Workplace Safety and Insurance
Appeals Tribunal

Tribunal d'appel de la sécurité professionnelle
et de l'assurance contre les accidents du travail

Shoulder Injury and Disability

Discussion paper prepared for

The Workplace Safety and Insurance Appeals Tribunal

Revised: January 2020

Prepared by:

Terry S. Axelrod
MD, MSc, FRCSC

and

Daniel E. Axelrod
MD, MSc.

Dr. Terry Axelrod was born and educated in Toronto, Ontario, Canada. He was the recipient of the Shafran and Cameron awards for highest marks in medicine/surgery when graduating from the University of Toronto Faculty of Medicine. He also completed both his Orthopaedic residency and MSc, at the University of Toronto.

Dr. Axelrod first completed a Trauma and Upper Extremity clinical fellowship at Sunnybrook Health Science Centre and then a clinical and research Hand surgery fellowship with Prof. Ueli Buchler at the Inselspital Bern in Switzerland.

On returning to Canada, Dr. Axelrod assumed a full-time clinical appointment at Sunnybrook Hospital and the University of Toronto, at the rank of Assistant Professor. He has held the position of Division Chief, Sunnybrook Orthopaedics and CME Chair, Dept of Surgery U of T. He has been the recipient of the Bruce Tovee as well as the Robert Salter post graduate resident teaching awards, Department of Surgery, as well as the Marvin Tile Distinguished award for service provided to Sunnybrook Hospital. At the undergraduate level, Dr. Axelrod has received the Peters-Boyd Academy teaching award, as well as the same award, years later for Continuing Education.

Currently, Terry holds the rank of Professor of Surgery at the University of Toronto and continues with a clinical practice in Upper Extremity Trauma and Reconstruction.

Dr. Axelrod has a long affiliation with AO Trauma North America and has served as faculty, chair and co-chair at a multitude of courses across North America, Europe and Asia.

To date, he is author or co-author of approximately 50 peer-reviewed publications, 16 book chapters and several manuscripts.

Terry Axelrod serves as a medical expert for the WSIAT when requested to do so.

Dr. Daniel Axelrod is a third year Resident trainee in Orthopaedic Surgery at McMaster University School of Medicine in Hamilton, Ontario. Currently completing his Masters of Science (MSc) in Health Research Methodology under the supervision of Drs. Bhandari, Sprague and Johal. Daniel has provided research support and fresh insight into this manuscript. To date, Daniel is author or co-author of approximately 15 peer-reviewed publications, 5 book chapters and several manuscripts.

This medical discussion paper will be useful to those seeking general information about the medical issues involved. It is intended to provide a broad and general overview of a medical topic that is frequently considered in Tribunal appeals.

Each medical discussion paper is written by a recognized expert in the field, who has been recommended by the Tribunal's medical counsellors. Each author is asked to present a balanced view of the current medical knowledge on the topic. Discussion papers are not peer reviewed. They are written to be understood by lay individuals.

Discussion papers do not necessarily represent the views of the Tribunal. A vice-chair or panel may consider and rely on the medical information provided in the discussion paper, but the Tribunal is not bound by an opinion expressed in a discussion paper in any particular case. Every Tribunal decision must be based on the facts of the particular appeal. Tribunal adjudicators recognize that it is always open to the parties to an appeal to rely on or to distinguish a medical discussion paper, and to challenge it with alternative evidence: see *Kamara v. Ontario (Workplace Safety and Insurance Appeals Tribunal)* [2009] O.J. No. 2080 (Ont. Div. Court). For more information about these papers, please consult the *WSIAT Guide to Medical Information and Medical Assessors*.

Table of Contents

Introduction:

In revising this document, it was our intention to simplify the layout of the position paper, following a traditional model of reviewing the anatomy, discussing variants of what is normal and then building on this with a discussion of traumatic injuries, abnormalities that are purely age related and those that are a combination of age related degeneration and with an element of trauma or injury contributing to them.

It is important to state at the outset of this paper that the same abnormalities can result in a wide variety of symptoms for any one individual. Some may have minimal, if any complaints in the presence of substantial pathology, yet others will have severely disabling symptoms in a shoulder that shows very little, if any structural pathology within it. Many patients will fall between these two extremes.

This variability of symptom expression is not specific to the shoulder, but rather, can be similarly found in many other areas of the body.

The term musculoskeletal disorder (MSD) has come to replace the term musculoskeletal disease (Wells 1997). None of the common MSDs are caused uniquely by work exposure. Physical and social aspects outside work have to be considered (National Research Council 2001). The same Council also states that MSD is not unique to any occupation; it is more activity-related than work–related. In other words, work-related disorders are multifactorial with work contributing, though not exclusively, to causing the disorder (WHO 1985). Lastly, although referred pain from the neck is common upper extremity complaint, it is outside of the scope of this paper.

Bernard (1997) specifically addressed occupational shoulder disorders (OSD). He used five criteria for assessing evidence:

1. Strength of association
2. Temporal relationship.
3. Consistency of association.
4. Coherence of evidence.
5. Exposure-response relationship

He stated that the evidence for risk involved in getting OSD is the maintenance of specific shoulder postures such as holding a tool while working overhead. Furthermore, he specified this position as being greater than 60 degrees of flexion (forward elevation) or abduction. Recent meta-analyses of clinical studies support this position, arguing that arm-hand elevation is likely associated with shoulder disorders, and certain occupations (assembly and manual workers, where the job environment requires that the arm be frequently used for reaching forward and overhead) are at increased risk for shoulder disorders. [1,2]

Anatomy

A. Bones. (Figure 1)

Three bones form part of the shoulder

1. The collar bone (**clavicle**) is located in front. It serves as a strut, helping to suspend the shoulder girdle
2. The upper arm bone (**humerus**) extends from the shoulder to the elbow, creating parts of both of these joints. The humeral head, at the top of the humerus, serves as one half of the major shoulder joint.
3. The **scapula** or shoulder blade is located on the back of the rib cage. Where it reaches the area of the shoulder, it has two processes (prolongations) (a and b), and two **articular cartilage** surfaces.
    a. The acromion on top of the shoulder, which can have different shapes which may impact on the space present for gliding of the rotator cuff. More details will be discussed below
    b. The coracoid process in front of the shoulder
    c. The glenoid cavity for articulation with the upper arm bone, the head of the humerus
    d. The acromial articular cartilage for articulation with the collar bone.

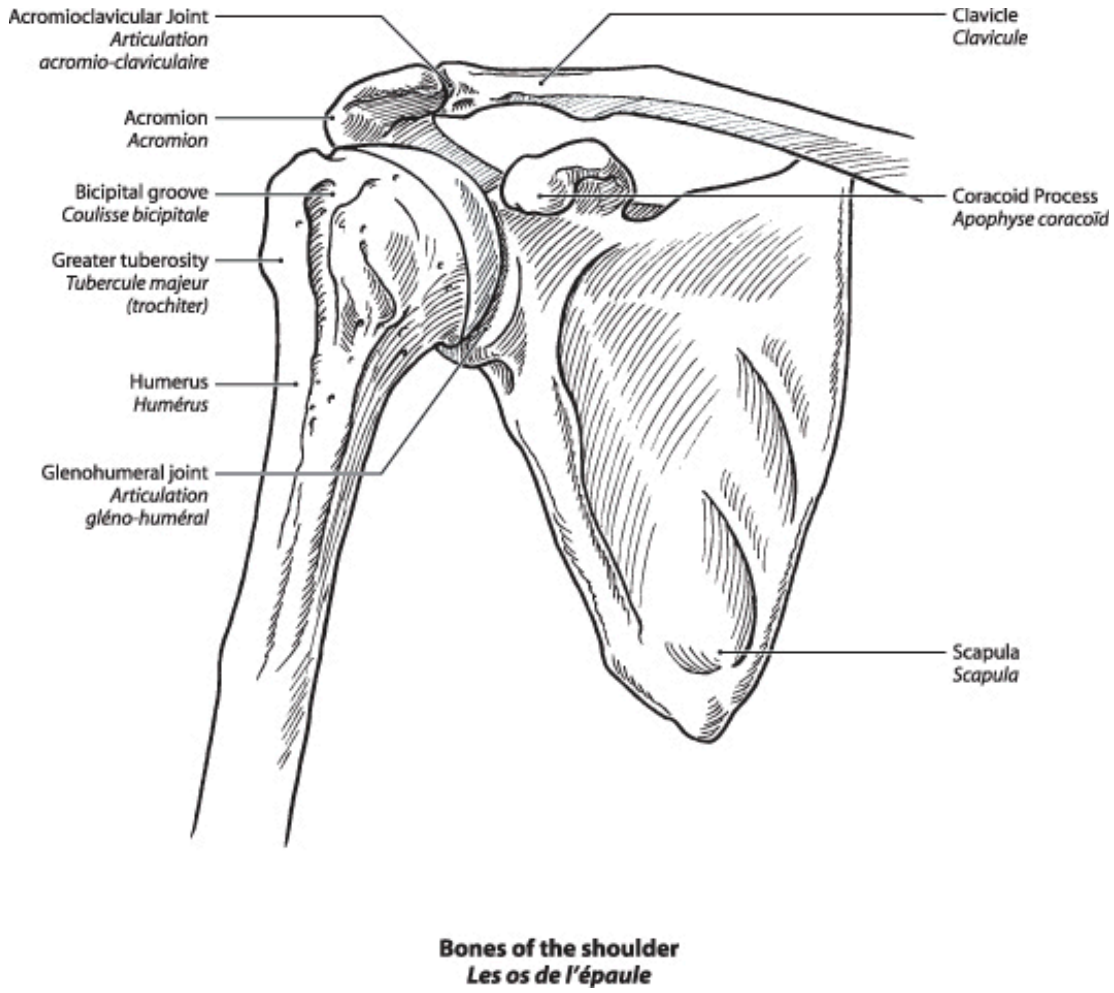

Figure 1: Skeletal anatomy of the shoulder girdle

B. Joints of the Shoulder Girdle

The main shoulder motions take place at three levels.

1. The articulation or joint between the shoulder blade socket (glenoid) and the humerus is known as the **glenohumeral** joint. The surface area of the socket (glenoid) is less than of that of the ball (humeral head). Because of this size discrepancy, the main shoulder joint, the glenohumeral joint is intrinsically unstable, and would fall apart if not for the tendons, ligaments and capsular structures that help to hold it together. This is quite different from the hip joint which is more of a true ball and socket contained joint. This configuration of the shoulder joint results in the ability to move the shoulder through such a wide range of different motions.

2. Motion also occurs between the shoulder blade and rib cage (**scapulothoracic** motion). There is no traditional synovial joint at this level. There is gliding motion between the two neighbouring, muscle-covered structures.

3. Motion also occurs between shoulder blade and collarbone (at the **acromio-clavicular** joint). This motion is largely rotational with shoulder elevation and translational with movements of the arm across the chest. This third joint is commonly referred to as the AC joint.

C. Soft tissue: Rotator Cuff

At the **glenohumeral joint** (between humerus and shoulder blade), we distinguish between a deep and a more superficial (directly under the skin) group of muscles.

The superficial muscle is known as the deltoid muscle. It serves as a cap that covers the shoulder and gives it a normal contour.

