

## INTRODUCTION

**D**istal radius fractures are the second most common fracture in the elderly, second only to hip fractures, and account for 18 % of all fractures in the geriatric population.<sup>(1)</sup> Whilst few would argue that simple, stable fracture patterns are best treated with a period of immobilization, debate continues as to the optimal treatment modality for dorsally displaced, unstable injuries.<sup>(2)</sup>

Historically, Kirschner (K)-wire stabilization was the preferred option, with external fixation and dorsal plating used either alone or in conjunction with K-wires, providing adjuncts to increase the stability of the surgical construct. Advancements in volar plating have been reflected by a rapid expansion in the popularity of such systems.<sup>(2)</sup>

In the United States in 1999, orthopedics trainees treated 58% of distal radius fractures with percutaneous pinning (PCP). By 2007, only 19% of cases were treated using PCP. Volar plates offer a number of distinct advantages over other techniques, including precise periarticular reconstruction, avoidance of dorsal scarring and disruption of the dorsal branches of the anterior interosseous artery, improve implant coverage within the pronator quadratus (PQ) fossa reduce risk of tendon irritation attrition and implant stiffness that will support the physiological loads placed on the wrist joint so it biomechanically superior.<sup>(2)</sup>

There are numerous studies in the literature showing the advantages of these systems over conventional treatment modalities. However there are no randomized controlled trials comparing the most common treatment of unstable distal radial fractures which are PCP and volar plates. PCP cannot

protect against radial collapse in osteoporotic bone as they are not load-bearing devices. It is accepted that malunion with loss of radial height is common in osteoporotic bone that has poor functional results.<sup>(2)</sup>

It was the aim of this study to compare both the functional and radiological outcomes of extra-articular distal radial fractures managed using open reduction and internal fixation (ORIF) with volar plates and closed manipulation with percutaneous pinning in a prospective randomized manner.<sup>(2)</sup>

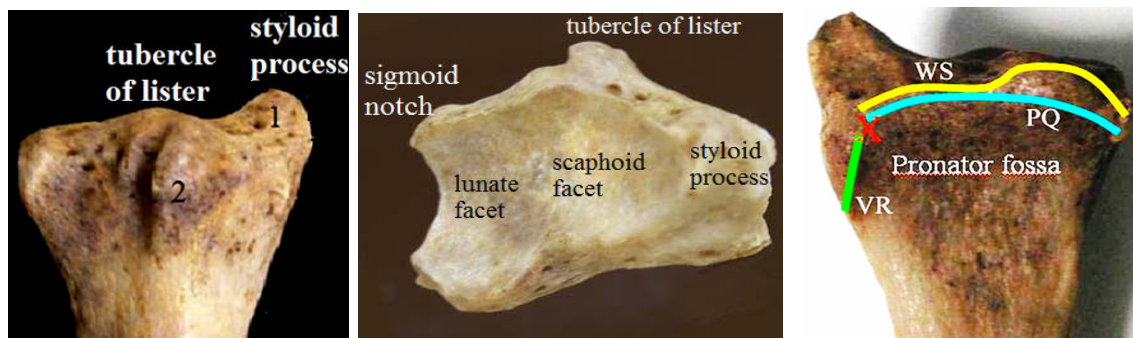
## **AIM OF THE WORK**

**T**his thesis aims at comparison between both the functional and radiological outcomes of extra-articular distal radial fractures managed using open reduction and internal fixation (ORIF) using volar plates through volar approach and closed manipulation, percutaneous pinning (PCP) using K-wire in prospective randomized manner.

## I- ANATOMY OF DISTAL RADIUS

### A) Osseous anatomy

**D**istal radius is composed 1<sup>ry</sup> of cancellous bone, has biconcave, triangular articular surface that covered with hyaline cartilage. A ridge divides the articular surface into a triangular lateral and quadrilateral medial facet articulating with the scaphoid and lunate respectively (fig. 1).<sup>(3)</sup>



**Figure (1):** Shows a) dorsal, b) articular, c) palmar surfaces of the distal radius.<sup>(2)</sup>

Lateral surface of the radius has a prominent styloid process. The medial surface forms a semicircular notch, enables the radius to swing around the head of the ulna,<sup>(1)</sup> forming the distal radioulnar joint (DRUJ) that extends from sigmoid notch of the radius to the ulnar head and ulnar styloid by the triangle of fibrocartilage complex (TFCC). It enhances joint stability and helps absorb compressive forces.<sup>(3, 4)</sup>

