Review Article

Distal radioulnar joint injuries

Binu P Thomas, Raveendran Sreekanth

Abstract

Distal radioulnar joint is a trochoid joint relatively new in evolution. Along with proximal radioulnar joint , forearm bones and interosseous membrane, it allows pronosupination and load transmission across the wrist. Injuries around distal radioulnar joint are not uncommon, and are usually associated with distal radius fractures,fractures of the ulnar styloid and with the eponymous Galeazzi or Essex_Lopresti fractures. The injury can be purely involving the soft tissue especially the triangular fibrocartilage or the radioulnar ligaments.The patients usually present with ulnar sided wrist pain, features of instability, or restriction of rotation. Difficulty in carrying loads in the hand is a major constraint for these patients. Thorough clinical examination to localize point of tenderness and appropriate provocative tests help in diagnosis. Radiology and MRI are extremely useful, while arthroscopy is the gold standard for evaluation. The treatment protocols are continuously evolving and range from conservative, arthroscopic to open surgical methods. Isolated dislocation are uncommon. Basal fractures of the ulnar styloid tend to make the joint unstable and may require operative intervention. Chronic instability requires reconstruction of the stabilizing ligaments to avoid onset of arthritis. Prosthetic replacement in arthritis is gaining acceptance in the management of arthritis.

Key words: Distal radioulnar joint, TFCC, distal radius fracture, DRUJ injuries, DRUJ arthroplasty

Introduction

The distal radioulnar joint (DRUJ) is part of the complex forearm articulation that includes proximal radioulnar joint (PRUJ), forearm bones, and interosseous membrane (IOM) allowing pronosupination. It is functionally and anatomically integrated with the ulnocarpal articulation of wrist.

The DRUJ has evolved from the primitive pectoral fin of early fish to the bipedal primate wrist to its current form in human wrist. From the syndesmotic DRUJ of brachiating primates with limited forearm rotation, three major changes occurred, (a) development of a distinctly separate DRUJ, (b) recession of the distal ulna from the ulnar carpus, and (c) development of a distinct ulnocarpal meniscus.[1] Along with these changes, humans have moved over from a knuckle walking to brachiating arboreal lifestyle to erect bipedal posture with almost 180° of pronosupination.

Injuries of the DRUJ may occur in isolation, or along with fractures of the distal radius. These may present acutely or as chronic instabilities or painful arthritis of the DRUJ. The diagnosis and management of these injuries require a good knowledge of the anatomy and clinical evaluation. The joint is important in the transmission of load and its anatomic integrity should be respected in surgical procedures if normal biomechanics are to be preserved.[2,3]

Anatomy

DRUJ is a diarthrodial trochoid synovial joint,[3] consisting of two parts—the bony radioulnar articulation and soft tissue stabilizers.

The *radioulnar articulation* is formed by the lower end of ulna *(seat)* and the sigmoid notch (medial articular facet) of the distal radius [Figure 1]. The sigmoid notch of the radius is concave with a radius of curvature of approximately 15 mm[4]. The ulnar head is semicylindrical, convex, with a radius of curvature of 10 mm.[4] The shape of sigmoid notch is not uniform and has been classified into—1) flat face, 2) ski slope, 3) C type, and 4) S type[5]—which influences the predilection to instability. The flat face type is most susceptible to injuries. The distal articular surface of the ulna (dome or pole) is mostly covered by articular cartilage. At the base of the ulnar styloid is a depression called *fovea,* which is

Dr. Paul Brand Centre for Hand Surgery, CMC Hospital, Vellore, Tamil Nadu, India

Address for correspondence:
Dr. Binu Prathap Thomas, Professor & Head, Dr Paul Brand Centre for Hand Surgery, Christian Medical College & Hospital, Vellore, Tamil Nadu, India.
E-mail: binu@cmcvellore.ac.in

Access this article online	
Quick Response Code:	**Website:** www.ijoonline.com
	DOI: 10.4103/0019-5413.101031

devoid of cartilage. The differential arc of curvature of ulna and sigmoid notch suggests that pronosupination involves rotation as well as dorsopalmar translation at the DRUJ. In pronation, the ulna translates 2.8 mm dorsally from a neutral position; in supination, the ulna translates 5.4 mm volarly from a neutral position relative to radius.[6]

The soft tissue stabilizers are collectively referred to as ulnoligamentous complex[7] or more popularly as the triangular fibrocartilaginous complex (TFCC).[8] It consists of the triangular fibrocartilage (TFC or articular disk), meniscal homologue, ulnocarpal [ulnolunate (UL) and lunotriquetral] ligaments, the dorsal and volar radioulnar ligaments, ulnar collateral ligament, and the extensor carpi ulnaris (ECU) subsheath.[8] The ECU subsheath is reinforced medially by linear fibers referred to as the *linea jugata*.[9] The radioulnar ligaments (dorsal and volar) are the primary stabilizers of the DRUJ. The secondary stabilizers include the ECU subsheath, the UL and ulnotriquetral (UT) ligaments, the lunotriquetral interosseous ligament (LTIOL). The distal interosseous ligament also plays a role in stabilizing the DRUJ. The principal attachment of the TFC, the radioulnar and ulnocarpal ligament is the fovea [Figure 2a,b]. The secondary attachment of these structures are the ulnar styloid. A fracture involving the base of the ulnar styloid, therefore, can make the DRUJ potentially unstable. Injuries that destabilize the DRUJ result from disruption of the TFC along with the primary stabilizers, ulnocarpal ligaments, and ECU subsheath. The important function of the DRUJ in load bearing and its effects following injury has been well studied.[10]

Clinical Evaluation

Patients most commonly complain of ulnar-sided wrist pain (USWP), especially on loading the hand and rotating the forearm, particularly following trauma, eg, a fall on the outstretched hand (FOOSH). There will be tenderness over the ulnar aspect of wrist, localized to the underlying anatomical structure. Persistence of USWP and stiffness following distal radius fractures (DRF) point to DRUJ involvement. Clicking sounds, obvious instability, and weakness on lifting objects are also common complaints.

Impingement sign is usually positive in TFC injuries, but is by no means exclusive to this condition. This test is done by supinating and pronating the ulnar deviated wrist with elbows resting at 90° on the table. Focal tenderness just distal to ulnar styloid is suggestive of TFCC tear, while that at the volar or dorsal margins of distal ulna head point to radioulnar ligament injury. Instability must be checked in different positions of supination and pronation. The *ulna fovea sign i*s useful in detecting foveal disruptions and UT ligament injuries, which are two common causes of USWP. This is elicited by pressing the area between the flexor carpi ulnaris (FCU) tendon and ulnar styloid, between the pisiform and volar margin of the ulna. The differentiation between these conditions can be made clinically, where UT ligament tears are typically associated with a stable DRUJ and foveal disruptions are typically associated with an unstable DRUJ.[11]

The *piano-key test i*s positive when the ulna head is depressed volarly with the examiner's thumb and released, and it springs back like a piano key, suggesting instability. The *table top test* is done by asking the patient to press both hands on a flat table with forearm in pronation. With DRUJ instability, the ulna is more prominent dorsally and appears to sublux volarly with increasing pressure, creating a dorsal depression.[12] The *Grind test* is done by compressing the distal ulna and radius with the examiner's hand and