The deep group of muscles comprises the **subscapularis** in front, the **supraspinatus** on the top and the **infraspinatus** and **teres minor** behind the humeral head. Their tendinous continuations form a hood over the humeral head, known as the **rotator cuff**. The rotator cuff interval is situated between the tendons of the supraspinatus and the subscapularis muscles. The functions of all four muscles are to stabilize the humeral head and provide active motion. The subscapularis muscle rolls the arm inward (internal rotation), the supraspinatus brings the arm away from the body (abduction) and the infraspinatus and teres minor roll the arm outwards (external rotation).) When one is referring to the “Rotator Cuff”, it is usually the supraspinatus tendon alone or some combination of the supraspinatus and the other tendons listed above.

Another deep structure is the long head of the **biceps muscle**, a muscle which serves to flex the both the shoulder and the elbow (it spans two joints). The long head of the biceps originates from the scapula inside the glenohumeral joint. It then travels in an interval between the subscapularis and supraspinatus tendons, and glides through a groove between two bony prominences of the humeral head (**lesser and greater tuberosities**). It is then joined below the exit from the groove by the short head of the biceps which originates from the coracoid process (biceps = two heads). The biceps ends as it attaches into one of the forearm bones, the radius. Its action at the shoulder is to bring the arm forward and at the elbow to bend and rotate the forearm.

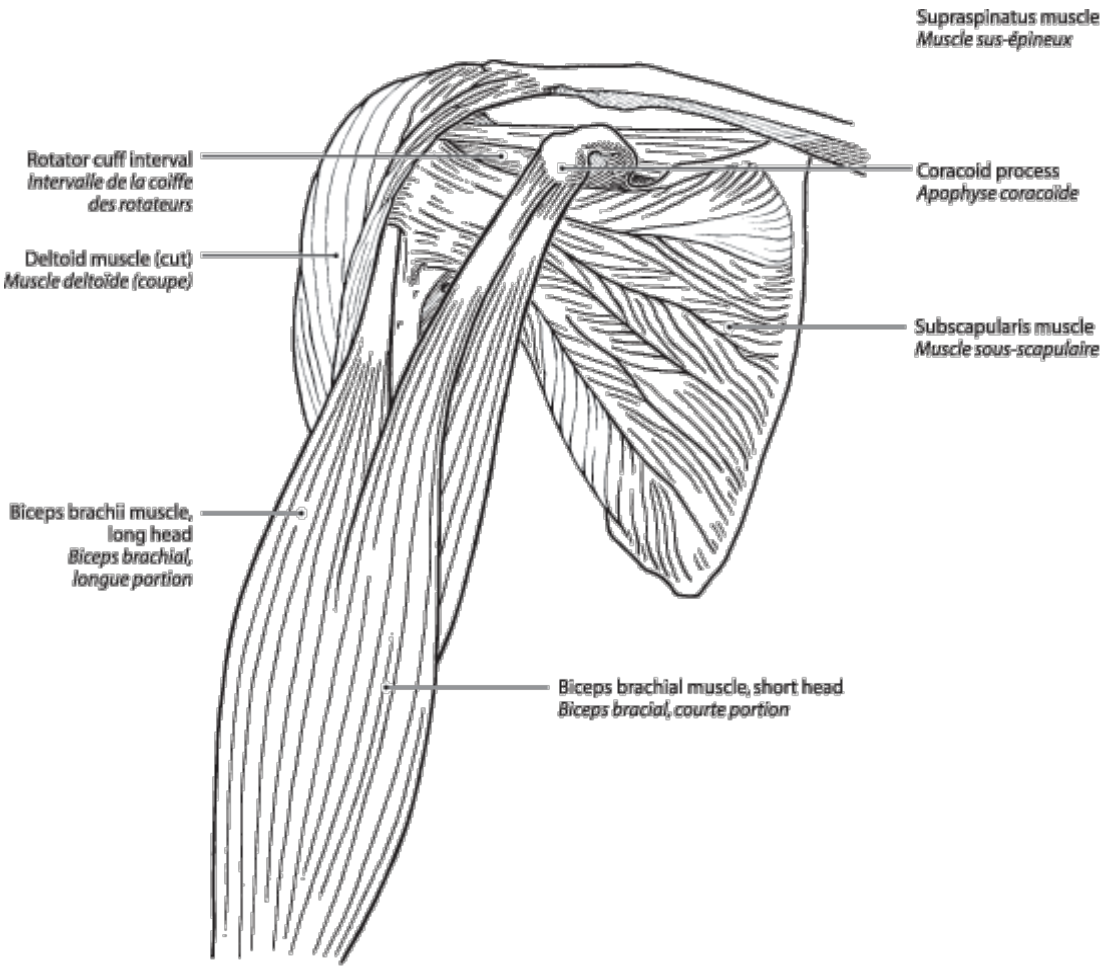

Figure 2: Muscle anatomy of the shoulder girdle, frontal view

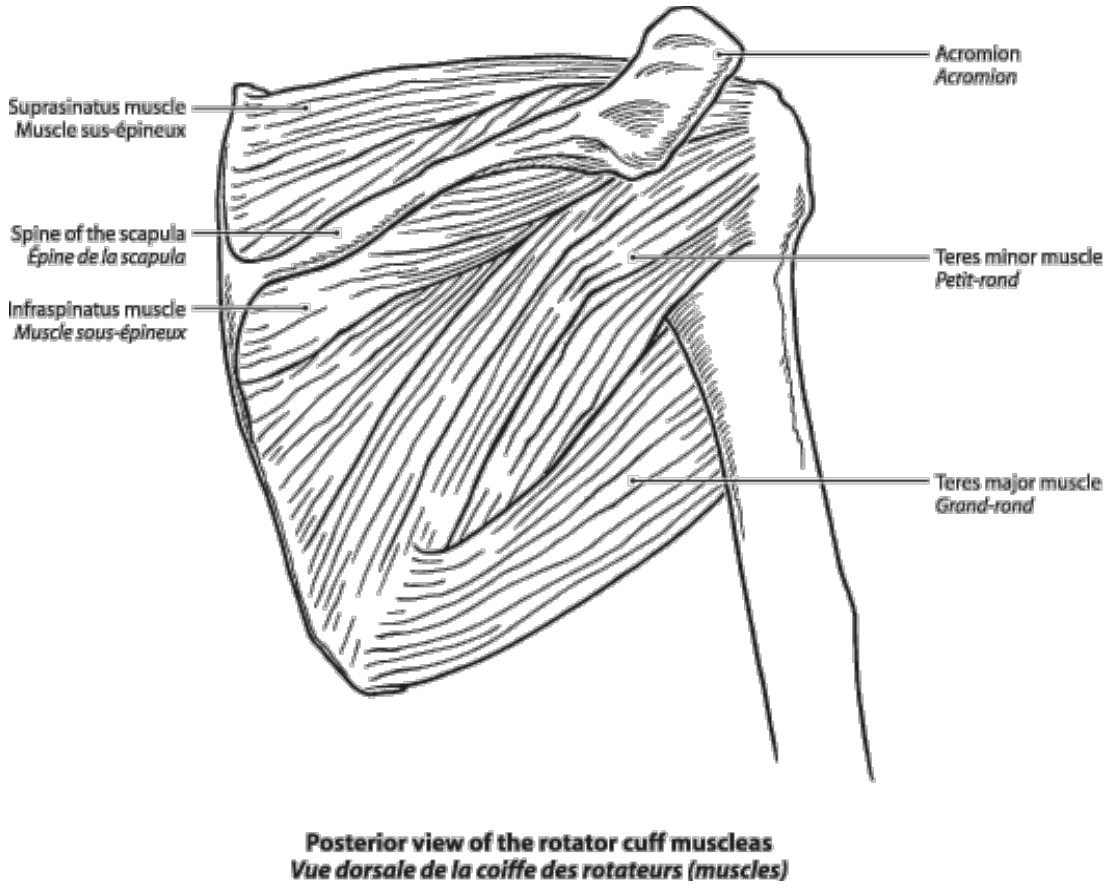

Figure 3: Muscle anatomy of the shoulder girdle, posterior view

Soft tissue: Capsule, ligaments, labrum and bursae

At the level of any joint, the bones are held together by an envelope of tissue (the capsule), and by strong bands (the ligaments). The innermost layer of the capsule is lined by a layer of cells, called synovium, that produces the joint fluid.

The bones, covered by articular cartilage, and the capsule form the joint cavity. The capsule is attached to glenoid as well as to the humeral head.

The capsule makes a joint watertight; containing the joint fluid, also known as Synovial fluid. Synovial fluid serves to provide lubrication of a joint. It also provides nutrition of articular cartilage cells. If the amount of joint fluid is increased, we speak of an **effusion**. This condition is often accompanied by an inflammation of the innermost layer of the capsule, a condition known as **synovitis.**

Ligaments provide the major support of the joint structure and serve to function as checkreins, limiting the extremes of motion. At the major shoulder joint (the glenohumeral joint) the anterior (**glenohumeral**) ligaments are one of the most important ones. They are further divided into the superior, middle and inferior glenohumeral ligaments. Before the shoulder can dislocate the ligaments must tear and the capsule rupture. In addition, patients with ligamentous laxity are at higher risk for dislocation. Generalized ligamentous laxity can be either associated with an issue in collagen production (such as in Marfan's syndrome) or can be of unknown origin.

The Glenoid Labrum is a circular cartilaginous structure that is found at the periphery of the glenoid. It serves much like the rim of a suction cup, to deepen the socket component of the glenohumeral joint. The labrum is a critical component contributing to shoulder stability. It is similar to the meniscus in the knee joint. Like the knee meniscus, the Labrum has a poor blood supply and generally has a poor capacity for spontaneous healing.

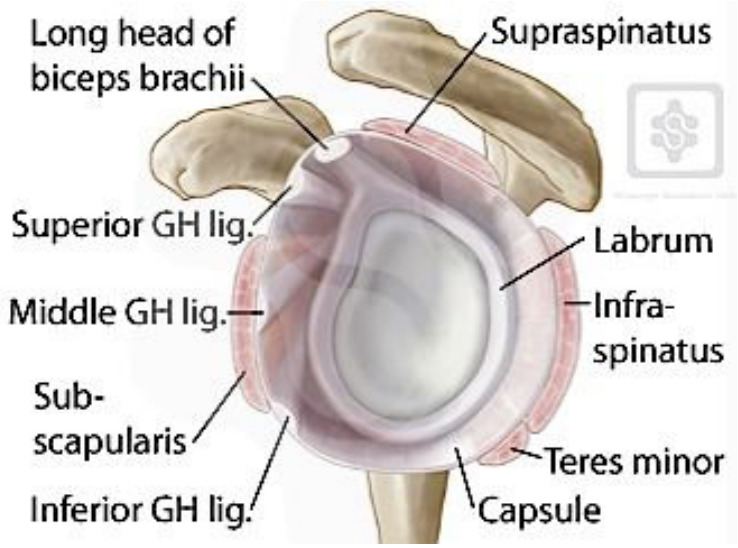

Figure 4: Glenoid labrum and associated capsular ligaments
(image courtesy of Lennard Funk, shoulderdoc.co.uk)

Since articular cartilage does not contain calcium like bones, it cannot be seen on plain x-rays. Instead, we see an apparent space between the bones on x-ray films. When the articular cartilage wears down, becoming thinner, the bones get closer to each other; we speak about a narrowing of the joint space, a sign of arthritis. The glenoid labrum is also made of cartilage and thus is also not seen on plain x-rays of the shoulder.

The other synovial joint within the shoulder girdle is the acromio-clavicular joint. This joint is also encased by a capsule that provides support to the joint. This joint is stabilized by ligaments that span from the coracoid process of the scapula to the undersurface of the clavicle. These ligaments, known as the Conoid and Trapezoid ligaments serve largely to prevent superior displacement of the clavicle through the AC joint.