#### **1 .Volar Radial Tuberosity:** marked "x" in

It is up to 3 mm in size on the radial margin of the PQ fossa. Plates that are placed too radial will be pronated, don't lie flat on the radius and become palpable (fig. 1).<sup>(5)</sup>

#### **2. Volar Radial Ridge (VR):**

It extends proximally from the volar radial tuberosity and marks the radial limit of the PQ fossa. It could pronate a plate placed too radially and proximally (fig. 1).<sup>(5)</sup>

### **3. Fibrous transition zone (FTZ):**

It lies between the distal margin of the PQ and the mobile wrist capsule. It doesn't move with capsule during wrist flexion and extension. Its elevation exposes volar fracture fragments. Leaving a strong edge 2 mm attached to the PQ line will facilitate its repair to form a thick and reliable interposition between the plate and tendons (fig. 1).<sup>(5)</sup>

### **4. Watershed Line (WS line):**

It is a theoretical line at the volar aspect of the volar margin of radius, covered by volar capsule. If volar Plate applied too volar may act as a fulcrum for tendons in power grip and leads to flexor tendons tenosynovitis and rupture (fig. 1).<sup>(5)</sup>

### **5. Lunate Facet Buttress:**

The volar rim of the lunate facet protrudes more than that of the scaphoid facet. It gives a relative flat surface for plate placement making it less palpable (fig. 1).<sup>(5)</sup>

## **B) Ligaments of wrist Joint:**

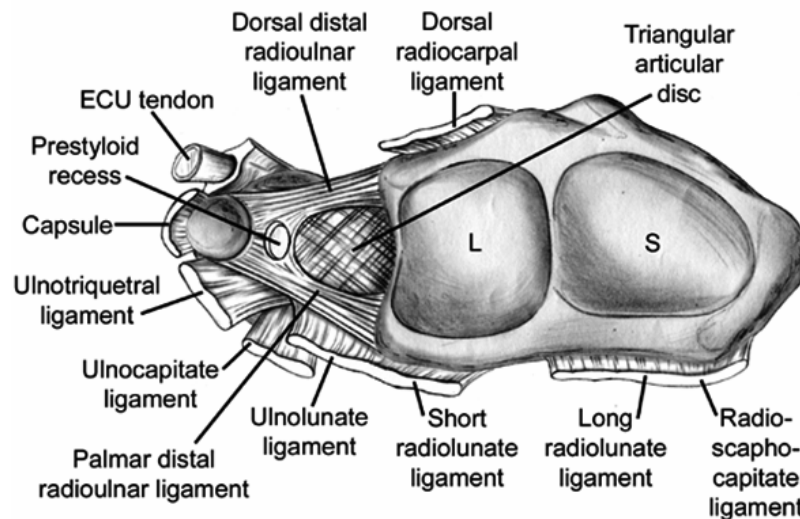
### **a. Extrinsic ligaments:**

Complex system of ligaments provides stability without sacrificing significant motion with significant role of the fracture patterns via ligamentotaxis.<sup>(4)</sup>

#### **1- Palmar ligaments:**

- **Radiolunotriquetral ligament (RLT):** Fibers originates on the palmar aspect of the radial styloid process, and then passes through the groove of the scaphoid waist to be inserts on the palmar aspect of the lunate (fig. 3).<sup>(4)</sup>
- **Short radiolunate ligament:** it doesn't appear well on MRI (fig. 2, 4).<sup>(4)</sup>

- **Radioscaphocapitate ligament (RSC):** it originates from the radial styloid process, passes through the waist of scaphoid, inserts to its distal pole and terminates on the capitate (fig. 2, 3, 4).<sup>(4)</sup>
- **Radioscapholunate ligament:** it originates from the palmar aspect of radius and inserts along the scapholunate ligament (fig. 3, 4).<sup>(4)</sup>



**Figure (2):** Extrinsic ligaments of the wrist at palmar and dorsal aspect of distal radius.<sup>(4)</sup>

## 2- Dorsal ligaments:

Dorsal radiotriquetral ligament (DRT) originates from the dorsal aspect of the distal radius, and inserts to the dorsal aspect of the triquetrum. The dorsal radiolunate ligament (DRL) (fig. 3, 4) originates from the DRU ligament then inserts to the dorsal aspect of the lunate.<sup>(4)</sup>