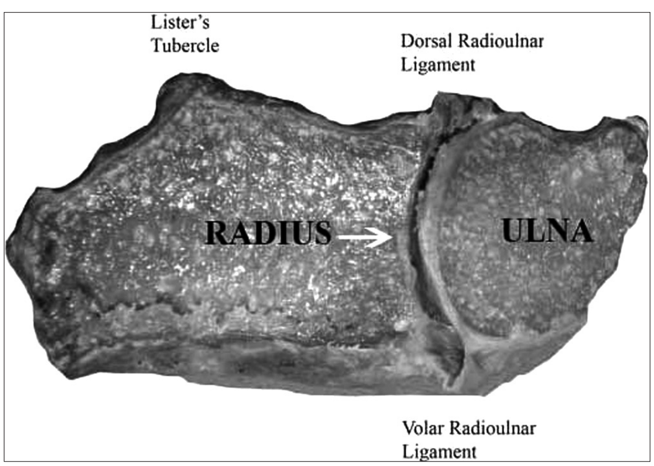

Figure 1: Transverse section through the DRUJ in a cadaver, showing the sigmoid notch of the radius (white arrow) and the head of the ulna along with the radioulnar ligaments

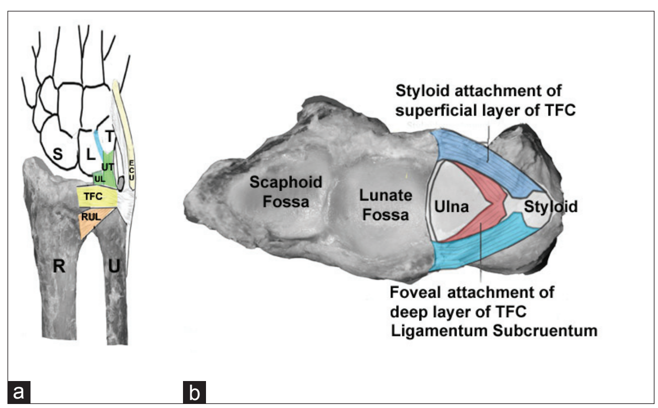

Figure 2: (a) Diagrammatic representation of the TFCC, superimposed on a dissected specimen, (b) Diagrammatic representation of triangular fibrocartilage (TFC) inserting into the fovea (deep layer) and ulnar styloid (superficial layer), RUL: Radioulnar ligament, TFC: triangular fibrocartilage, UL: ulnolunate ligament, UT: Ulnotriquetral ligament, ECU: extensor carpi ulnaris in its subsheath, SP: styloid process of ulna providing attachment to these structures—R: Radius, U: Ulna, S: scaphoid, L: lunate, T: triquetrum

producing a grinding motion, which elicits pain to suggest presence of DRUJ arthrosis.

Radiological Investigations

A standard posteroanterior (PA) and true lateral X-ray is mandatory. In the standard PA view, the groove for the extensor carpi ulnaris (ECU) tendon on the distal ulna must be visualized radial to the ulnar styloid [Figure 3a]. The *ulnar variance* is calculated by measuring the distance between a perpendicular drawn to the long axis of ulna at the distal articular surface and the perpendicular to the long axis of radius at the level of the volar distal articular margin. In a true lateral view, the volar surface of pisiform must be placed midway between the volar margins of the distal pole of scaphoid and capitate. A clenched fist PA view in forearm pronation to assess DRUJ gap[13] and weighted lateral stress view in pronation [Figure 3b] is helpful in assessing instability,[14] while routine lateral views is not.[15]

Computed tomography is useful to delineate sigmoid notch fractures and DRUJ injuries. Ligament injuries can be assessed indirectly by assessing the radioulnar articulation in various positions and also by loading views. Normal views are taken in neutral, supination, and pronation. Both wrists are imaged simultaneously to provide comparative views to assess degree of ulna displacement and asymmetry. Subsequently, loaded views may be taken using weights held in the hand and the views repeated. Three-dimensional (3D) reconstructions are helpful in assessing spatial relationship between the radius and ulna.

Magnetic resonance imaging (MRI) is useful for assessment of DRUJ ligaments [Figure 4a,b]. With a 3–T MRI, the radioulnar ligaments, ulnocarpal ligaments, and TFCC with its foveal attachment to distal ulna can be adequately visualized[16] with an 86% sensitivity for detection of TFCC tears.[17]

Arthroscopy

Arthroscopy is the gold standard for evaluation of TFCC injuries.[18] The TFC, foveal attachment, the radioulnar ligament (RUL) and ulnar collateral (UC) ligaments are well visualized with 3,4 portal and other ulnar portals. The volar and dorsal DRUJ portals also provide limited views of the structures. Arthroscopic debridement as well as repair of TFCC can be done [Figure 5a-d].

DRUJ injuries

The injuries of the DRUJ may involve purely soft tissues or fractures of the radius and/or ulnar styloid or, more rarely, isolated dislocations of the joint. Table 1 classifies various types of injuries of DRUJ.

Triangular fibrocartilaginous complex injury

Melone described the traumatic TFCC disruption as a continuum of injury beginning at the ulnar styloid and, with increasing force, extending to the midcarpal joints.[19] It was classified into five stages of increasing severity.[19] *Stage I:* detachment of TFC from ulnar styloid, *stage II:* ECU

Table 1: Injuries of DRUJ and TFCC- A working classification

	DRUJ injuries
A	Acute TFCC injuries
1.	Acute dislocations of DRUJ
2	DRUJ injuries associated with fractures, fracture dislocations
B	Chronic DRUJ injuries
1.	Chronic TFCC injuries
2	Ulnar Impaction syndromes
C	DRUJ Arthritis

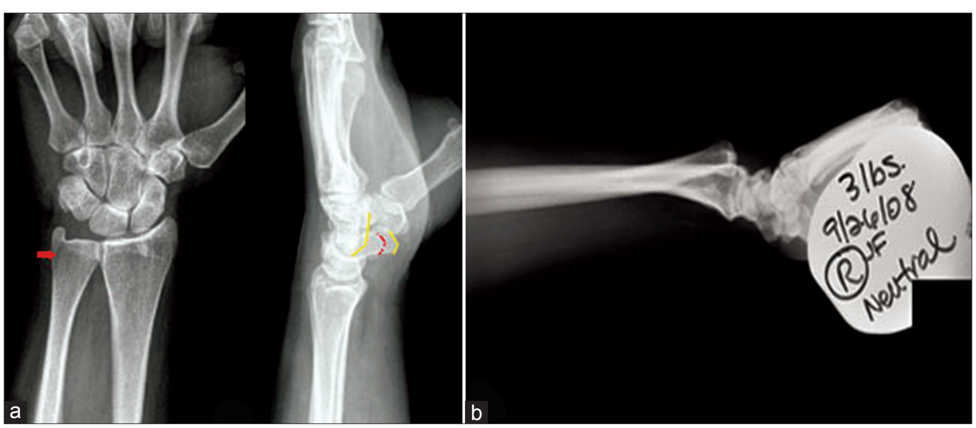

Figure 3: (a) X-ray evaluation of DRUJ. True PA views should show the groove for ECU radial to the ulnar styloid (red arrow). True lateral view should show the palmar edge of pisiform (red dotted line) midway between palmar borders of distal pole of scaphoid and capitate (yellow lines); (b) Scheker-weighted lateral view with patient holding 3 lb weight in the hand showing dorsal instability of the distal ulna. Weighted views provide loading of the DRUJ, bringing out instability, which may not be visible in routine X-rays (Scheker-weighted PA view is useful for diagnosis of ulna impingement syndrome following Darrach procedure if there is instability). [Picture courtesy, with permission: Dr Luis Scheker, Christine M Kleinert institute of Hand Surgery and Microsurgery, Louisville, KY, USA]

subsheath injury, *stage III*: ulnocarpal ligament disruption, *stage IV:* lunotriquetral ligament injury, and *stage V*: midcarpal ligament injury.

