INTRODUCTION

There is an increasing trend in medicine to utilize ultrasound for diagnosis of musculoskeletal pathology. Although magnetic resonance imaging provides excellent spatial resolution of musculoskeletal structures in multiple imaging planes and is generally the cross-sectional modality of choice, it does not provide dynamic functional assessment of muscles, tendons, and ligaments. (**Löfstedt T et al., 2012).**

Dynamic maneuvers with ultrasound provide functional data and have been shown to be accurate for diagnosis. (**Löfstedt T et al., 2012).**

Ultrasound image resolution has substantially improved over the past few decades, enabling increased clinical application. Unlike magnetic resonance (MR) and computed tomography (CT) imaging, which provide structural information, sonography allows acquisition of dynamic information. (**Yablon CM et al., 2013).**

In dynamic ultrasound imaging, the patient performs a movement while the physician holds the ultrasound probe relative to an anatomic landmark. This has particularly useful applications for musculoskeletal (MSK) imaging, where several pathological conditions are elicited only through patient movement. **(Khoury V et al., 2012).**

Ultrasound also offers the benefits of increased accessibility, lower cost, and no use of ionizing radiation. **(Khoury V et al., 2012).**

Ultrasound is a powerful screening examination for athletes with upper limb injuries. It is very effective in demonstrating injuries to muscle, tendon, ligament, and nerves. The technique is particularly useful in excluding joint effusion and in detecting soft tissue foreign bodies. (**David J and Georgina M, 2012).**

Dynamic ultrasound examination is especially useful in detecting subluxation of tendon and nerves; it may be the only means of demonstrating the cause of snapping. (**Roy A., 2013).**

Snapping occurs from impingement of a structure against another anatomic or heterotopic structure. It is associated with abrupt movement and a clicking or snapping noise. Also be called clunking, locking, or triggering. (**Roy A., 2013).**

Patients may require surgical intervention in cases of severe pain or dysfunction. Examples include trigger finger. Ultrasound is particularly useful in snapping syndromes. (**Roy A., 2013).**

Friction syndromes occur from a smooth impingement, resulting in pain, but without the audible snaps or clicks. Examples include intersection syndrome of the wrist band. Although ultrasound may demonstrate static findings similar to MR imaging (MRI), dynamic imaging is proven and applicable in certain conditions, but not well researched in others. **(Guillin R et al., 2012).**

Ultrasound has become the primary diagnostic tool in traumatic, inflammatory and degenerative soft tissue conditions. It is also used to monitor the condition of joints, ligaments, cartilage and muscles **(Sudoł-Szopińska et al., 2017).**

Ultrasound has some advantages over MRI,

- First, it costs less **(Acebes et al., 2013).**
- Second, with ultrasound it is possible to obtain dynamic imaging **(Acebes et al., 2013).**
- Third, all patients, including those who are claustrophobic, can undergo ultrasound **(Najafi et al., 2006).**
- Fourth, ultrasound facilitates bilateral comparison and repetitions at will **(Friedman et al., 2003).**
- Fifth, many ultrasound machines can be brought to the patient, and explanation of the results can be rapid **(Friedman et al., 2003).**

There are also limitations to using ultrasound. There is a relatively steep learning curve and dependence on the training, skill, and experience of the operator. **(Lee et al., 2001).**

A wide variety of MRI pulse sequences can be performed to produce diagnostic quality images. These include T1, proton density, T2, STIR, spin echo, fast (turbo) spin-echo, and gradient-echo sequences, which all have been proven suitable for musculoskeletal imaging. **(Romulo Balthzar et al., 2009).**

AIM OF THE WORK

The purpose of this study to evaluate the role of dynamic ultrasound in upper limb muscloskeletal traumatic and non-traumatic disorders.

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Chapter 1

ANATOMY

THE SHOULDER JOINT

- ***Rotator Cuff***

The rotator cuff consists of four muscles and their tendons: subscapularis, supraspinatus, infraspinatus, and teres minor. The subscapularis muscle arises from the subscapular fossa; its fibers extend anteriorly to the glenohumeral joint, and its tendon inserts in the lesser tuberosity of the humerus (Fig 1a). **(Anthony F.,et al.,2008)** .

