight the interest of the less invasive techniques for osteosythesis.

Mighell, MA; Kolm, GP; Collinge, CA; Frankle, MA. Outcomes of hemiarthroplasty for fractures of the proximal humerus. Journal of Shoulder and Elbow Surgery 12(6): 569-577, 2003.

Hernigou, P; Duparc, F; Hernigou, A. Determining humeral retroversion with computed tomography. Journal of Bone and Joint Surgery 84A (10): 1753-1762, 2002.

Demirhan, M; Kilcoglu, O; Altinel, L; Eralp, L; Akalin, Y. Prognostic factors in prosthetic replacement for acute proximal humerus fractures. Journal of Orthopedic Trauma 17(3): 181-188, 2003.

Becker, R; Pap, G; Machner, A; Neumann, WH. Strength and motion after hemiarthroplasty in displaced four-fragment fracture of the proximal humerus: 27 patients followed for 1-6 years. Acta Orthopedica Scandinavia 73(1): 44-49, 2002.

Webb, M; Funk, L. An anteriosuperior approach for proximal humerus fractures. Techniques in Shoulder and Elbow Surgery 7(2): 77-81, 2006.

This article described the anteriosuperior approach derived from Mackenzie and modified for internal fixation of a hemiarthroplasty. The authors describe how to extend the approach inferiorly and how to expose, mobilize, and protect the axillary nerve.

Hempfing, A; Leunig, M; Ballmer, FT; Hertel, R. Surgical landmarks to determine humeral head retrotorsion for hemiarthroplasty in fractures. Journal of Shoulder and Elbow Surgery 10(5): 460-463, 2001.

Frankle, MA; Mighell, MA. Techniques and principles of tuberosity fixation for proximal humeral fractures treated with hemiarthroplasty. Journal of Shoulder and Elbow Surgery 13(2): 239-247, 2004.

This review article describes the recent development in prosthesis design and tuberosity fixation and gives biomechanical explanations to support technique of fixation promoted by the authors.

Boileau, P; Sinnerton, RJ; Chuinard, C; Walch, G. Arthroplasty of the shoulder. Journal of Bone and Joint Surgery (Br) 88(5): 562-575, 2006.

This is an overview on recent advances in prosthetic designs for total shoulder arthroplasty, in hemiarthroplasty for acute fracture sequelae, and in reverse protheses.

De Wilde, LF; Berghs, BM; Beutler, T; Ferguson, SJ; Verdonk, RC. A new prosthetic design for proximal humeral fractures: reconstructing the glenohumeral unit. Journal of Shoulder and Elbow Surgery 13(4): 373-380, 2004.

The authors developed a new model of hemiarthroplasty for fracture and perform a biomechanical testing of the model with 2 different types of tuberosity fixation. The principle of this prosthesis is to improve the tuberosity fixation by adding sutures through the cuff which are fixed around the head of the prosthesis.

Loew, M; Heitkemper, S; Parsch, D; Schneider, S; Rickert, M. Influence of the design of the prosthesis on the outcome after hemiarthroplasty of the shoulder in displaced fractures of the head of the humerus. Journal of Bone and Joint Surgery (Br) 88(3): 345-350, 2006.

39 patients had been operated with 2 types of prosthesis: standard anatomical and implant designed for fracture. They found that the implant designed for fracture allows to increase the rate of tuberosity healing but they did not find significant difference in functional results.

32. Late Reconstruction Following Fracture

Sirveux, F; Favard, L; Oudet, D; Huquet, D; Walch, G; Mole, D. Grammont inverted total shoulder arthroplasty in the treatment of glenohumeral osteoarthritis with massive rupture of the cuff: Results of multicentre study of 80 shoulders. Journal of Bone and Joint Surgery (Br) 86(3): 388-395, 2004.

This article reported the results of a retrospective french multi center study about 80 cases. The authors propose a new classification of the glenoid erosion in cuff deficient shoulder and find that the status of the teres minor influence the recovery in external rotation. They emphasize on the problem of the glenoid notch.

Sirveux, F; Navez, G; Favard, L; Boileau, P; Walch, G; Mole, D. Reverse prosthesis for acute proximal humerus fracture, the mutlicentric study. In: Walch, G; Boileau, P; Mole, D (eds) Reverse Shoulder Arthroplasty, Clincal Results, Complications, Revision. Montpellier, Sauramps Medical, 2006.

The article reports the results of the reverse for acute fracture among a large retrospective multi center study. Eleven cases had been assessed clinically at a mean follow-up of 46 months. The authors conclude that the reverse is effective in restoring active mobility but not in external rotation. They compare the results with a previous series of hemiarthroplasty in patient over 70 years old.

Guery, J; Favard, L; Sirveaux, F; Oudet, D; Mole, D; Walch, G. Reverse total shoulder arthroplasty – Survivorship analysis of eighty replacements followed for 5-10 years. Journal of Bone and Joint Surgery 88(8): 1742-1747, 2006.

The authors investigate the medium term follow-up (mean 69 months) of the reverse prosthesis and analyze the influence of the etiology on results. They calculate the cumulative survival curve according to the etiology and show that the arthropathies with massive cuff defect demonstrate better outcome than the over etiology.

Seebauer, L. Reverse prosthesis through a superior approach for cuff tear arthropathy. Techniques for Shoulder and Elbow and Surgery 7(1): 13-26, 2006.

In this article, the authors describe a new classification of the cuff tear arthropathy based on pathomechanical and morphological findings. They describe in detail the technique by the superior approach and they report a series of 56 patients reviewed retrospectively at a mean follow-up of 39 months. They emphasize on a rate of 19% of inferior glenoid bone erosion.

Mansat, P; Guity, MR; Bellumore, Y; Mansat, M. Shoulder arthroplasty for late sequelae of proximal humeral fractures. Journal of Shoulder and Elbow Surgery 13(3): 305-312, 2004.

This article reported a retrospective study about 28 cases of shoulder replacement for fracture sequelae (8 total and 20 hemiarthroplasties). The results were considered satisfactory in 64% of the cases. The outcome is influenced by the status of the cuff and the need for greater tuberosity osteotomy.

Boileau, P; Chuinard, C; Le Huec, JC; Walch, G; Trojani, C. Proximal humerus fracture sequelae: Impact of a new radiographic classification on arthroplasty. Clinical Orthopedics and Related Research 442: 121-130, 2006.

The authors retrospectively evaluated 203 patients operated with a non constrained prosthesis for fracture sequelae. Type 1 is defined by osteonecrosis or collapse of the head. Type 2 is secondary to dislocations or fracture dislocation, the surgical neck nonunion define the type 3 and the type 4 is defined by severe tuberosity malunion.

Beredjiklian, PK; Iannotti, JP; Norris, TR; Williams, GR. Operative treatment of malunion of a fracture of the proximal aspect of the humerus. Journal of Bone and Joint Surgery 80(10): 1484-1497, 1998.

Antuna, SA; Sperling, JW; Sanchez-Sotelo, J; Cofield, RH. Shoulder arthroplasty for proximal humerus malunions: Long-term results. Journal of Shoulder and Elbow Surgery 11(2): 122-129, 2002.

Antuna, SA; Sperling, JW; Sanchez-Sotelo, J; Cofield, RH. Shoulder arthroplasty for proximal humerus nonunions. Journal of Shoulder and Elbow Surgery 11(2): 114-121, 2002.

Sperling, JW; Pring, M; Antuna, SA; Cofield, RH. Shoulder arthroplasty for locked posterior dislocation of the shoulder. Journal of Shoulder and Elbow Surgery 13(5): 522-527, 2004.

The authors reviewed twelve patients who underwent shoulder arthroplasty for locked posterior dislocation at a mean follow-up of nine years. The data from this study suggest that shoulder arthroplasty for locked posterior dislocation provides pain relief and improved motion. Among those with recurrent posterior instability, it usually appears in early postoperative period.

Sperling, JW; Cofield, RH; Rowland, CM. Minimum fifteen-year follow-up of Neer hemiarthroplasty and total shoulder arthroplasty in patients aged fifty years or younger. Journal of Shoulder and Elbow Surgery 13(6): 604-613, 2004.

114 cases of shoulder arthroplasty (78 HHR and 36 TSR) in patients younger than 50 years had been reviewed with a minimum of 15 years follow-up. The data from this study indicate that there is marked long-term pain relief and improvement in motion with shoulder arthroplasty. There is a moderate rate of hemiarthropasty revision for painful glenoid arthritis 60% of the HHR achieve unsatisfactory result compared to 48% for TSR.

33. Clavicle Fractures

McKee, MD; Wild LM; Schemitsch, EH. Midshaft malunions of the clavicle Journal of Bone and Joint Surgery 85A: 790-79, 2003.

This paper reviews the results of treatment of corrective osteotomy in 15 patients with malunion of midshaft clavicle fractures. A mean clavicular shortening of 2.9 cm following nonoperative treatment of midshaft clavicle fracture with patients presenting a mean of 3 years after the original injury. Patients complained of rapid fatigability and difficulty with prolonged work or athletic activities. Patients also complained of paresthesias consistent with thoracic outlet syndrome and also complained of a deep ache in the axilla. These symptoms were increased with overhead positioning of the arm and occasionally were associated with radicular symptoms in the forearm. Indications for operative intervention were chronic pain, shoulder weakness, or thoracic outlet symptoms unresponsive to nonoperative treatment. The preoperative DASH score improved from 32 points to 12 points. Uncomplicated union of the osteotomy was achieved in 14 of the 15 patients and the mean shortening was improved to 0.4 cm. One patient had loss of plate fixation 2 weeks post-operatively and subsequently developed symptomatic non-union requiring repeat fixation and bone-grafting. Local irritation from the plate required reoperation for removal of the plate in 2 patients. Pain and weakness was eliminated in 8 of 12 patients and improved in the remaining 4 patients. Paresthesias of the upper extremity were eliminated in 7 of 11patients, decreased in 3 patients and unchanged in 1 patient. The authors concluded that not all patients will do well with nonoperative treatment of clavicle fractures and some patients with malunions will develop significant symptoms that will need operative intervention. Osteotomy of the malunion can be reliably performed with minimal complications and significant improvement in patient function and satisfaction. Patient based outcome scores such as the DASH score are useful in determining that radiographic union alone is not a good measure of satisfactory patient outcomes. The authors attributed the patients' symptoms and poor outcome of malunion to shortening of the clavicle and corrective osteotomy restores clavicular anatomy and alleviates the patients' pain and improves function.

McKee, MD; Pedersen, EM; Jones, C et al. Deficits following nonoperative treatment of displaced midshaft clavicular fractures. Journal of Bone and Joint Surgery 88A: 35-40, 2006.

This study identified 30 patients that had been treated nonoperatively for disp for persistent laced midshaft clavicle fractures. These patients were subsequently evaluated for functional deficits using Constant Shoulder score and the DASH score. The mean Constant score was 71 points and the DASH score was 24.6 as compared to published normative values of 92 and 10.1 respectively indicating significant residual disability. Greater patient dissatisfaction and lower DASH score was associated with clavicular shortening greater than 2 cm. An isometric muscle testing device was used to determine objective strength of the injured shoulder relative to the uninjured shoulder. The maximum flexion strength of the

injured shoulder was 81% of the uninjured shoulder and the maximum abduction strength was 82% of the uninjured shoulder. The abduction endurance of the injured shoulder was only 67% of the uninjured shoulder. Increased shortening of the clavicle was associated with decreased abduction endurance. The authors felt that abduction strength may be preserved until there a critical threshold of 2 cm of shortening occurs and then there is a dramatic change in function and patient satisfaction.

Nowak, J; Holgerson, M; Larsson, S. Can we predict long-term sequelae after fractures of the clavicle based on initial findings? A prospective study with nine to ten years follow-up. Journal of Shoulder and Elbow Surgery 13: 479-486, 2004.