Palmer classified TFCC tears into *Type I (traumatic)* and *Type 2 (degenerative)*.[20] It is further subclassified based on the location of the injury in Type I or the extent of degeneration in Type 2 (see Table 2 for description). Type IA lesions are central tears and are the most common type of traumatic tears. This is not associated with instability of the DRUJ. These injuries can be symptomatic when there is an unstable flap of tissue, which "catch" on the joint surface.

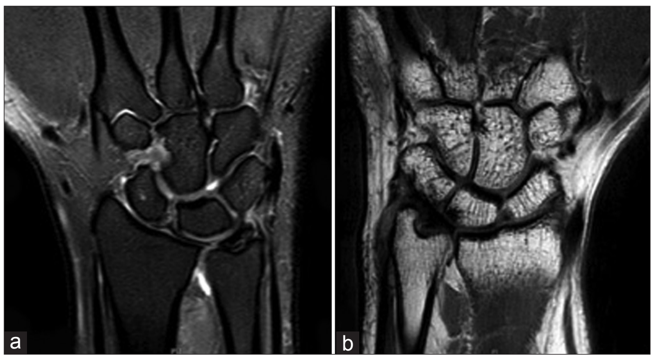

Figure 4: (a) MRI T2-weighted fat suppression image, showing a radial TFCC tear, fluid seen adjacent to DRUJ. In the sequence of MRI pictures (not shown here), the fluid is seen within the joint, (b) Proton density–weighted MRI, coronal view suggestive of ulnar impaction syndrome. Ulnar styloid process measures 8 mm (normal 2-6 mm), increased ulnar styloid index 0.61 (normal, 0.14–0.28). There is articular cartilage loss with erosion, marrow edema, subchondral cyst, and sclerosis of triquetrum and lunate

Type 1B lesions are tears of the TFCC from its insertion into the distal ulna, either ligamentous avulsions from the fovea or fractures through the base of the ulnar styloid.[21] Here, there is usually associated instability of DRUJ. Type 1C injuries involve the tear of volar ulnocarpal ligaments. These are high-energy injuries associated with DRUJ instability. Type 1D lesions are detachments of the radial insertion of the TFCC with or without marginal sigmoid notch fractures. These are associated with DRUJ instability.

Treatment of TFCC injuries commences with non-operative measures such as splinting or AE cast, modification of activity, occupational therapy, and nonsteroidal anti-inflammatory drugs (NSAIDs). Steroid injections into the DRUJ may be tried. Gross instability or associated unstable

Table 2: Classification of TFCC injuries

Type	Description
Type 1	Acute traumatic tears
1A	Central TFC perforation
1B	Peripheral ulnar side TFCC tear (±ulna styloid fracture)
1C	Distal TFCC disruption (disruption from distal UC ligaments)
1D	Radial TFCC disruption (±sigmoid notch fracture)
Type 2	Degenerative
2A	TFCC wear
2B	TFCC wear with lunate and/or ulnar chondromalacia
2C	TFCC perforation with lunate and/or ulnar chondromalacia
2D	TFCC perforation with lunate and/or ulnar chondromalacia with LTIOL perforation
2E	2D + ulnocarpal arthritis

Adapted from Palmer AK Triangular fibrocartilage complex lesions: a classification. J Hand Surg Am 1989 Jul;14(4):594-606

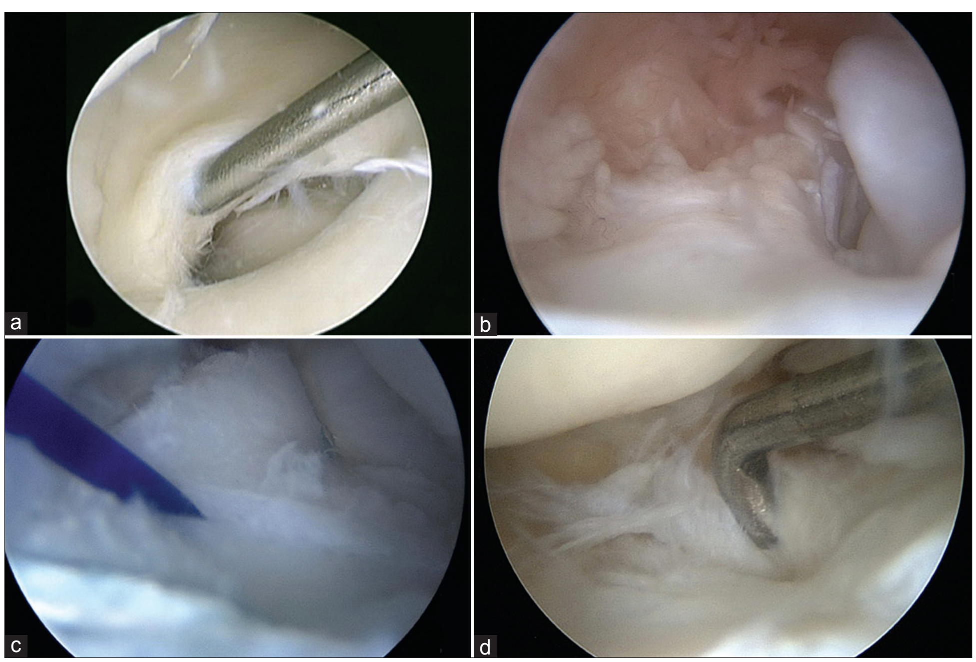

Figure 5: Arthroscopic evaluation of TFCC showing (a) Central TFCC tear, (b) Foveal detachment of the TFCC, (c) Reattachment of TFCC, and (d) Degenerative tears of TFCC. [Picture courtesy with permission: Dr Tuna Ozyerukoglu, Christine M Kleinert Institute of Hand and Microsurgery, Louisville, KY, USA.]

ulna styloid fractures warrants surgical intervention. Similarly, TFCC tears that fail to clinically improve following conservative care requires surgical treatment. Arthroscopic and open techniques for TFCC debridement or repair have been described for the treatment of acute and degenerative tears based on the location and size of the tears.[21] Type 1A injuries with central perforation can be treated by arthroscopic debridement. The unstable flap can be removed by debridement with clinical improvement of symptoms. It has been shown that up to 80% of the disc can be removed without ensuing instability. Central tears are not amenable to repair due to avascularity of the central zone of the TFCC, which precludes healing .Type 1B or peripheral ulnar sided tears involve the vascular zone of the TFCC and can be repaired either arthroscopically or by open technique. Various arthroscopic techniques of TFCC repair have been described, such as inside-out, outside-in, and all-inside techniques.[22-28] Similarly, Types 1C and D are also amenable to arthroscopic repair using the technique described by Trumble and coworkers.[29] The TFCC repair can be done by open technique also.[30]

Three surgical approaches to the DRUJ are used—dorsoulnar, ulnar, and palmar.[31,32] We prefer to expose the DRUJ by a linear incision about 4 cm, between the extensor digiti minimi (EDM) and ECU tendons centered over the ulnar head as described by Adams.[15] The EDM sheath is incised and tendon retracted to expose the capsule of DRUJ. Using an L-shaped capsulotomy, the DRUJ is exposed, taking care not to damage the DRUL. In this way, the TFC, ulna head, and soft tissues can be exposed and inspected. A transverse ulnocarpal capsulotomy is made to expose the distal aspect of TFC. Depending on the level of tear, insertion into ulna at the fovea or direct repair is with 2-0 absorbable sutures.