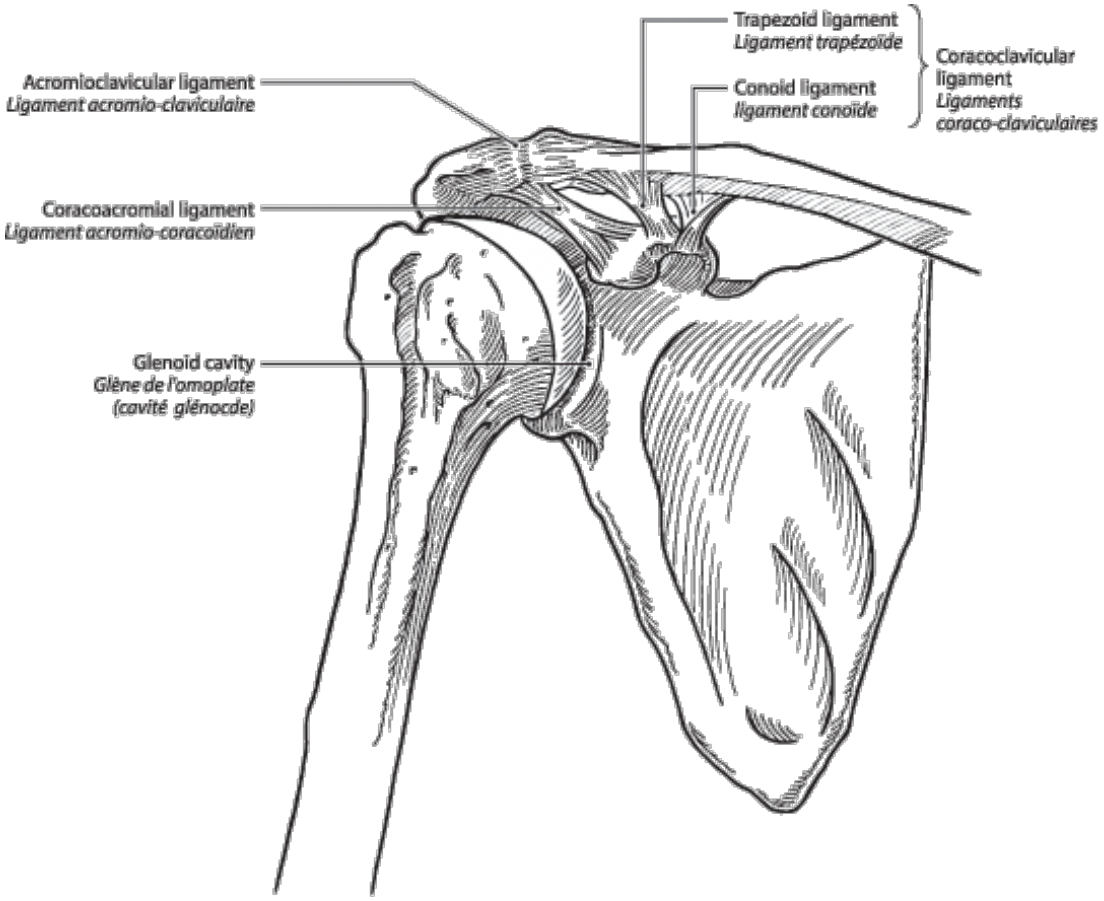

Figure 5: Ligaments of the shoulder

One other ligament needs to be mentioned, the **coraco-acromial** ligament **(Figure 5)**. It spans from the acromion to the coracoid process. The combination of the acromion, coraco- acromial ligament and coracoid process form the coraco-acromial arch, a structure which lies over the humeral head. In between the arch and humeral head, pass the rotator cuff tendons **(Figure 2).**

The area occupied by all the above-mentioned elements: the acromial arch, together with the rotator cuff and the humeral head play a role in the **impingement syndrome**.

This condition will be discussed more extensively later in the paper.

There are variants in the anatomy of the Acromion. The acromion creates a roof over the top of the shoulder joint as a part of the coraco-acromial arch. The undersurface of the acromion can have different anatomical shapes. As described by Bigliani; Type 1(6-32%) is flat, Type 2 (42-69%) is curved, following the shape of the humeral head, Type 3 (8-39%) has a distinct hook at the tip, which may impinge on the rotator cuff and, recently added to the classification is a Type 4, which has a reverse, or convex shape to it[3] (Figure 6). Although it is easy to assume that the presence of a hook shape of the acromion (Type 3) would lead to impingement of and eventual tearing of the rotator cuff, it is not so simple. The effects of the shapes of the acromion are unclear as we are unsure if the morphology causes Rotator Cuff issues or is a reflection of an already abnormal Rotator Cuff.

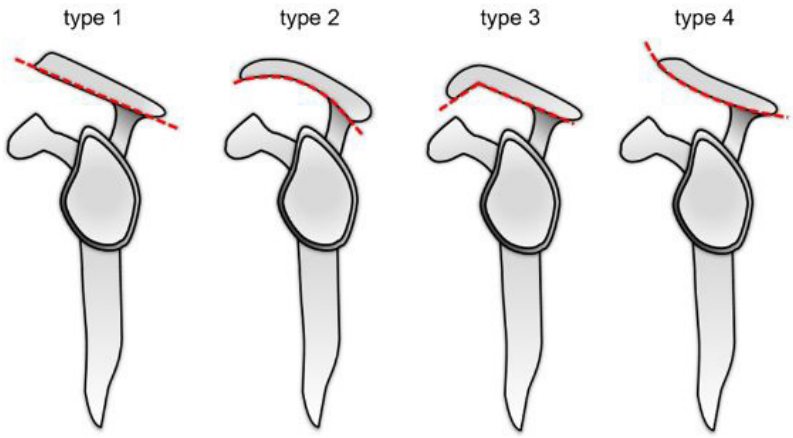

Figure 6: Skeletal variants of the acromion process
(image courtesy of Radiologykey)

Bursae are flattened sacs that contain small amounts of fluid. They allow gliding between two neighbouring structures. During movements, the humeral head together with the rotator cuff tendons covering it glides against the coraco-acromial arch. The smoothness of gliding is made possible by the subacromial bursa, a narrow but extensive sac filled with small amounts of lubricating fluid (synovial fluid). It extends also under the deltoid muscle, and this part is known as the subdeltoid bursa.

In front of the humeral head, a gliding motion also exists between the subscapular tendon and the underlying capsule. In this space we find the subscapular bursa.

When the amount of fluid increases, we speak of an effusion; it is often accompanied by a thickening of the wall of the bursa, known as bursitis. A bursitis can develop in response to other pathology causing local irritation. This could be due to tendinitis of the rotator cuff or arthritis of the shoulder and/or the AC joint. Bursitis can occur by itself in rare cases, such as with a localized infection of the structure itself.

Motion of the Shoulder Joint

Shoulder movements can be active, passive or active assisted. Active motion is when the individual moves a joint purely by themselves, through muscle contractions. Passive motion occurs when an examiner or a mechanical device moves the joint without the person contracting any muscles to help with that motion. Active assisted is a combination of the two, where the person initiates active motion which is then assisted by the examiner to further the motion achieved.

At the level of the shoulder, muscle contractions allow forward bending (**flexion**), backward movement (**extension**) (**Figure 7**), turning (external or internal **rotation**) (**Figure 8**), as well as movements toward (**adduction)** or away from the body **(abduction**) (**Figure 9**).

These motions are illustrated in the drawings below for reference.

A common way of measuring internal rotation is as the distance up the back the person can reach with their thumb, for example “internal rotation of right shoulder is to Thoracic spine level 10, T-10.