This prospective study had 208 patients of 245 initial patients with clavicle fractures return for long-term follow-up. All patients were treated non-operatively and subsequently re-evaluated for long-term follow-up at 9 to 10 years after initial injury. Patients were evaluated for whether patients felt fully recovered, pain at rest, pain with activity, and cosmetic defects. Although, 93% fractures were healed at 6 month follow-up 46% patients did not consider themselves fully recovered 9 years after the injury. Pain at rest was present in 9% of patients and 29% had pain with activity, and 27% had cosmetic defects. The authors felt that displacement without bony contact with a transversely oriented fragment was the strongest risk factor for continued patient complaints at long-term follow-up. A 45° tilted view was necessary to visualize comminution and displacement of the fracture that may lead to sequelae.

Robinson, CM; Court-Brown, CM; McQueen, MM et al. Estimating the risk of nonunion following nonoperative treatment of a clavicular fracture. Journal of Bone and Joint Surgery 86A: 1359-1365, 2004.

This prospective study evaluated the risk factors for developing a clavicle nonunion 24 weeks after clavicle fracture. There was 4.5% rate of nonunion of diaphyseal fractures and 11.5% rate of nonunion of lateral clavicle fractures. The risk of nonunion was increased with advanced patient age, female gender, fracture displacement and comminution. There was increased risk of nonunion of lateral fractures with increased patient age and displacement of the fracture. There were too few medial fractures to assess risk factors for nonunion of these fractures. The authors used regression analysis to develop an equation to determine the risk of nonunion based on the above independent variables. Fracture angulation, translation, and shortening were not significantly predictive for nonunion.

Strauss, EJ; Egol, KA; France, MA et al. Complications of intramedullary Hagie pin fixation for acute midshaft clavicle fractures. Journal of Shoulder and Elbow 16:280-284, 2007.

This retrospective study reviewed 16 patients with midshaft clavicle fractures treated with an intramedullary Hagie pin. The indications for fracture fixation were significant deformity, polytrauma, and neurovascular compromise. The rationale for use of Hagie pins in the treatment of clavicle fractures were small incision surgery, limited disruption of soft tissues, and relative protection of supraclavicular nerves. There were no intraoperative complications and the implants were removed a mean of 9 weeks (range 5-15 weeks) after insertion. Fracture union occurred in all cases a mean of 12.4 weeks after surgery (range 9-22 weeks). The authors reported 85.7% patients had full or near full range of motion but the authors did not report additional functional assessments. Furthermore, patient based assessment of the outcome was restricted to reporting 92.9% patients no residual in the shoulder or fracture site. Skin breakdown due to hardware prominence occurred in 3 patients, one of these patients required return to the operating room for surgical debridement. There 2 cases of hardware failure with breakage of the pin, 1 patient required revision surgery. The authors concluded that the high postoperative complication rate assocatiated with the use of the Hagie pin should preclude its use in the treatment of midshaft clavicle fractures.

Canadian Orthopaedic Trauma Society. Nonoperative treatment compared with plate fixation of displaced midshaft clavicular fractures. A multicenter randomized clinical trial. Journal of Bone and Joint Surgery 89A: 1-10, 2007.

The Canadian Orthopaedic Trauma Society reported on the results comparing nonoperative treatment and plate fixation of displaced midshaft clavicle fractures. This multicenter study prospectively evaluated the results of treatment of 111 clavicle fractures randomized to either sling treatment or operative treatment with plate fixation (49 treated nonoperatively and 62 treated operatively). The results were evaluated at one year follow-up with the Constant score, DASH score and plain x-rays. The operative group had superior Constant and DASH scores throughout the 1 year follow-up with 10 point Constant score difference and with 10 point DASH score difference. The patients were more likely to be satisfied with their treatment throughout the study period. There were no significant differences between the 2 groups with regards to range of motion. The operatively treated fractures were united at a mean time of 16.4 weeks while the nonoperatively treated fractures were united at a mean of 28.4 weeks. There were 3 wound infections in the operatively treated group that were successful treated with antibiotic treatment and removal of the hardware once fracture union was achieved. There was one nonunion which occurred after operative fixation and eight fractures which went onto nonunion after nonoperative treatment. There were 9 symptomatic malunions in the nonoperative treatment group that required operative intervention. Anatomic reduction was achieved and maintained in all but one (traumatic re-injury) of the operatively treated fractures. A higher DASH score was associated with greater total fracture displacement in the nonoperative group. The authors concluded that early plate fixation of completely displaced midshaft clavicle fractures

resulted in improved patient outcomes with early return to function and decreased rates of nonunion and malunion.

Lazarides, S; Zafiropaulos, G; Tydfil, M. Conservative treatment of fractures at the middle third of the clavicle: The relevance of shortening and clinical outcome. Journal of Shoulder and Elbow Surgery 15: 191-194, 2006.

This study retrospectively reviewed 132 patients available for follow-up from 168 patients with acute closed uncomplicated midshaft clavicle fractures that achieved radiographic union with nonoperative treatment. The authors utilized a modified Constant score and a patient questionnaire to assess patient outcomes relative to degree of fracture shortening following union. Clavicular shortening was determined by measuring both clavicles on a single chest x-ray. Dissatisfaction with the results of nonoperative treatment occurred in 25.8% of the patients. Pain requiring occasional analgesic medication was reported by 30.3% of patients and impairment of strength due to pain was reported by 16% of patients. Three patients experienced symptoms of thoracic outlet syndrome. Patient dissatisfaction was statistically associated with clavicular shortening of 18 mm in males and 14 mm in females. Patient age, gender, hand dominance and occupation were not associated with a poor result. Shoulder dysfunction and patient dissatisfaction was associated with clavicular shortening.

34. Degenerative Disorders of the Acromioclavicular Joint

Rabalais RD, McCarty E: Surgical treatment of symptomatic acromioclavicular joint problems: A systematic review. Clin Orthop 2006;455:30-37.

This review paper provides an outstanding systematic overview of research articles that pertain to surgical treatment of acromioclavicular (AC) pathologies. The authors performed a large literature search for all clinical research studies that were published in peer-reviewed journals by identifying those papers in which AC arthritis, AC osteolysis or distal clavicle excision was discussed. Each of the articles was then dissected to determine their level of evidence and grading systems. Separate categories were then established to compare the studies, including distal clavicle excision for osteoarthritis or osteolysis, excision after trauma and excision accompanied with secondary procedures.

Nine studies reported on their outcomes following open distal clavicle excision, of which all were level IV studies except for one level III study. Overall, 76.3% reported "good" or "excellent" results. There were six studies on isolated arthroscopic distal clavicle excision, all level IV. These papers identified a "good" or "excellent" result in 92.5% of patients. Although there was a higher percentage of "good" and "excellent": results reported for arthroscopic excision over open excision, the authors point out that the entire present literature as a whole is comprised of low-level studies and no definitive conclusions can be made. When the distal clavicle was excised in conjunction with another procedure, results were equal to when the excision occurred alone, although once again the studies were all level IV. The literature was unable to make concrete conclusions regarding distal clavicle excision following trauma, however there appeared to be a trend toward more "poor" results in this setting.

This unique review of all surgically treated AC joint pathologies provides an excellent source of information. Their technique of literature search ensured that they included all essential studies. Their categorization of the studies then allowed for ease of comparison between the studies. Finally, the conclusions drawn from all this work are well-written, clear and simple to understand. The lack of any level I or II studies on surgical intervention for AC pathology prevents us from making any definitive conclusions. Their bibliography provides an excellent source of essential research done in this area.

Shaffer BS: Painful conditions of the acromioclavicular joint. J Am Acad Orthop Surg 1999;7:176-188.

In this JAAOS review article, Dr. Shaffer provides a broad overview of the most common sources of acromioclavicular (AC) pathology. Specifically, the processes of primary osteoarthritis, posttraumatic arthritis and distal clavicle osteolysis are discussed in detail, in addition to specific techniques of evaluation to differentiate these entities from other possible sources of shoulder discomfort. The review begins with a brief anatomy and biomechanics discussion and then proceeds to describe the diagnostic evaluation, treatment options and

surgical techniques, outcomes and complications involving AC disease. The author completes the review with guidelines for resection amounts and contraindications for surgical intervention.

The focus of the review centers on the most common pathologies involving the AC joint. The presentation, physical exam and radiologic evaluation descriptions provided in the review are thorough and accompanied by detailed images and diagrams. The author also provides several tables, including the listing of all important publications showing the results following open and arthroscopic distal clavicle resection. The article also provides for in-depth protocols for performing both the open and arthroscopic techniques.

This is a concise and well-organized review of three common conditions afflicting the AC joint. It may be used as a starting point for an introduction to AC pathology and its treatment by orthopedic residents and medical students, but would also be useful as an adjunct to every shoulder surgeon's files for frequent review. The bibliography is complete and lists the key studies reporting the clinical results of AC resection. The article also highlights non-operative management pearls, including good descriptions of the anatomy and technique of AC injections. Finally, the detailed operative steps of both open and arthroscopic procedures are easy to follow and understand.

Buttaci CJ, Stitik TP, Yonclas PP, Foye PM: Osteoarthritis of the acromioclavicular joint: A review of anatomy, biomechanics, diagnosis, and treatment. Am J Phys Med Rehabil 2004;83:791-797.

This literature review article approaches the topic of acromioclavicular (AC) joint osteoarthritis from more of a medical background. The topic is systematically reviewed beginning with anatomy and biomechanics, progressing through clinical presentation and diagnosis and finishing with treatment options. A dedicated section on intraarticular injections is provided, which includes several references that document their results from steroid injections. The differential diagnosis section is complete and well detailed. Surgical intervention is only briefly mentioned, as again this review paper is from a medically-oriented journal.

This reference gives great details on the clinical presentation and medical management of AC joint arthritis. Key points of the physical exam are stressed and accompanying bibliography aids the reader in accessing further reading if needed. Conservative treatment is highlighted in this article, including a lengthy discussion on the mechanism of action and potential benefits and side effects of intraarticular corticosteroids. Several studies that pioneered the use of steroid injections are highlighted. Surgical management is only briefly reviewed.

Though this review article is from the medical literature, it still provides an easy to read and understandable review of AC osteoarthritis. All important references are documented and suggested additional readings are included with the bibliography. The discussion on the use of intraarticular injections, both as a diagnostic tool and as a therapeutic modality, is of high yield. There are no specific details in regard to the surgical care for AC joint arthritis nor are their outcomes mentioned. This well written article nonetheless remains an important adjunct to anyone reviewing the topic of AC joint osteoarthritis.

Worcester JN Jr, Green DP: Osteoarthritis of the acromioclavicular joint. Clin Orthop 1968;58:69-73.

This classic paper retrospectively reviewed 56 patients who had previously undergone excision of the outer end of the clavicle for a diagnosis of acromioclavicular (AC) degenerative arthritis. A brief summary of the anatomy and biomechanics of the AC joint precedes the study itself. All patients were diagnosed with physical examination and nearly all had a local anesthetic injection into the AC joint as part of their non-operative care. Patients were followed post-operatively for a mean of 4.5 years (1 month – 19 years). The majority of patients obtained complete pain relief, and those that had pre-operative decreased range of motion also regained full range by an average of four months. No significant weakness was found in any subject.

Several significant points from this classic reference from Columbia Hospital from 1968 deserve attention. First, the authors emphasize that pain relief from the pre-operative anesthetic injection correlated with post-operative surgical success. There were no patients who had complete pain relief after two or more injections who did not have a good or excellent surgical result. The only unsatisfactory results were in patients who did not receive a pre-operative injection or those in whom the response was only partial relief of pain. Of note, injections in this early study included 5-10 ml of 1% Lidocaine, with or without 1-2 ml of a steroid preparation. Second, all operative procedures were obviously done in an open technique, and excision of the outer end of the clavicle included up to 2.5 cm of bone. Lastly, physical examination included the adduction test, but the authors stated that well-localized tenderness over the AC joint was still the best single finding.