Isolated DRUJ dislocations

These are uncommon injuries and result from FOOSH or, rarely, a blow to the ulnar aspect of the wrist. This can be dorsal or volar.[33] DRUJ dislocation may be simple or complex (when there is soft tissue interposition, which prevents reduction). Failure to diagnose and treat a complex DRUJ dislocation will lead to chronic, persistent subluxation or dislocations, or both, and to symptomatic osteoarthrosis.[34] The dorsal dislocation is more common with the ulna moving dorsally in relation to the radius following hyperextension of the wrist with hyperpronation forces. The TFCC is avulsed from its foveal insertion in these injuries.[19] The secondary stabilizers of the DRUJ including the IOM, UC ligaments, and ECU subsheath provide sufficient stability to prevent instability following healing.[15] Clinically, a prominent ulnar head is visible over the dorsal wrist. In our experience, closed manipulation and reduction under anesthesia is usually successful. Forcible supination of radius while pushing the ulna head volarwards reduces dorsal dislocation, while forcible pronation with dorsally directed pressure on the ulna head reduces dorsal and volar-ward DRUJ dislocations, respectively. Once the joint is reduced, stability must be verified by translating the ulna volar and dorsally. We immobilize dorsal dislocations in an above elbow plaster of Paris (POP) cast in supination, and volar dislocations in pronation for a period of 6 weeks. If instability persists after reduction, radioulnar pinning is done in reduced position to allow soft tissue healing. TFCC repair, either open or arthroscopic, needs to be also considered in case of severe disruptions. Soft tissue interposition can result in irreducibility. The ECU tendon is the most common culprit. In this situation, open reduction and release of the interposed tendon or ligamentous structure is required followed by pinning of the joint.

DRUJ injuries associated with fractures and fracture–dislocations

Distal radius fractures and ulnar styloid fractures

Forearm supination and pronation is important for optimum function and positioning of the hand in space.[35] The most common cause of residual wrist disability after DRF is the DRUJ involvement. Three basic causes that result in radioulnar pain and limitation of forearm rotation are instability, joint incongruency, and ulnocarpal abutment. The last two entities initiate irreversible cartilage damage that eventually leads to degenerative joint disease. Early recognition and management in the acute stage aim at the anatomic reconstruction of the distal radioulnar joint including bone, joint surfaces, and ligaments in an effort to reduce the incidence of painful sequelae and functional deficit.[36] Experimentally, it is found that severely displaced DRF result in disruption of TFCC in the absence of ulna styloid fractures.[37] USF through the base results in DRUJ instability if the fragment involves the foveal insertion of the TFCC. Concurrent arthroscopic evaluation of patients with DRF requiring operative intervention for reduction revealed an incidence of TFCC injury in 43% of the cases.[38] Similarly, fractures through the sigmoid notch produce stiffness and late onset arthritis of the DRUJ. The DRUJ can be injured in association with almost any fracture of the forearm or as an isolated phenomenon. Failure to recognize a simple or complex dislocation of the DRUJ associated with a fracture of the forearm may result in inappropriate or inadequate immobilization of the dislocated joint after internal fixation of the fracture. As a consequence, the injured TFCC may not heal, leading to recurrent postoperative instability. After either a simple or a complex dislocation of the DRUJ has been recognized, the treatment is relatively straightforward and rewarding. Despite the severity of these injuries, with proper diagnosis and reduction, most patients will have a satisfactory outcome.[34] This has been the authors experience also.

Assessment of DRUJ stability following DRF are best done intraoperatively after fixation of the radius fracture by translation of the ulna in a dorsopalmar direction. If in doubt, we also compare it with the normal side. However, careful assessment of the preoperative X-rays can indicate a possibility of DRUJ instability. These include: 1) shortening of radius >5 mm relative to ulna, 2) fracture of the base of ulnar styloid, 3) widening of the DRUJ interval on PA view, and 4) dislocation of the DRUJ on lateral view.[39,40] Computed tomography scans, especially axial views, can provide information regarding subluxation and fractures of the ligamentous margins of radius and ulna. DRF with fracture of the dorsal or volar ulnar margins can be unstable as these include insertion of the dorsal or volar RUL. Similarly, sigmoid notch fractures, especially shearing type of fractures, produce instability due to involvement of TFC radial insertion. Therefore, it is necessary to include these fragments in the fixation of the DRF, either with the plate itself or with additional screws or K-wires [Figures 6 and 7]. Fragment-specific fixation is helpful in these situations. About 61% of DRF are associated with ulna styloid fractures.[41] However, there are recent reports that did not find significant relationship between functional outcome and ulnar styloid fractures (USF), which were not fixed following stable fixation of distal radius fracture.[42,43] In our practice, we tend to fix the unstable USF rather than not, commonly by open reduction and tension band fixation, when associated with DRF.

Ulna styloid fractures may also be seen in isolation. While styloid tip fractures are stable, basal fractures of the styloid are associated with DRUJ instability.[44,45] Fixation of styloid fracture makes the DRUJ stable, provided the TFCC is not otherwise injured. We use various fixation techniques that has been described for styloid fractures including closed pinning, tension band wiring [Figure 6], compression screw fixation, suture anchor technique, etc.[15] When symptomatic nonunions of styloid are seen, subperiosteal excision of the smaller fragments, or TFCC reattachment to the base with transosseous sutures and excision of larger fragments can be done.[46] Comminuted, unstable, or displaced distal ulna neck fractures must also be fixed to maintain DRUJ stability and congruence.

Galeazzi fracture–dislocation is a diaphyseal fracture of radius with associated DRUJ dislocation, with the fracture of radius seen 4-6 cm proximal to DRUJ. Palmer Type IB TFCC injury is classically seen. In the authors experience, operative fixation of the radius is necessary due to inherent instability.