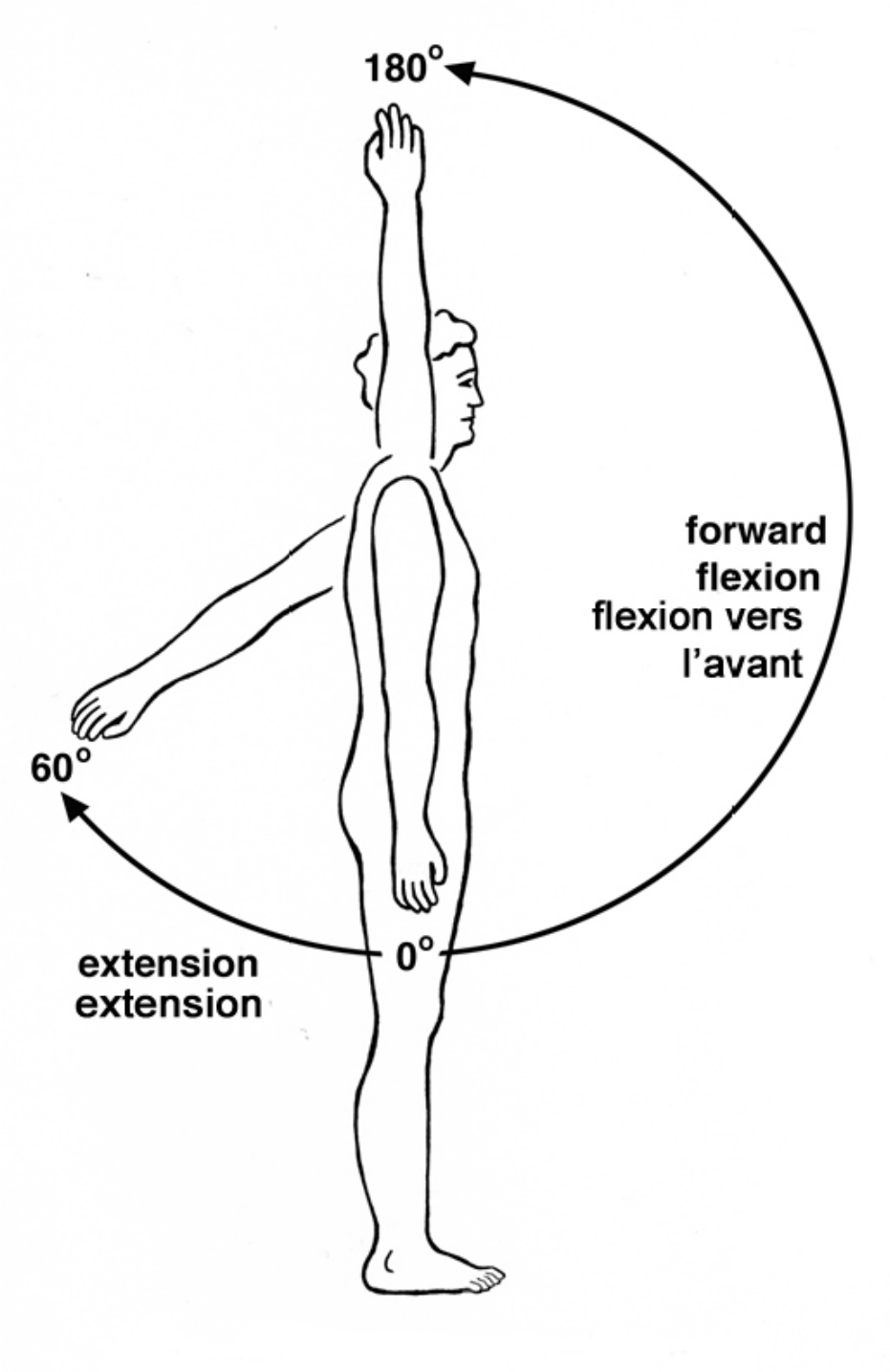

Figure 7: Flexion and Extension

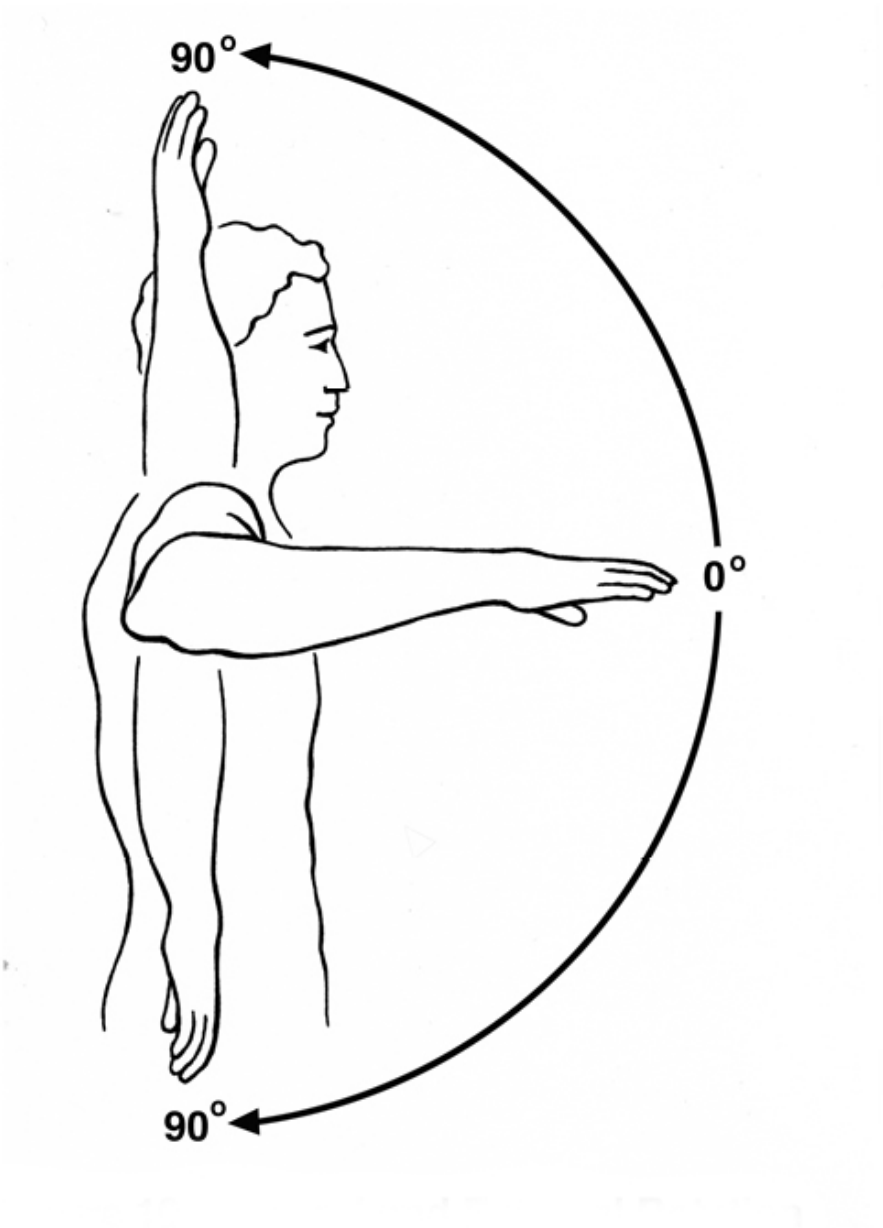

Figure 8: Internal and External Rotation

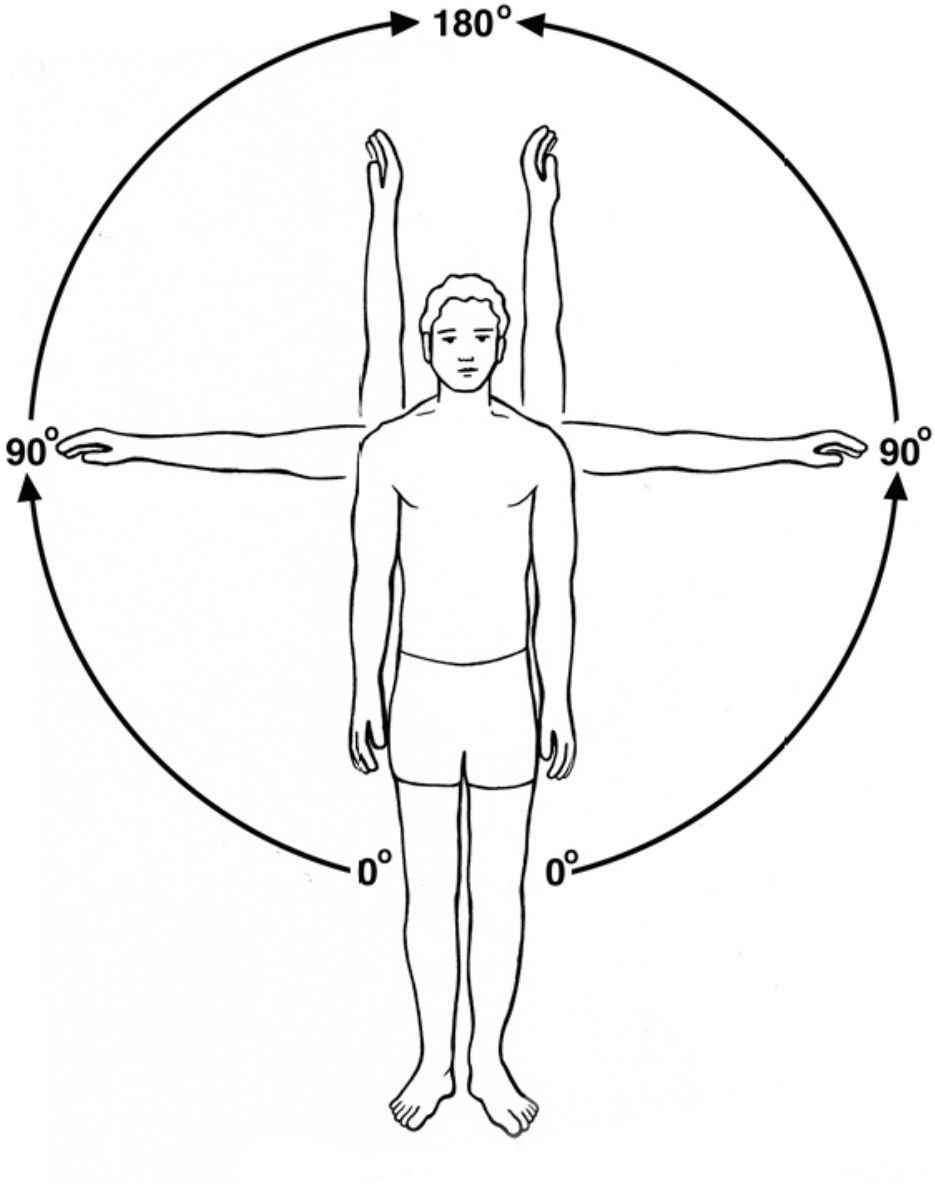

Figure 9: Abduction

Imaging of the Shoulder Girdle

As Orthopaedic surgeons, we rely extensively on radiographic and sonographic imaging of the shoulder in order to identify skeletal and soft tissue abnormalities.

Standard x-rays:

Otherwise known as plain x-rays, a series of images will reveal the skeletal anatomy, that is, the bones and joints. With plain x-rays alone, one can identify abnormalities such as a joint dislocation, fractures, degenerative arthritis and indirectly, evidence of massive rotator cuff tears with proximal migration of the humeral head relative to the glenoid, with subsequent undersurface erosion of the acromion.

Plain x-rays do not directly show the soft tissues such as the capsule, ligaments or tendons of the rotator cuff. However, if there is some deposition of calcium in the tendons of the rotator cuff, this will be visible on plain x-rays.

CT Scans:

Computer Tomography (CT) Scans provide detailed imaging by way of different slices of the shoulder girdle in various planes. Similar to plain x-rays, a CT will be of most use in identifying skeletal structures, less so the soft tissues. With the more sophisticated software available today, some soft tissue imaging can be done with a CT scan.

Arthrogram:

This refers to doing a plain x-ray series or a CT after direct injection of radiographic contrast material into a joint, specifically the shoulder joint. Dye leaking from the Glenohumeral joint through the rotator cuff into the subacromial space is evidence of a full thickness rotator cuff tendon tear. This type of study is rarely done with the advent of Magnetic Resonance Imaging (MRI) with or without contrast injection.

Ultrasound:

Ultrasounds (US) are an imaging modality that uses reflected sound waves to visualize the soft tissue structures of the shoulder. This tool can be useful as a screening test for rotator cuff pathology such as a tear. One often sees an US report that comments on the status of the Glenoid Labrum and the boney structures. This modality is neither as accurate or as sensitive as MRI when evaluating the status of the labrum[4].

Unlike other modalities, US quality and interpretation are dependent on the operator. Although US represents an inexpensive and readily accessible tool, given the variability in operator skills and training of the reporting radiologist, it may not be reliable for surgical decision making.

MRI:

Magnetic Resonance Imaging, MRI can be performed with or without injection of a systemic contrast agent, known as Gadolium (shortened to GAD contrast). An MRI uses powerful magnets to alter the spin of electrons in our bodies and uses this altered spin to create images of amazing detail. The soft tissue imaging with an MRI is striking in its detail and accuracy. Gadolium contrast injection immediately prior to an MRI scan being performed can help define labral tears, and scar from severe injury or previous surgery. Generally speaking, GAD contrast is only used in select cases, usually ordered by the sub-specialist shoulder surgeon.

At this point in time, MRI represents the “Gold Standard” in identifying soft tissue pathology, such as a Rotator Cuff Tear (RCT), of the shoulder.

Abnormalities of the Shoulder Girdle

This portion of the paper is divided into sections in an attempt to clarify abnormalities based on causation, rather than based on the pathology itself.

The sections are as follows:

1. Abnormalities of the shoulder that are purely traumatic in nature
2. Those that are purely age related
3. Those that are a combination of age related and trauma
4. Those that we are unsure about.

Furthermore, there will be a discussion of frequently used terms such as repetitive use and overuse, and how these terms apply to the shoulder boney and soft tissue structures.

Traumatic injuries of the shoulder girdle

These injuries are broadly grouped into fractures (broken bones), dislocations (joints that are pulled apart) or combinations known as fracture-dislocations.

Fractures usually occur as a result of direct trauma such as striking the bones of the shoulder on a hard object or such an object striking the bone. Fractures also often occur indirectly due to impact forces being transferred up to the shoulder via falling on an outstretched hand or elbow.

A broken bone is usually self-evident on a plain x-ray or CT scan. The severity of the injury and the natural history of the fracture pattern will generally dictate treatment, be it surgical with internal fixation devices such as plates, screws, or rods or non-surgical, allowing the bone break to heal by itself, supporting the limb with a sling or similar until comfortable.

As such, a fracture is almost always traumatic in nature, occurring as a result of a specific event. The rare exception is where there is a pre-existing abnormality of the bone, such as severe osteoporosis (osteopenia) or a tumour within the bone causing it to break, referred to as a pathological fracture.

