Understanding Wrist X-ray

- **Dr. Parag Lad**
  Hand & Reconstructive Microsurgeon
  Pinnacle Orthocentre & Jupiter Hospital, Thane, Mumbai
  E-mail- orthodoc_p@yahoo.com

- **Dr. Vigneswaran V.**
  Registrar- Hand & Reconstructive Microsurgery
  Ganga Hospital, Coimbatore
  E-mail- vigneshdr87@gmail.com

- **Dr. Praveen Bhardwaj**
  Consultant- Hand & Reconstructive Microsurgery
  Ganga Hospital, Coimbatore
  E-mail- drpb23@gmail.com

HOLDING HANDS MARCHING AHEAD

ISSHACADEMICS

In spite of the advances in the diagnostic modalities for wrist pathologies, the 'modest' radiograph continues to be a useful and a 'first line' investigation for any wrist pathology. Wrist being composed of eight carpal bones packed together in a small space, does pose a challenge to the reader as the bones look jumbled up on each other especially in a lateral view. However, this also makes reading wrist x-ray an interesting exercise and an art worth mastering to minimize the use of costlier higher investigations. With a good understanding of the radiology of the wrist, one can derive immense information about various wrist pathologies without depending on advanced investigations and deliver an optimal care to the patient. X-rays are indicated for various traumatic (bone and ligamentous injuries) and non-traumatic (inflammatory, degenerative and tumorous) conditions of the wrist.

Getting Familiar with a Wrist X-ray:
Graziani, in 1940, proposed 16 projections of the wrist for its evaluation. With improved understanding of the anatomy and biomechanics of the wrist multiple other projections have been added to the list to improve diagnostic accuracy but it has also added to the complexity of the topic. However, the basic information could be derived by the two standard projections of the wrist i.e. the posteroanterior (PA) and the lateral views which would suffice in many clinical conditions and the special views are reserved for specific clinical condition suspected on detailed history and clinical examination.

Routine wrist x-rays:

The accurate analysis of radiographs is possible only when the anatomical position is identical in both projection planes, i.e., without prono-supination which is nothing but the middle rotation (mid-prone) of the forearm between the extreme positions of pronation & supination. Therefore, standardized radiographs of the wrist in neutral position have the following prerequisites:

- *For the Posterio-anterior (PA) or Dorso-palmar view*, (Fig 1) the upper arm is abducted 90^0 at the shoulder and placed on a block so that the forearm and the hand are at shoulder level with the elbow flexed at 90^0

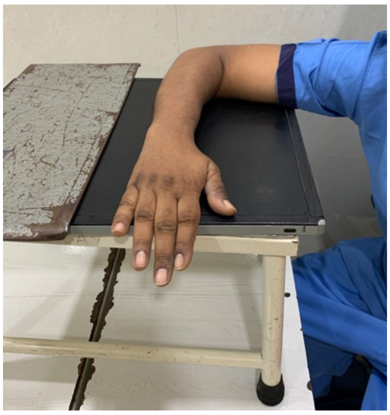


Fig 1- Positioning of the hand for a true PA view and the view obtained.

- *For the lateral view*, the upper arm is adducted at the shoulder and the elbow is flexed 90^0 so that the forearm and the ulnar edge of the hand lie on X-ray cassette

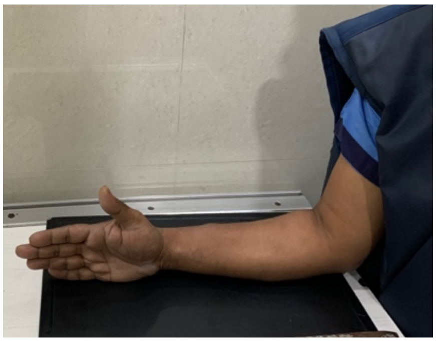


Fig 2- Positioning of the hand for a true lateral view and the view obtained.

To analyze the radiological findings accurately one must be sure that the x-rays have been taken in the mid-prone position of the forearm and there is no unwanted pronation or supination. It is important to have a true PA view when measuring ulnar variance because, *the apparent length of radius and ulna changes* in prono-supination. It is called *translatory shift*. In pronation, the ulna looks more distally and in supination, the ulna is located more proximally in relation to radius. The radiological parameters that are helpful in ascertaining this include:

In a true PA view (with forearm in neutral rotation) of wrist**, *the ulnar styloid*** appears in its full profile with it being on the medial most edge of ulna head and the **extensor carpi ulnaris groove (ECUG)** [Fig 3] is well seen and is radial to the ulnar styloid.
In all other views (either pronation or supination of the forearm) the ulnar styloid looks as 'en face' projection. If X-ray is taken in supination (position of the forearm in an AP view of the wrist), the ulnar styloid is seen at the middle of ulnar head (in line with the pisiform). If X-

ray is taken in pronation, the ulnar styloid is seen over the medial half of the head but not at the medial edge.

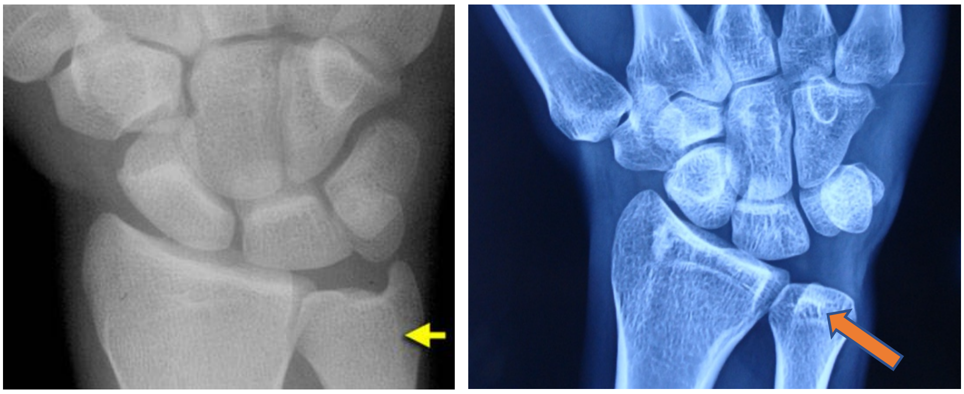


Fig 3: Comparison between the PA and AP views of the wrist. In the former the ulnar styloid is seen as the most medial aspect of the ulna and the ECUG (arrow) is radial to the ulnar styloid. In the later (AP view) however, the ulnar styloid lies over the mid part of the ulnar head (orange arrow). Also, note the flexed and foreshortened shape of the scaphoid in the AP view as compared to the PA view.