Figure 6: X-ray of wrist with distal forearm and hand anteroposterior and lateral views showing (a) Ulnar styloid with DRUJ instability (b) treated by open reduction and tension band fixation. Joint was stable following union of fracture. (c) Pre- and postoperative X-rays of a patient with fracture of the ulnar head (d) treated by ORIF with screws

When the radius fracture is within 7.5 cm of the distal radius, DRUJ injury is highly likely.[47] Other radiologic parameters of instability mentioned above may also be considered. About 80% of these injuries presented with complete dislocation of DRUJ.[48] Once the radius is stabilized, the DRUJ usually falls into position in most cases (simple dislocations). Further, instability is checked and if present, the DRUJ is pinned [Figure 7]. If the DRUJ fails to reduce after radius fixation, interposition of soft tissue, especially the ECU tendon, must be suspected (complex dislocations). In these situations, open reduction with extraction of the interposed soft tissue and open repair of the TFCC is required.[49]

The Essex–Lopresti injury is the eponymous injury with comminuted fracture of radial head associated with DRUJ dislocation.[50] The injury is by an axial compression force resulting in longitudinal disruption of the proximal and distal radioulnar articulation and the IOM. Long-term longitudinal instability will persist if not adequately treated with proximal radius migration and distal ulna impaction. In suspected cases, radiographs of the elbow, forearm, and wrist must be taken. MRI and ultrasound evaluation of soft tissue damage of IOM is helpful.[39] Excision of radial head is contraindicated in these injuries. A classification system has been proposed with suggested management options[51] [Table 3]. The DRUJ stability is evaluated following fixation of radial head and if unstable, radioulnar pinning/TFCC repair may be necessary.

Chronic DRUJ instability

Persistent USWP and chronic DRUJ instability can result from fractures of the distal radius and ulna following inadequate treatment or malunions. If untreated, these lead to chronic pain and disability due to stiffness, decreased grip strength, and arthritis. The dynamic and static stabilizers of DRUJ may become dysfunctional or injured resulting in chronic instability. Acute instabilities that are unnoticed or poorly treated also become chronic. Poorly reduced DRF, especially increased dorsal tilt, reduced radial inclination and radial shortening results in DRUJ incongruity.[52] There are reports suggesting that anatomical reduction of DRF is more critical in avoiding persistent DRUJ issues rather than associated fixing or union of ulna styloid fractures.[42,53]

Management of chronic DRUJ instability depends primarily on the underlying cause. Length discrepancy between radius and ulna, malunions, and ulnocarpal impaction needs to be corrected primarily by osteotomy and bone grafting techniques [Figure 8a,b] before considering ligament reconstructions. Arthritis of DRUJ requires salvage procedures (discussed later). Soft tissue reconstruction of DRUJ is indicated in symptomatic patients in whom TFCC is irreparable and sigmoid notch competent.[54] Various procedures directed at stabilizing the DRUJ, broadly considered under four main heads[55]: 1) extrinsic radioulnar tether, 2) extensor retinaculum capsulorrhaphy, 3) ulnocarpal sling, and 4) reconstruction of volar and dorsal radioulnar ligaments.

Extrinsic radioulnar tether was described by Fulkerson and

Table 3: Classification of Essex–Lopresti classification and suggested management

Type	Radial head fracture	Proposed treatment
Type I	Large fragments	ORIF
Type II	Comminuted	Radial head excision and prosthetic replacement
Type III	Chronic injuries with proximal migration of radial head	Radial head replacement and ulnar shortening osteotomy

Modified from Edwards GS, Jr, Jupiter JB Radial head fractures with acute distal radioulnar dislocation. Essex-Lopresti revisited. Clin Orthop Relat Res. 1988 Sep(234):61-9

Figure 7: (a) Acute fracture involving the sigmoid notch with DRUJ instability and ulnar translation of carpus. (b) Open reduction, internal fixation (ORIF) of the fragment and repair of volar wrist ligaments (radioscaphocapitate ligament) were done. Galeazzi fracture–dislocation with ulnar styloid fracture and grossly unstable DRUJ treated by ORIF of radius and trans fixation of radius and ulna. DRUJ was stable following POP removal after 6 weeks

Figure 8: X-ray anteroposterior and lateral views (a) Malunited distal radius fracture following an old gunshot injury with gross deformity and relative ulnar lengthening, treated by corrective osteotomy and bone grafting of radius using a volar approach, and volar plate fixation. Intraoperatively, a distractor was used to correct the deformity, (b) Postoperation follow-up X-rays showing deformity correction, the restitution of DRUJ and correction of radial inclination and height

Watson,[56] using a tendon graft looped around the neck of ulna and threaded through the radius for the management of anterior dislocation of distal ulna. It has recently been used for traumatic DRUJ instability also.[57] This is not an anatomical reconstruction of RUL and is therefore seldom used.

The extensor retinaculum capsulorrhaphy or the Herbert sling procedure uses an ulnar-based flap of extensor retinaculum to stabilize the DRUJ.[58,59] This is a useful procedure for DRUJ instability originally described for stabilizing ulnar head prosthesis.

Ulnocarpal sling procedure was described y Hui and Linshead using a distally based strip of FCU tendon to reconstruct the volar ulnocarpal ligament.[60] The repair also imbricates the dorsal radioulnar ligament upon itself, and the forearm initially pinned in supination by a K-wire until ligament healing.

Reconstruction of the volar and dorsal radioulnar ligaments have been described to anatomically reconstruct the dorsal and volar radioulnar ligaments and is often used[12,14,61] with good results. The authors prefer to use the techniques described by Adams and Berger [Figure 9] or Scheker for reconstructing the radioulnar ligaments[12,14] in cases of chronic DRUJ instability when arthritis is not present and when the radial inclination, slope and ulnar height are normal or already corrected.

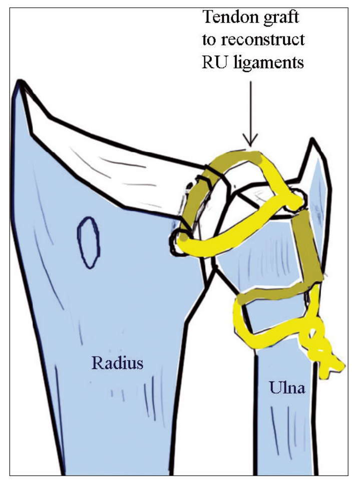

Figure 9: Diagrammatic representation of Adams–Berger procedure for chronic DRUJ instability. The dorsal and volar radioulnar ligaments are reconstructed with a palmaris longus graft. (Adams BD, Berger RA. An anatomic reconstruction of the distal radioulnar ligaments for posttraumatic distal radioulnar joint instability. J Hand Surg Am. 2002 Mar;27(2):243-51)

Ulnar impaction syndrome

Due to repetitive loading of the ulnocarpal joint, especially in the presence of ulna plus variance degenerative changes occur in the TFC, lunotriquetral articulation referred to as ulnar impaction or ulnocarpal abutment syndrome. Palmer Type 2 or degenerative tears of TFCC result from such chronic loading of the ulnar aspect starting with progressive wear of TFCC, perforation to ulnocarpal arthritis.[20] This should be differentiated from the ulna impingement syndrome due to an unstable ulnar stump painfully abutting the radius following a Darrach procedure.[15] An acquired ulna plus variance caused by malunited distal radius fracture is the most common cause of this condition [Figure 10]. Typical clinical features are ulnar-sided wrist pain, especially on loading and rotation movement. The PA view demonstrates the ulna plus. MRI is useful for observing changes in the lunate and triquetrum [Figure 4b], and arthroscopy demonstrates the classical stages described by Palmer. The treatment include conservative management by splinting, NSAIDs, and modification of activities. Surgical treatment is required if symptoms continue and include wafer resection of the distal ulna as described by

