A Case Study of Rotator Cuff Insufficiency and the Use of Ultrasound Guided Corticosteroid Injection as Conservative Treatment

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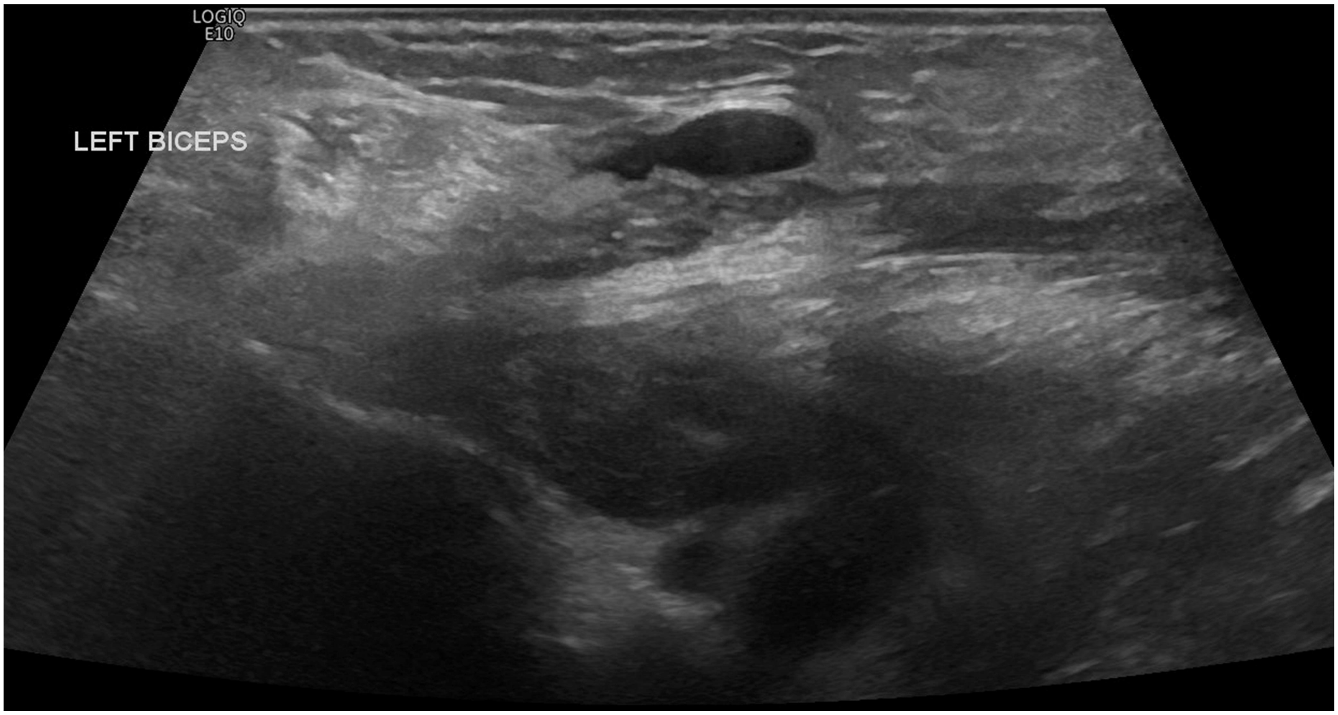
Case Presentation