We refer to a complete separation of a joint as a dislocation. The ball is no longer in the socket of the ball and socket joint. (Figure 10). A joint dislocation is also, usually due to an acute injury, but this not always the case. The typical dislocations that occur as a result of direct trauma are those of the Gleno-humeral joint (shoulder joint) and those of the Acromio-clavicular joint (AC Joint).

The gleno-humeral joint can dislocate anterior and inferiorly (most common) and occasionally, posteriorly. There are rare reported cases of intrathoracic shoulder dislocations.

The force needed to cause a first-time dislocation is considerable. However, less and less force is required to cause each subsequent dislocation. If a shoulder joint dislocates more than once, a patient is referred to as a recurrent dislocator. With frequent dislocations, a patient may even dislocate their shoulder unknowingly in their sleep.

Unrelated to any injury at all, some persons are able to dislocate their shoulder at will – a condition called voluntary or habitual dislocation. This is a rare situation, but for a shoulder specialist, will be seen a few times per year in clinical practice. Habitual dislocation may be due to soft tissue laxity, a mental health disorder or a combination of the two. As described above, ligamentous laxity may be attributable to an issue with collagen production (Marfan's, Ehlers Danlos) or idiopathic.

When a joint slips partially out of joint, we refer to this as a joint subluxation, rather than a full dislocation.

Before the shoulder can dislocate the ligaments must tear and the capsule rupture. When this tear occurs at the labrum, the site where the capsule inserts into the anterior aspect of the glenoid, clinicians speak of a Bankart lesion. This Bankart lesion is in essence a tearing off of the anterior labrum from its attachment to the anterior inferior rim of the glenoid bone. At times, rather than just a cartilage separation from the bone, the labral detachment includes

a fragment of bone being cracked off the anterior inferior glenoid rim. This is called a Bankart Fracture, or a Bony Bankart lesion. In essence, it represents a variant of a fracture dislocation of the shoulder.

In addition, an anterior dislocation often produces a dent in the back surface of the humeral head, known as a Hill-Sachs lesion. This is actually an impaction fracture of the humeral head, much as occurs when you drive your thumb into a soft-boiled egg. This lesion occurs as the upper portion of the back of the humeral head jams up against the anterior inferior glenoid rim during the joint dislocation.

As the labrum is devoid of blood vessels (avascular), labral tears do not usually heal on their own. If these structures do not heal after a first-time dislocation, the capsule and ligaments now being stretched out or frankly torn, may not provide the shoulder with the needed stability, allowing it to re-dislocate with minor effort. In such a case, surgery may be needed to restore the original tension of ligaments and capsule.

The Relationship Between Subluxation and Dislocations and Specific Accidents at the Workplace

For first time dislocations and subluxations to occur, a definite injury must have taken place. Without such a history, we must be dealing with a recurrence and not a first-time condition.

Shoulder Instability

This term is often used to describe a laxity of the capsule and ligaments of the shoulder leading to an inability of those structures to hold the joint firmly together. As such, the glenohumeral joint can slip partly or fully in and out of joint (subluxation or dislocation respectively). Patients complain about a feeling of insecurity while attempting certain movements.

It may result from a first-time dislocation, an injury. In the absence of such an injury, the condition is very unlikely to have been caused by a workplace incident.

There is a small group of individuals that have congenitally lax joint ligaments and can spontaneously sublux or dislocate their shoulders at will or with minimal positional maneuvers. In the author’s opinion, it would be inappropriate to attribute such a condition to any occupational demands or workplace duties, as these factors, in and of themselves, would not normally cause a shoulder dislocation to occur.

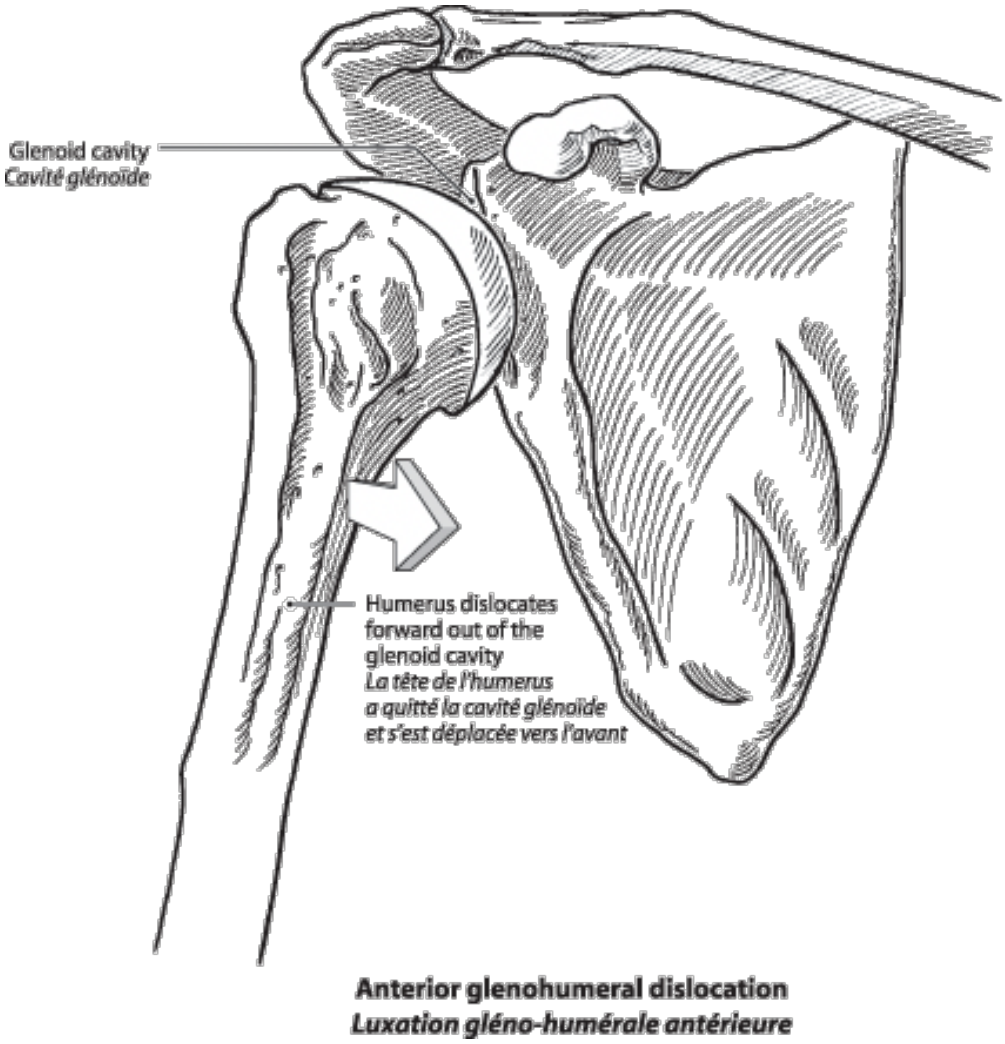

Figure 10: Anterior Shoulder Dislocation

A separation of the shoulder, the **acromioclavicular** dislocation (**Figure 11)**, is only possible when ligaments tear, either the ligaments reinforcing the capsule or the ligaments holding the clavicle down to the scapula (coraco- clavicular ligaments) or commonly, both the capsule and the C-C ligaments. The latter ligaments are not situated at the level of the acromioclavicular joint but further medial, between the mid part of the collar bone and coracoid process. This occurs most frequently in bicycling accidents and in contact sports[5]. In the workplace, the most common cause of an AC separation would be a fall onto the outer edge, that is the side, of the shoulder.

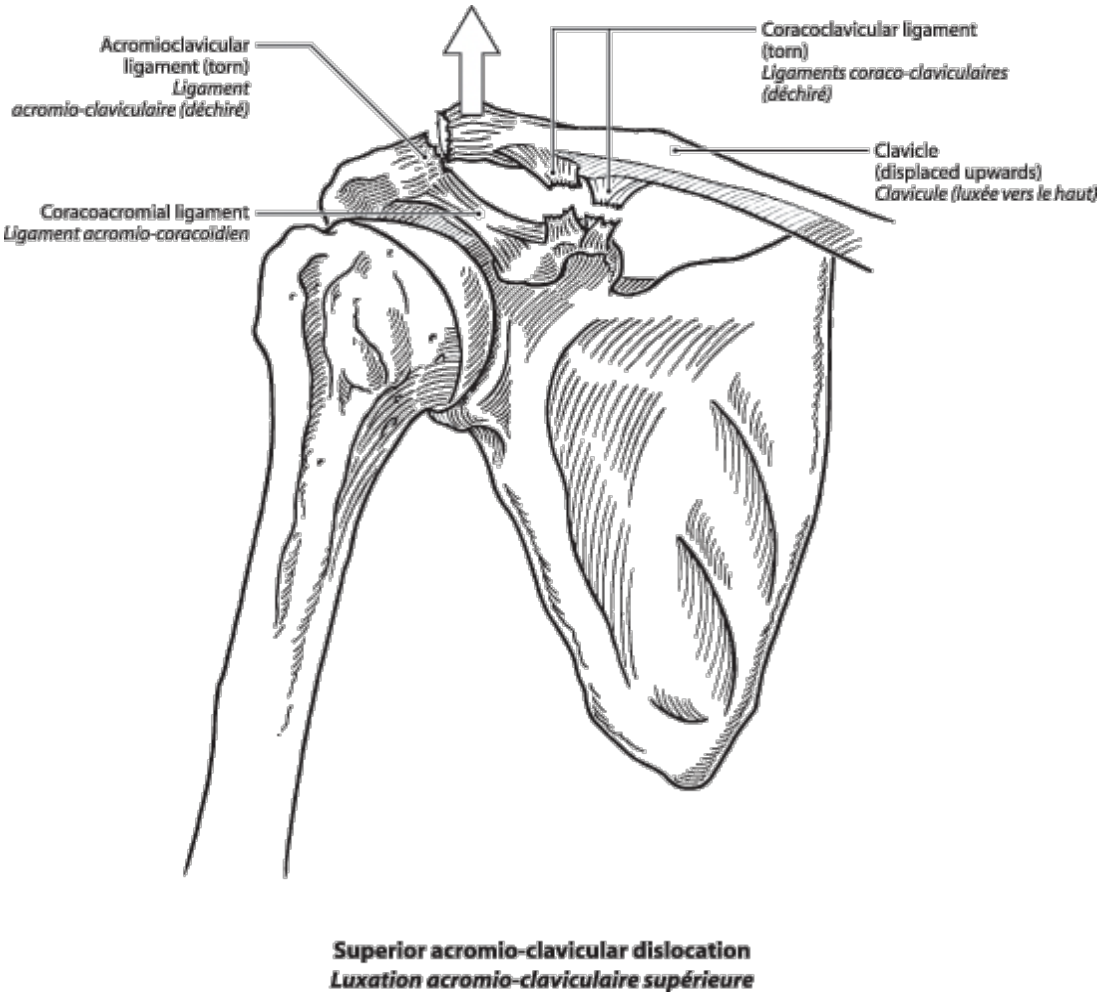

Figure 11: AC Joint Dislocation (shoulder separation)

In many cases, the AC joint separation is left dislocated as surgery is the only way to keep it reduced (placed back in place). The recent literature has shown that in the vast majority of cases, patients with an AC separation do better without surgical intervention but are left with the deformity of the prominent distal clavicle. Fortunately, acromioclavicular subluxations and dislocations are often well tolerated.

Osteoarthritis can develop after any acute AC joint injury, either subluxations or dislocations. This can take decades to develop and may be very well tolerated. Occasionally, there are significant symptoms of pain localized to the arthritic AC joint and further treatment is required.