Other indicators of a neutral PA (without medio-lateral or antero-post deviation) view are- one half or more of lunate should contact the distal radius articular surface; clear visibility of the 2nd -5th carpo-metacarpal joints.

An appropriate Lateral view of the wrist in neutral position is **confirmed by *position of the pisiform- the scapho-piso-capitate (SPC) relationship.*** A good true lateral view of the wrist is one in which the palmar cortex of pisiform overlies the central third of the interval between the palmar cortices of the distal pole of scaphoid and the capitate head.

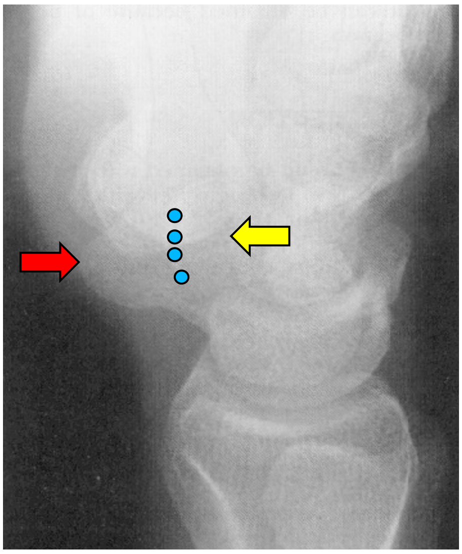


Fig 4- A true lateral view of the wrist as indicated by the position of the pisiform between the scaphoid and the capitate. The palmar cortex of the pisiform (blue dots) lie midway between the palmar cortex of the capitate and the scaphoid (arrows).

Clinical relevance of PA view of wrist

1. ***Radial Inclination***: It is an angle of distal radius surface with respect to line perpendicular to shaft of radius. It is usually 20^0 to 23^0.

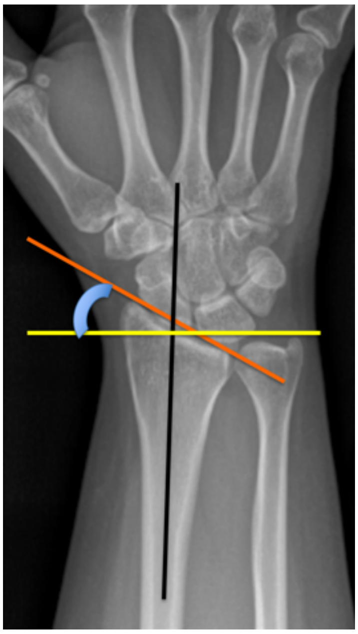


Fig 5: Radial Inclination

2. ***Radial height***: It is measured as distance between a line perpendicular to the long axis of the radius passing through the distal tip of the radial styloid and a line drawn by intersecting the articular surface of the head of ulna. The normal range of radial height is 11-13mm.

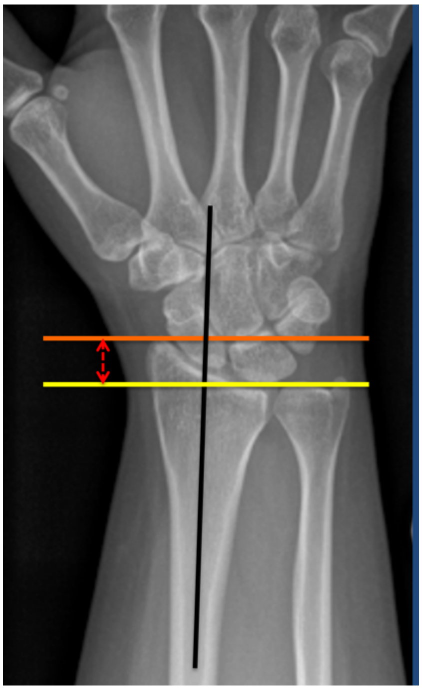


Fig 6: Radial Height

3. ***Ulnar variance***: Ulnar variance is measured by extending a line along the distal articular surface of the radius towards the ulna and measuring the distance from this line to the distal articular surface of ulna. It is also known as **Hulten variance**. It measures relative length of distal articular surface of radius and ulna. It can be neutral (both articular surfaces are in one line); positive (ulna projects more distally than radius) or negative (ulna projects more proximally than radius). Usually 1-2mm of variance is considered neutral.

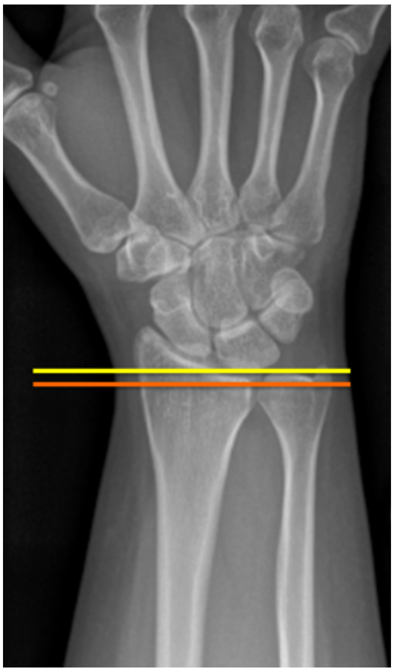


Fig 7: Ulnar Variance

Principles of Reading a Wrist PA view:

The alignment and interrelationship of the carpal bones with respect to each other is eternal to the stability of the wrist. This can assessed using the **three principles** stated by Gilula- Arcs, spaces and parallelism.