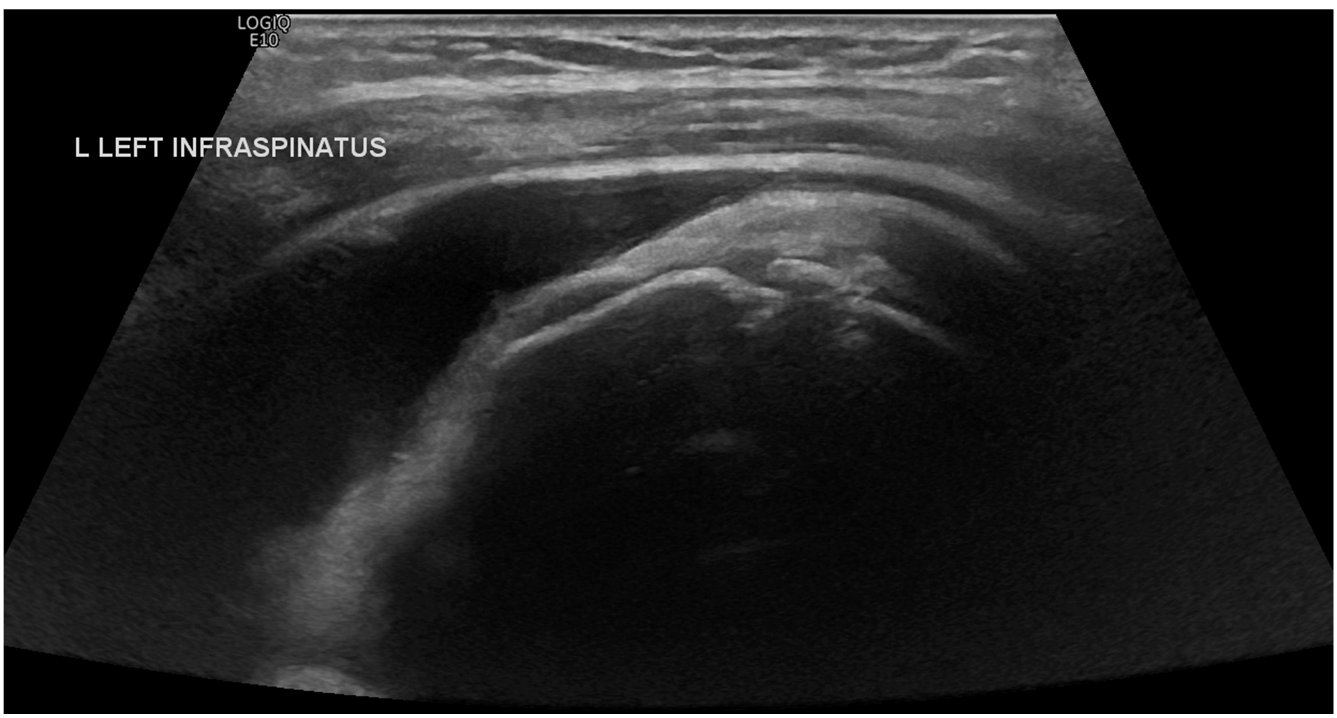
78 years old female patient was referred by her GP for suspected subacromial-subdeltoid bursitis. Patient presented with a large swelling on left anterior shoulder and was in great pain with very limited movement in her left shoulder. Patient reported that the range of movements of her left shoulder had been reducing for a number of years, and the swelling was not new. However, in recent months the swelling had increased in size significantly with great constant pain in her shoulder. She had been prescribed various types of painkillers and non-steroidal anti-inflammatory drugs (NSAIDs) over the years. The combined oral medications did not provide adequate pain relief since her new symptoms developed. She had physiotherapy sessions in the past, yet no significant improvements were noted. Patient also complained of diminishing quality of life, waking up at nights from the pain and loss of independency. She had been relying on carers and family members for basic daily activities including bathing and getting dressed.

Ultrasound Findings

Dynamic ultrasound scan was performed using GE Logic E9 machine. Shoulder Preset on Linear Transducer ML6-15 was selected. On ultrasound examination, the long head of biceps tendon was found to be completely ruptured with muscle atrophy (pic 1). The infraspinatus (pic 2) and subscapularis (pic 3) tendons were also fully ruptured. Minimal intact fibres were noted at the supraspinatus tendon which was also largely torn. Large amount of effusion was seen at glenohumeral joint (pic 4). The subacromial-subdeltoid bursa was markedly distended by a large volume of anechoic fluid (pic 2 and pic 3). Significant degenerative changes were evident at glenohumeral joint and at acromioclavicular joint (pic 5).