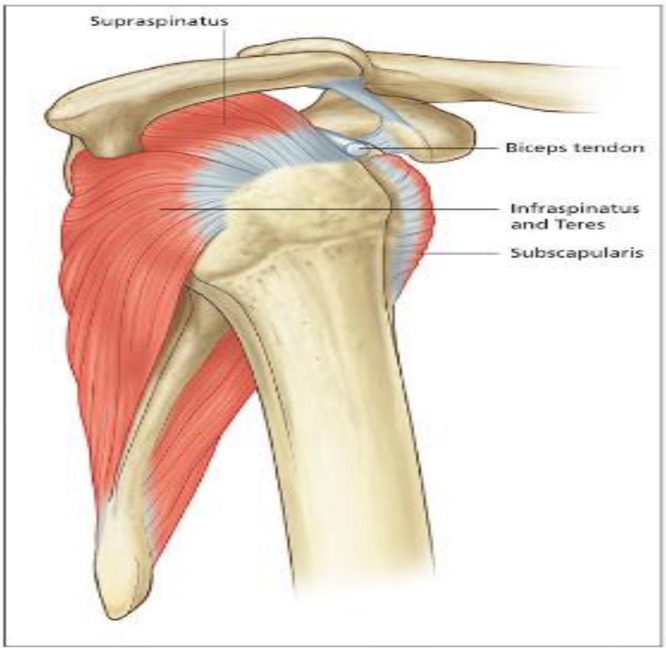

Figure 1a: The glenohumoral joint is stabilized by a combination of the joint capsule with its condensators. ***(Quoted from Eugene G. McNally., 2014).***

The supraspinatus muscle originates from the supraspinatus fossa of the scapula and passes under the acromioclavicular joint, its tendon inserts in the anterior portion of the greater tuberosity of the humerus. The infraspinatus muscle arises from the infraspinatus fossa of the scapula, and its tendon inserts in the posterior portion of the greater tuberosity, touching the posterior aspect of the supraspinatus tendon. The teres minor muscle originates from the lateral border of the scapula and inserts in the posterior aspect of the humeral head, posteroinferiorly to the infraspinatus tendon (Fig 1b). **(Papatheodorou A., et al 2006)** .

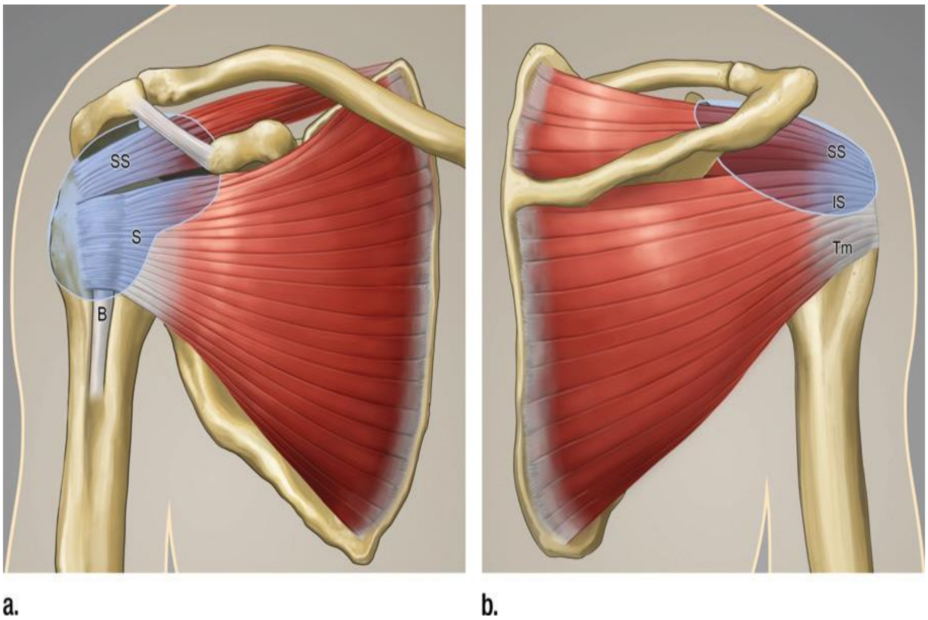

Figure 1b: Shoulder anatomy. Illustrations of (a) anterior and (b) posterior shoulder show supraspinatus (SS), infraspinatus (IS), subscapularis (S), teres minor (Tm), and long head of the biceps brachii tendon (B). Subacromial-subdeltoid bursa is overlying the rotator cuff (light blue). **(Quoted from Jacobson JA., 2011).**