Arcs of Gilula: These are the lines to be drawn on PA view of wrist as mentioned below (Fig 8):

1. Arc along the proximal part of proximal carpal row
2. Arc along the distal part of proximal carpal row
3. Arc along the proximal part of distal carpal row

Any discontinuity noted in all three *arcs* is suggestive of disruption of carpus anatomy (Fig 8). However, two normal variants of disrupted arcs: a congenitally short triquetrum resulting in a lunotriquetral off and a proximally prominent hamate with a type two lunate disrupting the distal two arcs should also be kept in mind. Pathologies like perilunate dislocation or carpal instability can be diagnosed based on continuity of these arcs.

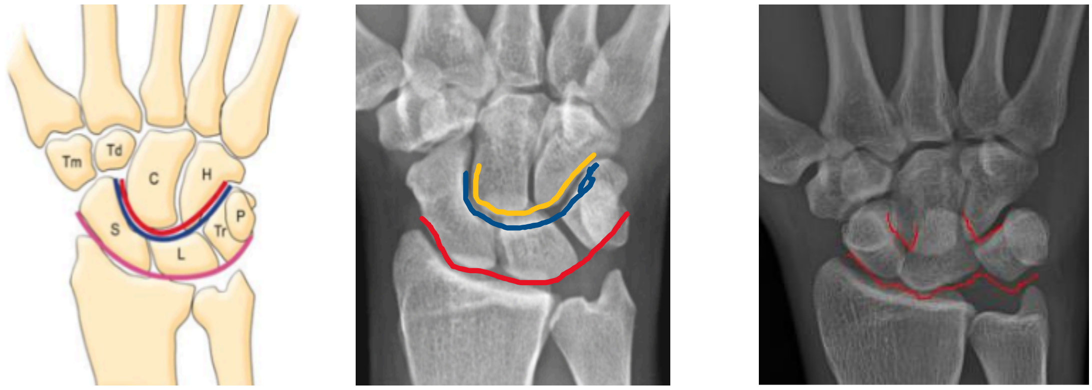


Fig 8: Gilula's Arcs: Three arcs are continuous and parallel to each other. The picture on the right shows the disruption of the proximal and middle arcs in a case of lunate dislocation.

In addition to the three arcs, Gilula also stated that in a PA view the joint space between the two carpal bones is same as that between pair of other carpal bones (*rule of spaces*) and that the articular surfaces of the adjacent carpal bones are parallel to each other (*rule of parallelism*).

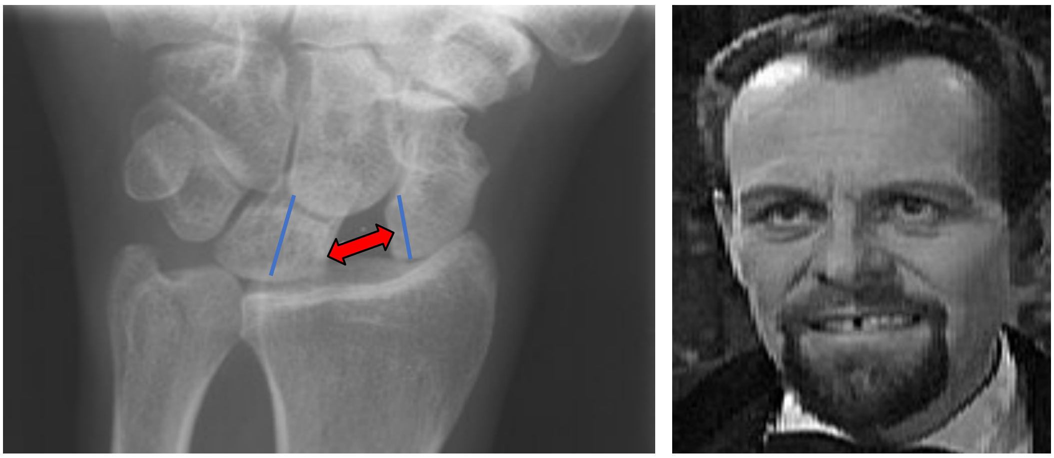


*Fig 9: A case of scapho-lunate dissociation with widened space between the scaphoid and lunate (termed as **Terry Thomas Sign**) and loss of parallelism between the scaphoid and lunate.*

Scapho-lunate Gap (S-L Gap):
The gap between the scaphoid and lunate is measured at the center of the scapho-lunate articulation. It is best seen in an AP view or a PA view with the beam angled from the dorsal ulnar aspect of the wrist approximately 10 degrees. Normally the S-L distance in about 2 mm.

Clinical relevance of lateral view of wrist

1. ***Distal radius articular tilt:*** It is an angle between a line drawn connecting the volar & dorsal tip of distal radius to the line drawn perpendicular to long axis of radius. It measures around 11^0 towards the volar side in normal subjects (Volar Tilt). Commonly the fractures of the distal radius result in an angulation in the dorsal direction causing a dorsal tilt which can be measured using this method.

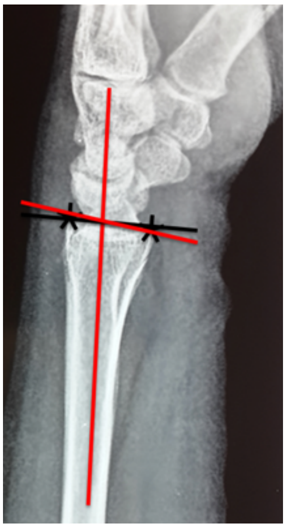


Fig 10: Normal Palmar tilt of the distal radius articular surface- black lines represent the longitudinal axis of the radius and a line drawn perpendicular to it. The star marks the volar and the dorsal articular rim tip and the red line connects the two points. The tilt angle is the angle formed by the red line with the horizontal black line.

Distal radius tilt, along with the radial inclination and height are the parameters one has to look for while assessing the fracture displacement and reduction after a distal radius fracture. The parameters can be easily remembered as 11-22-11 with 11 being the radial height and volar inclination and 22 being the radial inclination!

2. **Tear drop angle**: Tear drop is the U-shaped outline of the volar rim of the lunate facet of the distal radius. The teardrop angle is formed between a line through the central axis of the teardrop & a line through the central axis of the radius.
   Normal teardrop angle is around 45^0. In case of lunate fossa or ulnar die-punch fracture, this angle is disturbed. Accurate reduction & fixation of ulnar die-punch fragment will restore the teardrop angle.