This reference provides insight to the knowledge that was present at that time and also demonstrates how far we have come in the treatment of AC arthritis. The brief anatomy and biomechanics review differs little from the more recent literature. Great emphasis was placed on both the technique and results of the pre-operative injection test. Upon review of their surgical outcomes, it is clear that the anesthetic injection should continue to be part of our diagnostic armamentarium. As excessive excision of the clavicle is still of major concern today, it is interesting to note how these authors removed nearly 1 inch of distal clavicle without significant morbidity. This article remains an important contribution to the understanding and treatment of AC joint osteoarthritis.

Cadet E, Ahmad CS, Levine WL: The Management of acromioclavicular joint osteoarthrosis: Débride, resect or leave it alone. AAOS Instr Course Lect 2006;55:75-83.

In this Instructional Course Lecture, the authors address degenerative changes of the acromioclavicular (AC) joint, with specific reference to its association with subacromial impingement syndrome. A detailed section on the anatomy and biomechanics of the AC joint is followed by sections on the pathophysiology, physical exam and treatment options for the degenerative processes involving that region. Emphasis is placed on the association between AC arthrosis and subacromial impingement, with the authors using several articles to assist the reader in determining the correct treatment algorithms.

This review paper focuses on the common clinical entity of simultaneous AC joint disease and subacromial impingement syndrome. Several classic Neer articles are referenced that describe the relationship between these two entities. The article also includes various references within the biomechanics discussion that discuss the importance of the coracoclavicular ligaments and their increased contributions following AC resection. A detailed section regarding the diverse methods of radiographic visualization of AC pathology is also included. The section of the treatment alternatives includes decision-making recommendations for either débridement or distal clavicle resection based on numerous references.

Although the authors chose to concentrate their efforts on AC joint degenerative disease coinciding with subacromial impingement, the discussion nonetheless provides a high-yield review of AC joint pathology in general. The biomechanics and pathoanatomy sections are detailed yet succinct, and the management discussion effectively reviews all important publications involving the care of patients with both AC and impingement pathologies. From non-operative care to débridement to complete AC resection, the paper provides sound justifications for each treatment option without personal opinions offered by the authors. Overall, the review paper provides a solid assessment of AC joint arthrosis and specifically details its interaction with concomitant subacromial impingement syndrome.

Basamania CJ, Wirth MA, Rockwood CA Jr, Moya D: Failed distal clavicle resections. Orthop Trans 1995-1996;19:355.

This paper represents the only article in the literature documenting the various modes of failure following distal clavicle resection. Forty-two shoulders (42 patients) were analyzed in order to classify the cause of persistent pain following surgery. Three categories were established. The first group consisted of those patients who were judged to be misdiagnosed with acromioclavicular (AC) joint arthritis. The second group included patients suffering from persistent AC symptoms. The final group contained all patients in which a complication from the actual surgery had occurred. The authors conclude that in order to achieve good results following distal clavicle excision, pre-operative work-up must include a correct diagnosis, a suitable surgical candidate and a properly performed surgical procedure.

In group one, misdiagnoses included subacromial impingement (15 patients) and anterior glenohumeral instability (4 patients). All four patients with instability and 7 out of 15 patients with impingement symptoms underwent further surgery and received good outcomes. Group two consisted of persistent pain secondary to either insufficient distal clavicle resection resulting in AC impingement or AC joint instability in those patients who had a complete AC dislocation. The third group contained patients with complications such as clavicular regrowth, excessive clavicular resection and recurrent AC instability.

As the sole reference that provides information of the types of failure following AC joint resection surgery, this paper is an essential component of any compilation of AC joint literature. The three groups of differing modes of failure help identify many pre-operative factors that must be addressed prior to surgical intervention. The astute conclusions include three criteria that should be met before an AC resection is contemplated and include

tenderness at the AC joint with cross-adduction test, radiographic evidence of AC arthritis and significant pain relief after intraarticular injection. This article should be part of every shoulder surgeon's library.

Chen AL, Rokito AS, Zuckerman JD: The role of the acromioclavicular joint in impingement syndrome. Clin Sports Med 2003 Apr;22(2):343-357.

This summary paper reviews the involvement of acromioclavicular joint (AC) arthritis with subacromial impingement and rotator cuff pathology. The introduction focuses on the pathoanatomy and biomechanics of AC impingement, including a dedicated discussion on AC joint osteophytes the mechanism of coracoacromial arch impingement. The clinical presentation and physical exam is then detailed, with special emphasis on the appropriate techniques of performing each provocative examination. Treatment options are then outlined, starting with non-operative modalities and progressing to surgical options. Each therapeutic intervention is accompanied by literature that either supports or disputes the specific technique. The concluding portion of the article reports on the successes and failures regarding the concept of co-planing the AC joint, as well as the indications for performing a concomitant subacromial decompression and AC resection. Both open and arthroscopic techniques are reviewed.

Although several papers have documented the association of AC arthritis with subacromial impingement, this article provides a detailed background of the subject, as well as containing all important references pertaining to this topic. The anatomy section, in addition to describing the mechanism of various sources of impingement, provides documentation supporting the theory that it is the presence of inferiorly directed osteophytes that cause rotator cuff lesions and not simply age-related changes. The specific physical exam tests are explained in detail and radiologic work-up is also explicitly clarified. Non-operative treatment modalities including the use of rest, heat and cold, NSAIDS, PT and steroid injections are explained with supporting literature. Finally, the operative intervention discussion gives several references that explain the controversies surrounding co-planing or beveling the AC joint.

The role of AC pathology coinciding with subacromial impingement is well-outlined in this paper from 2003. All pertinent points of interest regarding this topic are included, each with accompanying supporting literature. The sections on clinical evaluation and treatment options are especially well written. Surgical techniques are not included in this review, however the discussion still allows the reader to opt for the appropriate treatment based on their clinical exam and radiographic evaluation. This paper provides an excellent source of information and summary of the topic of combined AC and subacromial impingement syndrome.

35. AC Separations

Fukuda, K; Craug, EV; An, K-N et al. Biomechanical study of the ligamentous system of the acromioclavicular joint. Journal of Bone and Joint Surgery 68: 434-440, 1986.

This biomechanical study using sequential sectioning of the ligaments and load-displacement testing evaluated ligamentous contributions to joint constraint. It found that both AC and CC ligaments contributed to joint constraint, the magnitude of contribution depending upon direction and magnitude of the load. The AC ligaments acted as primary constraints to anterior-posterior displacement and for posterior axial rotation. At low loads, the AC ligaments also contributed to superior constraint. The CC ligaments played major roles in constraining anterior superior rotation and anterior and superior displacement, and played larger roles as loads increased.

All of the ligaments of the AC articulation are important in stabilizing the joint. The AC ligaments appear to have major roles especially in physiologic load situations. Too generous distal clavicle resection may not allow AC ligament functions.

Larsen, E; Bjerg-Nielsen, A; Christensen, P. Conservative or surgical treatment of AC dislocation. Journal of Bone and Joint Surgery 68: 552-555, 1986.

This prospective study compared symptomatic based conservative treatment with repair by fixation by wires and suture of the torn ligaments. The results were measured by a clinical rating scale based on pain, range of motion, and strength. Both groups had a large majority of excellent results, although half of the operated group had problems with the pins.

This study, using operative techniques that are not currently used, recommended operative treatment for patients with prominent cosmetic deformity, a need to do heavy work, and who require repetitive use of the arm above 90 degrees of abduction and flexion.

Flatow, E. Biomechanics of the acromioclavicular, sternoclavicular, and scapulothoracic joints. AAOS Instructional Course Lectures 42: 237-240, 1993.

This review establishes a baseline of understanding regarding how the AC articulation is integrated in motion, position, and function with the other articulations on the ends of the scapula and clavicle. It demonstrates how 3 dimensional motion allows stable movement at the AC joint with minimal stress, and how this should be taken into account in evaluation and treatment.

Weinstein, DM; McCann, PD, McIllveen, SJ et al. Surgical treatment of complete acromioclavicular dislocations. American Journal of Sports Medicine 23: 324-330, 1995.

This clinical study reviewed results of operative fixation of AC separations. The technique included CA ligament transfer plus suture augmentation around the coracoid and through the clavicle. Overall, a high rate (89%) of the patients reported satisfactory results based on pain, range of motion, strength, and subjective use of the extremity. 93% were able to return to athletic activities. Patients who underwent acute surgical treatment had better results than those who had surgery more than 3 months after the injury (96% vs 77%). There was also a lower rate of loss of reduction (15% vs 29%) in the early repair group.

This type of repair achieved satisfactory functional results and could be advocated as an early repair when surgery is indicated.

Branch, TP; Burdette, HL, Shahriari, AS et al. The role of the acromioclavicular ligaments and the effect of distal clavicle resection. American Journal of Sports Medicine 24: 293-297, 1996.

This biomechanical study used sequential sectioning of the superior and inferior AC ligaments and removal of 5mm of distal clavicle to determine the control of scapular rotation around the clavicle by the ligaments and bony strut.

The results showed that 5mm of bony resection of the distal clavicle was enough to ensure no bone to bone contact. Cutting one of the ligaments and resecting the bone resulted in some increase in rotation. However, cutting both ligaments and resecting the bone resulted in large (up to 2x) increases in scapular motion around the clavicle in the presence of intact CC ligaments.

Mumford type distal clavicle resections should only remove 5mm of bone, and care should be taken to ensure that at least one of the AC ligaments are repaired or are left intact.

Klimkiewicz, JJ; Williams, GR; Sher, JS et al. The acromioclavicular capsule as a restraint to posterior translation of the clavicle: A biomechanical analysis. Journal of Shoulder and Elbow Surgery 8: 119-124, 1999.

This cadaveric study evaluated the contributions of different parts of the AC joint capsule to posterior displacement of the clavicle. It found that the superior capsule contributed over one half of the constraint, followed by the posterior capsule.

This study suggests that surgery on the AC joint should strive to protect, preserve, repair, or reconstrauct the AC joint capsule in order to maintain maximum joint stability and biomechanics.

Shaffer, B. Painful conditions of the acromioclavicular joint. Journal of the American Academy of Orthopaedic Surgeons 7: 176-188, 1999.

This review covers pathophysiology and treatment options for the painful AC joint with arthrosis or osteolysis. It presents techniques for clinical and radiographic evaluation, and guidelines for operative and non-operative treatment. It reviews the results of both open and arthroscopic approaches to distal clavicle resection, and points out the poor putcomes associated with over-generous removal of distal clavicle tissue. The best guidelines for the surgical approach include removing bone to remove the bony abutment, resection of less than 1 cm of clavicle, and preservation of the AC joint soft tissues.

Debski, R; Parsons, IM; Woo, S et al. Effect of capsular injury on AC joint mechanics. Journal of Bone and Joint Surgery 83: 1344-1351, 2001.

This laboratory study evaluated the effect of cutting the AC joint capsule on AC joint kinematics and CC ligament loads. Transection of the capsule resulted in increased force in the CC ligaments. The amount of increased force depended upon the direction of the applied load. Intact CC ligaments cannot control anterior-posterior AC joint translation in the presence of AC ligament deficiency.

The differential force loading characteristics of the conoid and trapezoid ligaments suggest that they should be considered as separate ligaments in reconstructive procedures.

Schlegel, TF; Burks, RT; Marcus, RL et al. A prospective evaluation of untreated grade III AC separations. American Journal of Sports Medicine 29: 699-703, 2001.

This clinical study evaluated patients by both subjective and objective measures one year after AC separation. Initial treatment was limited to a sling for comfort, and progression of activity as tolerated. 80% were subjectively satisfied with the result. Objective measurements showed no deficit of range of motion or rotational strength. Bench press and military press strength was decreased by 17%. Subjects who required repetitive overhead use noted decreased strength and endurance. The study population included no overhead throwing athletes.