➢ *Non-Rotator Cuff*

The Non–Rotator Cuff structures include several tendons, ligaments, and bursae in the shoulder area. The 9-10 Cm long tendon of the long head of the biceps muscle (LHBT) arises from the supraglenoid tubercle and the superior glenoid labrum, courses over the top of the humeral head intra-articularly but extra-synovially, and goes down into the bicipital groove between the greater and lesser tuberosities. (Fig 2) (**Charles E., et al., 2017)**

Figure 2. Biceps tendon, transverse view. The biceps tendon (arrows) lies within the bicipital groove, between the lesser (LT) and greater (GT) tuberosities and below the deltoid muscle **(Quoted from Papatheodorou A, et al., 2006)**

➢ *Rotator Interval*

The rotator cuff has two tendinous gaps that are exclusively covered by capsular tissue: one anteriorly between the subscapularis (SSC) tendon and the supraspinatus (SSP) tendon, termed the anterior rotator interval, and one posteriorly between the supraspinatus tendon and the infraspinatus tendon, termed the posterior rotator interval(Fig 3). (**Klaus W.,et al., 2015).**

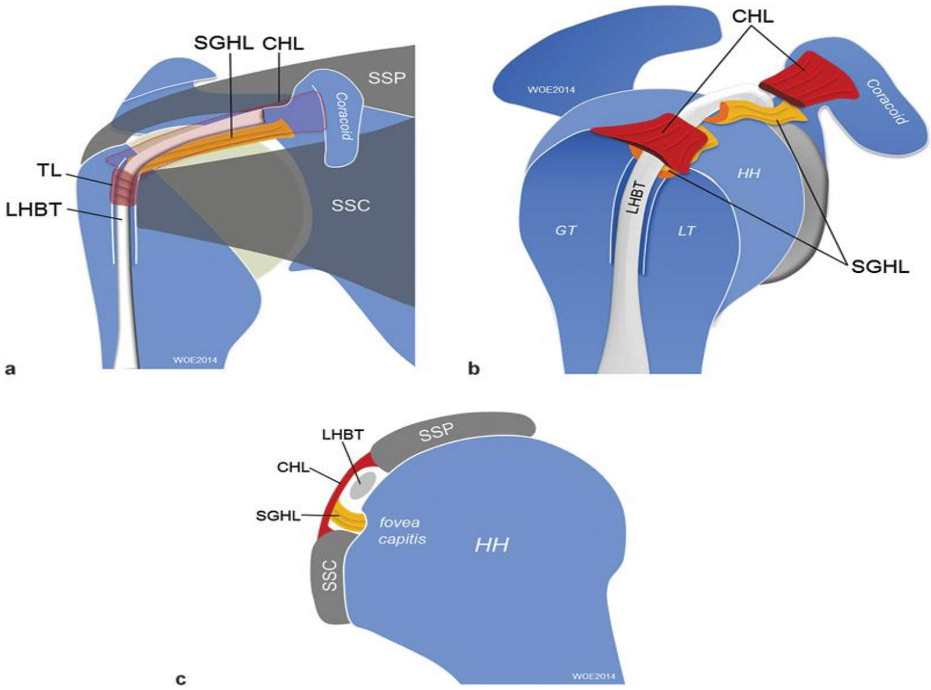

Figure. 3 Schematic drawings of the anatomy of the rotator interval. **(Quoted from Klaus W.,et al., 2015).**

➢ *The glenohumeral joint*

The glenohumeral joint capsule extends from the glenoid rim to the humeral neck. This capsule normally contains no US-detectable fluid. The fibro-cartilaginous labrum surrounds the glenoid rim. Because of capsular laxity, certain synovial redundant spaces become prominent when the joint contains an effusion: the axillary pouch lying below the teres minor, the posterior recess lying deep to the infraspinatus tendon, the anterior recess lying next to the anterior labrum, and the superior subscapularis recess lying anterior to the superior surface of the subscapularis tendon. **(Papatheodorou A. el al., 2006)**.