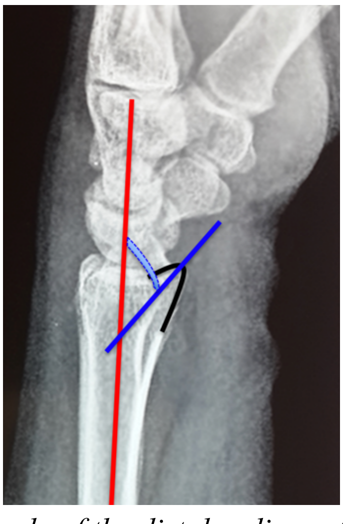


Fig 11: Tear drop angle of the distal radius articular surface.

3. **Scapho-lunate Angle:**

Scapho-lunate angle shows the relationship of the scaphoid and lunate in lateral plane (Fig 12). Normally this angle ranges from 30-60 degrees. The angle is measured as described in fig. 12. An angle of more than 60 degrees indicate that the scaphoid is unduly flexed as happens in a scapho-lunate ligament injury; whereas an angle of less than 30 degrees indicates extension of the scaphoid as happens in luno-triquetral ligament injuries. The former is termed as DISI (dorsal intercalated segmental instability) deformity with reference to the dorsiflexed posture of the lunate and the latter is termed as VISI (volar intercalated segmental instability) deformity with reference to the volar flexed posture of the lunate.

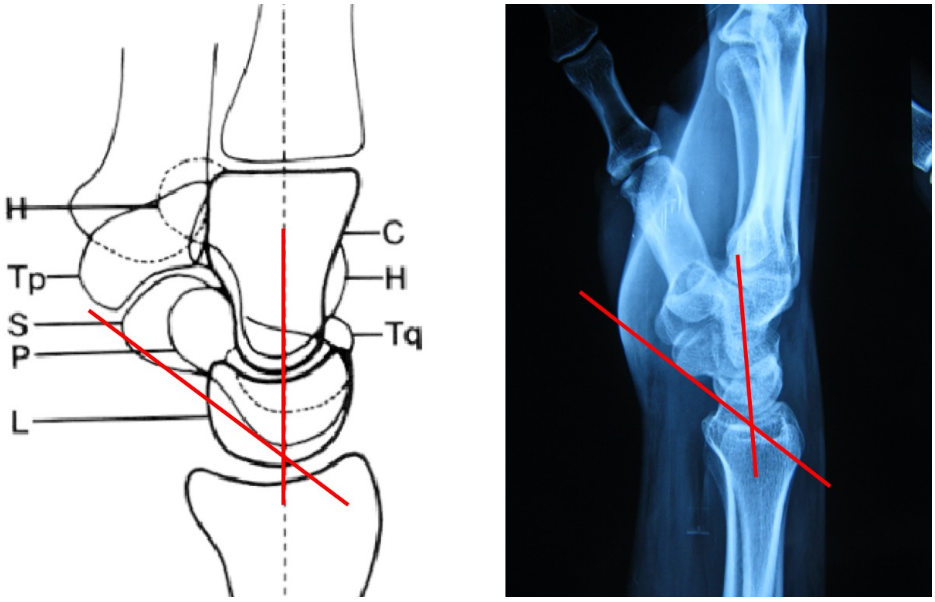


Fig 12: The scapho-luante angle is measured as the angle between the long axis of the lunate and the tangential line drawn connecting the palmar outlines of the proximal and distal poles of the scaphoid (this lines is found to be parallel to the true central axis of scaphoid and is much easier to draw). The long axial of lunate is drawn as a line perpendicular to the line connecting the volar and dorsal distal articular tips of the lunate.

Special parameters to be seen in wrist Lateral radiographs:

Column of the wrist: Central column of wrist in lateral view consists of third metacarpal, capitate, lunate and distal radius in one longitudinal axis (Fig 13).

Lunate pathologies are described as per the position of the lunate, in the central column. So, if the lunate is dislocated out of the normal axis, the injury is termed as '*lunate dislocation*' whereas if the lunate remains in its fossa of the radius but the capitate with other carpal bones is out of the axis it is termed as '*peri-lunate dislocation*'.

The lunate fallen out volar to the central axis in lunate dislocation is termed as '**spilled tea pot sign**'.