This study shows generally good results with non-operative treatment of AC injuries, but also shows deficits in strength and in certain activities that may predispose to altered function.

Lee, SJ; Nicholas, SJ; Akizuki, KH et al. Reconstruction of the coracoclavicular ligaments with tendon grafts. American Journal of Sports Medicine 31: 648-654, 2003.

This cadaveric study evaluated initial failure characteristics of several methods of CC ligament reconstructions. Tensile testing to failure compared CA ligament transfer (Weaver-Dunn), mersilene tape and suture, and tendon graft reconstruction. Tendon graft reconstructions were shown to have superior initial biomechanical properties with failure strengths equal to native ligaments. Long term results following cyclic loading were not evaluated.

Reconstructions involving biologic tissue and restoration of anatomic positioning of the tissue appear to have superior initial characteristics and suggest better function as healing occurs.

Bowen, MK; Nuber, GW (eds). Acromioclavicular and sternoclavicular injuries. Clinics in Sports Medicine 22 (April): 2003.

This review publication contains articles summarizing all aspects of AC joint mechanics, injury, pathophysiology, clinical and radiographic evaluation, and treatment. It contains reviews of the subjects, different methods of evaluation, and author's preferred treatments.

This volume is helpful in providing a broad based, single source overview of the AC (and SC) joints, and properly points out that while many issues concerning AC joint injury and treatment are being resolved, the consensus regarding optimal treatment of AC separations and maintenance of optimal AC kinematics is not established.

Dumonski, M; Mazzocca, AD, Rios, C et al. Evaluation and management of acromioclavicular joint injuries. American Journal of Orthopedics 526-532, 2004.

This review article gives an overview of AC joint mechanics and pathophysiology, and presents data regarding the strength of various reconstructive procedures for complete AC joint separations. It describes a method of allograft fixation using anatomic restoration of the CC ligament footprint with anchor fixation. This construct has the closest strength to the normal anatomic configuration.

Cadet, E; Ahmad, CS; Levine, WN. Management of acromioclavicular joint arthrosis. AAOS Instructional Course Lectures 55: 75-84, 2006.

This review outlines pertinent biomechanics and pathophysiology of the AC joint, and provides guidelines for evaluation, operative, and non-operative treatment. It emphasizes the importance of distinguishing between symptomatic conditions (arthrosis and bone spurs) and non-symptomatic conditions that may be seen on X-ray, as being part of the pathophysiology of shoulder pain the patient has.

36. Disorders of the Sternoclavicular Joint: Pathophysiology, Diagnosis, and Management

Eskola A, Vainionpaa S, Vastamaki M, Slatis P, Rokkanen P. Operation for old sternoclavicular dislocation. Results in 12 cases. J Bone Joint Surg Br. 1989 Jan;71(1):63-5.

Introduction
This is a case series of 12 patients who had surgery for unsuccessful conservative treatment of a sternoclavicular joint dislocation.

Important Points
-Eight patients were treated with fascial loop reconstruction or tendon grafts. Of these, four had good results and four had fair results.
-Four patients were treated with resection of the medial clavicle. All four had poor outcomes.

Commentary
While not a randomized controlled study, this case series suggests that resection of the medial clavicle will produce poor results for treating chronic sternoclavicular joint instability. Reconstruction of the joint, with fascial loops or tendon graft has an improved outcome.

Bearn JG. Direct observations on the function of the capsule of the sternoclavicular joint in clavicular support. J Anat. 1967 Jan; 101(pt 1):159-70.

Introduction
Until recently, Bearn's 1967 manuscript was the only biomechanical study investigating the ligamentous support of the sternoclavicular joint. In this simple, elegant study, weights were suspended from the clavicle and ligaments were cut to see which structures were responsible for the "poise" of the shoulder, which was originally thought to be the role of the trapezius.

Important Points
-The sternoclavicular joint capsule is the structure responsible for maintaining the poise of the shoulder.
-The interclavicular ligament, the disk, and the costoclavicular ligaments have little effect.
-The costoclavicular ligament limits elevation of the clavicle, but more commonly serves as a fulcrum about which the clavicle rotates relative to the thorax.

Commentary
The biomechanics of the sternoclavicular joint during activities and injury remain poorly understood. This study introduced the concept that the ligamentous structures, particularly the joint capsule are responsible for joint stability, and that the costoclavicular ligament is a pivot point about which the clavicle moves in the axial plane.

Outstanding Reviews (1 or 2)

Higginbotham TO, Kuhn JE. Atraumatic disorders of the sternoclavicular joint. J Am Acad Orthop Surg 2005 Mar-Apr;13(2):138-45.

Introduction
Sternoclavicular joint disorders can be divided into traumatic and atraumatic types. A variety of atraumatic disorders affect the sternoclavicular joint, but many are extremely rare. This manuscript catalogues these rare disorders.

Important Points
-Clinicians should maintain a high index for infection. If infection is suspected, aspiration with fluid sent for gram stain, cultures and sensitivities, followed by irrigation and debridement is indicated.
-Most other conditions of the sternoclavicular joint are evaluated with computed tomography and can be treated nonoperatively.
-If surgery is required, the medial head of the clavicle can be resected. It is important to preserve the costoclavicular ligament and perform a structurally sound repair of the joint capsule to preserve joint stability.
-Surgical excision of the medial head of the clavicle is contraindicated for atraumatic subluxation of the sternoclavicular joint due to high failure rates.

Commentary
This manuscript is helpful to have available during a busy clinic. It includes a table delineating the clinical features of the various rare atraumatic conditions that assists in making the diagnosis.

Wirth MA, Rockwood CA Jr. Acute and chronic traumatic injuries of the sternoclavicular joint. J Am Acad Orthop Surg 1996 Oct'4(5):268-278.

Introduction
This manuscript reviews concepts relevant to traumatic instability of the sternoclavicular joint. Traumatic posterior dislocations carry significant morbidity and in some can be fatal. As such traumatic injuries to this joint need careful assessment and approach.

Important Points
-Posterior dislocations may be difficult to diagnose clinically and require computed tomography.
-Posterior dislocations may be life threatening and are an orthopaedic emergency.
-Injuries in patients under 25 years of age may be physeal injuries as the medial physis of the clavicle is one of the last to close, usually at age 23-25.
-Acute anterior dislocations should undergo an attempt at closed reduction, open reduction is rarely indicated.

-Acute posterior dislocations should be reduced open if closed attempts fail. Thoracic surgeons should be available as posterior dislocations may tamponade vascular injury, which may rapidly hemorrhage upon reduction.
-There is no role for metallic pin fixation of the sternoclavicular joint as pin breakage and migration to vital structures has been reported.

Commentary
Instability of the sternoclavicular joint is one of the few conditions in orthopaedics with potentially fatal consequences. Orthopaedists must learn to recognize and treat this collection of disorders. Wirth and Rockwood have extensive experience in the evaluation and treatment of these disorders. This manuscript is an outstanding review of traumatic disorders and is a great resource to practicing clinicians.

Other References with Important Concepts
Spencer EE, Jr., Juhn JE. Biomechanical analysis of reconstructions for sternoclavicular joint instability. J Bone Joint Surg Am. 2004 Jan; 86-A(1):98-105.

Introduction
Instability of the sternoclavicular joint, while rare, is capable of producing significant pain and functional limitations. Chronic posterior instability can produce fatal consequences. A variety of techniques have been described to reconstruct the sternoclavicular joint. This manuscript is an in-vitro biomechanical evaluation of three of the most popular techniques: The Rockwood technique (transfer of the disk and ligament to the intramedullary canal of the clavicle, the Burrows technique (a tenodesis of the subclavius tendon), and a figure-of-eight with semitendinosis.

Important Points
-The figure of eight semitendinosis reconstruction has superior biomechanical properties compared to the intramedullary ligament reconstruction and the subclavius tendon reconstruction.
-In 25% of specimens the subclavius tendon was of insufficient length to perform a reconstruction.

Commentary
Reconstructions for sternoclavicular joint instability are indicated for symptomatic anterior and posterior joint subluxation and fixed posterior dislocations of the sternoclavicular joint. The posterior capsule of the joint has been found to be the most important soft tissue stabilizing structure. The figure-of-eight reconstruction, which most closely reconstructs the posterior and anterior capsules was found to have superior biomechanical properties for stiffness and ultimate load. We await clinical trials evaluating this technique.

Spencer EE, Kuhn JE, Huston LJ, Carpenter JE, Hughes RE. Ligamentous restraints to anterior and posterior translation of the sternoclavicular joint. J Shoulder Elbow Surg. 2002 Jan-Feb;11(1):43-7.

Introduction
This work expands upon the biomechanical study by Bearn (1967), and is an in-vitro ligament cutting biomechanical study of the soft tissue restraints to anterior and posterior translation of the sternoclavicular joint.

Important Points
-The posterior capsule of the sternoclavicular joint is an important restraint to anterior and posterior translation.
-The anterior capsule of the sternoclavicular joint is an important restraint to anterior translation.
-The costoclavicular and interclavicular ligaments had little effect on anterior and posterior translation of the sternoclavicular joint.

Commentary
This manuscript demonstrates that the posterior capsule is biomechanically the most important stabilizing structure for anterior and posterior translation of the sternoclavicular joint. The clinical importance of this work is that the of the variety of reconstruction techniques that have been described for instability of this joint, the ones that reconstruct the posterior capsule would be more likely to restore normal kinematics.

Rockwood CA Jr,, Groh GI, Wirth MA, Grassi FA. Resection arthroplasty of the sternoclavicular joint J Bone Joint Surg Am. 1997 Mar;79-A(3):387-93.

Introduction
Resection of the sternoclavicular joint may be indicated in cases of osteomyelitis, or arthritis or other atraumatic disorders refractory to nonoperative treatment. This manuscript is a retrospective review of patients divided into two groups: those who had a resection lateral to the costoclavicular ligament, and those whose resection preserved the costoclavicular ligament.

Important Points
-The surgical technique preferred by Rockwood is described. It involves transferring the intra-articular disk and ligament into the intramedullary canal.
-The authors suggest having a thoracic surgeon available if complications should ensue, particularly in the high-risk situation of a chronic posterior dislocation.
-Excellent results can be expected if the costoclavicular ligament remains intact.
-Chronic pain and instability are expected if the resection extends laterally and violates the costoclavicular ligament.

Commentary
This manuscript describes one technique for medial clavicle resection. The critical point – preservation of the costoclavicular ligament is illustrated quite well.

Bisson LJ, Dauphin N, Marzo JM. A safe zone for resection of the medial end of the clavicle. J Shoulder Elbow Surg 2003;12(6):592-4.

Introduction
Many authors agree that preservation of the costoclavicular ligament is of critical importance in resection of the medial head of clavicle. In this cadaver dissection the authors measured the distance from the articular surface to the costoclavicular ligament in 43 bilateral specimens.

Important Points
-The distance from the inferior articular surface to the costoclavicular ligament was 1.0cm +/- 0.3cm (1.0com +/- 0.2cm for women and 1.2 cm +/- 0.3cm for men)
-In some individuals the measured distance was 0.5cm
-Surgeons should identify the costoclavicular ligament and keep the resection between 1.0cm or less to preserve it.

Commentary
In this simple study the safe zone was determined. When performing this surgery, care must be taken to preserve the costoclavicular ligament. To do this, the medial clavicle excision should be between 0.5 and 1.0cm.

Acus RW 3rd, Bell RH, Fisher DL. Proximal clavicle excision: an analysis of results. J Shoulder Elbow Surg 1995 May-Jun;4(3):182-7.

Introduction
This case series of 15 patients who underwent a medial clavicle resection for anterior instability (4), posterior instability (1), osteoarthritis (9), and osteomyelitis (1).