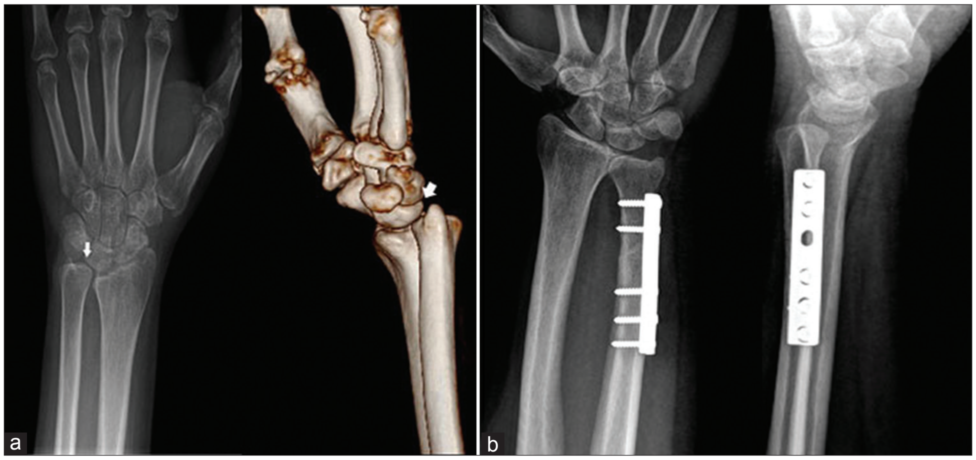

Figure 10: (a) X-ray, and computed tomography reconstruction showing the impingement to the lunate and triquetrum ulnar impaction syndrome secondary to long-standing malunited distal radius fracture presenting as USWP with painful supination/pronation on loading the wrist, a positive impingement sign. (b) X-ray posteroanterior and lateral views showing Ulna was shortened by cuff resection and compression plating with relief of pain and improved movement

Feldon,[62,63] which can be done arthroscopically or open, or an ulna shortening osteotomy as originally described by Milch.[64] We prefer an ulna shortening osteotomy and compression plate fixation in this situation once conservative management fails to alleviate the symptoms.

DRUJ arthritis

DRF through the sigmoid notch or the distal ulna, malunions, chronic instability of DRUJ, and failed reconstruction of the DRUJ progress to arthritis, with pain and stiffness of the joint. Various options are available in the management of this situation.

Surgical treatment DRUJ

Resection of distal ulna (Darrach procedure)

This procedure removes the distal articular surface of the ulna,[65] thereby relieving pain and improving supination and pronation. This is useful in the elderly and in patients with limited activity. However, reported problems of this procedure in a physically active patient include ulna impingement syndrome,[66] loss of grip strength, and possible ulnar translation of carpus.[67] To address the ulna instability following a Darrach procedure,[65] FCU or ECU tendon slings have been fashioned to attach to the distal ulna.[68,69] The authors reserve the use of the Darrach procedure in the older age group with less physical demands and routinely combine the excision of distal ulna with an ECU sling in an attempt to reduce the likelihood of impingement.

Sauve-Kapandji procedure

Originally described in 1936, this combines DRUJ arthrodesis and surgical pseudarthrosis of the distal ulna.[70] This has the advantage of preserving the ulnar support of the wrist by retaining the distal ulna [Figure 11]. The indications and surgical technique is well described in other articles.[67] The proximal pseudarthrosis allows supination and pronation. We prefer

Figure 11: Postoperation X-ray of a 48-year-old female patient who underwent Sauve–Kapandji procedure for chronic instability of DRUJ with painful arthrosis

this procedure in young active adults with DRUJ arthrosis as compared to a Darrach procedure.[65] However, painful instability of the proximal ulna stump can still remain a problem.

Hemiresection–interposition arthroplasty

Bowers described partial resection of the articular surface of ulna and interposing a capsular flap for DRUJ arthritis, while retaining the ulnar attachment of the TFCC.[71] Interposition can be augmented by a tendon roll or allograft [Figure 12]. Ulnocarpal impaction is described as a relative contraindication of this procedure. The authors have used this procedure for treating DRUJ arthrosis with mild degree of ulna plus variance with good results.

DRUJ implant arthroplasty

Prosthetic replacement for the head of ulna has been described for primary DRUJ arthrosis and in failed DRUJ surgery. Swanson and Herbert has developed prosthesis for distal ulna replacement. Scheker has described a semiconstrained modular implant for total replacement of the DRUJ (APTIS DRUJ prosthesis) [Figures 13 and 14]. This has a stainless steel radial implant, which articulates with an ultra-high molecular weight (UHMW) polyethylene sphere and an ulna stem.[72] Though long term results are still awaited, the implant shows great promise in the management of DRUJ arthrosis providing a stable pain- free joint. While the implant is yet unavailable in the subcontinent, the author has been impressed by the functcionality of this prosthesis on reviewing Dr. Scheker's patients who had underwent this procedure

Conclusion

The DRUJ injuries presents as ulna sided wrist pain resulting most commonly from traumatic episodes. Clinical

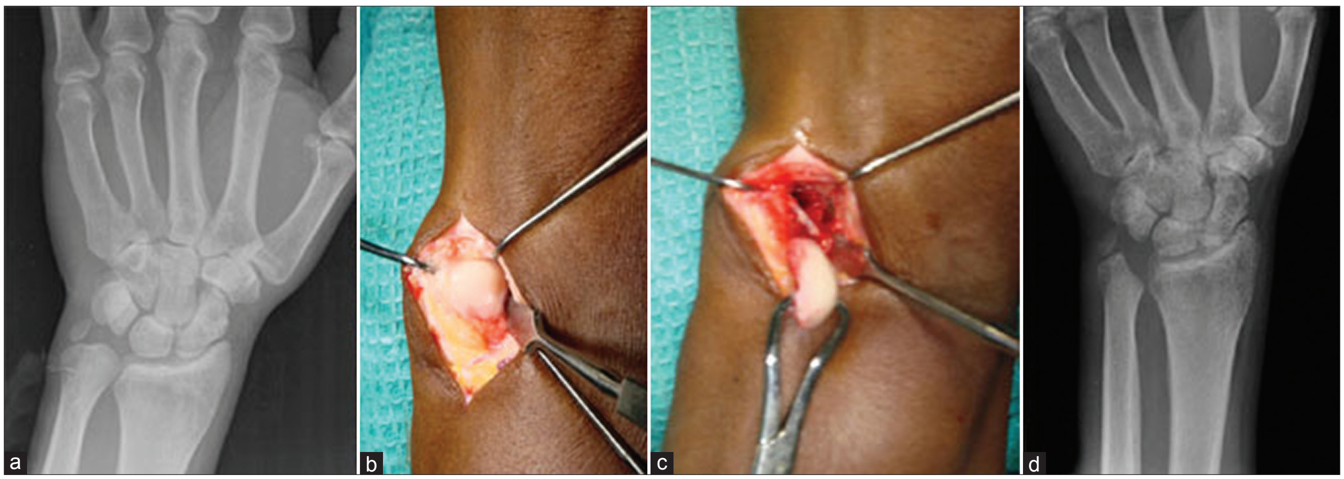

Figure 12 (a-d): Bowers hemiresection interposition arthroplasty (HITE) for DRUJ arthrosis and minimal impingement, preoperative X-ray, intraoperative images and postoperative X-ray