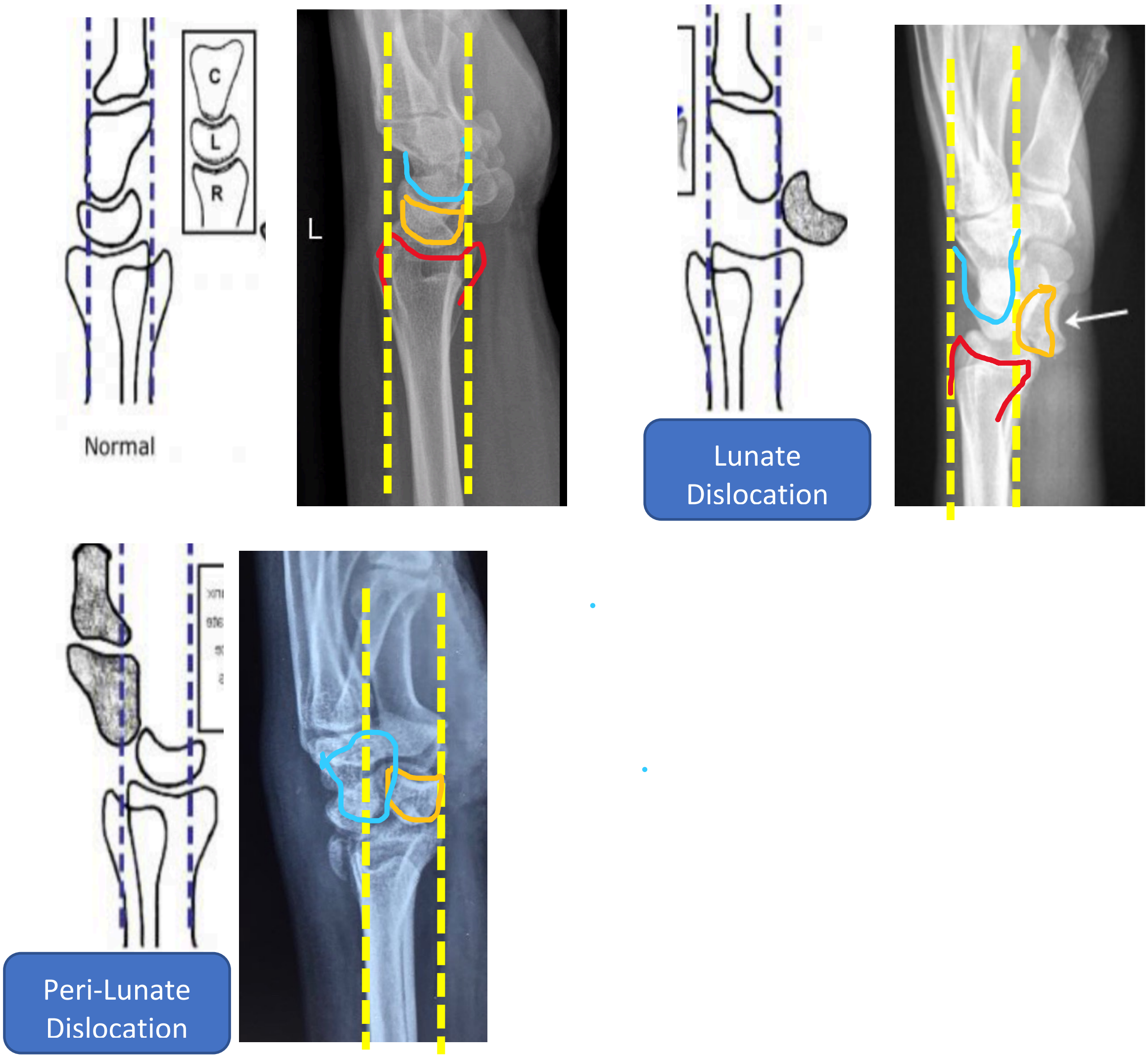


Fig 13: Figure showing the profile of the carpal bones in the lateral view and the common disruption patterns.

Radiology for Suspected Scaphoid Fracture:

Scaphoid fracture is by far the commonest carpal injury and the hence the commonest reason for taking a wrist X-ray. However, scaphoid being a 'crooked' and obliquely placed bone in the wrist is not visualized easily in the standard PA and lateral views, leading to proposal of plethora of views to see it better. Knowing, all the views is not a must if one understands the principle behind them and with experience one can get the desired information with few special projections as described under.

Whenever there is a clinical suspicion of scaphoid fracture, one should order for three standard views- postero-anterior (PA) with ulnar deviation of wrist, lateral and semi pronated or 45º pronation oblique views. If these views are normal and still the suspicion persists, one can order for special views of the scaphoid. Due to the complex shape and oblique orientation of the scaphoid, assessment of its anatomy from the radiographs remains difficult. The special views are designed to align the plane of the fracture with the central beam. Most of the scaphoid fractures are transverse and lie perpendicular to the longitudinal axis of the scaphoid. Since the scaphoid is normally flexed about 40-60º, the fracture and beam can be aligned either by angling the X-ray tube or by dorsiflexing the scaphoid by ulnar deviating and extending the wrist (Fig 14). In all these views the beam should be directed at the radial half of the wrist.

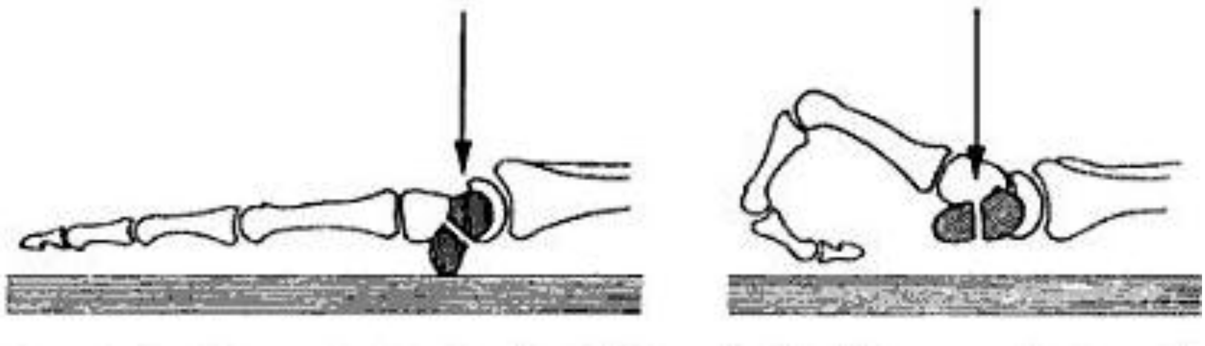


Fig. 14: Representative diagram showing how ulnar deviation and slight dorsiflexion of wrist places the scaphoid in more horizontal position and the fracture site becomes parallel to the x-ray beams allowing its easy detection.

Stetcher in 1937 described a view where the prone hand is placed on the cassette with a clenched fist. This position produced dorsiflexion of the scaphoid. For better visualization of the scaphoid, ulnar deviation was added. When it was thought that ulnar deviation could displace or distract the fracture fragments, Bridgeman in 1949, proposed a technique in which the hand rests on a 17º dorsally angled board. This results in the central beam aligned perpendicular to the waist of the scaphoid and parallel to the fracture plane.

