ANATOMICAL ANALYSIS OF GUIDELINES FOR OPTIMAL PLATE PLACEMENT IN VOLAR AND DORSAL ASPECTS OF DISTAL RADIUS

G. Mohan[1], M. Nirmal[2], K. Raju[3]

[1]Senior Assistant Professor, Department of Orthopaedics, Govt. Kilpauk Medical College.
[2]Junior Resident, Department of Orthopaedics, Govt. Kilpauk Medical College.
[3]Professor, Department of Orthopaedics, Govt. Kilpauk Medical College.

ABSTRACT

BACKGROUND

Distal radius fractures are one of the most common fractures encountered in the orthopaedic department accounting for 16% of all fractures. Intra-articular screw penetration following surgery for distal radius fractures is one of the most dreaded complication following surgery. The aim of this study is to determine the optimal plate placement in volar and dorsal aspect of distal radius in relation to its articular surface.

MATERIALS AND METHODS

40 radius bones were procured and analysed with a measuring device and radiologically to accurately find out the distance from volar and dorsal tip of distal radius for proper plate placement.

RESULTS

Male radii - The mean distance from volar tip is 2.67 mm with a standard deviation of 0.15 mm. The mean distance from dorsal tip is 3.58 mm with a standard deviation of 0.19 mm. Female radii - The mean distance from volar tip is 2.28 mm with a standard deviation of 0.15 mm. The mean distance from dorsal tip is 3.21 mm with a standard deviation of 0.14 mm.

CONCLUSION

We conclude that our study helps in determining optimal plate placement in distal radius in respect to its articular surface. For male patients, volar side - 2.67 mm from volar tip, dorsal side - 3.58 mm from dorsal tip. For female patients, volar side - 2.28 mm from volar tip, dorsal side - 3.21 mm from dorsal tip.

KEYWORDS

Anatomical Analysis, Distal Radius, Plate Placement.

HOW TO CITE THIS ARTICLE: Mohan G, Nirmal M, Raju K. Anatomical analysis of guidelines for optimal plate placement in volar and dorsal aspects of distal radius. J.Evolution Med. Dent. Sci. 2016;5(84):6270-6275, DOI: 10.14260/jemds/2016/1417

BACKGROUND

In day-to-day practice of most orthopaedic surgeons, fractures of distal part of radius are one of the most commonly occurring fractures, accounting about 16% of all fractures in orthopaedic casualty and it has bimodal age distribution.(1) Distal radius fractures are mostly insufficiency fractures in osteoporotic bone of elderly and following high velocity injuries in young patients. Hence, there is a bimodal age distribution for distal radius fractures.

There are many treatment options for distal radius fractures. Undisplaced stable fractures can be treated conservatively with casting. Unstable fractures can be treated with percutaneous K wire fixation. Communited fractures can be treated with external fixation and K wires. But there is a period of immobilisation for the wrist joint when treated with external fixation which can lead to wrist stiffness. There are dynamic external fixators available to treat communited distal radius fractures but the reduction achieved with this method is not satisfactory most of the times. Furthermore, reduction of intra-articular fragments if involved could not be achieved to a satisfactory degree with an external fixator.(2)

Open reduction and plating is a very good option to treat communited intra-articular fractures of the distal radius. Plates provide stable fixation throughout the entire healing process and also satisfactory articular reduction could be obtained with open reduction. Hence, plating of distal radius fractures, especially with communition is in vogue these days because of the better functional outcome which could be achieved with these plates.

While volar and dorsal locking plates are effective, intra-articular screw penetration can be troublesome in distally placed implants. This is especially common in facilities where availability of intraoperative fluoroscopy is a constraint. Since the articular surface of the distal radius is at a lower level than the volar and dorsal rim, inadvertent intra-articular screw penetration can occur. Unrecognised articular screw penetration can lead to radiocarpal arthritis with symptoms of chronic wrist pain which in turn can lead to malpropagation of forces in the wrist joint resulting in reduced grip strength leading on to restriction of mobility, and finally wrist stiffness results compromising clinical outcomes. There have been no studies till now to determine the optimal plate placement for distal radius in respect to its volar and dorsal rim so as to avoid intra-articular screw penetration.