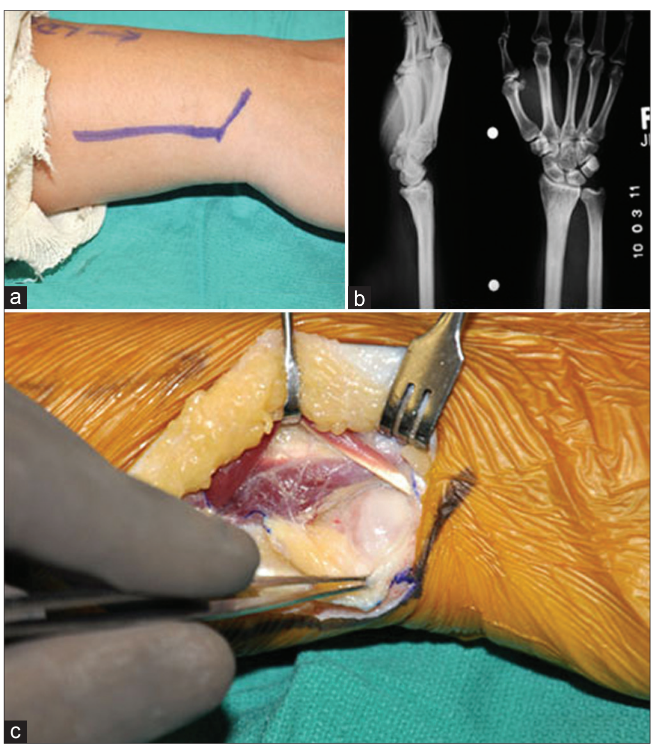

Figure 13: Scheker total DRUJ arthroplasty (APTIS DRUJ prosthesis) for DRUJ arthritis. (a) Peroperative photograph showing incision mark. (b) X-rays lateral and posteroanterior views showing degenerative changes in the DRUJ. (c) Peroperative photograph showing ulnar head devoid of cartilage with sigmoid notch osteophytes

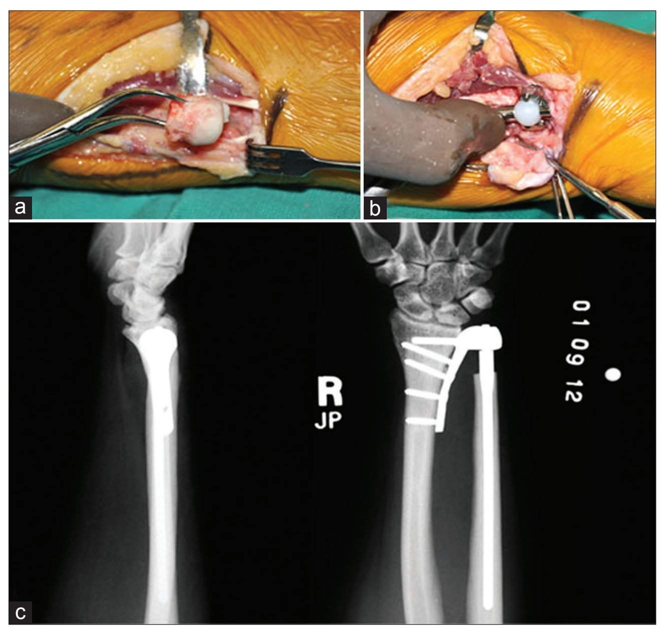

Figure 14 (a-c): Scheker total DRUJ arthroplasty (APTIS DRUJ prosthesis) for DRUJ arthritis: (continued from Figure 13) Ulnar head was excised and DRUJ replacement with APTIS size 20 radial plate assembly and a 4.0 mm diameter 1-cm ulnar stem. The patient had excellent recovery with full range of motion and is able to lift weight without any pain. She returned to her regular occupation (Picture series 13 and 14, courtesy, with permission: Dr. Luis Scheker, Christine M Kleinert institute of Hand Surgery and Microsurgery, Louisville, KY, USA) examination provide information regarding the anatomical structures injured. Investigations helping in diagnosis include plain X-rays and MRI. Arthroscopy is considered the gold standard in diagnosis. Treatment include splinting, ORIF of fractures and repair of torn ligaments and TFCC by arthroscopy or open methods. In late presentations, instability is addressed by various techniques which have been described. DRUJ arthroplasty is emerging as a treatment in cases of arthrosis of the joint.

Acknowledgment

The authors thank Dr Luis Scheker and Prof. G. A. Anderson for showing the way and also extend their thanks to Dr. Samuel Raj Pallapati and Dr. Jyothi Surekha for discussions and feedback in the management and investigations of patients with problems in this complex joint.