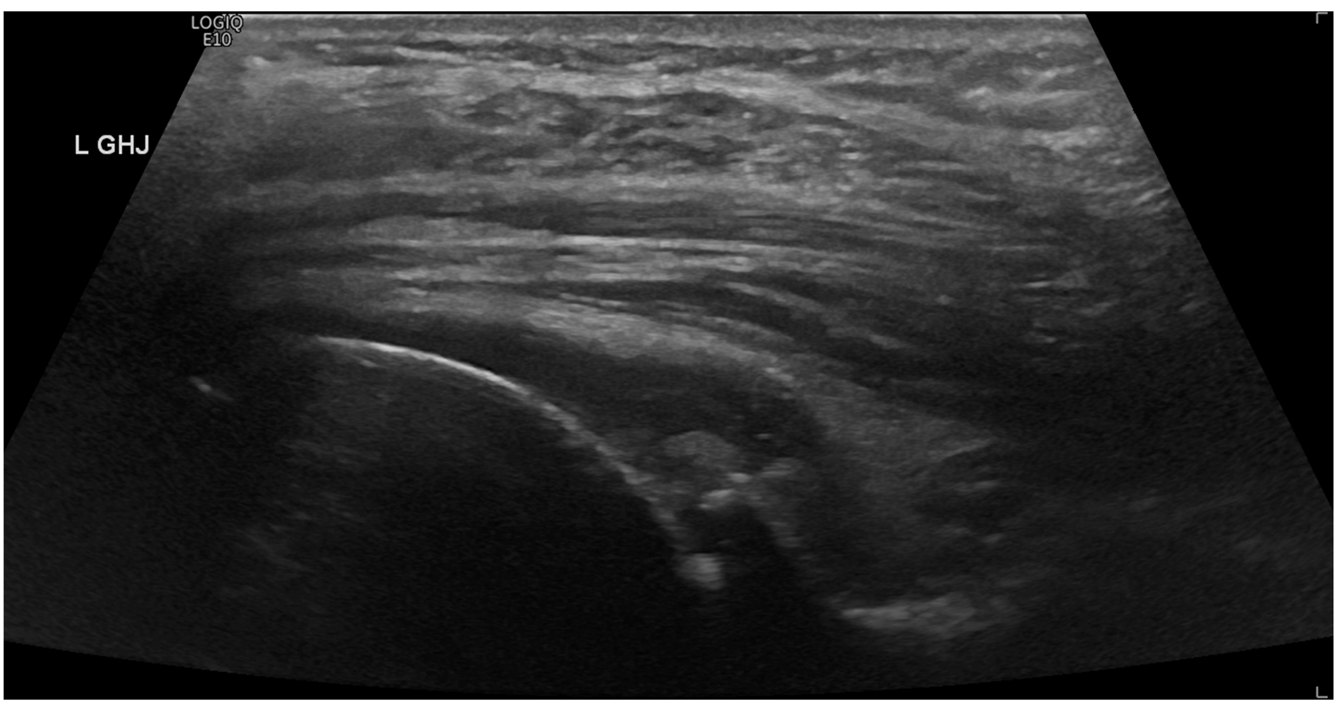


Pic 1. The long head of biceps tendon was ruptured with muscle retracted and atrophied.