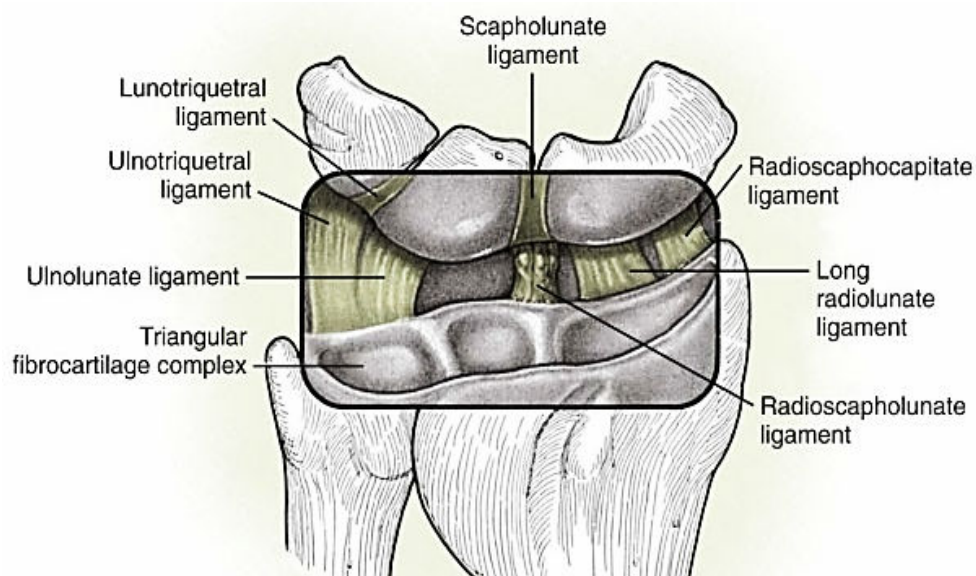
## 3- Lateral ligaments:

Radial collateral ligament (RC): it originates from tip of the radial styloid process and inserts into the scaphoid waist before joining the capsule to insert into the trapezium, so it should not be sacrificed during the volar approach (fig. 3).<sup>(4)</sup>

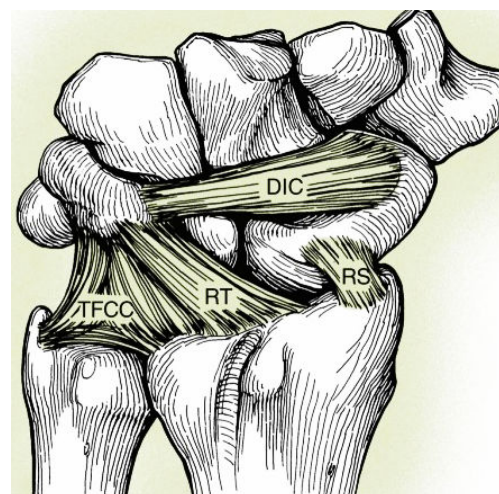
The extrinsic ligaments have a major role in intercarpal dynamic stability than the intrinsic ligaments. the little fibrocartilage, sparse amounts of elastin and more collagen Type 3 make them stronger biomechanically and elongate further prior to failure.<sup>(6)</sup>