Financial or Other, Competing Interest: None.
Submission 12-09-2016, Peer Review 06-10-2016,
Acceptance 13-10-2016, Published 20-10-2016.
Corresponding Author:
Dr. G. Mohan,
D5/159, KP-Towers,
Arcot Road,
Vadapalani, Chennai-600026.
E-mail: dr_gmohan@yahoo.com
DOI: 10.14260/jemds/2016/1417

Anatomy of Distal Radius

Osseous Anatomy

The distal portion of the radius has a quadrilateral cross section and includes the metaphyseal and epiphyseal regions.[3] Anatomic features of the distal radius include the styloid process, the dorsal tubercle, and four surfaces: anterior, lateral, posterior, and medial. The scaphoid fossa, lunate fossa, and sigmoid notch are three concave articular surfaces. The scaphoid fossa and the lunate fossa are separated by a dorsal-volar ridge which defines the scaphoid and lunate facets.

The anterior surface is concave, angled anteriorly, and covered by the pronator quadrates. Its rough surface provides an attachment point for the palmar radiocarpal ligaments. The anterior surface extends radially from the radial styloid, ulnarly to the triangular fibrocartilage complex (TFCC).

It extends distally and ulnarly to the capitate (radiocapitate), lunate (radiolunate), and triquetrum (radiotriquetral).

The lateral surface extends along the lateral margin to form the styloid process. The styloid process is conical and projects 10–12 mm beyond the articular surface for the proximal scaphoid and lunate. The distal part of the styloid provides an attachment for the articular capsule and for the capsular thickening of the collateral ligament. A more proximal area at the base of the styloid provides the brachioradialis attachment. The radial styloid area may have a flat groove for the tendon of the first dorsal compartment (abductor pollicis longus and extensor pollicis brevis tendons).

The posterior surface of the distal radius is irregular, convex and acts as a fulcrum for the extensor tendon. A prominent dorsal tubercle (Lister's tubercle) lies 5–10 mm from the distal joint surface. There is a smooth groove for passage of the extensor pollicis longus (EPL) tendon on the medial aspect of the dorsal tubercle.

The medial surface of the distal radius consists of the ulnar notch and the articular surface for the ulnar head. The distal radius rotates about the ulnar head by means of the sigmoid notch, which is concave with well-defined dorsal, palmar, and distal margins. Its depth varies according to the articulation with the ulnar head. Ulnar length varies with radial length and changes with pronation and supination. There are various degrees of positive or negative ulnar variance which affect the amount of force transmitted to the distal radius and to the TFCC. Between the distal radioulnar joint and the radiocarpal joint, there is a ridge located in the ulnar notch; this ridge provides the radial attachment point for the TFCC. At various radioulnar deviations, there may be greater or lesser contact with the TFCC. The distal articular surface of the radius has a radial inclination averaging 22 (21–25) and an average volar tilt of 11 (2–20). The sigmoid notch angles distally and medially an average of 22.

Ligamentous Anatomy[4]