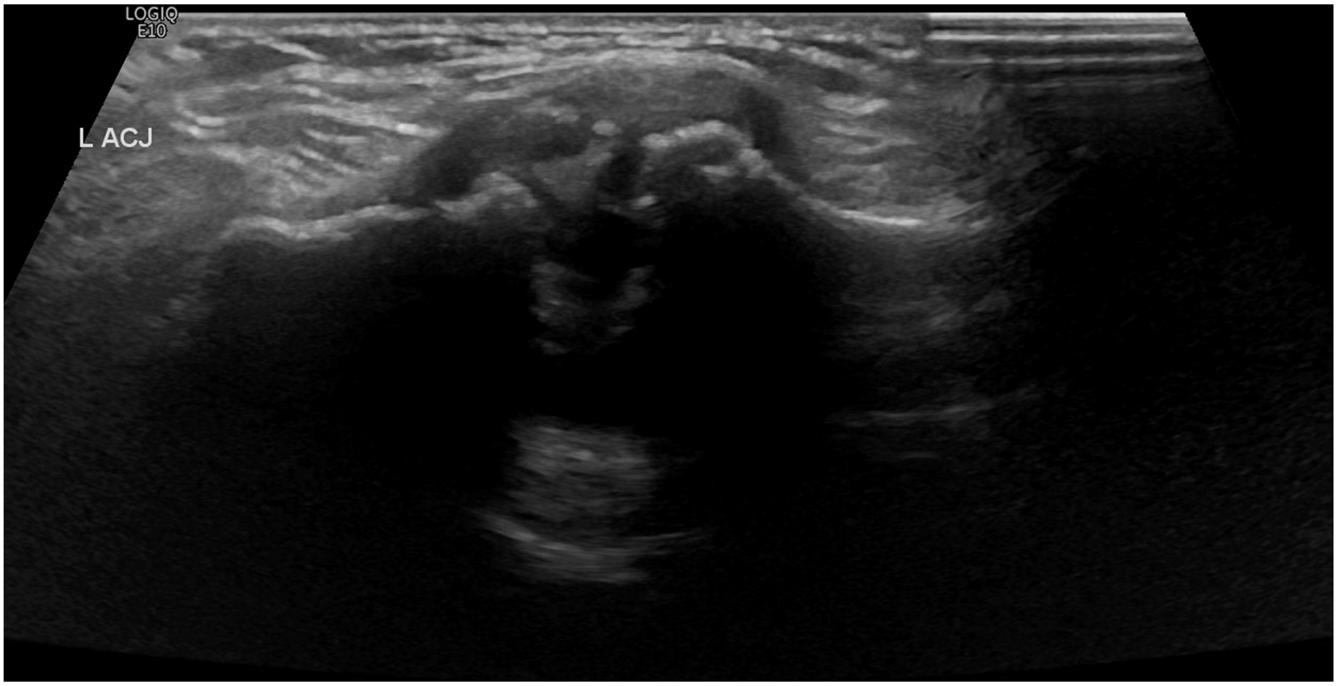


Pic 2. The infraspinatus tendon was ruptured with enthesopathy. Large amount of bursa fluid was seen at posterior shoulder.

Pic 3. Patient could not externally rotate the shoulder. The subscapularis tendon appeared ruptured with osteoarthristis changes of the glenohumeral joint. Large volume of subacromial-subdeltoid was seen from anterior shoulder.



Pic 4. Glenohumeral joint effusion seen posteriorly.



Pic 5. Acromioclavicular joint is degenerative with osteophytosis and synovial hyperplasia.

Patient Consent

An information leaflet issued by local NHS Trust on corticosteroid injection was sent to patient prior to the appointment outlining the procedure with attached consent form. Risks and benefits were discussed based on the initial ultrasound scan results. Patient had no known allergy; she was not diabetic and was not on any anticoagulants. There was no contraindication to note. She proceeded to signing a written consent form.

Ultrasound Guided Aspiration and Corticosteroid Injection Procedure

Patient was positioned sitting up with backrest to support her. The procedure was carried out with aseptic technique. The skin around the injection site was cleaned with Sani Cloth 70% Alcohol wipes. The transducer was also cleaned with Sani Cloth 70% Alcohol wipes, from transducer head to mid length of the attached cable. Sterile ultrasound gel was applied to the transducer.

Under ultrasound guidance, 40ml of the subacromial-subdeltoid bursa fluid was aspirated using 21G needle, followed by an injection of 80mg Kenalog in 3ml of 1% Lidocaine. The aspirated fluid was yellowish and clear, no precipitation or blood within. The aspiration and injection were performed with a single needle. A small plaster was placed over the needle site.

The procedures were well tolerated. She suffered no immediate complications and was well enough to make her way home with a family member. She was again reminded of the potential side effects. Given the extensive rotator cuff tears, explanation was made to the patient highlighting that the corticosteroid injection was part of the conservative treatments, and other treatment options should be discussed with a shoulder surgeon should the conservative treatments fail to bring adequate symptomatic relief.

Follow up

Patient reported no significant side effects post procedure. She took extra painkillers for 24 hours as precautions yet she did not suffer any significant discomfort. No excessive bleeding from the needle site, nor she noted any fever or chills. She recorded good pain relief up to 4 months at the time of follow up. She had since regained adequate range of movement but still relied on family members and carers for heavier duties such as cooking and cleaning.