➢ *The acromioclvicular joint*

The acromioclavicular joint (Fig 4) is made up of a fibro-cartilaginous articular disk of highly variable size and with a weak capsule, is reinforced by the superior, inferior, anterior and posterior acromioclavicular ligaments. The superior and posterior components provide the most significant contribution to horizontal stability at the joint. The acromioclavicular joint is further strengthened by the delto-trapezius aponeurosis. (**Fraser M.J. A et al., 2008)**

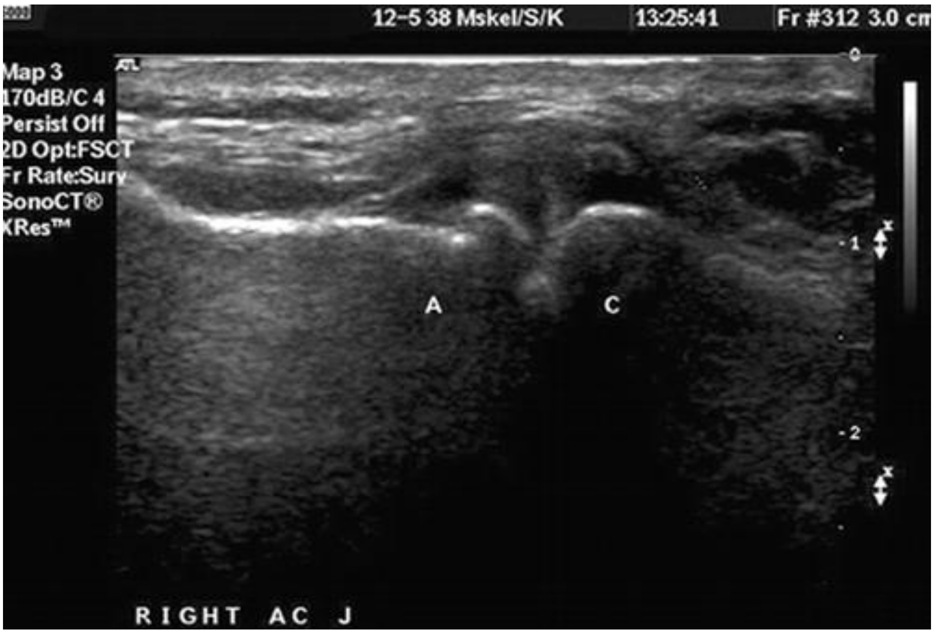

Figure 4 Acromioclavicular joint, longitudinal view. The acromioclavicular joint is the area between the acromion (A) and clavicle (C). The superior aspect of the joint capsule is seen as a hypoechoic band above the joint. **(Quoted from Papatheodorou A, et al., 2006)**

THE ELBOW JOINT

Joint articulation anatomy

The distal humerus is composed of 2 articulations: the trochlea, and the capitellum. The trochlea has a slight posterior tilt that prevents posterior translation by relying on the coronoid buttress**. (Karbach, L. E., & Elfar, J., 2017)**.

The proximal ulna contains 2 articulations, the greater and lesser sigmoid notches. The trochlea and greater sigmoid notch have highly congruent anatomy. The lesser sigmoid notch articulates with the margin of the radial head at the proximal radioulnar joint. The radial head is a concave elliptical structure, covered with articular cartilage along the radiocapitellar joint, this articulates with both the capitellum and the lesser sigmoid notch. (Fig. 5) **(Karbach, L. E., & Elfar, J., 2017)**.