Volar Extrinsic Ligaments

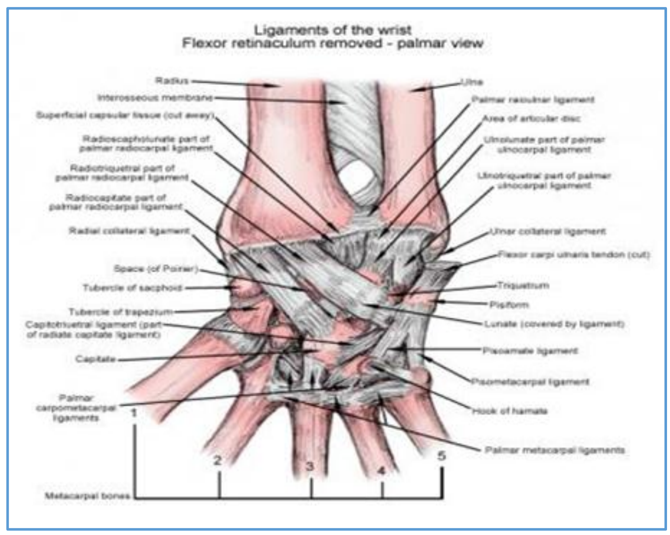
The following ligaments constitute the extrinsic ligaments in the volar side of distal radius:

- Radioscaphocapitate ligament.
- Long radiolunate ligament.
- Short radiolunate ligament.
- Radioscapholunate ligament.
- Ulnolunate ligament.
- Ulnocapitate ligament.

Volar Intrinsic Ligaments

The following ligaments constitute the intrinsic ligaments in volar aspect of distal radius:

- Lunotriquetral ligament.
- Trapeziotrapezoid ligament.
- Scaphotrapezial ligament.
- Scaphotrapezoidal ligament.
- Scaphocapitate ligament.
- Capitotrapezoid ligament.
- Capitohamate ligament.
- Triquetrocapitate ligament.
- Triquetrohamate ligament.



Dorsal Extrinsic Ligaments

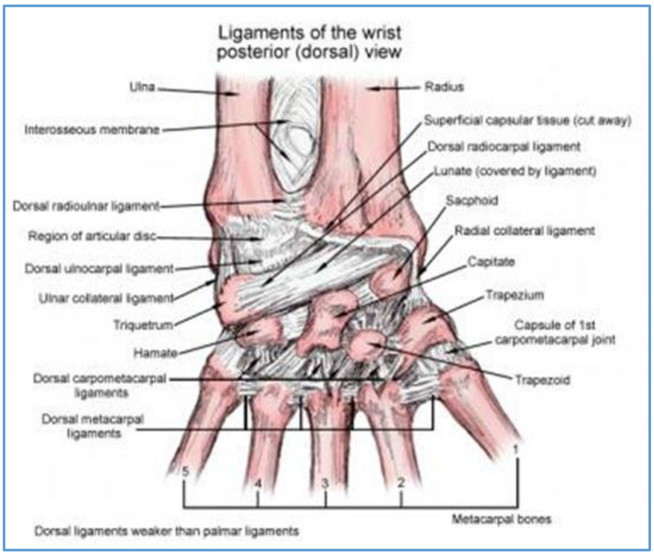
The following ligaments constitute the extrinsic ligaments in dorsal side:

- Intercarpal ligaments
- Radiocarpal ligament

Dorsal Intrinsic Ligaments

The following ligaments constitute the intrinsic ligaments in dorsal side:

- Intercarpal ligament
- Trapeziotrapezoid ligament
- Capitotrapezoid ligament
- Capitohamate ligament
- Triquetrohamate ligament



Interosseous Ligaments

- Scapholunate ligament.
- Lunotriquetral ligament.
- Trapeziotrapezoid ligament.
- Capitotrapezoid ligament.
- Capitohamate ligament.

Triangular Fibrocartilage Complex (TFCC)

The TFCC is triangular in shape with its apex pointing radially extending from the ulna proximally to the proximal carpal row distally.