**Figure (3):** Dorsal , volar and lateral extrinsic ligaments of the wrist course shown on x-ray.<sup>(4)</sup>



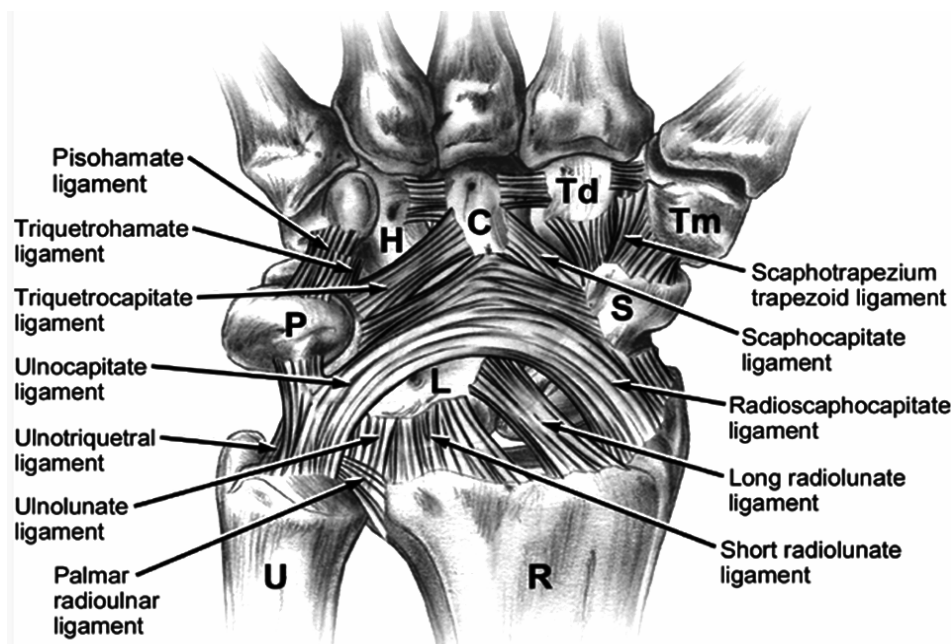
**Figure (4):** Palmar, dorsal and lateral extrinsic ligaments of the wrist of distal radius.<sup>(7)</sup>





**b. Intrinsic (intercarpal ligaments) ligaments:**

They connect adjacent carpal bones (proximal and midcarpal rows). They are trapeziocapitate, capitolunate, scapholunate ligament and lunotriquetral ligaments (fig. 4, 5). The last two considered the most commonly liable to injury in the wrist. If not properly diagnosed, it may lead to late carpal instability and poor function.<sup>(8)</sup>



**Figure (5):** Intrinsic and extrinsic ligaments of the wrist.<sup>(9)</sup>

## **C) Muscles**

### **1. Pronator quadrates (PQ)**

It is a flat, quadrilateral muscle that arises from the pronator ridge on ulna and is inserted at the lower  $\frac{1}{4}$  of lateral border and volar surface of the radius. PQ is innervated by anterior interosseous nerve (C7-8). PQ should be repaired to add stability to the DRUJ and provide a soft layer between the plate and the overlying tendons.<sup>(10)</sup>

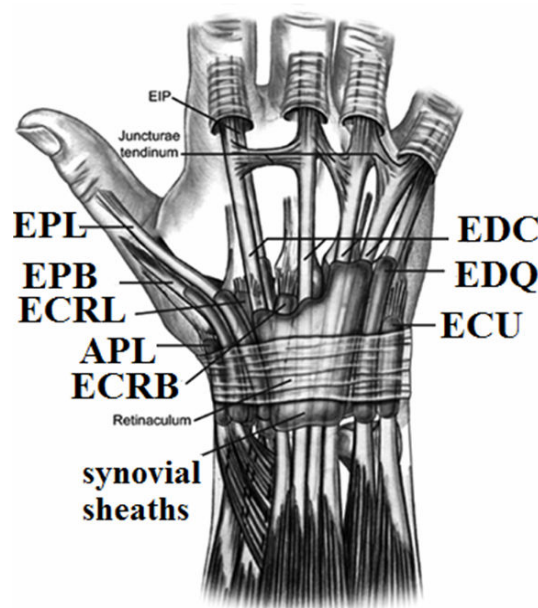


## 2. Brachioradialis (BR)

It originates from the upper  $\frac{2}{3}$  of lateral supracondylar ridge of the humerus and is inserted into the lateral side of styloid process of the radius. It acts as a deforming force and may be the cause of redisplacement. To reach the dorsal side of the fracture we incise the BR tendon in a Z fashion during volar approach for hematoma and callus debridement. <sup>(10, 11)</sup>

### **D) Extensor Retinaculum (ER) and its compartments**

It is a strong fibrous band extends obliquely across the back of the wrist. Five septa divide its under surface into six compartments. Each transmits one or two tendons (fig. 6), and is lined with synovial sheath which envelope the tendon/s and facilitates their sliding. <sup>(12)</sup>