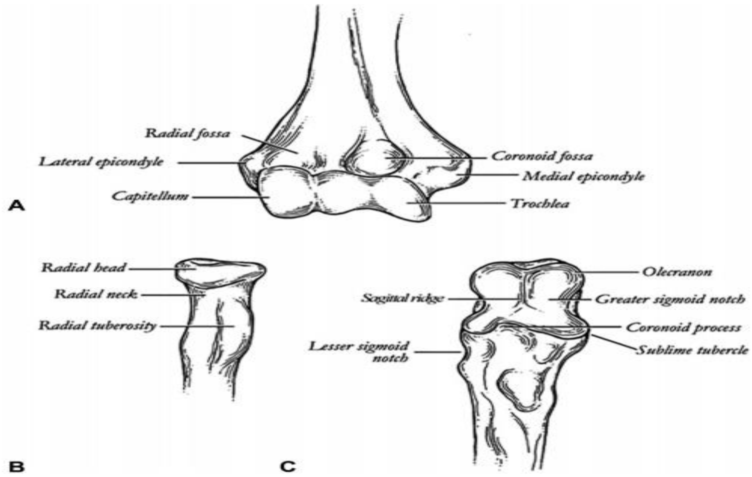

Figure 5. Osseous elbow anatomy. **(Quoted from Bryce, C. D., & Armstrong, A. D. 2008).**

Soft tissue anatomy

The collateral ligaments of the elbow are medial and lateral capsular thickenings that provide enhanced stability. The MCL, also known as the ulnar collateral ligament, comprises three ligamentous portions: anterior bundle (AMCL), posterior bundle, and transverse ligament (Cooper ligament). The AMCL and the posterior bundle originate at the anteroinferior medial epicondyle of the elbow. The AMCL inserts at the sublime tubercle on the coronoid and the posterior bundle inserts on the medial olecranon. **(Karbach, L. E., & Elfar, J., 2017)**.

The lateral collateral ligament (LCL) is a complex with 4 primary ligamentous portions: lateral ulnar collateral ligament (LUCL), radial collateral ligament (RCL), annular ligament, and accessory collateral ligament. The LUCL and RCL originate from an isometric point on the inferior surface of the lateral epicondyle, providing consistent tension through elbow motion. The LUCL attaches to the supinator crest of the proximal ulna and is a restraint to varus and posterolateral rotatory instability (PRLI). The annular ligament encircles the radial head and attaches to the anterior and posterior margins of the lesser sigmoid notch. The RCL attaches to the annular ligament to stabilize the radial head (Fig. 6). **(Ahmed I. and Mistry J.,et al.,2015)**

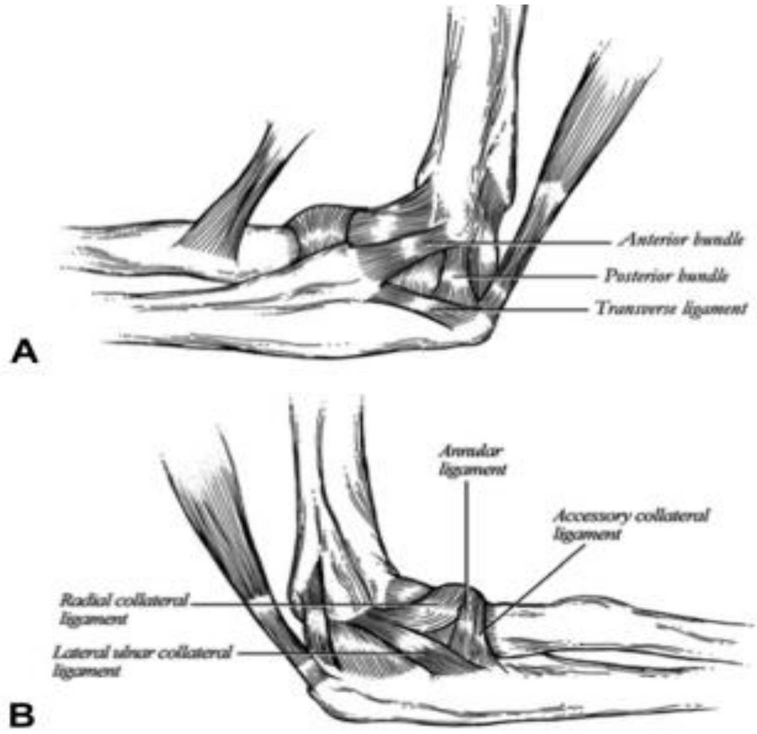

Figure 6: Medial and lateral ligamentous stabilizers of the elbow. A MCL complex. B LCL complex. **(Quoted from Karbach, L. E., & Elfar, J., 2017).**