Fracture dislocations can occur as a result of severe trauma. These occur when the joint is not only out of place (dislocated) but also has fractures involving the associated bones. These fractures can be minimal and stable or severe

and widely separated. These injuries are difficult to treat with more long-term problems such as stiffness, pain, and a high risk of developing arthritis of the shoulder.

Other Traumatic Soft Tissue Injuries of the Shoulder Girdle

Rotator Cuff Tears

The soft tissue structures about the shoulder can tear as a result of trauma. The most commonly involved other than those associated with shoulder or AC dislocations (already discussed) are the tendons of the Rotator Cuff and the glenoid labrum.

Rotator cuff tendons may tear in response to an injury where the external force is greater than the strength of the tendon. These tears can either be where the entire tendon is torn through (**Figure 12**) or partial. A partial tear, commonly known as a partial thickness tear is one where some fibres of the tendon remain intact, holding the tendon together. Partial thickness tears are often graded by the radiologists as low grade, intermediate or severe (high) grade. This grading refers to how much of the thickness of the tendon is involved in the tear, be it only a thin slice or most of the substance of the tendon. The vast majority of rotator cuffs tears occur without a specific traumatic event, and are often caused by the progression of more minor pre-existing cuff pathology, such as partial thickness tears or simply due to age-related degeneration of the tendon leading to frank tearing.

The term tendinopathy refers to any pathology within the structure of the tendon. This may be inflammation without a tear, a partial thickness tear or a complete full thickness tear.

Tendinitis and tendinosis are interchangeable terms. Defined as follows:

Tendinitis or tendinosis is considered an inflammation of the tendons of the rotator cuff. It is due to microtears of the fibres of the rotator cuff tendons. No actual tear will be seen on the MRI with tendinitis, rather just increased blood flow and swelling (edema) of the tendon is noted.

Any variety of tear can occur after trauma to the arm, depending on the mechanism of injury, the amount of force transferred to the tendons and the quality of the underlying tendon tissue. As such, tendinitis (tendinosis) can occur after trauma or excessive strain on the rotator cuff tendons both in vocational and avocational activities. Rotator cuff tendons that have suffered from tendinosis are poorer quality tissue and will tear much easier than strong unaffected tendons.

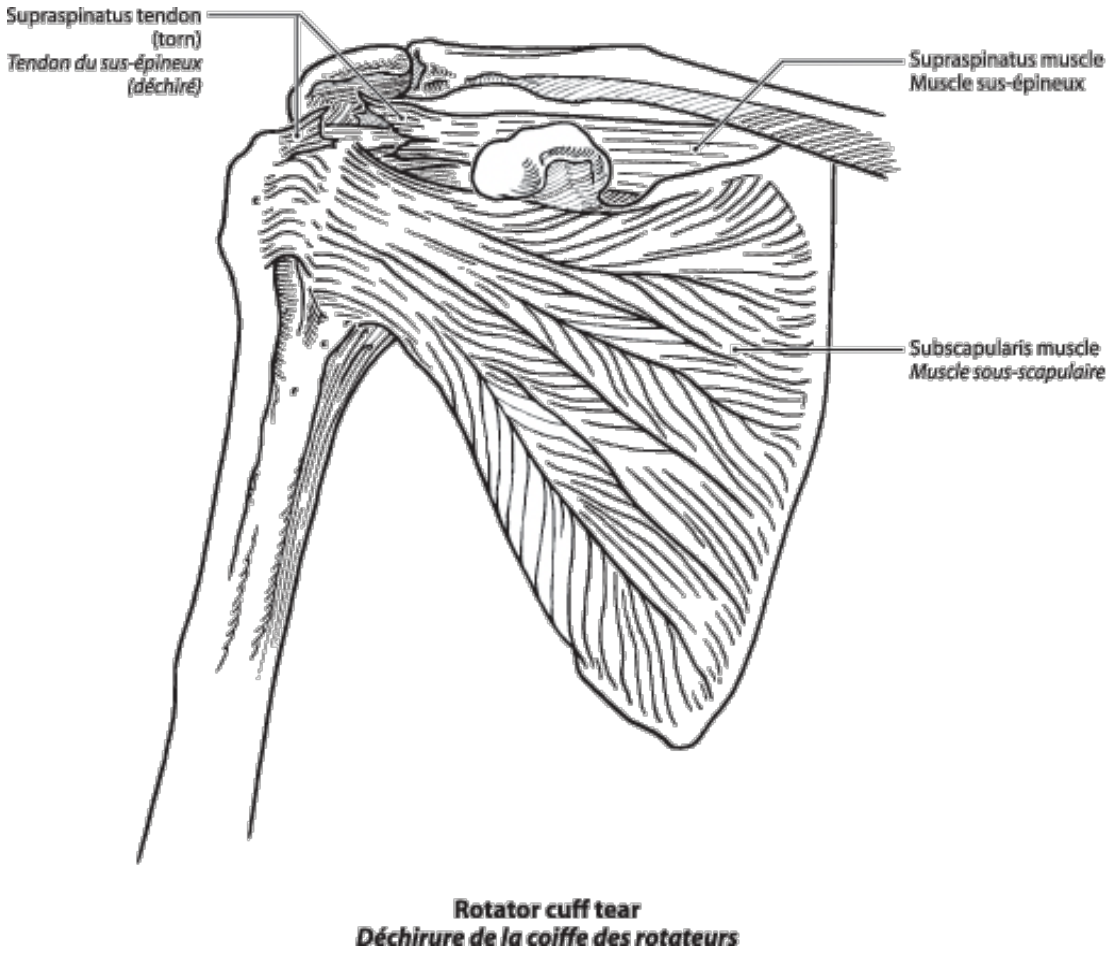

Figure 12: Rotator cuff (supraspinatus tendon) tear

Following an acute traumatic tear, active movements are restricted, painful or impossible because the continuity between origin and insertion of the muscle-tendon-bone unit is disrupted. As the supraspinatus tendon is usually affected,[6] it results in impaired forward elevation and abduction. The person cannot hold his/her arm in a position at 90 degrees away from the body (abduction). If the infraspinatus is torn, external rotation is weak and if the subscapularis is disrupted, internal rotation is affected. There are a variety of physical examination maneuvers that can help identify specific tears within the rotator cuff. [7]

As explained below, changes to active shoulder motion with chronic rotator cuff tears may or may not be seen. This is quite a different scenario than with the acute, traumatic cuff tear.

Tendinitis is a lesser degree of rotator cuff pathology. This term refers to inflammation of the tendon, also known as tendinopathy. On a microscopic

level, one can see microtears of the rotator cuff tendons. However, on the macroscopic level, there is no fraying or tearing of the tendon. This inflammation can cause pain and limitations of motion.

Bursitis refers to inflammation with fluid accumulation of the sub-acromial and sub-deltoid bursae of the shoulder. Bursitis is usually a reaction to some other injury or a more chronic condition. With an acute rotator cuff tear, there will be associated local inflammation and bursitis. The patient will complain of pain and a sense of grinding or catching of the shoulder with movement.

Bursitis, in of itself rarely occurs in isolation after an acute injury to the shoulder girdle. Bursitis almost always develops in response to an irritation by neighbouring structures. A bony outgrowth (spur of the acromion or osteophytes from an arthritic acromio-clavicular joint) or a thickened or a partially torn tendon of the rotator cuff may lead to an irritation of the bursa. With the exception of rheumatoid arthritis, bursitis is rarely a primary or free-standing diagnosis.

An acute injury to the rotator cuff can result in the development of bursitis, meaning that this can occur as a result of a workplace injury. This is possible, but not common.

Previous researchers have argued that the structure of a patients' acromion can contribute to or be a part of rotator cuff pathology including impingement, tendinitis (tendinopathy) or cuff tears. However, it is not clear whether the rotator cuff pathology causes a change in the acromion or vice versa. A detailed review of acromion types (the Bigliani classification) is found below.[8,9]

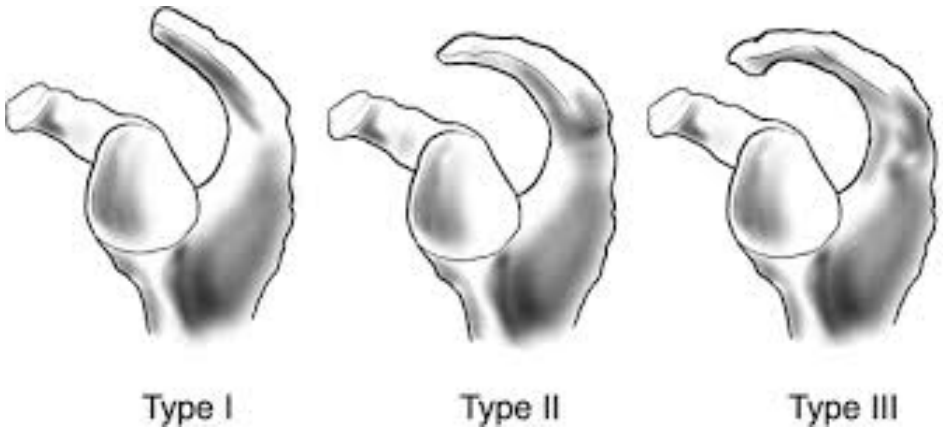

Figure 13: The Bigliani Classification

In particular, the Type III can protrude down into the cuff itself, causing or irritating a tear. It is not clear as to whether or not the hook (acromial spur) causes the rotator cuff pathology or occurs in response to it. This a question of cause and effect, in either direction or of simply an association, meaning that the issues occur together. Quite clearly, one can have a rotator cuff tear in the presence of a Type I or II acromion.

The best available research suggests that patients with a type III acromion are more likely to have non traumatic RCTs, however the direction of this association is unclear. Other research suggests that acromion positioning, including tilt and slope is more likely to contribute to a patients' risk of RCTs.[10]. Without long term studies and appropriate imaging, it will remain challenging to identify the relationship between acromial morphology and RCTs.

It is important to note at this junction in this paper that, although rotator cuff tendons can tear as a result of trauma, the vast majority simply tear as a consequence of age-related degeneration, occasionally with some minor component of trauma added.

Shoulder Strain

A shoulder "strain" is a generic term that does not reflect any specific pathology. It is often used to describe a soft tissue stretch or contusion (bruise) of some muscles around the shoulder in one of two situations. The first would be when first assessing a patient after a shoulder injury in which no imaging has been performed to assess the status of the bones and soft tissues. The practitioner uses the term "strain" to broadly describe shoulder pain due to a soft tissue injury, yet there is no imaging to make an accurate diagnosis. Findings on physical examination maneuvers may suggest rotator cuff pathology, however the injury may be termed a "strain" until the appropriate imaging is performed. The second situation is when someone has a shoulder injury and imaging (MRI, U/S) is reported as normal. The pain cannot be explained by a disruption of the rotator cuff or labrum, so in the absence of any specific diagnosis, the term "strain" is applied to the injury. This term is often utilized in initial assessment, though the term alone represents an imprecise and often inaccurate opinion of the injury.

Trapezius Strain

Trapezius strain refers to a contusion or stretching, perhaps with micro-tears of the upper fibres of the trapezius muscle. This is a large muscle that originates in the midline of the neck and upper to mid back and extends up and out to the shoulder blade (scapula). A pull or strain (microtear) of this muscle can cause neck pain that radiates to the top and back of the shoulder following the

course of the muscle. The patient will complain of shoulder pain, yet the area of discomfort is in the back and side of the neck radiating to the upper portion of the shoulder girdle and/or to the back of the shoulder in the region of the scapula (shoulder blade). There is no injury or symptoms within the shoulder joint or rotator cuff. At times, the practitioner will call this a shoulder injury, whereas in actuality, it is not, rather a problem with a muscle that is outside of the shoulder girdle region. This serves only to confuse the situation further.