Volar Components

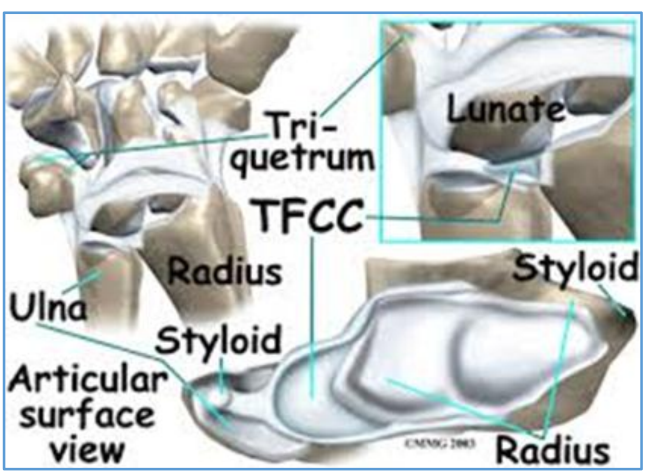
- Volar radioulnar ligament.
- Ulnotriquetral ligament.
- Ulnolunate ligament.

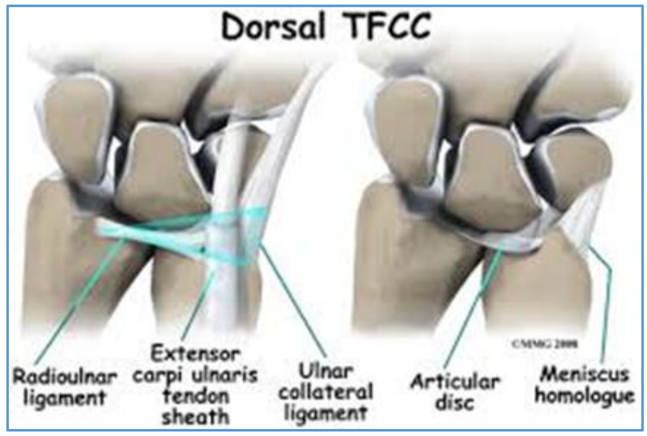
Ulna Components

- Triangular ligament.
- Ulna collateral ligament.
- Meniscal homologue.

Dorsal Components

- Dorsal radioulnar ligament.
- Extensor carpi ulnaris tendon sheath.





Aim of the Study

To determine optimal plate placement in volar and dorsal aspect of distal radius in relation to its articular surface.

MATERIALS AND METHODS

Study Centre

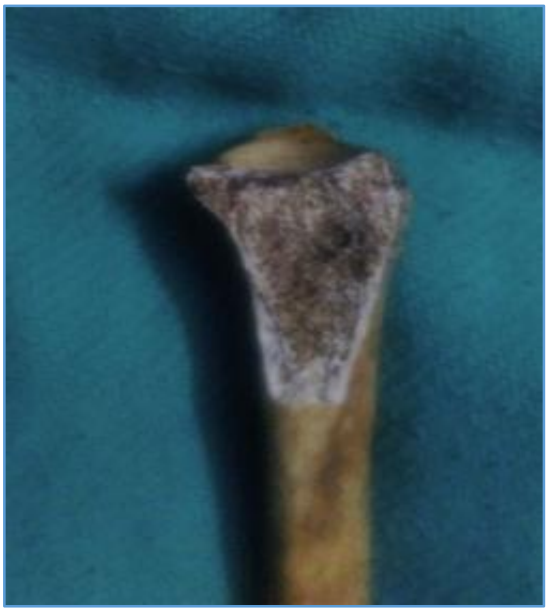
Department of Orthopaedics, Govt. Kilpauk Medical College and Hospital.

Study Design

Descriptive Study.