Important Points
-60% were graded as good to excellent.
-Of the nine with osteoarthritis, six were raged as good and three were fair.
-Of the five with instability, three were excellent, one good, and one fair.
-Heterotopic ossification was seen in 58% in postoperative radiographs.
-Overall 93% (14/15) had significant pain relief and reported they would undergo the procedure again.

Commentary
While this treatment based case series is flawed by the inclusion of different indications for surgery, no trends were reported to suggest that medial clavicle excision works well for, or is

contraindicated for any particular group. All but one patient had >1cm of bone resected suggesting that the costoclavicular ligament may have been sacrificed in many patients, which may explain the 40% failure rate.

de Jong KP, Sukul DM. Anterior sternoclavicular dislocation: a long-term follow-up study. J Orthop Trauma 1990;4(4):420-3.

Introduction
There is debate regarding the ideal methods for treating anterior sternoclavicular joint dislocations. Many surgeons treat this nonoperatively. This is a case series of ten patients with traumatic anterior sternoclavicular joint dislocations followed for 63 months.

Important Points
-The authors were able to make the diagnosis clinically in 12/13 patients and required radiographic assistance for one.
-Of the 10 patients who had follow up greater than 12 months, seven hade no complaints, two had fair results and one patient (who also had a glenohumeral joint dislocation) had a poor outcome.

Commentary
This manuscript suggests that many chronic anterior sternoclavicular joint dislocations do well with nonoperative treatment. In general it is reasonable to attempt a closed reduction of an acute anterior dislocation. If closed reduction fails, the treating physician should consider leaving the joint dislocated. Surgery may be reserved for those who fail nonoperative treatment.

Bae DS, Kocher MS, Waters PM, Micheli LM, Griffey M, Dichtel L. Chronic recurrent anterior sternoclavicular joint instability: results of surgical manamement. J Pediatr Orthop 2006 Jan-Feb;26(1):71-4.

Introduction
While many patients with anterior sternoclavicular joint instability do well with nonoperative treatment, some continue to have symptoms. This manuscript is a retrospective review of 15 patients (age 12-23 years) followed at an average of 55 months after surgical treatment of anterior sternoclavicular joint instability refractory to nonoperative treatment.

Important Points
-Eleven patients had sternoclavicular joint repair or reconstruction, four had a resection of the medial clavicle.
-60% (9/15) reported stable joints, 27% (4/15) had moderately stable joints, and 13% (2/15) continued to have significant instability.
-60% (9/15) had no pain, 27% (4/15) had pain rated at 1-2/10, and 7% (1/15) had pain rated as >5/10.

-87% reported subjective limitations in athletics or recreational activity.

Commentary
While this retrospective review has several limitations it does point out that many patients do fail nonoperative treatment of anterior sternoclavicular joint dislocations. Surgery can be offered to these patients to reconstruct the sternoclavicular joint, however patient expectations should be clear. There is a substantial risk of continuing symptoms of instability and pain, and it is unlikely the patient will return to unrestricted high level activities such as athletics.

Ross JJ, Shamsuddin H. Sternoclavicular septic arthritis: review of 180 cases. Medicine (Baltimore) 2004 May;83(3):139-48.

Introduction
Septic arthritis affecting the sternoclavicular joint is unusual and has an atypical presentation for infection. This manuscript is a literature review of 170 reported cases added to 10 new cases of infection of the sternoclavicular joint.

Important Points
-The majority (23%) of patients were healthy without a predisposing condition.
-IV drug abuse was seen in 21% of patients.
-Surgery was performed in 58% of patients in of this group, half required extensive debridement with resection of bone for osteomyelitis.
-Staphylococcus Aureus was responsible for 49% of infections with pseudomonas in 10%, and brucella melitensis in 7%.

Commentary
While this is not a systematic review, the wealth of information from this combination of case series is helpful. As presenting symptoms may be minimal and serologic exam may be normal, clinicians must be diligent in evaluating sternoclavicular joint pain for infection. Early irrigation and debridement is essential to prevent complications of osteomyelitis, mediastinitis, emphema, and abscess formation.

37. Guide to Shoulder Disorders – Scapular Disorders

Kibler, WB. The role of the scapula in athletic function. American Journal of Sports Medicine 26(2): 325-337, 1998.

This classic article identifies the importance of the scapula in regards to shoulder function. It describes both normal and abnormal mechanics of the scapula and how that contributes to shoulder dysfunction. It is one of the first manuscripts to describe the specific clinical evaluation techniques and rehabilitation of the scapula.

The scapula plays a critical role in normal shoulder function. Normal shoulder mechanics occur when scapular motion is controlled and the scapula itself is properly stabilized. The main roles of the scapula in overhead function include appropriate acromial elevation, acting as a base for the rotator cuff muscles, retraction and protraction during active shoulder motion, and serving as a link in the kinetic chain. Abnormal scapular motion can be seen frequently and in conjunction with a variety of shoulder injuries. The abnormal motion creates alterations in the scapular roles which can lead to decreased performance and function. It is for these reasons that the scapula should be included as part of a standard clinical shoulder evaluation and rehabilitation of this structure should be completed early in the treatment process.

Warner, JP; Micheli, LJ; Arslanian, LE; Kennedy, J; Kennedy, R. Scapulothoracic motion in normal shoulders with glenohumeraal instability and impingement syndrome. Clinical Orthopaedics and Related Research 285: 191-198, 1992.

This controlled laboratory study attempted to use a diagnostic tool to quantify scapular function.

Scapular motion of 51 total subjects (22 asymptomatic, 22 with instability, and 7 with impingement) was statically and dynamically evaluated using Moire topography. Static topography showed 14% of asymptomatic subjects, 32% of unstable subjects and 57% of impingement subjects had asymmetric scapular position. Dynamic topography demonstrated 18% of asymptomatic subjects, 64% of unstable subjects and 100% of impingement subjects had abnormal scapular motion.

While this study did not determine if the abnormal scapular motion was primary or secondary to injury, it was the first to show that abnormal scapular position and motion are present in the vast majority of patients with shoulder pathology.

Kuhn, JE; Plancher, KD; Hawkins, RJ. Scapular Winging. Journal of the American Academy of Orthopaedic Surgeons 3: 319- 325, 1995.

This article discussed the possible causes of “scapular winging” noting primary, secondary, and voluntary causes. Primary winging was noted to occur from neurologic

injury, pathologic changes in bone, or peri-scapular soft-tissue abnormalities. Secondary winging arises from internal derangement within the glenohumeral joint whereas voluntary winging may be due to an underlying psychological disorder. Injury to the spinal accessory nerve, long thoracic nerve, and/or dorsal scapular nerve would compromise the function and position of the scapula. Pathologic changes in bone included osteochondromas and fracture malunions. Soft-tissue concerns such as contractures, muscle avulsions, and bursitis can cause scapular winging to occur as well. The authors noted that conservative treatment will often help alleviate this problem. While specific exercises were not discussed, it was noted that the peri-scapular musculature should be the point of focus in rehabilitation.

Ludewig, PM; Cook, TM; Nawoczenski, DA. Three dimensional scapular orientation and muscle activity at selected positions of humeral elevation. Journal of Orthopaedic Sport Physical Therapy 24(2): 57-65, 1996.

This was the first study to describe normal 3D scapular orientation and scapular muscle activity during humeral elevation. Digitized 3D scapular motion and surface EMG data from the upper and lower trapezius, levator scapulae and serratus anterior was obtained from 25 asymptomatic subjects. Each subject performed active humeral elevation in the plane of the scapula. As the humeral elevation increased, a pattern of increased upward rotation, decreased internal rotation, and increased posterior tilt was noted. EMG means showed all muscles tested increased in activity as the humeral angle increased.

The authors suggested that secondary scapular motions which include anterior/posterior tilting and internal/external rotation are significant contributors to abnormal kinematics in shoulder dysfunction.

Ludewig, PM; Cook, TM. Alterations in shoulder kinematics and associated muscle activity in people with symptoms of shoulder impingement. Physical Therapy 80(3): 276-291, 2000.

52 construction workers (26 without shoulder impairment and 26 with impingement) were examined in this study. Surface EMG of the upper and lower trapezius as well as the serratus anterior was obtained along with 3D scapular motion. Subjects were instructed to actively elevate their arm in the plane of the scapula under 3 conditions: no load, 2.3kg load, and 4.6kg load. Variables were examined at 3 phases of motion – 31° to 60°, 61° -90°, and 91° -120°.

The subjects with impingement demonstrated decreased upward rotation, increased anterior tilt, and increased internal rotation when loaded. The serratus anterior activity was decreased across all loads and phases of motion.

This study provides evidence that shoulder pain arising from “impingement” alters the scapular kinematics and scapular muscle activity. These findings indicate these areas should be a point of focus in shoulder rehabilitation programs.

McClure, PW; Michener, LA; Sennett, BJ; Karduna, AR. Direct 3-dimensional measurement of scapular kinematics during dynamic movements in vivo. Journal of Shoulder and Elbow Surgery 10(3): 269-277, 2001.

This controlled laboratory study was the first reported study to quantitatively describe the motions of the scapula during dynamic shoulder movements using an invasive method of analysis. Direct measurement of scapular motion was examined in 8 healthy subjects by inserting 2 1.6mm bone pins into the spine of the non-dominant arm scapula. A 3D sensor was attached to the pins in order to track the kinematics of the scapula.

During active scaption, the scapula upwardly rotated 50° ± 4.8°, posteriorly tilted 30° ± 13°, and externally rotated 24° ± 12.8°. Lowering of the arm resulted in a reversal of the patterns. The mean ratio of glenohumeral to scapulothoracic motion was 1.7:1.

The study resulted in the confirmation that scapular motion consists of 3 rotations around 3 axes, not just upward rotation as originally described. These motions are upward/downward rotation around a frontal plane axis; anterior/posterior tilt around a sagittal plane axis slightly elevated; and internal/external rotation around a transverse plane axis.

Kibler, WB; Uhl, TL; Maddux, JWQ; Brooks, PV; Zeller, B; McMullen, J. Qualitative clinical evaluation of scapular dysfunction: a reliability study. Journal of Shoulder and Elbow Surgery 11(6): 550-556, 2002.

This controlled laboratory study was the first attempt at classifying scapular dyskinesis into different categories due to the lack of accepted terminology regarding the finding.

4 blinded evaluators (2 physicians and 2 physical therapists) were familiarized with the devised method of clinical observation for scapular dyskinesis. The classification system for scapular dyskinesis was based on 4 possible observances: Type I = inferior angle prominence, Type II = medial border prominence, Type III = superior border prominence and Type IV = symmetric motion. Once this was completed, each evaluator viewed a video tape of 26 subjects with and without scapular dysfunction. Each evaluator was asked to categorize the predominant scapular movement pattern observed during bilateral humeral scaption and abduction movements. Inter-tester reliability was 0.4 whereas intra-tester reliability was 0.5.

It was concluded that the classification system was not diagnostic for a specific injury. The observation system developed in this study was an attempt at creating a non-invasive method of assessing the various movement patterns related to scapular dyskinesis.

Kibler, WB; McMullen, J. Scapular dyskinesis and its relation to shoulder pain. Journal of the American Academy of Orthopaedic Surgeons. 11(2): 142-151, 2003.

This article focuses on the definition, causes, and evaluation of scapular dyskinesis and how it affects shoulder function.

Scapular dyskinesis is an alteration in the normal position or motion of the scapular during scapulohumeral movements. It occurs in various injuries and often results in inhibition or disorganization of activation patterns in the scapular stabilizing muscles. Scapular dyskinesis is a non-specific response to shoulder dysfunction. Three effects of scapular dyskinesis have been identified: loss of retraction/protraction control, loss of elevation control, and loss of kinetic chain function. These effects have been related to posterior shoulder tightness, loss of the lower trapezius/serratus anterior force couple, and inefficient force transmittance from the lower segments of the kinetic chain. Evaluation of this altered scapular motion is performed through assessment of dynamic shoulder motion, manual muscle testing, and corrective maneuvers such as the scapular assistance test and scapular retraction test.