Stecher's projection to see full length of scaphoid (Fig 15):

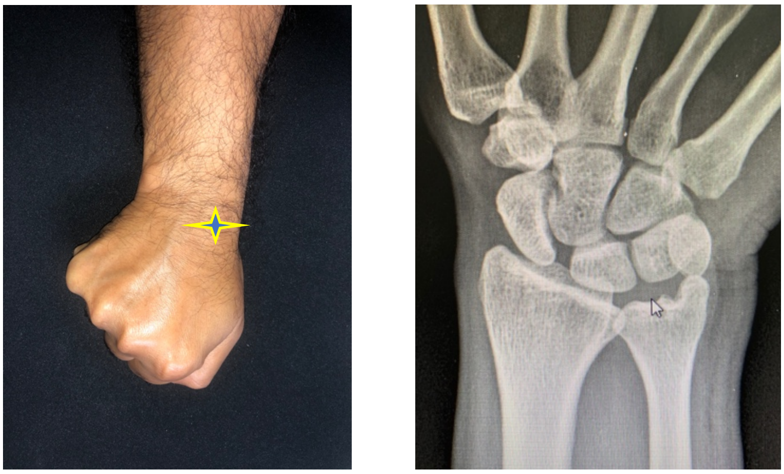


Fig 15: Stecher's projection to see the full length of the scaphoid.

A similar radiograph can be obtained with the hand placed flat on the cassette with ulnar deviation and the central beam can be angled 17º towards the elbow. In the similar '**banana' view,** the central beam is directed 20º towards the elbow which is found to show the true anatomical waist of the scaphoid. This view also shows a better view of the radiocarpal joint.

Bridgeman's projection to see proximal pole and scapho-capitate joint:

Fig 16: Bridgeman's view to see the proximal pole and scapho-capitate joint.

Compson recommended five views for the complete study of the scaphoid to know additional information such as fracture pattern, displacement and reduction. It includes the posteroanterior with ulnar deviation, lateral, the 'banana' view, the semi-pronated oblique and the semi-supinated oblique views (Fig 17). The former three views delineate the proximal part, the waist and full length of the scaphoid. The 45º semi-pronated oblique view helps to study the distal pole along with the STT joint. The 45º semi-supinated oblique view shows a clear view of the proximal pole of the scaphoid and also gains importance in assessing the flexion deformity seen in scaphoid non-union. *It is easy to remember that the volar radial (distal scaphoid) and dorsal ulnar (triquetrum) structures are seen well in the semi pronated oblique view and the dorsal radial (proximal pole of scaphoid) and volar ulnar structures (hamate, piso-triquetral joint) are seen well in the semi supinated oblique view.*

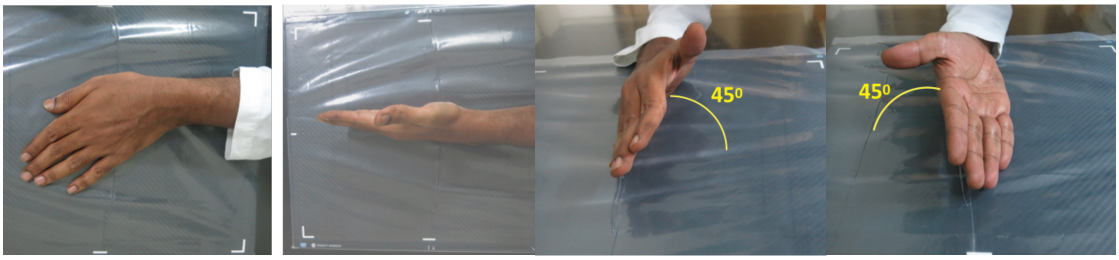


Fig 17: These four scaphoid views and the 'banana' view (PA with ulnar deviation with central beam directed 20^o towards the elbow) completes the scaphoid series

We should be aiming to obtain maximum information from minimum films and avoid unwanted radiation exposure to the patient. Hence, the knowledge about the advantages and limitations of each view is essential.

Other special views which may be useful in specific clinical conditions are mentioned below:

View	Position	Portion of scaphoid to be seen
Schreck's projection	-Oblique position Quill-holding position -hand placed on 45^0 wedged pad	-Scaphoid tuberosity
Hyper pronation view	-Closed fist -Ulnar deviation -Palm placed 30^0 elevated	-Scaphoid is straight along the axis of forearm

Schreck's projection to see scaphoid tuberosity (Fig 18):

Fig 18: Schreck's projection to see scaphoid tuberosity

Hyper pronation view to see straight scaphoid along the axis of forearm (Fig 19):

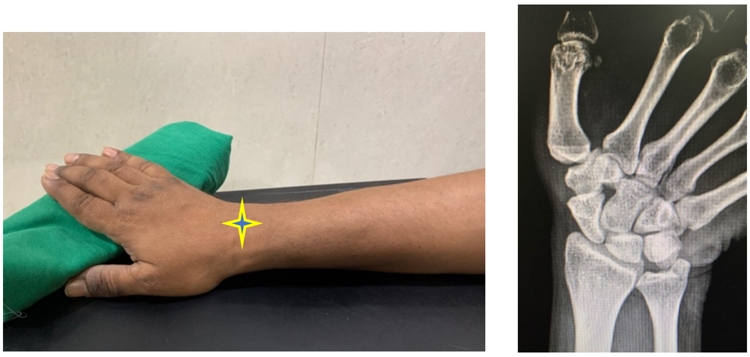


Fig 19: *Hyper pronation view to see full straight profile of scaphoid along the axis of forearm*

Special views in hand and wrist

Brewerton view:

When to take: To see the fractures, avulsion and erosion of metacarpal heads and MCP joint spaces, especially in patients with rheumatoid arthritis.

How to take (Fig 20): The dorsum of the fingers is placed in contact with the cassette with the MCP joints flexed to 65º. The central beam is directed at the apex of the web space at an angle of 15º ulnar to radial. The angulated beam will clear off the extended thumb obscuring the head of second metacarpal.

Fig 20: Position of the hand and direction of the x-ray beam for obtaining a Brewerton view

Why special: The tangential view delineates the groove between the articular cartilage of the metacarpal head and the collateral ligament, the site of early destruction in inflammatory arthritis. It also discloses the chip fractures involving this area. The standard AP and oblique views show the outlines of bones and joints in the neutral position but not in the flexed position of the MCP joints which is the functional position while doing most of the day to day activities. Also, this is the position in which the ulnar deviation or subluxation of the MCP joints is first detected in rheumatoid arthritis. Hence it can be useful in diagnosing the disease at an earlier stage and avulsion fractures of the head.