**Figure (6):** Extensor retinaculum and underneath structures at the dorsum of the wrist. <sup>(13)</sup>

### **E) Volar Tendons and neurovascular structures**

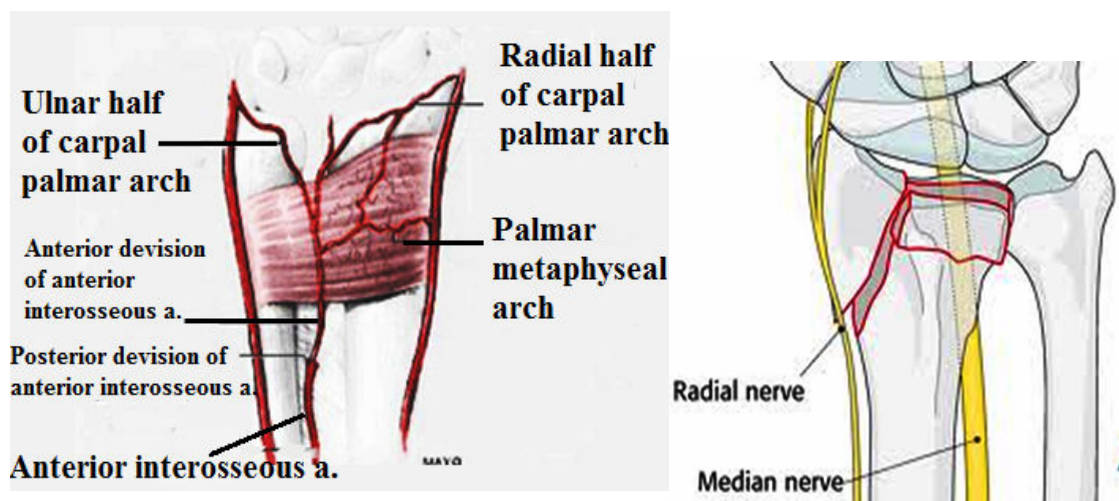
Radial artery lies just medial to the brachioradialis insertion. The flexor carpi radialis (FCR) and palmaris longus (PL) tendons lie medial to it with the median nerve in between. Deeper to the FCR lies the Flexor pollicis longus tendon (FPL). <sup>(13)</sup>

## **F) Neurovascular anatomy of the distal radius**

The dorsum of the radius is supplied by branches from superficial radial nerve (SRN) and dorsal cutaneous branches of ulnar nerve (fig. 7). The SRN exits beneath the brachioradialis 5 cm proximal to the radial styloid then bifurcates into volar and dorsal branches 4.2 cm proximal to it. The lateral antebrachial cutaneous nerve overlaps with the SRN 6 cm proximal to the ulnar head and becomes subcutaneous 5 cm proximal to the pisiform.<sup>(3)</sup>

There are 3 main blood supply systems (fig. 7): epiphyseal, metaphyseal, and diaphyseal. The metaphyseal area periosteal and cortical branches arising deep in the PQ and the anterior interosseous artery forms a network inside the bone providing the main blood supply to the distal radius.<sup>(15)</sup>

The palmar epiphyseal vessels arising from the radial artery, palmar carpal arch, and anterior branch of the anterior interosseous artery enter the bone through the radial styloid process. The dorsal epiphyseal vessels are contributed dorsally to tubercle of Lister's.<sup>(15)</sup>