Myers, JB; Laudner, KG; Pasquale, MR; Bradley, JP; Lephart, SM. Scapular position and orientation in throwing athletes. American Journal of Sports Medicine 33(2): 263-271, 2005.

This study attempted to quantify scapular position and orientation in throwing and non-throwing athletes. Scapular upward/downward rotation, internal/external rotation, anterior/posterior tilting, elevation/depression, and protraction/retraction were assessed in 21 male throwing athletes and 21 matched (age, gender, height, weight, arm dominance) non-throwing subjects. The throwing subjects demonstrated significantly increased upward rotation, internal rotation, and retraction during humeral elevation.

These findings indicate that throwing athletes possibly develop adaptations for efficient performance of the throwing motion. However, excessive protraction and/or internal rotation can be deleterious in shoulder dependent activities such as throwing due to the fact that those positions decrease the subacromial space.

McClure, PW; Michener, LA; Karduna, AR. Shoulder function and 3-dimensional scapular kinematics in people with and without shoulder impingement syndrome. Physical Therapy 86(8): 1075-1090, 2006.

This study compared 3D scapular kinematics, shoulder ROM, muscle force, and posture in subjects with and without shoulder impingement syndrome.

45 subjects with impingement syndrome and 45 matched controls (matched by age, gender, and hand dominance) were examined. ROM and posture were measured with a goniometer. Muscle force was measured using a hand-held dynamometer and the "break tests" of neutral shoulder external rotation at the side of the body, neutral shoulder internal rotation at the side of the body, and scaption at 90° with neutral rotation. Scapular kinematics was obtained during active elevation in the sagittal plane scapular plane, and external rotation with the arm at 90° of elevation in the frontal plane.

The subjects with impingement had more scapular upward rotation and clavicular elevation during flexion as well as more posterior tilt and clavicular retraction during elevation compared to the control subjects. This group also had less ROM and strength compared to the control group.

This study suggests that impingement patients may develop scapular motion changes which are compensations for scapular muscle weakness. These findings support the notion of rehabilitating the scapula as a part of shoulder therapy in order to reestablish proper scapular humeral motion.

38. Neurological Injuries Around the Shoulder

Hershman, EB. Brachial plexus injuries. Clinics in Sports Medicine 9: 311-329, 1990.

This clinical review provides a comprehensive overview of this injury in athletics. It describes the relevant anatomy, physical examination, other methods of testing, and principles of treatment.

This paper provides useful information on the anatomy of the plexus, causation of injury, and recognition of injury patterns.

Warner, JJP; Krushell, RJ; Masquelet, A, et al. Anatomy and relationships of the suprascapular nerve: anatomical constraints to mobilization of the supraspinatus and infraspinatus muscles in the management of massive rotator cuff tears. Journal of Bone and Joint Surgery 74: 36-45, 1992.

This cadaver study delineated the position of the suprascapular nerve and its relation to the supraspinatus muscle. It demonstrated limited ability to mobilize and advance the supraspinatus muscle laterally – perhaps only up to 3cm – before there was traction on the nerve. Care must be taken when attempting to mobilize the supraspinatus to not injure the nerve by excessive traction.

Birch, R. Surgery for brachial plexus injuries. Journal of Bone and Joint Surgery 75: 346-348, 1993.

This editorial reviews the historically poor results of early surgical attempts at nerve repair, but also summarizes more specific diagnostic techniques and better surgical techniques for repair and grafting. It highlights which type of evaluation and treatment should be advocated for specific types of injuries.

Rayan, GM; Jensen, C. Thoracic outlet syndrome: provocative examination maneuvers in a typical population. Journal of Shoulder and Elbow Surgery 4: 113-117, 1995.

This study evaluated neurologic changes and vascular changes in extremities of normal subjects with 3 different clinical maneuvers that may be utilized for diagnosis of thoracic outlet syndrome. It found that women had changes more frequently than men, that vascular changes were more frequent than neurologic changes, and that the hyperabduction maneuver created more changes than the Adson's maneuver.

If these tests are positive in the presence of other symptoms and signs, these results add to the confirmation of the diagnosis.

Phipps, GJ; Hoffer, MM. Latissimus dorsi and teres major transfer to rotator cuff for Erb's palsy. Journal of Shoulder and Elbow Surgery 4: 124-129, 1995.

This paper reviewed long term results of muscle transfers for resistant and progressive internal rotation contractures following Erb's palsy. Patients showed increase in active and passive external rotation, and most also showed increase abduction strength. The results improved functional use of the arm in daily activities.

Martin, SD; Warren, RF, Martin, T, et al. Suprascapular neuropathy – results of non-operative treatment. Journal of Bone and Joint Surgery 79: 1159-1165, 1997.

This retrospective paper reviewed non-operative treatment of patients diagnosed by EMG with suprascapular neuropathy. The treatment consisted of strengthening the periscapular and rotator cuff muscles, and avoiding positions or activities that would place extra tension on the nerve. 12/15 had good to excellent results based on range of motion, strength, and pain criteria. Even though subjective strength was considered good by most patients, objective strength was decreased in half of the patients with good results.

Romeo, AA, Rotenberg, DD; Bach, BR. Suprascapular neuropathy. Journal of the American Academy of Orthopaedic Surgeons 7: 358-367, 1999.

This review article describes the anatomy and possible causes of suprascapular neuropathy. Compression and traction etiologies are outlined. The clinical presentation and clinical examination are described. A complete treatment algorithm is provided.

Cummins, CA; Messer, TM; Nuber, GW. Suprascapular nerve entrapment. Journal of Bone and Joint Surgery. 82: 415-424, 2000.

This current concepts review provides detailed information regarding all aspects of compression or injury to the suprascapular nerve. It details anatomy, pathophysiology, clinical evaluation, and treatment options. It documents the results of non-operative and operative treatment.

This paper allows an in depth understanding of this clinical entity, which can be missed as a cause of shoulder dysfunction.

39. Rehabilitation

Burkhead, WZ; Rockwood, CA. Treatment of instability of the shoulder with an exercise program. Journal of Bone and Surgery 74: 890-896, 1992.

This study retrospectively evaluated the success of a progressive resistance exercise program focused mainly on the shoulder muscles in preventing the need for surgery in patients with traumatic or atraumatic shoulder instability. Patients with atraumatic instability or predominantly posterior instability had much higher levels of success than patients with traumatic anterior instability.

Specific rehabilitation exercises focused on stabilizing the glenohumeral articulation and restoring scapulohumeral rhythm can have high rates of success in decreasing the need for surgical stabilization in atraumatic and posterior instability, and should be utilized as the initial method of treatment.

McCann, PD; Wootten, ME; Kadaba, MP, et al. A kinematic and electromyographic study of shoulder rehabilitation exercises. Clinical Orthopedics and Related Research 288: 179-188, 1993.

This study investigated muscle activation and scapulohumeral rhythm in normal subjects as they performed exercises in all phases of the Neer exercise program – Phase I (passive), Phase II (active), and Phase III (resistive). There was a gradation of EMG activity as the exercises progressed from Phase I to Phase III. EMG activities in Phase I are low enough so that these exercises should be safe in the early post-operative period.

This study provides background to show which exercises can be considered at various stages of post operative rehabilitation. The major problem is deciding when each phase should begin and end.

Sapege, AA; Kelley, MJ. Strength testing of the shoulder. Journal of Shoulder and Elbow Surgery 3: 327-345, 1994.

This review describes the indications, methods, and interpretations of strength testing around the shoulder. It discusses definitions of strength, power, and endurance, describes the various methods of manual and machine assisted testing, and provides guidelines for how to interpret the data from the several methods.

This is a key reference to understanding strength testing and rehabilitation based on the testing.

Lephart, SM; Pincivero, DM; Giraldo, JL, et al. The role of proprioception in the management and rehabilitation of athletic injuries. American Journal of Sports Medicine 25: 130-137, 1997.

This current concepts article defines proprioception and demonstrates its role in mediating coordinated activities in the neuromuscular system. Injury often disrupts the normal proprioceptive pathways. Rehabilitation protocols must include exercises to restore the proprioceptive control of dynamic joint stability as part of functional restoration.

This article discusses clinical applications at the knee, ankle, and shoulder, and demonstrates techniques for the exercises.

Kibler, WB; Livingston, B. Closed chain rehabilitation for upper and lower extremities. Journal of the American Academy of Orthopaedic Surgeons 9: 412-421, 2001.

This clinical review provides an overview of components of closed chain rehabilitation. It defines a closed chain exercise, how closed chain exercises may be used to promote functional restoration, and provides examples of closed chain exercises that may be used in the various stages of shoulder rehabilitation.

Closed chain exercises can be key elements in functional rehabilitation programs, especially in the early phases where control of joint position and loads are important to minimize stress on healing tissues. This review outlines methods to maximize the effectiveness of this type of exercise.

Roddy, TS; Olson, SL; Gartsmann, GM, et al. A randomized controlled trial comparing 2 instructional approaches to home exercise instruction following arthroscopic full thickness rotator cuff repair surgery. Journal of Orthopaedic Sports Physical Therapy 32: 548-559, 2002.

This prospective randomized trial compared video instruction for specific exercises following rotator cuff surgery with personal instruction by a physical therapist. Self reported subjective outcomes scores were the measurement tools. Physical therapists were available to the video group to answer questions about the exercises. There were no physical performance or impairment based measurement tools. There were no significant differences in overall self reported outcomes between the 2 groups.

This study suggests that videotapes can be helpful in patient education regarding rehabilitation. It appears that therapist involvement to answer questions about the exercises and to provide assessment regarding when to progress in exercises is also an important factor. The absence of objective range of motion and strength data limits the knowledge of how patients progressed in the exercises.

Burkhart, SS; Morgan, CD; Kibler, WB. The disabled throwing shoulder: Spectrum of pathology part III: the SICK scapula, scapular dyskinesis, the kinetic chain, and rehabilitation. Arthroscopy 19: 641-661, 2003.

This article presents a biomechanical rationale for scapular dyskinesis in throwers, provides techniques for evaluation of alterations in scapular position and motion, and demonstrates exercises and protocols for rehabilitation of the scapula as part of shoulder rehabilitation.

This article is helpful in placing scapular dyskinesis in a context that can be used to provide functional rehabilitation for the shoulder.

Kim, SH; Ha, KI; Jung, MW, et al. Accelerated rehabilitation after arthroscopic Bankart repair for selected cases: A prospective randomized clinical study. Arthroscopy 19: 722-731, 2003.

This prospective study compared immobilization for 3 weeks, followed by conventional strengthening with immediate range of motion and strengthening exercises in patients with isolated Bankart repairs. Functional and subjective outcomes scores were no different between the 2 groups. The immediate rehabilitation group achieved functional range of motion and desired activity level earlier, and reported less pain and more satisfaction with the rehabilitation program.

Early rehabilitation can be successfully implemented in this group of surgical patients. It is not known if the same approach can be equally successful in surgical patients with other pathologies and other treatments.

Ide, J; Maeda, S; Yamaga, M, et al. Shoulder strengthening exercise with orthosis for multidirectional instability: Quantitative evaluation of rational shoulder strength before and after the exercise program. Journal of Shoulder and Elbow Surgery 12: 342-345, 2003.

This study evaluated strength and outcomes in patients with multidirectional instability following an exercise program that was facilitated by a brace that helped to stabilize the scapula in a position of retraction. There was no control group. Significant improvement was seen in outcomes scores and rotational strength. The best results were seen in those with the largest strength gains. 11% continued to have recurrence of signs and symptoms.

Rehabilitation, with emphasis on scapular control and balance of external and internal rotation, can improve clinical stability and shoulder function in patients with multidirectional instability.