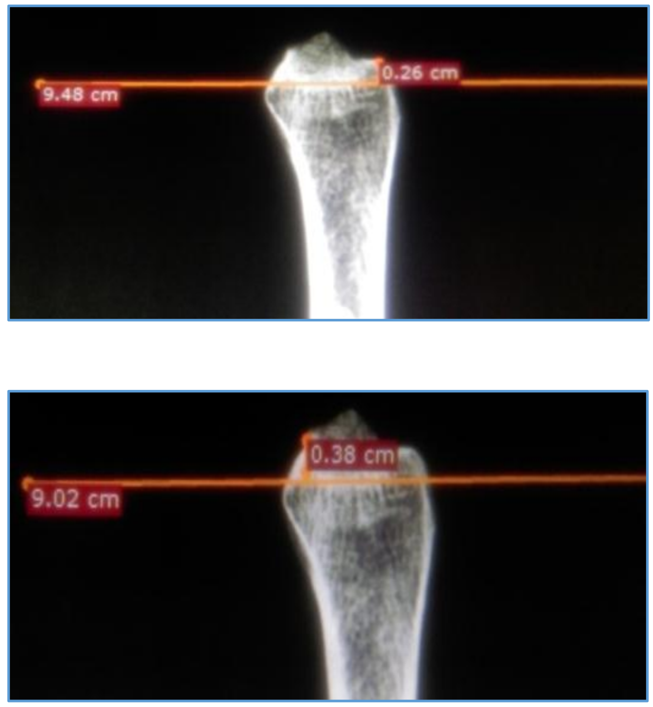
40 skeletally mature radius bones were procured from the Department of Anatomy, Govt. Kilpauk Medical College and Hospital among which 23 were male and 17 were female and the deepest point in the concave articular surface of the distal end was identified from the medial edge of the distal end. The radius was osteotomised at the previously measured deepest point to facilitate measurements from volar and dorsal rim. The distance from volar and dorsal edge of the distal radius was measured from the deepest point already identified. This process was done for all distal radii. The obtained measurements were confirmed by radiological evaluation.

Deepest Point in Articular Surface



Osteotomised Radius

Measurements from Volar and Dorsal Rim



Radiological Measurements

OBSERVATIONS

Sl. No.	Distance from Volar Rim	Distance from Dorsal Rim
1	2.5 mm	3.3 mm
2	2.9 mm	3.9 mm
3	2.7 mm	3.5 mm
4	2.8 mm	3.5 mm
5	2.6 mm	3.3 mm
6	2.5 mm	3.4 mm
7	2.6 mm	3.6 mm
8	2.8 mm	3.7 mm
9	2.9 mm	3.8 mm
10	2.4 mm	3.3 mm
11	2.7 mm	3.6 mm
12	2.5 mm	3.3 mm
13	2.5 mm	3.3 mm
14	2.8 mm	3.9 mm
15	2.9 mm	3.9 mm
16	2.4 mm	3.4 mm
17	2.8 mm	3.8 mm
18	2.7 mm	3.6 mm
19	2.6 mm	3.5 mm
20	2.5 mm	3.4 mm
21	2.6 mm	3.7 mm
22	2.8 mm	3.7 mm
23	2.8 mm	3.9 mm
Mean	2.67 mm	3.58 mm

Male Radii

Sl. No.	Distance from Volar Rim	Distance from Dorsal Rim
1	2.1 mm	3.0 mm
2	2.5 mm	3.3 mm
3	2.2 mm	3.1 mm
4	2.4 mm	3.3 mm
5	2.5 mm	3.4 mm
6	2.2 mm	3.2 mm
7	2.3 mm	3.2 mm
8	2.4 mm	3.3 mm
9	2.1 mm	2.9 mm
10	2.3 mm	3.2 mm
11	2.0 mm	3.1 mm
12	2.4 mm	3.3 mm
13	2.2 mm	3.1 mm
14	2.4 mm	3.3 mm
15	2.1 mm	3.1 mm
16	2.3 mm	3.2 mm
17	2.4 mm	3.5 mm
Mean	2.28 mm	3.21 mm
Female Radii		

RESULTS

Male Radii

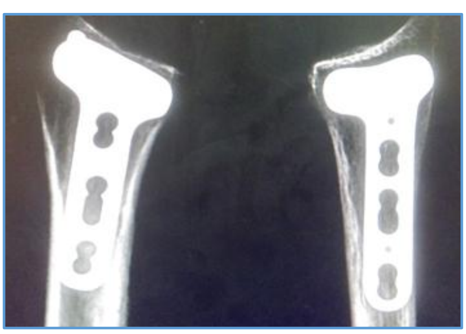
- The mean distance from volar tip is 2.67 mm with a standard deviation of 0.15 mm.
- The mean distance from dorsal tip is 3.58 mm with a standard deviation of 0.19 mm.