Roberts view:

When to take: To see the articular fractures of the base of first metacarpal and the involvement of first CMC and ST joint space in basilar arthritis

How to take (Fig 21): The dorsum of the thumb is placed on the cassette with maximal hyperpronation of the forearm and the central beam is directed perpendicular to the first CMC joint. In Modified Roberts view, the beam is directed 15º proximally to see the ST joint which is otherwise obscured by a soft tissue shadows with a Roberts view.

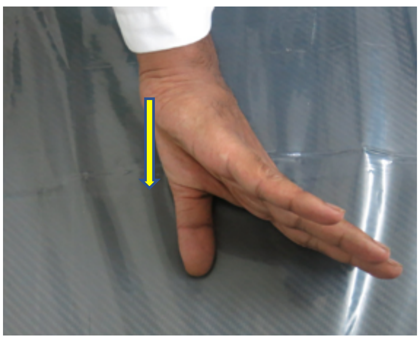


Fig 21: Positioning of the hand and direction of the x-ray beam for obtaining Roberts view.

Why special: The trapezium and base of first metacarpal are neither parallel nor perpendicular but obliquely placed when compared to the other digits. Also, the trapezium lies anterior to the other carpal bones. To see the full length of the joint space, the dorsal or palmar surface of the joint should lie flat on a surface. In a reciprocal articulation like first CMC joint, it is difficult to make the palmar surface to lie flat on the surface. Hence the dorsal surface is made to lie flat on the cassette. Robert recommended maximum pronation, as with supination, it is difficult to place the joint flat and the position is not comfortable for the patient. With this true AP view, all the four articulations of the trapezium are seen without bony overlap.

Carpal tunnel view:

When to take: To see the uncommon fractures involving the hook of hamate and pisiform.

How to take: The pronated forearm is placed on the cassette and the patient is asked to manually dorsiflex the hand by pulling on the fingertips with the opposite hand. The central beam is angled 25-35º, directing proximally at the volar surface of the carpus in line with the third metacarpal. Another method involves the patient placing the hand flat on the cassette and the wrist is hyperextended. The central beam is directed 40º proximal to distal at the palmar surface of the carpus (Fig 22). The first mentioned method could create a ring artifact produced by overlapping of the fifth metacarpal base on the carpal bones.

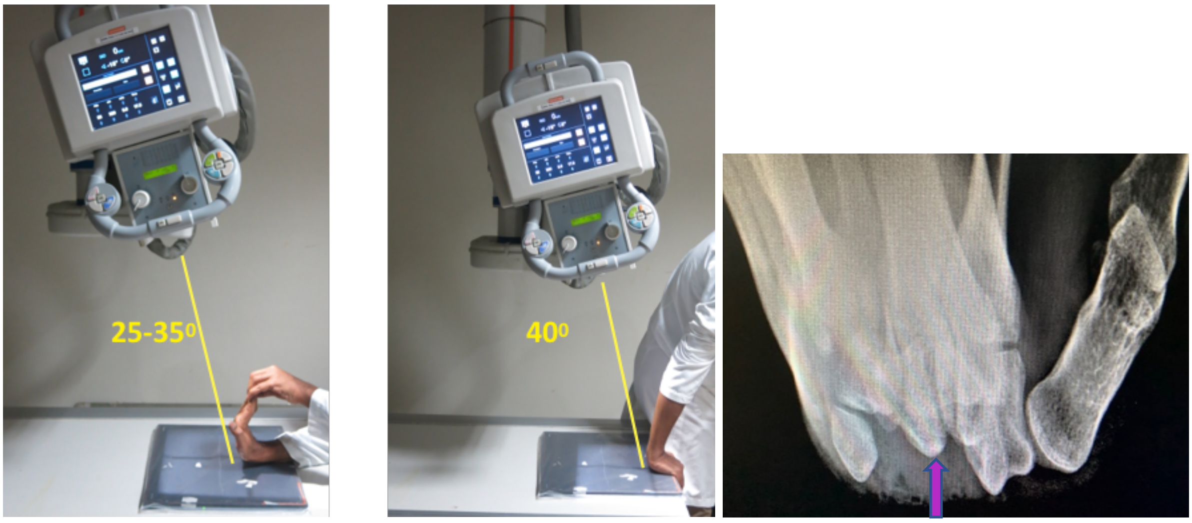


Fig 22: Positioning of the hand and direction of the x-ray beam for obtaining carpal tunnel view with two techniques. Arrow shows the hook of hamate seen in this view.

Why special: The view shows the palmar soft tissues and palmar surface of the trapezium, scaphoid tuberosity, capitate, hook of hamate, triquetrum and the whole of pisiform.

Carpal bridge view:

When to take: To see for foreign bodies and fractures involving the dorsum of the wrist

How to take: The patient makes a triple right angle, arm at right angle to the trunk, forearm at right angle to the arm and the wrist at right angle to the forearm with the palm facing up. The central beam is directed at an angle of 45° proximally.

Why special: Any lateral view can identify lesions that are dorsal to the carpus. However, it cannot identify the specific location or origin. A carpal bridge view, named so as it is the exact opposite of the carpal 'tunnel' view which shows the palmar soft tissues and the bones, can identify the exact location of foreign bodies, origin of fractures involving the dorsal surface of the carpal bones, lunate dislocation indicated by sagging or disruption of the dorsal carpal arch and dorsal soft tissue calcifications (Fig 23).