The muscles forming the medial complex of the elbow include the flexor carpi ulnaris, flexor carpi radialis, flexor digitorum superficialis, and pronator teres. Together, this group provides a support that is capable of resisting valgus forces. In comparison, the muscles forming the lateral complex of the elbow (extensor carpi ulnaris, extensor digitorum communis, extensor carpi radialis brevis, extensor carpi radialis longus, and anconeus) provide a reinforcement to resist varus forces. Together, the medial and lateral musculo-tendinous complexes contribute to a dynamic stability of the elbow as a result of compression of the joint surfaces against each other. (Fig 7) (**Ahmed I. and Mistry J.,et al.,2015)**

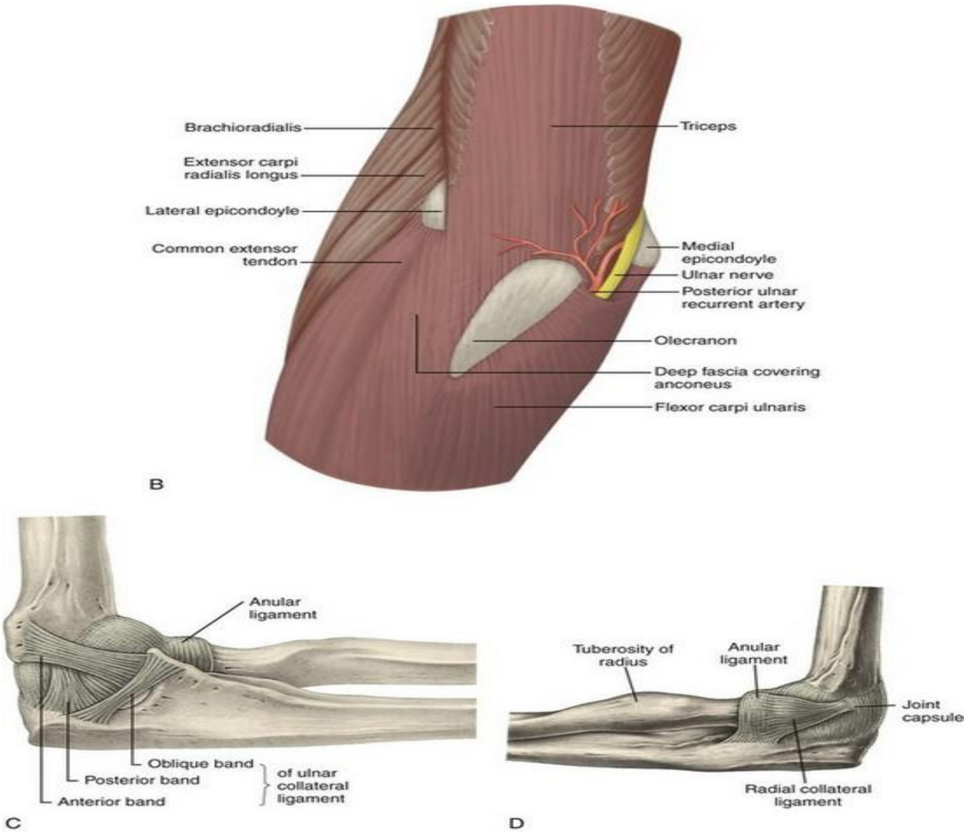

Figure 7 Elbow anatomy. A, Anterior aspect of the left elbow showing deep structures. B, Posterior aspect of the left elbow showing superficial structures. C, Medial aspect of the left elbow joint. D, Lateral aspect of the left elbow joint. **(Quoted from Standring S: Gray's anatomy 2005).**