Labral Tears

The glenoid labrum can tear as a result of direct trauma with a shoulder dislocation pulling the labrum off of its boney attachment (Bankart lesion) or tearing it within its mid substance. This type of labral tear is mostly trauma related. In the absence of trauma, some symptomatic labral tears can occur secondary to age related degeneration (similar to tears of the meniscus in the degenerative knee).

The superior portion of the glenoid labrum can tear away from the glenoid or tear mid substance through an indirect injury via the long head of biceps tendon, which inserts on the labrum itself. This long head of biceps tendon originates from the superior apex of the labrum and runs down the arm to the elbow. If excessive force is applied to the biceps tendon, it can either tear itself or pull away the superior labrum in the area of its attachment. This results in a superior labral tear, commonly known as a SLAP (Superior Labrum Anterior to Posterior) tear. SLAP tears can also occur in the older individual with minimal or no trauma at all, once again due to degeneration of the tissues, leading to weakness and failure.

However, there is good evidence that certain types of SLAP tears may represent normal variants in a proportion of the population. For this reason, practitioners are hesitant to offer surgical management to patients with isolated SLAP lesions without consistent history, physical examination and imaging findings.[11]

Generally speaking, young individuals have strong soft tissues and tears of these tissues, be it the rotator cuff tendons or the labrum are usually traumatic in nature. Whereas the older patient, with poorer quality soft tissues due to age related degeneration, will more often have tears occur spontaneously or with minimal trauma or injury. This applies to the labrum as well as the rotator cuff.

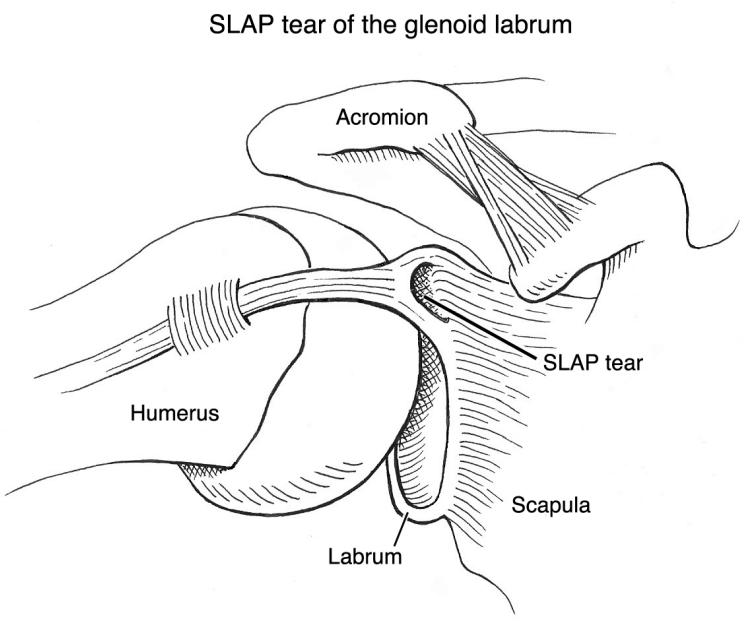

Figure 14: SLAP Tear of glenoid labrum

Abnormalities of the Shoulder Girdle that Occur in the Absence of Trauma

The most common type of rotator cuff tear is one in which the tearing occurs in older individuals within a tendon that has been weakened by age-related, and perhaps by activity-related, changes (middle aged and older persons). The incidence of age-related rotator cuff tears increases with age to a point where tears, whether symptomatic or not, are the norm (with nearly 80% of patients who are 80 having rotator cuff disease on MRI, even as the majority are not symptomatic[12]). This happening should be considered as a feature of aging and not as an injury.

The size of the tear generally increases over time, usually starting as a partial thickness tear, advancing to full thickness and then enlarging further with retraction of the muscle masses.

Several points warrant clarification regarding age related rotator cuff degeneration. First of all, the presence of a rotator cuff tear, be it partial or full thickness, does not mean that an individual will have symptoms or any complaints at all. The majority of degenerative rotator cuff tears are asymptomatic. This means that the person does not have any pain, limitations of shoulder motion or significant weakness of the shoulder girdle despite having a rotator cuff tear.

As surgeons, it is not at all clear to us why most patients with rotator cuff tears are asymptomatic and others suffer pain, weakness and limited motion as a result of similar pathology. This quandary is similar to that of a person with large joint osteoarthritis (hip or knee). Many have no symptoms; others are severely disabled by similar abnormalities.

Finally, the most confusing situation is when a patient presents with pain, weakness, limited motion and/or dysfunction of their shoulder due to a rotator cuff tear in which there is clear evidence that the tear has been present, but asymptomatic for many years to decades prior to any specific triggering event. The age of most chronic rotator cuff tears can be roughly determined by the MRI findings related to the size of the tear, extent of retraction of the ends of the tear, the presence of atrophy of the associated muscles and proximal migration of the humeral head under the acromion.[13].However, utilizing these approaches only yields a relatively imprecise estimate of the age of a given patient's unique rotator cuff tear. These individuals clearly have had a rotator cuff tear for many years that was typically not bothering them at all, yet with some minor event, the cuff tear becomes a problem for the patient. Why this happens is not at all clear. It may be no more than a trivial additional tear to an already torn tendon, a more major extension of the pre-existing tear or some other mechanism of irritation of the surrounding tissue. At times, no real anatomical explanation for the change in symptoms can be found.

Long Head of the Biceps Tendon

A tear of the long head of the biceps is often seen in patients suffering from a degenerative rotator cuff tear and usually occurs without any significant trauma. As a result, the biceps muscle shortens and bunches up in the front of the arm. This is often described as a "Popeye deformity" referring to the large bulbous biceps of the cartoon character "Popeye the Sailor man." The tear is usually well tolerated, not painful after a short time, and is of little functional consequence, though there is a permanent cosmetic deformity. This tear is most frequently the consequence of intrinsic degeneration and thus, weakness of the tendon, not of an injury. It simply tears with minimal regular use of one's arm. Occasionally, some specific traumatic incident, in the workplace or other, can result in such a tear, but usually there is some component of degeneration in the tendon that allows it to fail in this manner.

Impingement Syndrome

Impingement syndrome (IS) is caused by a squeezing of the contents of the space bordered on one side by the coraco-acromial arch and the other side by the humeral head. Both structures are visible on plain x-rays. The contents consist of soft tissues, namely the rotator cuff, in particular the supraspinatus

tendon, and the subacromial bursa. The squeezing of these contents in an unyielding space can have two causes:

1. A thickening of the contents, a swelling of the tendon (tendonitis) and/or a swelling of the bursa (bursitis).
2. A decrease of the space, mostly caused by bony outgrowths, such as acromial spurs, osteophytes of the acromio-clavicular joint and/or osteophytes of the humeral head.

The pain caused by IS is usually aggravated by internal rotation and flexion (forward elevation) of the glenohumeral joint.

It has been argued that impingement may cause a rotator cuff tear through wear and tear. This is unclear. In most instances, the tendon is the site of the original disease, leading to a tear due to the structural weakening of the tendon; the resulting impingement will make the situation worse. In fact, outgrowths of the acromion (bony spurs) may form in response to a continued pressure of thickened tendon against the acromial arch, similar to explained above (see section: Rotator Cuff Tears). This is important, as the argument often goes that spurs lead to tendinitis; whereas spurs may serve to aggravate the existing tendinitis.

Impingement can start at an early age, particularly in athletes. It can develop spontaneously in older people (around 50 to 60 years of age). Type II and III acromia may have a higher association with impingement syndrome, thought to be due to the reduced space available for the rotator cuff to glide through. In these cases, perhaps the pathology begins with the type of acromion, with the tendon pathology developing in response to the anatomically reduced area for tendon gliding.

Given the available evidence, it can be argued that repetitive overhead work and/or throwing or other overhead sports activities can cause impingement, usually secondary to irritation of the rotator cuff tendons. This may ultimately lead to rotator cuff partial or full thickness tearing, but not universally so. However, there remains an absence of high-quality longitudinal studies detailing the natural history from exposure to overhead activities, through shoulder irritation and ultimately rotator cuff pathology.[14,15] Therefore, the authors cannot draw definitive conclusions regarding the association between overhead activities and cuff pathology.

Arthritis of the Shoulder

Osteoarthritis

Osteoarthritis is considered a progressive, degenerative condition. Osteoarthritis is when the articular cartilage of a joint wears down, ultimately leading to bone on bone contact of the joint surfaces. The body reacts to this by forming bone spurs (osteophytes) and thickening of the bone under the joint surfaces. The diagnosis is made based on plain x-rays of the shoulder. Rarely, a CT is needed to help plan a future operation, and generally, an MRI is little or no value in diagnosis or management. Degenerative osteoarthritis is most commonly seen in the middle aged and older population. Although inflammation of a joint is sometimes stated as a cause, an actual inflammatory process is uncommon for osteoarthritis.

In instances of osteoarthritis, bony outgrowths often form at the periphery of the joint surfaces, termed marginal osteophytes. Patients often complain of a decrease in the range of motion of a joint and of pain. Within the shoulder girdle, both the glenohumeral and the acromioclavicular joints can be the site of osteoarthritis. In some instances, total shoulder arthroplasty is required for relief of pain.

Causes of Osteoarthritis

There is significant controversy as to whether some activities (overhead work, use of vibrating tools) do or do not increase the risk of developing joint arthritis. Much akin to the idea of runners developing knee arthritis supposedly due to overuse or repetitive trauma to their joints, one could extrapolate the current state of knowledge to other joints such as the shoulder.

However, based on the limited evidence we currently have, there is little support for the idea of a joint wearing out (becoming arthritic) due to “overuse”. Rather, there is a general relationship between musculoskeletal soft tissue disorders of the shoulder (including biceps tendonitis and bursitis) and overhead or repetitive activities, but no obvious link to osteoarthritis[16] has been reported in the current literature.

This is in contrast to other forms of arthritis which may have clear causal relationships. For example, patients with chronic rotator cuff deficiency are at high risk of developing a unique form of shoulder arthritis called rotator cuff arthropathy. This same relationship between overuse and shoulder arthritis is not clearly evident.

Two specific circumstances, however, have been clearly associated with the development of osteoarthritis. These are fractures that occur within the shoulder joint, and deep joint infection. Fractures that occur within the joint affect the cartilage surface which helps facilitate movement between the ball and socket. With cartilage damage, along with altered biomechanics following any severe traumatic injury, these patients are at risk of developing osteoarthritis, termed post traumatic arthritis. Similarly, deep infections within the joint quickly destroy cartilage thus leading to the same process, eventually causing arthritis.

Therefore, there is a clear relationship between the injury sustained and the development of arthritis for patients who have suffered an intra-articular fracture (affecting the joint surface) within the shoulder. In contrast, repetitive use of one's arm or sustained overhead use does not appear increase the risk of developing shoulder arthritis.

Is There a Relationship Between Isolated or Recurrent Dislocation of the Shoulder and Osteoarthritis?

Not for the situation of a single dislocation or even after multiple dislocations in the absence of an associated glenoid rim fracture. With a glenoid rim fracture, the risk of post-dislocation arthritis does increase significantly due to the incongruency of the joint surface and potential for joint instability.