Wise, MB; Uhl, TL; Mattacola, CG, et al. The effect of limb support on muscle activation during shoulder exercises. Journal of Shoulder and Elbow Surgery 13: 614-620, 2004.

This study evaluated muscle activation intensity during unsupported (open chain) and supported (closed chain) shoulder exercises at different arm angles and speeds. Greater muscle activation was seen in open chain over closed chain exercises, diagonal over vertical arm positions, and faster over slower arm speeds.

The gradation in muscle activation can be varied and progressed by manipulating type of exercise, arm angle, and arm speed. These variables can be used in developing a progression of exercises based on healing and strength of the tissues.

Diercks, RL; Stevens, M. Gentle thawing of the frozen shoulder: A prospective study of supervised neglect versus intense physical therapy in patients with frozen shoulder syndrome. Journal of Shoulder and Elbow Surgery 13: 199-502, 2004.

This prospective study compared supportive symptomatic therapy and exercises within pain limits versus intensive stretching and mobilization. Constant score was the outcome measure. No specific range of motion values were recorded after treatment. The constant score was higher in the supportive therapy group.

Organized intense physical therapy may not positively affect the healing in idiopathic frozen shoulder.

Brotzman, SB; Wilk, KE (eds). Clinical Orthopedic Rehabilitation 2003, Handbook of Orthopedic Rehbailitation 2007. Mosby Elsevier, Philadelphia.

These 2 books provide a strong foundation for rehabilitation of all joints including the shoulder. They include sections on pathophysiology of injury and examination for deficits as well as detailed protocols, exercises, and progressions. The protocols and progressions are injury specific.

40. Techniques of Rehabilitation

Wilk, KE, Meister, K, Andrews, JR. Current Concepts in the Rehabilitation of the Overhead Throwing Athlete. Am. J. Sports Med. 30 (1);136-151, 2002

Rehabilitation of the overhead throwing athlete requires knowledge of anatomechnics, sport specific techniques and the physiology of exercise response. The joint and soft tissue stress during athletic competition can be enormous. Adaptive changes allow the over head athlete to compete at high levels; however, the neuromuscular system must optimally function to prevent injury. Efficient rehabilitation is required to maximize tissue healing, minimize performance loss and return the athlete to play when injury occurs.

This review article gave an excellent review of physical characteristics of the overhead athlete including; shoulder range of motion, laxity, strength and proprioception. The authors provide a multiphase approach to shoulder rehabilitation of the throwing athlete beginning with the acute phase in which pain and inflammation are controlled by using modalities, appropriate exercise and rest from the overhead sport. The return or normalization of range of motion is critical especially internal rotation range of motion. Posterior capsule, posterior rotator cuff and pectoralis minor tightness are assessed and treated progressively. The intermediate phase concentrates on improving strength, muscular balance and flexibility. Both rotator cuff and scapular muscle coordination and strength are emphasized using the "Thrower's Ten Program". Both core strength and aerobic training are developed. The third phase emphasizes advanced strengthening and endurance exercise utilizing the thrower's ten program, closed chain exercise, plyometrics and functional position exercises using resisted bands. Short distance throwing or overhead sport specific activity is initiated. The fourth phase prepares the athlete to return t activity by progressing the interval throwing program toward competitive throwing intensity. The authors discussed disorder specific rehabilitation guidelines including impingement, SLAP lesions and instability. Evaluation and identification of improper throwing mechanics was discussed.

The authors provided a straight forward yet comprehensive review of shoulder rehabilitation specific to the overhead throwing athlete. They presented the adaptive changes recognized in this type of athlete and synthesize it with the multiphase rehabilitation approach. The discussion of identifying improper throwing mechanics was very helpful to the reader as was the pathology specific rehabilitation guidelines. This review is very helpful to the clinician who may not be familiar with treating the overhead throwing athlete but is also an excellent review for the seasoned clinician.

Griggs S, Ahn A, Green A. Idiopathic adhesive capsulitis: A prospective functional outcome study of nonoperative treatment. J Bone Joint Surg. 2000;82(10):1398-1417.

Adhesive Capsulitis or frozen shoulder is a commonly encountered orthopaedic disorder affecting the shoulder. Adhesive capsulitis is considered a self-limiting process

lasting between 12-18 months; however, patients have been shown to have protracted symptoms. Many interventions have been used to treat adhesive capsulitis including oral medication, steroid injections, exercise, mobilization, distension, acupuncture, manipulation, nerve blocks and surgery. Physical therapy and exercise is typically the first intervention chosen to address the associated pain and stiffness that are the hallmarks of adhesive capsulitis. It remains unclear whether physical therapy is the best intervention.

Griggs et al performed a prospective study of 75 consecutive patients with Phase II adhesive capsulitis. The mean age of patients was 53 years, more females (77%) than males (23) were among the group and the mean duration of symptoms was 9.2 months. The study found that 90% of the patients managed with a conservative range of motion (ROM) program were satisfied with the outcome of their shoulder. All outcome measures (ROM, pain, Disabilities of the Arm, Shoulder and Hand Questionnaire (DASH), Simple Shoulder Test (SST) and the Short Form-36 (SF-36)) significantly improved. Five patients went on to either manipulation or capsular release and 2 did not improve following these interventions (both had diabetes mellitus). Even though the majority of patients were satisfied 40 percent demonstrated abnormal DASH scores (9.7 + 13.6). They found that ROM did not correlate with functional outcomes but pain with activity did correlate with a lower SST and DASH score.

Griggs et al study provided insight into the efficaciousness of physical therapy and a simple ROM program in treating adhesive capsulitis. Other prospective studies have demonstrated that physical therapy directed programs result in improved outcomes, however, many previous studies only use pain and or ROM as final outcomes. Griggs et al used shoulder specific outcome tools and emphasized that patient satisfaction does not correlate with the return of full motion or complete function. Griggs et al. provided a rich prospective outcome oriented study that provides evidence for the use of physical therapy in treating adhesive capsulitis.

Kelley, MJ and Leggin BL, Rogers, K. General Techniques of Shoulder Rehabilitation. In Diagnosis and Management (2nd ed). Iannotti JP and Williams GR (eds). Lippincott, Philadelphia, PA, 2006.

Shoulder rehabilitation is critical to the recovery of patients following trauma or surgery. Effective physical therapy requires the use of anatomy, biomechanics and knowledge of tissue response to trauma. Therapeutic interventions are adapted to the pathology or surgical procedure to maximize outcome.

This chapter provides an overview of shoulder rehabilitation related to different shoulder disorders. A variety of rehabilitation modalities, techniques and exercise are described related to specific pathologies or postoperative conditions. Evidence regarding supervision level and frequency of rehabilitation is discussed. There is evidence to support less frequent visits with emphasis of a therapists directed home exercise program. However, the patient must be treated individually based upon there presentation. Phases of rehabilitation were highlighted based upon tissue reactivity and tissue healing parameters. A phased exercise progression was presented related to range of motion,

active exercise and strengthening. Rotator cuff repair outcome literature was highlighted and used to demonstrate the importance of protecting the repair by encouraging exercises requiring minimal muscle activation instead of emphasizing exercises that encourage maximal muscle recruitment. This is particularly important during the early phases of treating patients following rotator cuff repair or hemiarthroplasty following a 4-part fracture. Rehabilitation techniques such as manual therapy (PNF and joint mobilization) were described and rationale for their use discussed. Integrating and progressing the use of various exercise equipment such as the BodyBlade (Hymanson Inc., Playa Del Ray, CA) and plyometrics was discussed. The reader will become familiar with late stage rehabilitation which prepares the patient for return to work or the athlete, return to play.

This was an excellent overview of shoulder rehabilitation because the authors integrate knowledge regarding tissue response to commonly performed exercises. The reader will become familiar with all aspects of shoulder rehabilitation, exercise indications and contraindications.

41. Outcomes Measurement

Kirkley A., Alvarez C., Griffin S. The Development and Evaluation of a Disease-specific Quality-of-Life Questionnaire for Disorders of the Rotator Cuff: The Western Ontario Rotator Cuff Index. Clinical Journal of Sport Medicine 2003; 13:84-92

The goal of this study was to develop a health-related quality of life assessment tool to specifically evaluate patients with rotator cuff disease. A pool of 150 patients who had received no treatment to date was complied investigate several aspects of this questionnaire's development. Patients were eligible for this study is they presented with acute rotator cuff tendinitis, rotator cuff tendinosis with no tear, partial thickness rotator cuff tears or rotator cuff arthropathy. Diagnosis was confirmed by patient history, examination and imaging studies. A total of 21 equally weighted questions were chosen across the five domains to gauge subject's health. These domains included pain and physical symptoms (6 questions), sports and recreation (4), work function (4), social function (4) and emotional function (3). Each question was to be answered in the form of a 100mm length Visual Analog Scale. Each question was worth a total of 100 points recorded to the closest mm. Summation of these 21 scores gave a total possible score of 2100. It was recommended total scores should be reported as the percentage with 0% being the most symptomatic (2100 pts.) and 100% being asymptomatic (0pts). 55 of a total 100 participants' who reported no change in symptoms between baseline and 2 weeks were found to have an intraclass correlation coefficient of .96 for total score. Scores per domain were considerably less correlated. Total score should be considered the only reliable measure. The Western Ontario Rotator Cuff Index (WORC) was validated without the use of a standard but instead by using several common evaluation questionnaires. The WORC correlated best with the ASES (r=.75) followed by the UCLA Shoulder rating scale (r=.65).

This questionnaire relies on clinician/patient interaction therefore emphasis is put on following provided instructions to each question strictly. This questionnaire can be used consistently with this population with hesitation being made for comparison between seemingly similar tests. This research was outstanding in the extensive length researchers took to choose the most effective and a germane question to cover the many aspects of evaluating what is considered "healthy".

Harvie P., Pollard T.C.B., Chennagiri, Carr, A.J. The use of outcome scores in surgery of the shoulder The Journal of Bone & Joint Surgery 2005; 87-B: 151-4

This study was a systematic review of the use of outcome scores and research methods in surgery of the shoulder. All articles relating to the shoulder with a clinical outcome published between 1992 and 2002 in the Journal of Shoulder and Elbow Surgery and the Journal of Bone and Joint Surgery [British and American] were evaluated and grouped according to clinical questionnaire and levels of evidence. The amount of patients, minimum and maximum mean periods of follow-up time were recorded. The mean follow

up time was 27 months with a minimum of 12 and a maximum of 68 months. The Constant–Murley shoulder score (CMS)was the most prevalently used, followed by the American Shoulder and Elbow Surgeons standardized shoulder assessment form (ASES) and Rowe instability score. Clinician based assessment scores such as the CMS were criticized for possibly being biased while a patient based-assessment score were recommended for use in clinical trials and comparing cohort studies.

Recommendations were made to push towards patient based assessment forms to improve the amount of evidence but one must use caution in properly administering the appropriate scale to the originally intended patient population for which the assessment form was used. Scores of assessment tests were considered invalid and incomparable to other studies if ever modified, therefore modification of scores is not recommended. Exception was found for the patient self-reporting section of the modified American Shoulder and Elbow Surgeons assessment form (M-ASES) which has undergone validation.