Discussion

1 in 5 elderly populations of age 65 and above have significant rotator cuff tears (Fehringer et al, 2008). It is recognized that tendons in older populations show significant irreversible degenerative changes as studied by Brewer in 1979 using tendon specimens in autopsy subjects. The rotator cuff injuries can occur over time and often asymptomatic (Tempelhof,, Rupp and Seil, 1999) until sudden onset of symptoms caused by inflammation and mechanical impingement. Patients complain of wide range of debilitating symptoms include

pain, limited movement and usage of the shoulder, night pain and disturbed sleep and weakness.

Ultrasound is widely accepted as an effective first line of investigation to assess the integrity of the rotator cuff (Smith et al., 2011; Thakker et al., 2017) with low interobserver variability in the hands of experienced operators (O'Connor et al, 2005; Middleton, Teefey and Yamaguchi, 2004). When the initial ultrasound scan shows musculoskeletal pathology which may be beneficial with a corticosteroid injection (Foster et al., 2015), patients are offered the procedure on the same visit at my department. Risks and benefits will be assessed and discussed, corticosteroid injection, sometimes with aspiration and calcification lavage, is carried out with patient consent. This setup is effective and convenient to patients. Patients receive diagnosis and treatment on the same day without the need for a second appointment which also helps with cutting down ever increasing waiting list for ultrasound appointments in our department.

Ultrasound guided intraarticular corticosteroid injection

Intraarticular corticosteroid injections were administrated since the 1950s (Benedek, 2011) in treatments of rheumatoid arthritis. Ultrasound guided corticosteroid injections have higher accuracy compared to non-guided applications (Aly, Rajasekaran and Ashworth, 2015; Soh et al., 2011). Combined with physiotherapy, targeted application using a small dose of corticosteroid is effective in treating common musculoskeletal pathology; however, the efficacy varies (Foster et al., 2015). Intraarticular corticosteroid injection is found to be superior non-surgical treatment for adhesive capsulitis (Challoumas et al., 2020) in short term pain relief and improved range of movement in long term (Wang et al. 2017). For patients with lateral elbow tendinopathy, corticosteroid injection not only is ineffective, it worsens the condition (Olaussen et al. 2013). Soler-Pérez et al. (2021) gathered evidence of good pain reduction and shoulder functionality improvement from corticosteroid injection into glenohumeral joint, the study, however, only involved a small sample size. Despite multiple studies and decades of applications of corticosteroid injections, some scholars remain doubtful on the absolute benefit for certain joints such as hip and knee (Kompel et al., 2019)

Synthetic corticosteroid has potent anti-inflammatory effects. It is designed to imitate our body hormone cortisol produced in the adrenal glands, which is vital in regulating immune response (Coutinho and Chapman, 2011). Barnes (2005) detailed the complicated mechanisms of how corticosteroid controls inflammation. Kenalog-40 (triamcinolone acenotide) and Depo-Medrone (methylprednisolone acetate) are available at my department and are commonly used for musculoskeletal injections in Radiology in the United Kingdom (Shah et al., 2019). Due to poor consensus and lack of rigid guidelines, Shah et al. (2019) proposed recommendations on choice and dosage of corticosteroid for different body parts. Kenalog-40 is recommended for larger joints as it has larger particles thus. Depo-medrone, on the other hand, is more suitable for small joints. An 80mg dose of corticosteroid provides significant symptomatic relief for a longer period compared to a 40g dose for severe osteoarthritis patients (Robinson et al., 2007).

Mixing in a small volume of short acting local anaesthetics, such as Lidocaine, is a common practice for good reason. The extra fluid volume of the local anaesthetics not only acts as hydrodilatation which expands the joint space and dilutes existing inflammatory agents in the joint, it also dilutes the potency of corticosteroid to lower the risks of damaging adjacent tendon and soft tissue structures (Dean et al., 2014; Maman et al., 2016; Brinks et al, 2010). Short acting anaesthetics provide pain relief within 10 minutes of administration if the symptoms are arising from the injected joint. This reflects the potential symptomatic relief from the corticosteroid injection. Local anaesthetics are known to cause severe reactions including local anaesthetics systemic toxicity which is fatal in a small group of population. The estimated incidence is 0.03% (Šimurina et al., 2019).