THE WRIST AND HAND JOINTS

Bones of the wrist (Carpus): The carpus contains eight bones in proximal and distal rows of four. Proximally, in lateral to medial order, are the scaphoid, lunate, triquetral and pisiform; in the distal row is the trapezium, trapezoid, capitate and hamate.(Fig 8) ***(Roger, 2015).***

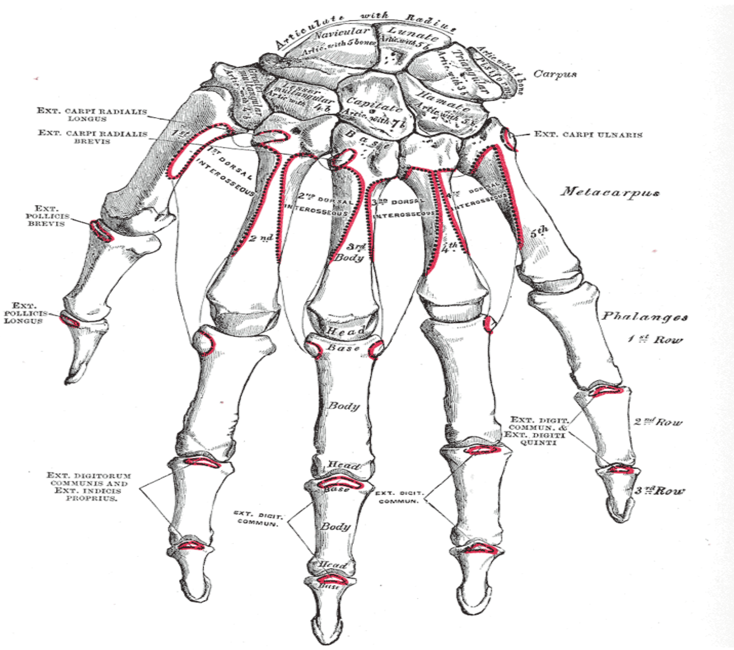

Figure. 8: Bones of the left hand from the dorsal aspect. **(Standring,et al., 2010).**

The wrist (radiocarpal) joint:

It is a synovial biaxial and ellipsoid joint.(Fig 9) ***(Standring, et al.,2010).***

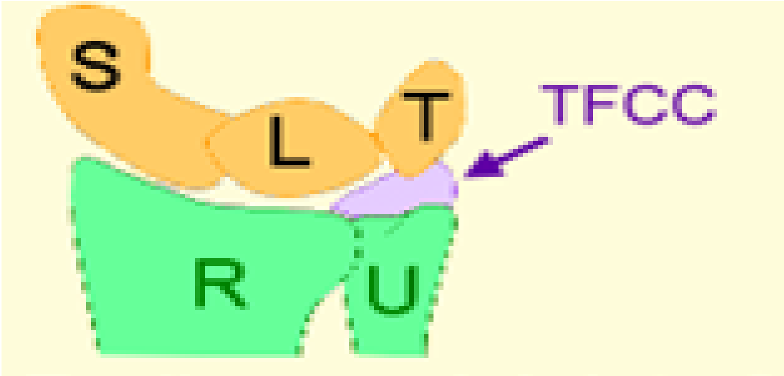

Figure 9: Radiocarpal joint; TFCC (triangular fibro-cartilage complex) **(Quoted from Neumann,et al., 2015).**

1. Articular surfaces:

The convex proximal surface of the carpus (formed by the scaphoid, lunate and triquetrum bones and their interosseous ligaments), and the concave socket formed by the distal surfaces of the radius and the triangular articular disc. This disc joins the medial edge of the articular surface of radius to the styloid process of ulna, separating the ulna from the joint **(Romanes, et al.,2010).**

2. Fibrous capsule and synovial membrane:

The capsule passes from the margins of distal ends of radius and ulna, and from the margins of the articular disc to the proximal row of carpal bones, excluding the pisiform bone ***(Romanes et al., 2010).***

3. Tendons:

The tendons of the wrist are grouped into flexor and extensor compartments ***(Joseph et al., 2011).***