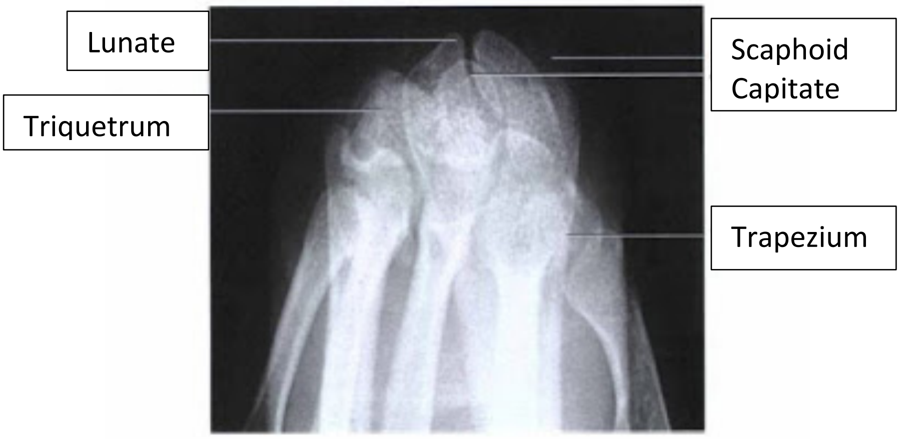


Fig 23: Carpal bridge view

Special X-rays of the other carpal bones to diagnose specific etiologies

1. **Semi pronated Oblique view ("triquetrum" special)**

   Position: Quill-holding (pen holding) position by tilting palm to 45^0. X-ray beam perpendicular to cassette aligning to the ulnar side of carpus (Fig 24).

Criteria: Dorsal triquetrum is shown tangentially

Fig 24: Semi pronated oblique view

2. Semi supinated Oblique view ("pisiform" special)

Position: Ball catcher's view position by keeping palm in 60^0 supination (Fig 25). X-ray beam perpendicular to cassette aligning to the ulnar side of carpus

Criteria: Pisotriquetral joint is seen clearly

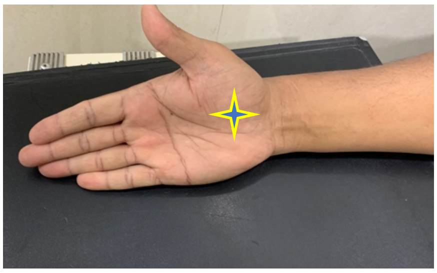


Fig 25: Semi supinated oblique view

3. Axial oblique view ("trapezium" special)

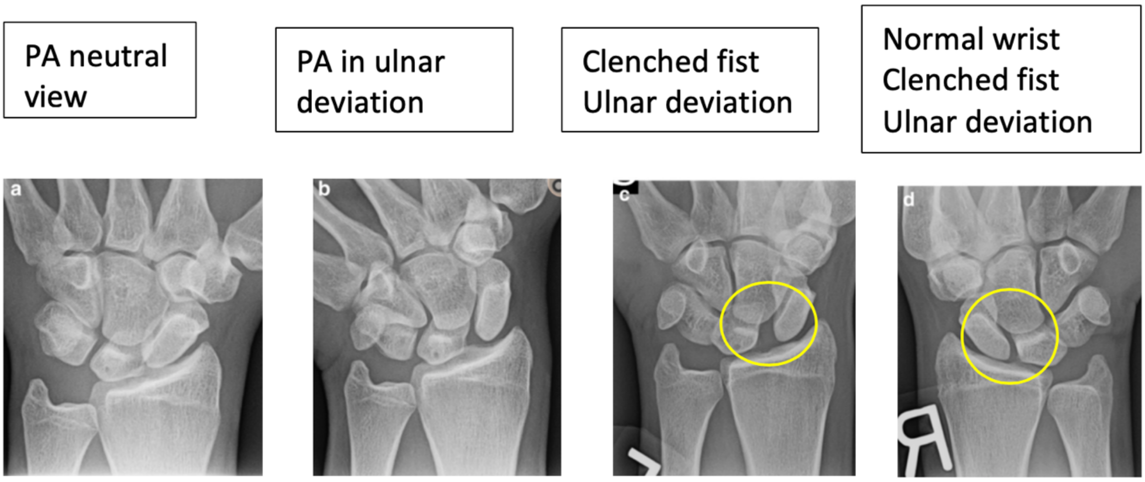
Position: Thumb in abduction is placed laterally on cassette. X-ray beam is projected perpendicular to cassette aligning to the distal third of carpus (Fig 26)

Criteria: Both trapezium & trapezoid bones are seen
Good visualization of thumb metacarpal base fracture or arthrosis of the first CMC joint.

Fig 26: Axial Oblique View- showing good view of the thumb base and the first CMC Joint

4. **Clenched fist view (“scapholunate special”)**

In patients with scapholunate dissociation, with a tight or clenched fist, the contracting forces within the wrist drive the capitate proximally in between the scapholunate joint. It is also valuable to compare the scapholunate interval of both the wrists aiding in the diagnosis.



AP projection of the wrist has been proposed by Taleisnik instead of PA view for assessment of the rotatory subluxation of the scaphoid. As, the supinated position of the forearm exerts a volar-flexing action on the dissociated scaphoid through the radio-scapho-capitate ligament, accentuating the abnormal foreshortened appearance of the subluxed scaphoid, and causing a widening of the scapholunate gap.

Summary:

- Radiographs remain the most useful, cheap & convenient modality of investigation in orthopedics, especially in hand & wrist.
- Thorough clinical examination and proper order of radiographs can obviate the need of higher investigations in many situations.
- We must supervise or teach our technician for taking proper wrist x-rays.
- Sometimes, scaphoid fractures are missed on usual wrist radiographs. In suspected scaphoid fracture, special views are very important.
- If we suspect specific carpal bone injury, then special x-rays are very useful to avoid missing such fractures
- We should always look for arcs of Gilula and wrist column to diagnose perilunate dislocation or carpal instability

Suggested readings:

1. Loredo RA, Sorge DG, Garcia G. Radiographic Evaluation of the wrist: A vanishing art. SeminRoentgenol. 2005;40:248–89.
2. Gilula LA, Yin Y. Imaging of the wrist and hand.
3. Philadelphia: Saunders, 1996;
4. Schmitt R, Lanz U. Diagnostic imaging of the hand. New York, NY: Thieme, 2008.
5. Bhat AK, Kumar B, Acharya A. Radiographic imaging of the wrist. Indian J Plast Surg. 2011;44:186–96.
6. Yang Z, Mann FA, Gilula LA, Haerr C, Larsen CF. Scaphopisocapitate alignment: A new criterion to establish a neutral lateral view of the wrist. Radiology. 1997;205:865–9.