<u>Side effect, adverse reactions and contraindication of corticosteroid injection</u>

Side effects from corticosteroid injections were recorded and studied as popularity increased (Benedek, 2011). Most of the side effects are temporary and self-limiting with some exceptions.

Up to 48 hours after corticosteroid injection, 2-10% of patients experience increased pain known as steroid flare (Stephens, Beutler and O'Connor, 2008) as corticosteroid may crystalize in the body (Alsop et al., 2016) and causes irritation. Facial flushing is self-limiting and patients recover within a few minutes or a few days without the need for any treatment. Vasovagal reaction can be due to patient anxiety or systemic steroid absorption. Patients recover promptly after a short rest of 30 minutes.

Corticosteroid also affects diabetic patients by reducing liver sensitivity to insulin, results in raised blood sugar level (Cardoza-Jiménez et al., 2021; Tamez-Pérez et al., 2015). Patient with diabetes should be carefully counselled on potential steroid induced hyperglycaemia and the effects on blood sugar level fluctuations which may last up to the effective duration of the choice of corticosteroid use.

Superficial injections and corticosteroid leakage along the needle track leave a small pool of corticosteroid solution in the subcutaneous layer reacting with the fatty tissue and acting on the skin causing fat atrophy and hypopigmentation at treatment site with incidence rate of 1.5 to 40% and 1.3 to 4% respectively (Brinks et al., 2010). The wide difference in subcutaneous atrophy rate is likely due to the heterogeneity of the types and locations of the injection as well as the study populations. Shanmugasundaram (2015) speculated that hypopigmentation may be caused by temporary impairment of melanocytes cells by the corticosteroid, which later recovered spontaneously. Subcutaneous fat atrophy is reported reversible after a few years (Park, Choi and Kim, 2013).

The theory of cartilage loss from repeat corticosteroid intraarticular injections is validated by McAlindon et al. in 2017 by giving corticosteroid injections for patients with knee pain every 3 months for 2 years. Significant cartilage volume loss was quantified in MRI scans compared to controlled group injected only with saline. Both group reported similar pain score. This supports the practice to refer patients for other treatments instead of frequent repeated corticosteroid injections.

Tendon rupture post corticosteroid injection is rare but undesirable. Coombes, Bisset and Vicenzino (2010) noted the rate of tendon rupture to be 0.1% in a systematic review. Retrospective study conducted by Lu et al. (2016) recorded 13 cases of spontaneous tendon rupture after corticosteroid injection in the span of 5 year in their hospital. However, 6 out of 13 patients had three or more injections. This is not a common practice and is even advised against. Corticosteroid changes the tendon cells in vitro, decreasing cell viability, cell proliferation and collagen synthesis as well as reducing tendon mechanical properties (Dean et al., 2014). Repeated use of corticosteroid in rat models showed weaker bone and deteriorated osteotendinous junction (Maman et al., 2016).

Septic arthritis is a rare but life threatening side effect with a mortality rate of 11.5% (Šimurina et al., 2019). Petersen, Hansen and Andreasen (2019) recorded septic arthritis rate at their centre to be 0.08% (or 1 in 1300) with slight increased risks in elderly patients. Stephens, Beutler and O'Connor (2008) reviewed available evidence and concluded similar septic arthritis incidence of less than 0.072%. Rheumatoid arthritis is also known to increase the risks of septic arthritis (Favero et al., 2008; Jung and Vossen, 2016). Mohamed et al. (2019) retrospectively analysed cases of iatrogenic septic arthritis from a single outpatient centre and identified inadequate training and poor aseptic techniques were the main contributors in their centre. Previous studies and cases (Chittick et al, 2013; Olshtain-Pops et al., 2011; Weist et al., 2000; Abdelfattah et al., 2017) had reported ultrasound gels, ultrasound machines and transducers as sources of contamination. Sherman et al. (2015) concluded that 70% isopropyl alcohol adequately decontaminated the injection sites as well as the instruments. Same study, however, found no difference infection risks in using sterile or non-sterile ultrasound gels during intraarticular injections. Nevertheless, worldwide professionals and regulatory bodies have since updated their recommendations to promote good aseptic techniques for all invasive procedures including the use of only sterile ultrasound gel (Nyhsen et al, 2017; Costello et al, 2020; European Society of Radiology, 2020; World Federation for Ultrasound in Medicine and Biology Safety Committee, 2020).