However, contrary to what would normally be expected, simple recurrent dislocations of the glenohumeral joint do not increase the risk of osteoarthritis. In fact, it is only after surgery for recurrent dislocations, with older surgical techniques (such as the Putti-Platt or Magnuson-Stack procedures) that may overtighten the soft tissues about the shoulder, that osteoarthritis of the shoulder joints becomes a frequent, but late, development.

Acromioclavicular Joint

The acromioclavicular joint is one of the most common joints in the human body to develop degenerative osteoarthritis. It can occur very early in life, during the third to fourth decades and progresses with noticeable bumps (osteophytes) over the top of the joint. In the vast majority of cases, it is not only frequent but also not at all symptomatic. Some people do develop pain due to the arthritis or instability of this joint, but once again, it is not at predictable as to whom or why any one individual is symptomatic and many others not.

There is weak evidence of an association of repetitive overhead work and having a more symptomatic arthritic AC joint. Thus, if one has an already arthritic AC joint, doing repetitive overhead work may lead to more aggravation of this arthritis and in some cases more symptoms.

Labral Degenerative Tears

The glenoid labrum consists of cartilage, a substance that we well know can wear with aging and tear spontaneously. As such, in addition to the traumatic labral tears described above, there exists the subset of labral tears that are degenerative or age related in nature. Shoulders with osteoarthritis invariably will have some degree of labral degeneration and tears. This is identical to that seen in arthritic knees.

Rotator Cuff Arthropathy

This is a well-recognized chronic condition that is seen in some patients with massive, complete rotator cuff tears. In rotator cuff arthropathy there may be osteoarthritis of the shoulder in association with a massive full thickness rotator cuff tear. The pathophysiology suggests that this condition occurs because the humeral head migrates upwards under the acromion and actually contacts the latter structure. This occurs because there is no longer a rotator cuff to act as a spacer between the two structures, along with the loss of the stabilizing dynamic action of the cuff. The humeral head no longer sits concentrically within the glenoid resulting in eccentric loading of the joint and with this, wearing out of the articular cartilage. This wearing of the cartilage is the origin of the arthritis. Arthritic changes are seen both between the humeral head and glenoid as well as between the humeral head and the acromion above.

The presence of this condition, Rotator cuff arthropathy, is clear evidence of long standing (decades old) rotator cuff abnormalities, which, once again may or may not have been symptomatic. Even with severe rotator cuff arthropathy, some patients have minimal, if any pain and have reasonable shoulder function.

Shoulder-Hand Syndrome

This autonomic dystrophy is known to occur in 10 to 30% of patients having had a myocardial infarction, a stroke, or injury to the upper limb and hand. It is characterised by shoulder stiffness and diffuse arm pain. It may be considered a part of the Complex Regional Pain Syndrome. This disorder may follow an injury, often trivial, such as a minimal wrist fracture.

Neck Problems and Shoulder Problems

There is no doubt that pain from cervical spine problems, in particular in instances of degenerative disc disease, can radiate to the shoulder. A good clinical examination will help to distinguish between symptoms originating in the shoulder and those referred to the shoulder. Discussion of cervical spine problems exceeds the limits of the discussion paper of the shoulder.

Abnormalities of the Shoulder Girdle That May Be a Combination of Age-Related Degeneration With an Element of Trauma or Injury Contributing to Them or That Occur for Reasons That We Currently Do Not Understand

These situations are perhaps the most difficult to manage and evaluate from the viewpoint of causation. Quite often a patient will have clear evidence of pre-existing shoulder pathology such as a rotator cuff tear yet will have been minimally or not at all symptomatic before some acute episode occurs. This episode may be severe such as a fall directly onto the shoulder or less so, with the episode being no more than the development of shoulder pain after doing the regular day to day overhead work of one's normal job. It is not at all clear how or why an abnormal, but pain free shoulder becomes symptomatic after any such events. Perhaps it is the tearing of the few remaining rotator cuff tendon fibers that are keeping the structure functional that causes the change in symptoms, or other physiologic or non-physiologic factors. Not all symptoms will have a clear organic explanation.

In a similar fashion, a patient may have an asymptomatic arthritic shoulder. After doing the normal workday duties, or some other overhead, lifting, pushing or pulling activity for some unclear reason, the shoulder begins to hurt. From a medical perspective, this is considered an aggravation of an underlying pre-existing condition. It is very hard to sort out the role of workplace duties in this situation, in the absence of any specific out of the ordinary event. The shoulder may just as easily become symptomatic over a leisurely weekend of doing no specific activities that would aggravate it.

Once the symptoms begin, they often persist for a substantial period of time, and may need additional interventional treatment.

Frozen Shoulder (Adhesive Capsulitis)

This term is used to describe a severe, often painful and incapacitating limitation of passive and active movements. This disorder can follow a prolonged immobilization of the shoulder or it may be due to a tendinitis. At times it comes on spontaneously after a viral illness or without an obvious inciting event. It is more common in diabetic patients.[17] This condition usually resolves, but may take up to one year of rehabilitation, consisting mainly of active exercises. The pain can be reduced by judicious use of cortico-steroid joint injections. Rarely is surgical treatment needed, and if undertaken the results are often disappointing. In some cases, it does not resolve, and stiffness may be permanent.

Calcific Tendinitis

This is an abnormality involving the deposition of calcium into the tendons of the rotator cuff. Like many other soft tissue conditions, it is often asymptomatic and only discovered serendipitously. It is not clear if the deposit occurs in response to some rotator cuff pathology such as tendinitis or the deposit leads to tendinitis. In symptomatic patients, pain free calcific deposits are found in the opposite shoulder in up to 40% of cases. Tendinitis can occur from workplace repetitive overhead duties, calcific tendinitis can occur in response to this tendinitis, thus theoretically, at least, calcific tendinitis can occur from certain work duties over time.

Treatment

The various roles of treatment modalities lay largely outside of the scope of this paper. Except for the acute traumatic shoulder fractures, dislocations and fracture-dislocations, most shoulder problems can be, at least initially, managed non-operatively.

The mainstays of non-operative treatment include physiotherapy, massage therapy, acupuncture and other forms of therapy. Physiotherapy remains the sole non-operative treatment that has been shown to be beneficial for rotator cuff abnormalities, labral tears, adhesive capsulitis and arthritis.

There are a series of substances that can be injected into the shoulder joint or the sub-acromial space for some potential benefit – though there remains little high quality evidence to suggest sustained benefit after initial treatment. These include corticosteroids such as Depo-Medrol, Plasma Rich Protein (PRP) and synthetic joint lubricants. There is weak evidence for the benefits of steroid as well as PRP injections for symptomatic rotator cuff pathology. There is no evidence supporting the use of synthetic joint lubricants nor novel methods such as stem cell injections.

Surgery is offered for many acute shoulder injuries such as fractures and fracture dislocations, for symptomatic recurrent shoulder dislocations and a multitude of other long-standing shoulder conditions described in the body of this paper. Rotator cuff disease, be it a full thickness tear or simply impingement with tendinitis may not respond to physiotherapy and/or injections and surgery may be offered to repair and at times, decompress the cuff. Suffice it to say that there is extreme variability in the results to be expected from the different types of surgery for the multitude of shoulder conditions treated.

References Cited

1. Van der Molen, Henk F., et al. “Work-related risk factors for specific shoulder disorders: a systematic review and meta-analysis.” *Occup Environ Med* 74.10 (2017): 745-755.
2. Van Rijn RM, Huisstede BM, Koes BW, Burdorf A. Associations between work-related factors and specific disorders of the shoulder—a systematic review of the literature. Scandinavian journal of work, environment & health. 2010 May 1:189-201.
3. Paraskevas, G., et al. “Morphological parameters of the acromion.” *Folia Morphologica* 67.4 (2008): 255-260.
4. Taljanovic MS, Carlson KL, Kuhn JE, Jacobson JA, Delaney-Sathy LO, Adler RS. Sonography of the glenoid labrum: a cadaveric study with arthroscopic correlation. American Journal of Roentgenology. 2000 Jun;174(6):1717-22.
5. Tischer, Thomas, et al. “Incidence of associated injuries with acute acromioclavicular joint dislocations types III through V.” *The American journal of sports medicine* 37.1 (2009): 136-139.
6. Löhr, J. F., and H. K. Uhthoff. “Epidemiology and pathophysiology of rotator cuff tears.” *Der Orthopade* 36.9 (2007): 788-795.
7. Meislin, Robert J., John W. Sperling, and Todd P. Stitik. “Persistent shoulder pain: epidemiology, pathophysiology, and diagnosis.” *American journal of orthopedics (Belle Mead, NJ)* 34.12 Suppl (2005): 5-9.
8. Kim, Jong Moon, et al. “The relationship between rotator cuff tear and four acromion types: cross-sectional study based on shoulder magnetic resonance imaging in 227 patients.” *Acta Radiologica* 60.5 (2019): 608-614.
9. Morelli, Kimberly M., et al. “Acromion morphology and prevalence of rotator cuff tear: A systematic review and meta-analysis.” *Clinical Anatomy* 32.1 (2019): 122-130.
10. Balke, Maurice, et al. “Correlation of acromial morphology with impingement syndrome and rotator cuff tears.” *Acta orthopaedica* 84.2 (2013): 178-183.
11. Popp D, Schöffl V. Superior labral anterior posterior lesions of the shoulder: Current diagnostic and therapeutic standards. *World journal of orthopedics*. 2015 Oct 18;6(9):660.

12. Milgrom, Charles, et al. “Rotator-cuff changes in asymptomatic adults. The effect of age, hand dominance and gender.” *The Journal of bone and joint surgery. British volume* 77.2 (1995): 296-298.

13. Somerson JS, Hsu JE, Gorbaty JD, Gee AO. Classifications in brief: Goutallier classification of fatty infiltration of the rotator cuff musculature.

14. Frost P, Andersen JH. Shoulder impingement syndrome in relation to shoulder intensive work. Occupational and environmental medicine. 1999; 56(7):494–8. PMID: 10472322; PubMed Central PMCID: PMC1757767.

15. Svendsen SW, Gelineck J, Mathiassen SE, Bonde JP, Frich LH, Stengaard-Pedersen K, et al. Work above shoulder level and degenerative alterations of the rotator cuff tendons: a magnetic resonance imaging study. Arthritis and rheumatism. 2004; 50(10):3314–22. https://doi.org/10.1002/art.20495 PMID: 15476229

16. Van Rijn Rogier M., et al. “Associations between work-related factors and specific disorders of the shoulder—a systematic review of the literature.” *Scandinavian journal of work, environment & health* (2010): 189-201.

17. Le HV, Lee SJ, NazaSrian A, Rodriguez EK. Adhesive capsulitis of the shoulder: review of pathophysiology and current clinical treatments. Shoulder & elbow. 2017 Apr;9(2):75-84.

Other Texts Utilized

1. Bernard BP 9 (ed): Musculoskeletal disorders and work-place factors. Washington DC. DHHS (NIOSH) , publication No 97-141, 1997

2. Halpern M, Hurd JL, Zuckerman JD: Occupational shoulder disorders, In: The Shoulder, Rockwood CA, Matsen III FA, Wirth MA, Lippitt SB (eds), 4th edition. Philadelphia, Saunders, 2009, pp.1489-1508.

3. National Research Council: Musculoskeletal disorders and the workplace. Washington DC. National Academic Press 2001

4. Wells R: Task analysis. In: Chronic musculoskeletal injuries in the workplace. Ranney D (ed). Philadelphia WB Saunders. 1997 pp.41-63