Dawson J., Hill G., Fitzpatrick R., Carr A. Comparison of Clinical and Patient-Based Measures to Assess Medium-Term Outcomes Following Shoulder Surgery for Disorders of the Rotator Cuff. Arthritis & Rheumatism 2002; 47 (5): 513-519

This study compared the long term effectiveness of three forms of assessment for rotator cuff disorders. These assessment methods included two patient-based assessments; 1) The Oxford Shoulder Score (OSS), a condition specific assessment, 2) The Medical Outcomes Study Short Form-36 questionnaire (SF-36), a general health status instrument and 3) a clinician-based Constant Shoulder Score involving subjective assessments of pain, function and objective measurements of active range of motion and strength. These three assessment methods were compared amongst each other for 4 types of surgeries received. 82 patients completed this study in full with conditions being rotator cuff tears requiring full repair(n=16), partial repair(6), full tear with no repair(11), and a 4th group with no rotator cuff tear requiring no repair(49). Each patient was evaluated with all assessments prior to surgery, 6 months post surgery, and after a median of 3.9 years (2.2-5.6 yrs.) post surgery. In addition to these three assessments, both post surgical sessions involved completing a separate questionnaire evaluating the patient's view on the success of their surgery using an ordinal answer scale. These questions were "How successful do you feel your shoulder operation has been?", "How have the problems related to your shoulder changed since you had your operation?" and "How has your shoulder operation changed you day-to-day life so far?" Changes in scores from the preoperative to the two post operative assessments were reported. Results for both post surgical assessments remained relatively constant with the Constant Shoulder Score having slightly lower values. The authors indicate that this study should not be viewed as an outcome study for different types of treatment but rather a tool to gage which types of assessment tests should be used to properly evaluate surgical patients.

This paper's clinical application is in its recommendation to use a patient's input when evaluating the outcome of rotator cuff surgeries after an extended period of time. Results of score changes for all tests are given as a reference and no significant finding were seen between test but this is most likely due to the small effect size after breaking the population down into groups. Despite the lack of significance in findings, all score changes

for every measurement point are reported which could be useful information for comparing one's own surgical results to a similar patient population when the appropriate sample population is used. Most scores indicate that at a lengthy follow up period, patient based assessments might be the easiest to implement and give as much useful information as opposed to a clinician based assessment. Caution should be exercised on an individual basis since the competence of the patient's ability to judge a possible complication might be of concern.

Gartsman G., Brinker M., Khan M., Karahan M. Self-assessment of general health status in patients with five common shoulder conditions. Journal of Shoulder Elbow Surgery 1998; 7(3): 229-237

The SF-36 Health Survey (SF-36) is a patient self-administered survey designed to evaluate the effect of disease on the patient's perceived general health. The SF-36 attempts to evaluate the physical and mental components of health using 36 items grouped into 8 categories; Physical functioning, Role-Physical, Bodily Pain, General Health, Vitality, Social Functioning, Role-Emotional and Mental Health. This paper examines 5 specific ailments of the rotator cuff using collected and previously reported data collected using the SF-36 health survey with the goal of establishing baseline comparisons for clinicians for these particular conditions. The population consisted of 544 patients presenting with exclusively one of 5 conditions which were anterior glenohumeral instability(149), complete reparable rotator cuff tear(111), adhesive capsulitis(100), osteoarthritis(67), and impingement(117). Results of the SF-36 were compared with U.S. general population norms by age and sex as well as with five other unrelated major medical conditions specifically hypertension, congestive heart failure, diabetes mellitus type II, myocardial infarction and clinical depression. In general, scores for rotator cuff ailments were significantly lower than the U.S. population norm and comparable to other health ailments.

This paper does an outstanding job of reporting quantitative data for all aspects of scores for all investigated categories. Also, extensive information is given for elaboration of specific aspects of this assessment method opposed to being referred to the original paper involving development of this test. Despite no direct questions concerning the shoulder in the SF-36, it is apparent that conditions affecting the shoulder do effect an individual's perception of their general health comparable to the effect several major medical conditions have on determined general health. It is recommended that this method be used in conjunction with disease specific assessments such as the ASES questionnaire.

Beaton D, Richards RR. Assessing the reliability and responsiveness of 5 shoulder questionnaires. Journal of Shoulder and Elbow Surgery 1998; 7(6):565-572.

This study compared 5 separate shoulder questionnaires along with the SF-36 for their reliability and responsiveness in patients with shoulder pathologies. The five shoulder questionnaires evaluated were the Shoulder Pain and Disability Index, Simple Shoulder Test, Modified American Shoulder and Elbow Surgeons Form, Subjective Shoulder Rating Scale

and the Shoulder Severity Index. All questionnaires were found to have very good reliability except for the Subjective Shoulder Rating Scale. To evaluate responsiveness, patients that would be expected to change over the course of 6 months such as those undergoing surgery for rotator cuff repair or shoulder arthroplasty were evaluated. All shoulder questionnaires demonstrated a moderate to large effect except for the Subjective Shoulder Rating Scale. It was also demonstrated that the SF-36 was not as responsive to change in patients except for the subscales of pain.

This is an important study as it demonstrates the importance of using joint or region specific questionnaires in measuring disability and function for orthopaedic populations. The SF-36 is a very useful general health status questionnaire but is not necessarily sensitive to important changes in shoulder function. This study provides important reliability basis for several questionnaires used in evaluating shoulder function while simultaneously demonstrating several questionnaires' ability to measure change.

Michener LA McClure PW, Sennett BJ. American shoulder and elbow surgeons standardized shoulder assessment form, patient self-report section: reliability, validity, and responsiveness. Journal of Shoulder and Elbow Surgery 2002; 11(6):587-594.

This study evaluated the psychometric properties of the ASES form using 63 patients with shoulder pain of varying diagnoses. The total ASES score ranges from 0 – 100 points with 50 points derived from a visual analog pain question, "How bad is your pain today?" and 50 points derived from a 10 question functional composite score. The individual components and total score demonstrated good reliability (above .75) ranging from .79 to .84. The scores of the ASES were compared to a Penn Shoulder Score and physical function score of the SF-36 and were found to have high correlation r = .78 with the Penn Score and moderate but significant correlation with the SF-36 (r =. 41). The authors demonstrate through divergent validity statistical measure that the point that region specific ASES questionnaire provides important information about shoulder function but other components of a patient's mental and emotional state cannot be captured with an ASES self-report questionnaire. Therefore, if the physician is interested in capturing mental and emotional information about their patients, other measures such as the SF-36 heat status measure should be utilized.

The responsiveness or ability to detect change was evaluated using both a patient's global rating of change and a physical therapist's perspective of a patient's change. The authors do a great job of explaining why and how the statistical measures are used and calculated. Their data demonstrated that the ASES total score can determine a statistically meaningful change in function with a change score of 16 points based on a 90% confidence interval. However a clinically meaningful change could be perceived by patients with a change of only 6.4 points which might be more relevant for clinical practice. The application of this paper for clinicians is that it validates the ASES self-report form and gives clinicians threshold points of both clinically and statistically meaningful changes over the course of an intervention. This scale appears to be very appropriate to evaluate change in shoulder function over the course of an intervention.

Leggin BG, Michener LA, Shaffer MA, Brenneman SK, Iannotti JP, Williams GR. The Penn shoulder score: reliability and validity. Journal of Orthopaedic and Sports Physical Therapy 2006; 36(3):138-151.

This study evaluated the psychometric properties of a new shoulder self-report form developed at the University of Pennsylvania. The total Penn score ranges from 0 – 100 points with 3 subscales; pain accounting for 30 points, satisfaction accounting for 10 points, and function accounting for 60 points of the total score. One novel component to the function subscale is that if a function or multiple functions is not performed by a patient before an injury, the scoring system allows this question to be removed and will still provide a score out of 60. The overall reliability of the Penn Shoulder Score was very good (ICC =.94) and the individual components were all greater than ICC >.88. The Penn shoulder scores were highly correlated (r=.85) with the ASES and Constant-Murley scores indicating good convergent and construct validity to other shoulder outcome measures. The authors provide minimal clinically import differences based on score ranges and an overall change of 12.1 points. This provides clinicians who work with different levels of function a better idea of how much change is meaningful depending on the starting level of function.

The research was evaluated using a wide variety of shoulder pathologies which improves the implication of this device to a general population of shoulder patients. The authors provide the reader with very comprehensive tables which are helpful for comparisons in the future. The authors also do a very good job of explaining the statistical tests in a very clear and practical manner for a reader not familiar with some of the intricacies of measures such as minimal detectable change. The information provided allows the future users of this scale with good background information on the psychometric properties of the scale, provides a sample of the scale and how the test should be scored. This scale appears to be a very good scale to evaluate patients with shoulder dysfunction.

Sally PI, Reed L. The measurement of normative American shoulder and elbow surgeons score. Journal of Shoulder and Elbow Surgeons 2003; 12(6):622-627.

The purpose of this article is to provide baseline descriptive normative values of the ASES self-report shoulder form across the lifespan from 6-87 years of age. The authors verbally screened 343 subjects but did not do any confirmatory diagnostic testing to assess normal function of the individuals. The authors provide overall score values categorized by age and provide baseline values for each functional task. The overall score was found to be 92.2 + 14.5 indicating that 100, which is the maximal value, is not the average baseline value of normal function. As expected, there is a slight but not statistically significant drop in ADL scores in the older cohorts. The authors did inquire if these patients thought that their shoulder was normal and a small group (n= 50) reported their shoulder was not normal and their average score reflected a lower score 68+20.5 which was significantly lower than the remaining 293 mean score ($p<.0001$). Additionally, those who play sports had slightly higher score (96.4 + 8) over those who did not (93+ 10)

This is an important article for those using the ASES to assess functional and impairment. It is unrealistic to expect patients to return to a score of 100. In reality it is quite

reasonable to consider a score of 78 based on the results of this study to be a normal level of function for an individual. Clinicians can use these values in determining if their patients are approaching normal functional levels. Additionally, these results provide supporting information of the reliability and discriminate capabilities of the ASES self-report form.

Jaeschke R, Singer J, Guyatt GH. Measurement of health status. Controlled Clinical Trials 1989; 10:407-415

The underlying premise of this study is to describe the psychometric technique of how to measure minimally clinically important differences. This measure is a very important property of any outcome questionnaire used to evaluate change in function. The authors introduce combining a global rating of change scale with the questionnaire of interest to determine minimally clinically important differences (MCID) that might not necessarily be statistical differences but are important changes in function to the patient. In daily clinical practice this is likely a more important measure to determine if interventions are effective. This method provides researchers with a technique to calculate this score for other questionnaires. This psychometric property has been reported in many of the reliability and validity studies reviewed.

In this particular study the authors evaluated pulmonary function questionnaires across time along with a global rating of change score, which is a simple question to the patient as to their current status of condition; “Are you worse, no change, or better”. If the person responds to either worse or better then there is a 7 point Likart scale that the patient marks to give a range of 15 points from -7 to +7. The ends of the scale indicate extremes of change while values such as -1 would indicate a slight worsening and a 0 = no change. The authors, prior to this study, determined from their previous clinical experience observations of physiologically change that they thought would be considered minimally important change on the Chronic Respiratory Questionnaire. It was interesting that the authors were right in line with what was actually found to be what a patient considers clinically meaningful based on the global rating of change and the CRQ form. This accentuates the point that often what we perceive to be a meaningful change is present. The self-report questionnaires can document that for the health care professional and diminish some of their biases.

Hiebert Rudi, Nordin M. Methodological aspects of outcomes research. European Spine Journal 2006; 15(supplement 1):S4-S16.

The primary purpose of this article is to help the health care professional to better understand the quality of an outcomes study, and how the findings of the study support the conclusions made. The authors discuss 7 critical points that should be identified when reading an article to determine if the study is of value. The seven points are

1. identify the research question
2. identify how subjects are enrolled
3. identify the treatments being compared
4. identify the outcomes being assessed

5. identify the study design
6. evaluate the study for potential confounding biases
7. evaluate statistical power

The authors review each point and provide detailed examples of various study designs. These designs are described and illustrated along with limitations and advantages of each design are discussed.

This article provides the health care professional who is not familiar with reading and critically reviewing intervention studies with valuable background information. The article has several references for further details but is a short straightforward read that provides the basics. This is a good first article to read for a health care professional who is not in advance training like a fellowship or some advanced degree program where they will be expected to do more than regurgitate the information. This is a good tool for when they will be expected to analyze the information they have read and determine the relative merit of the information.