Female Radii

- The mean distance from volar tip is 2.28 mm with a standard deviation of 0.15 mm.
- The mean distance from dorsal tip is 3.21 mm with a standard deviation of 0.14 mm.

The results obtained were further tested by applying plates over various distal radius bones based upon the above-mentioned guidelines and checking them radiographically. There was no intra-articular screw penetration in all the radii in which plates were applied.

Radiological Confirmation



DISCUSSION

Intra-articular screw penetration is one the most troublesome complications in distal radius fracture surgeries. Many radiological studies have been done with respect to the radiological views necessary to confirm intra-articular screw penetration in the distal radius. Since the radial inclination is not uniform distally, a study conducted by Soong et al[5] showed that no single radiographic view can show whether all distally placed screws are extra-articular. Hence, we should take a minimum of 3 lateral tilt views (15^0, 23^0 and 30^0).[6] The lower angle tilt views (15^0 and 23^0) show the screws placed in the ulnar side above the sigmoid notch since the inclination of the distal radius near the sigmoid notch is lesser than that of radial side. The higher angle tilt views (30^0) show the screws placed in the radial side near the radial styloid[7] since the inclination of the distal radius is more on the radial side than that of the ulnar side. Our study helps to confirm whether all screws placed distally in the radius are extra-articular further augmenting the findings we get by radiological assessment intraoperatively. We can either place the distal screws of the plate as per the recommendations of our study or use the plate as a buttress distally without any screw placement.

If distal screws are deemed necessary based on the morphology of the fracture, especially in a setup where availability of a C-arm is a constraint, the findings obtained in our study could be used for distal screw placement while using fixed angle locking plates. Hence, we recommend use of variable angle locking plates if available for distal radius fractures, if not we could use fixed angle locking plates placed as per the recommendations of our study and taking at least 3 lateral tilt views (15^0, 23^0 and 30^0) before closure for confirmation in order to avoid intra-articular screw penetration.

CONCLUSION

- We conclude that our study helps in determining optimal plate placement in distal radius in respect to its articular surface.
- For male patients
    - Volar side - 2.67 mm from volar tip.
    - Dorsal side - 3.58 mm from dorsal tip.
- For female patients
    - Volar side - 2.28 mm from volar tip.
    - Dorsal side - 3.21 mm from dorsal tip.

REFERENCES

1. Nellans KW, Kowalski E, Chung KC. The epidemiology of distal radius fractures. Journal of Hand Surgery 2012;28(2):113-25.
2. Chang HC, Poh SY, Seah SC, et al. Fragment-specific fracture fixation and double-column plating of unstable distal radial fractures using AO mini-fragment implants and Kirschner wires. International Journal Of Care Of The Injured 2007;38(11):1259-67.
3. Obert L, Loisel F, Gasse N, et al. Distal radius anatomy applied to the treatment of wrist fractures by plate: a review of recent literature. SICOTJ 2015;1:14.
4. Singh AP. Anatomy of distal radius. Bone and Spine Journal 2014.

5. Soong M, Got C, Katarincic J, et al. Fluoroscopic evaluation of intra-articular screw placement during locked volar plating of the distal radius: a cadaveric study. Journal of Hand Surgery 2008;33(10):1720-3.
6. Boyer MI, Korcek KJ, Gelberman RH, et al. Anatomic tilt x-rays of the distal radius: an ex vivo analysis of surgical fixation. Journal of Hand Surgery Am 2004;29(1):116-22.
7. Tweet ML, Calfee RP, Stern PJ. Rotational fluoroscopy assists in detection of intra-articular screw penetration during volar plating of the distal radius. Journal of Hand Surgery Am 2010;35(4):619-27.