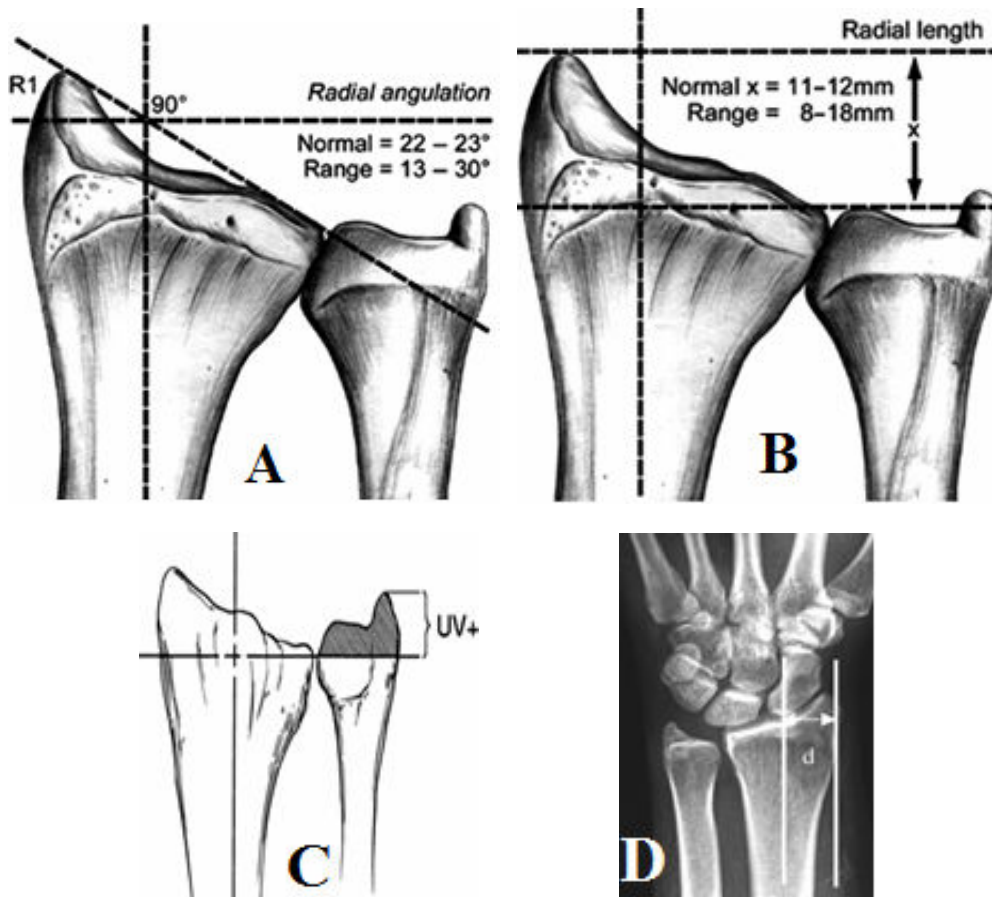


**Figure (7):** Palmar vascular and nervous anatomy related to distal radius<sup>(14)</sup>

## **G) Radiological Anatomy**

### **a) Anteroposterior view: (AP view)**

- 1. Radial inclination** (fig. 8): The angle between 2 lines one drawn perpendicular to the long axis of the radius at the ulnar corner of the lunate fossa and the other between that point in the lunate fossa and the tip of the radial styloid  $\approx 23^\circ$ . <sup>(16, 17)</sup>
- 2. Radial (height) length** (fig. 8): The distance between two parallel lines drawn perpendicular to the long axis of the radial shaft, one from the tip of the radial styloid and the other from the ulnar corner of the lunate fossa  $\approx 12$  mm. <sup>(16, 17)</sup>
- 3. Ulnar variance** (fig. 8): The distance between two parallel lines drawn perpendicular to the long axis of the radius at the distal articular surface of the ulna and the ulnar corner of the radial sigmoid notch. 60% of the population has neutral ulnar variance. <sup>(16, 17)</sup>
- 4. Radial width** (fig. 8): The distance between 2 lines parallel to the longitudinal axis, at the most lateral tip of the styloid process and the other through center of the radius. <sup>(18)</sup>
- 5. Widening distal radioulnar joint:** In ligamentous or syndesmotomic injury. <sup>(16)</sup>



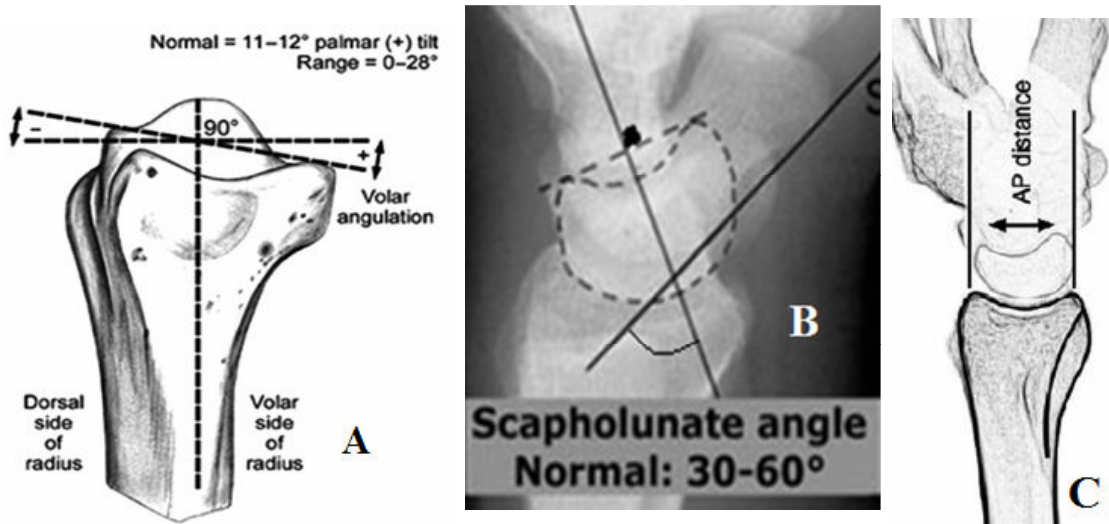
**Figure (8):** Shows normal A) radial inclination, B) radial height, C) ulnar variance and D) radial width. <sup>(7, 16, 18-21)</sup>