Several cautions and contraindications are applicable when considering corticosteroid injection (Kim and Gharibo, 2015). Patient prescribed with anticoagulants may have increased risks of excessive bleeding or developing haematoma. In the presence of local infection, suspected joint sepsis and for immunocompromised patients, corticosteroid injection should be avoided at all cost due to high risks of spreading infection and developing sepsis. Immunosuppressive nature of corticosteroid can worsen an underlying infection, patient taking antibiotics should delay corticosteroid injection temporarily. High risk of joint infection is also recorded if patients have the same joint operated on within 3 months of corticosteroid injection (Werner et al., 2016). Corticosteroid also disrupts bone healing thus inadvisable for patient with recent joint fracture (Liu et al., 2018).

<u>Anatomy and biomechanics of glenohumeral joint stability and rotator cuff insufficiency</u>

Anatomically, the glenohumeral joint is remarkably stable despite its bony construct. Universally considered as a ball and socket joint, the glenohumeral joint is, however, unusually shallow. The humeral head (the 'ball') is roughly the size of a racquet ball whilst the glenoid fossa (the 'socket') is not much deeper or larger than a teaspoon. The shallow surface of the glenoid allows great degrees of movements, which also contributes to the laxity of the joint and increases the risks of shoulder dislocation. The precise stability of glenohumeral joint depends on a well-balanced combined static and dynamic forces applied by the fibro-capsular components and the adjacent muscles including the rotator cuff (Labriola et al, 2005, Lippitt et al, 1993, Omoumi et al, 2011).

The glenohumeral ligaments, including superior glenohumeral ligament, middle glenohumeral ligament and inferior glenohumeral ligament come in superior, medial and the inferior aspects to connect humerus to glenoid forming a watertight capsule and acts as main static stabilizer protecting the joint from anterior dislocation. Corococlavicular and coracohumeral ligaments, along with corocoacromial ligament, maintain the positions of the clavicle and scapula to provide stability superiorly. Glenoid labrum is a fibrocartilaginous rim around the glenoid fossa. It deepens the concavity of the glenoid fossa, and continues anteriorly as part of the long head of biceps tendon. The glenoid labrum is likened to a valve block in sealing the glenohumeral joint from the atmospheric pressure, results in a very strong negative intra-articular pressure aiding to joint stability anteriorly and posteriorly centring the humeral head on the glenoid fossa (Lugo, kung and Ma, 2008).

The glenoid fossa has a unique oblong shape with a narrow top lip which further stabilise the humerus head in the centre of the glenoid. As a result, the humeral head must be lifted laterally away from the glenoid fossa during shoulder movements. The shoulder movements and the required stability are the responsibility of the surrounding muscles. Subscapularis, supraspinatus, infraspinatus and teres minor muscles originated from the scapula and are collectively called the rotator cuff. The muscles and their associated tendons provide stability in a manner distinctively termed Concavity Compression first described by Lippitt et al in 1993. The rotator cuff muscles are arranged in a unique way to compensate the displacing force and the upward force by the deltoid muscles at any shoulder movements. The shoulder is stable as long as the net vector force acting on the humeral head is balanced. The rotator cuff alone cannot completely compensate the upward force by the deltoid muscles. Coracoacromial arch also provides a concrete superior construct. This explains the reason that an isolated substantial supraspinatus tear does not cause significant superior subluxation. Combined compression of the intact infraspinatus and subscapularis muscles are able to adequately centre the humerus to the glenoid when supraspinatus muscle is insufficient.