### **b) Lateral view**

The standard lateral results in an oblique projection of the articular surface. <sup>(22, 23)</sup>

- 1. Palmar inclination** (fig. 9): the angle between 2 lines one perpendicular to the long axis of the radius and the other between dorsal and palmar lips of the distal radial articular surface Average =  $12^{\circ}$ . <sup>(16)</sup>
- 2. Anteroposterior distance (AP distance):** the distance between 2 parallel lines one at the apex of the dorsal rim and the other at the volar rim on the lateral view (fig. 9). <sup>(16)</sup>

- 3. Scapholunate angle** (fig. 9): the angle between the axis of the scaphoid and axis of the lunate (30–80°), more than 80 is abnormal. Increase intercarpal distance due to carpal instability.<sup>(16)</sup>



**Figure (9):** Normal anatomical A) volar tilt, B) Scapholunate angle and C) AP distance.<sup>(7, 16, 18-21)</sup>

**c) AP and Lateral Contralateral Wrist:**

It is done to assess the patient's normal ulnar variance and scapholunate angle.<sup>(20)</sup>

**d) Oblique view:**

It can define the dorsal lunate facet to detect compression fractures.

**e) Tilted Lateral View**

It is taken by tilting the radius 22° toward the beam. It eliminates the shadow of the radial styloid and provides a clear tangential view of the lunate facet (fig. 10) to assess (a) residual depression of lunate facet and (b) hardware penetration of the articular surface.<sup>(22, 23)</sup>

The teardrop or the U-shaped outline of the volar rim of the lunate facet is identified on the lateral view and more distinct on the 10° lateral projection (fig. 10) between the central axis of the radial shaft and a line

through the central axis of the tear drop, it is about  $70^\circ$ . In extra-articular distal radius fractures the angle is reduced by the amount of dorsal rotation. <sup>(22, 23)</sup>



**Figure (10):** shows 1) Teardrop angle, 2) Standard lateral (A) tilted lateral projection (B). <sup>(23)</sup>

**f) Computerized tomography (CT) scan:** it has superior details about articular involvement and degree of comminution, classification, preoperative planning. <sup>(22, 24)</sup>



## II- BIOMECHANICS OF THE WRIST

The wrist is a very mobile composite articulation that sustains substantial loads without yielding achieved through a perfect interaction of wrist tendons, joint surfaces and soft tissue constraints. Both radiocarpal and intercarpal joints are involved in all movements being acted upon by the same muscles so it moves in all planes of motion.<sup>(25-27)</sup>

### **A. Wrist kinematics:**

It moves passively by an external force or actively by muscles of the forearm that cross the joint and the effects of one muscle depend on the location and moment arm. The wrist has basically two degrees of freedom. When added to pronation and supination the hand can be oriented at any angle to grasp or hold an object this occurs around two axes:<sup>(27, 28)</sup>

- i. Transverse axis takes place in the sagittal plane with movement: a) Flexion the palmar surface of the hand moves towards the anterior aspect of the forearm b) Extension the dorsal surface of the hand moves towards the posterior aspect of the forearm.<sup>(28)</sup>
- ii. Antero-posterior axis takes place in the frontal plane with movements: a) Adduction or ulnar deviation the hand moves toward the axis of the body. b) Abduction or radial deviation: the hand moves away from the axis of the body.<sup>(28)</sup>

Movement of circumduction (combination of the movement of flexion, extension with adduction and abduction) takes place in two axes of the wrist. Dart-throwing motion, from radial-extension to ulnar-flexion occurs almost entirely at the midcarpal joint.<sup>(27, 28)</sup>