Concavity compression is a highly effective mechanism when glenoid concavity is preserved. Experiments demonstrated that when the labrum is removed, the stability of the glenohumeral joint diminished in all directions (Lippitt et al, 1993). Wermers et al. (2021) are able to demonstrate that glenoid concavity is more important in maintaining glenohumeral stability independent of the glenoid bony defects. The rotator cuff, as well as adjacent muscles including pectoralis, latissimus dorsi, teres major and minor, deltoid and biceps brachii, is part of important components for effective concavity compression. Using computational and cadaveric models, Labriola et al. (2005) study the role of muscles in shoulder stability. Weakened infraspinatus muscle found to reduce the compression effect posteriorly, similar effect was demonstrated with increased in pectoralis major muscle force alone.

The Rotator cuff insufficiency or deficiency is used to define major rotator cuff tendon tears with damaged and loss of the associated muscles. As the rotator cuff plays a crucial role in shoulder stability, disruption of the delicate balance results in considerable structural changes and degeneration of the shoulder. The loss of concavity compression results in unopposed force of the deltoid causing upward shift of the glenohumeral joint. Superior migration of the shoulder further results in bony erosion, cartilage damages and eventually humeral head complete collapsed. 'Femoralisation' and 'acetabularisation' are specific findings when the humerus is eroded and the acromial arch is remodelled as a result of significant bony destruction. These observations were published by Neer, Craig and Fukuda in 1983, and termed as Cuff Tear Arthropathy. Large amount of joint effusion and subacromial-subdeltoid bursa fluid are also common findings (Hollister et al, 1995).

<u>Other Treatments for rotator cuff insufficiency</u>

The choice of surgical procedures is decided by many factors when conservative treatments are unsuccessful. Total shoulder arthroplasty and hemiarthroplasty are not suitable when there is a deficient rotator cuff and proximal humeral migration (Caniggia et al, 1999; Lin, Wong and Kazam, 2016).

Reversed total shoulder arthroplasty is preferable when the rotator cuff is insufficient but the deltoid muscles are intact. So named as the humerus head is replaced with a plastic socket while the metal ball is anchored to the scapular, reversing the original bony architect. As humerus is thicker in volume, it is highly suitable to create a deeper 'socket'. Insufficient deltoid function and arthritis are the contraindications (Sevivas et al, 2017).

Arthrodesis involves fusion of the glenohumeral joint. The humerus head is fused to the glenoid fossa and limits the range of movement which greatly improves stability and reduces pain. It is considered as last solution to offer symptomatic respite after failed reconstructions and for patients with inadequate deltoid functions (Diaz et al, 2003). Despite the obvious disadvantage, arthrodesis has proven to reduce pain when full range of shoulder movements is not as essential (Arenas-Miqueles et al., 2020).

Radiofrequency ablation (RFA) has been increasing popular as minimal invasive therapy for musculoskeletal pathology. Electric currents produced by radio wave are transmitted along the probe to ablate the scapular nerve under ultrasound guidance and thereby disrupt the pain signal from shoulder to the brain. Local anaesthetics is injected to the subscapular nerve prior to RFA, it serves as temporary pain relief for the procedure, and provides insights on how effective the RFA would be after the procedure. RFA of the scapular nerve has shown to be an effective alternative treatment for rotator cuff arthropathy (Chua, Vissers and Sluijter, 2011) for those who are not the ideal candidates for surgical interventions. RFA is often well tolerated and carries out as outpatient appointments. Post procedures complication risks are low, and the long term pain reliefs are well documents (Orhurhu et al., 2019; Agarwal et al, 2020).

Conclusion

Rotator cuff insufficiency can be a painful and debilitating condition. Treatments aim to reduce pain, restore some of the shoulder functions and strength. Ultrasound is readily available as first line of investigation and corticosteroid injection is very useful as conservative therapy before other more invasive options are discussed. Corticosteroid injection is not without its risks, but the benefit of short term pain relief is well received by patients. Despite the risks and side effects of intraarticular corticosteroid injection being generally low, multiple dosages within a short period is not encouraged. Corticosteroid and local anaesthetics, likely any other drugs, must be used only indicated with no contraindications. Aspiration of excess joint and bursa fluid increases the effectiveness of corticosteroid injection (Weitoft and Uddenfeldt, 2000). The effect of corticosteroid might be short-lived for rotator cuff arthropathy (Rodriguez-García et al, 2021), however it provides effective temporary symptomatic relief and allows planning for further treatments.

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