References

1. Louis DS, Jebson PJ. The evolution of the distal radio-ulnar joint. Hand Clin 1998;14:155-9.
2. Shaaban H, Giakas G, Bolton M, Williams R, Scheker LR, Lees VC. The distal radioulnar joint as a load-bearing mechanism–a biomechanical study. J Hand Surg Am 2004;29:85-95.
3. Hagert E, Hagert CG. Understanding stability of the distal radioulnar joint through an understanding of its anatomy. Hand Clin 2010;26:459-66.
4. Szabo RM. Distal radioulnar joint instability. Instr Course Lect 2007;56:79-89.
5. Tolat AR, Stanley JK, Trail IA. A cadaveric study of the anatomy and stability of the distal radioulnar joint in the coronal and transverse planes. J Hand Surg Br 1996;21:587-94.
6. Pirela-Cruz MA, Goll SR, Klug M, Windler D. Stress computed tomography analysis of the distal radioulnar joint: A diagnostic tool for determining translational motion. J Hand Surg Am 1991;16:75-82.
7. Ekenstam F. Osseous anatomy and articular relationships about the distal ulna. Hand Clin 1998;14:161-4.
8. Palmer AK, Werner FW. The triangular fibrocartilage complex of the wrist--anatomy and function. J Hand Surg Am 1981;6:153-62.
9. Taleisnik J, Gelberman RH, Miller BW, Szabo RM. The extensor retinaculum of the wrist. J Hand Surg Am 1984;9:495-501.
10. Shaaban H, Giakas G, Bolton M, Williams R, Wicks P, Scheker LR, *et al*. The load-bearing characteristics of the forearm: Pattern of axial and bending force transmitted through ulna and radius. J Hand Surg Br 2006;31:274-9.
11. Tay SC, Tomita K, Berger RA. The "ulnar fovea sign" for defining ulnar wrist pain: An analysis of sensitivity and specificity. J Hand Surg Am 2007;32:438-44.
12. Adams BD, Berger RA. An anatomic reconstruction of the distal radioulnar ligaments for posttraumatic distal radioulnar joint instability. J Hand Surg Am 2002;27:243-51.
13. Iida A, Omokawa S, Akahane M, Kawamura K, Takayama K, Tanaka Y. Distal radioulnar joint stress radiography for detecting radioulnar ligament injury. J Hand Surg Am 2012;37:968-74.
14. Scheker LR, Belliappa PP, Acosta R, German DS. Reconstruction of the dorsal ligament of the triangular fibrocartilage complex. J Hand Surg Br 1994;19:310-8.
15. Adams BD. Distal radioulnar joint instability. In: Wolfe SW, Hotchkiss RN, Pederson WC, Kozin SH, editors. Green's operative hand surgery. 6th ed. Philadelphia: Elsevier Churchill Livingstone; 2011. p. 523-60.
16. Amrami KK, Moran SL, Berger RA, Ehman EC, Felmlee JP. Imaging the distal radioulnar joint. Hand Clin 2010;26:467-75.
17. Magee T. Comparison of 3-T MRI and arthroscopy of intrinsic wrist ligament and TFCC tears. AJR Am J Roentgenol 2009;192:80-5.
18. Bednar JM, Osterman AL. The role of arthroscopy in the treatment of traumatic triangular fibrocartilage injuries. Hand Clin 1994;10:605-14.
19. Melone CP Jr, Nathan R. Traumatic disruption of the triangular fibrocartilage complex. Pathoanatomy. Clin Orthop Relat Res 1992;275:65-73.
20. Palmer AK. Triangular fibrocartilage complex lesions: A classification. J Hand Surg Am 1989;14:594-606.
21. Kovachevich R, Elhassan BT. Arthroscopic and open repair of the TFCC. Hand Clin 2010;26:485-94.
22. Trumble T. Radial side (1D) tears. Hand Clin 2011;27:243-54.
23. Yao J. All-arthroscopic repair of peripheral triangular fibrocartilage complex tears using FasT-Fix. Hand Clin 2011;27:237-42.
24. Yao J, Lee AT. All-arthroscopic repair of Palmer 1B triangular fibrocartilage complex tears using the FasT-Fix device. J Hand Surg Am 2011;36:836-42.
25. Bohringer G, Schadel-Hopfner M, Petermann J, Gotzen L. A method for all-inside arthroscopic repair of Palmer 1B triangular fibrocartilage complex tears. Arthroscopy 2002;18:211-3.
26. Corso SJ, Savoie FH, Geissler WB, Whipple TL, Jiminez W, Jenkins N. Arthroscopic repair of peripheral avulsions of the triangular fibrocartilage complex of the wrist: A multicenter study. Arthroscopy 1997;13:78-84.
27. de Araujo W, Poehling GG, Kuzma GR. New Tuohy needle technique for triangular fibrocartilage complex repair: Preliminary studies. Arthroscopy 1996;12:699-703.
28. Geissler WB. Arthroscopic knotless peripheral ulnar-sided TFCC repair. Hand Clin 2011;27:273-9.
29. Trumble TE, Gilbert M, Vedder N. Isolated tears of the triangular fibrocartilage: Management by early arthroscopic repair. J Hand Surg Am 1997;22:57-65.
30. Nakamura T, Sato K, Okazaki M, Toyama Y, Ikegami H. Repair of foveal detachment of the triangular fibrocartilage complex: Open and arthroscopic transosseous techniques. Hand Clin 2011;27:281-90.
31. Garcia-Elias M, Hagert E. Surgical approaches to the distal radioulnar joint. Hand Clin 2010;26:477-83.
32. Garcia-Elias M, Smith DE, Llusa M. Surgical approach to the triangular fibrocartilage complex. Tech Hand Up Extrem Surg 2003;7:134-40.
33. Ellanti P, Grieve PP. Acute irreducible isolated anterior distal radioulnar joint dislocation. J Hand Surg Eur Vol 2012;37:72-5.
34. Bruckner JD, Alexander AH, Lichtman DM. Acute dislocations of the distal radioulnar joint. Instr Course Lect 1996;45:27-36.
35. Kleinman WB. Distal radius instability and stiffness: Common complications of distal radius fractures. Hand Clin 2010;26:245-64.
36. Geissler WB, Fernandez DL, Lamey DM. Distal radioulnar joint injuries associated with fractures of the distal radius. Clin Orthop Relat Res 1996;327:135-46.
37. Pogue DJ, Viegas SF, Patterson RM, Peterson PD, Jenkins DK, Sweo TD, *et al*. Effects of distal radius fracture malunion on

wrist joint mechanics. J Hand Surg Am 1990;15:721-7.
38. Geissler WB, Freeland AE, Savoie FH, McIntyre LW, Whipple TL. Intracarpal soft-tissue lesions associated with an intra-articular fracture of the distal end of the radius. J Bone Joint Surg Am 1996;78:357-65.
39. Carlsen BT, Dennison DG, Moran SL. Acute dislocations of the distal radioulnar joint and distal ulna fractures. Hand Clin 2010;26:503-16.
40. Fujitani R, Omokawa S, Akahane M, Iida A, Ono H, Tanaka Y. Predictors of distal radioulnar joint instability in distal radius fractures. J Hand Surg Am 2011;36:1919-25.
41. Frykman G. Fracture of the distal radius including sequelae–shoulder-hand-finger syndrome, disturbance in the distal radio-ulnar joint and impairment of nerve function. A clinical and experimental study. Acta Orthop Scand 1967;Suppl 108:3+.
42. Kim JK, Koh YD, Do NH. Should an ulnar styloid fracture be fixed following volar plate fixation of a distal radial fracture? J Bone Joint Surg Am 2010;92:1-6.
43. Souer JS, Ring D, Matschke S, Audige L, Marent-Huber M, Jupiter JB. Effect of an unrepaired fracture of the ulnar styloid base on outcome after plate-and-screw fixation of a distal radial fracture. J Bone Joint Surg Am 2009;91:830-8.
44. Sasao S, Beppu M, Kihara H, Hirata K, Takagi M. An anatomical study of the ligaments of the ulnar compartment of the wrist. Hand Surg 2003;8:219-26.
45. Scheer JH, Adolfsson LE. Pathomechanisms of ulnar ligament lesions of the wrist in a cadaveric distal radius fracture model. Acta Orthop 2011;82:360-4.
46. Hauck RM, Skahen J 3rd, Palmer AK. Classification and treatment of ulnar styloid nonunion. J Hand Surg Am 1996;21:418-22.
47. Rettig ME, Raskin KB. Galeazzi fracture-dislocation: A new treatment-oriented classification. J Hand Surg Am 2001;26:228-35.
48. Mikic ZD. Galeazzi fracture-dislocations. J Bone Joint Surg Am 1975;57:1071-80.
49. Bruckner JD, Lichtman DM, Alexander AH. Complex dislocations of the distal radioulnar joint. Recognition and management. Clin Orthop Relat Res 1992;275:90-103.
50. Essex-Lopresti P. Fractures of the radial head with distal radio-ulnar dislocation; report of two cases. J Bone Joint Surg Br 1951;33B:244-7.
51. Edwards GS Jr, Jupiter JB. Radial head fractures with acute distal radioulnar dislocation. Essex-Lopresti revisited. Clin Orthop Relat Res 1988;234:61-9.
52. Adams BD. Effects of radial deformity on distal radioulnar joint mechanics. J Hand Surg Am 1993;18:492-8.
53. Kim JK, Yun YH, Kim DJ, Yun GU. Comparison of united and nonunited fractures of the ulnar styloid following volar-plate fixation of distal radius fractures. Injury 2011;42:371-5.
54. Adams BD, Lawler E. Chronic instability of the distal radioulnar joint. J Am Acad Orthop Surg 2007;15:571-5.
55. Kakar S, Carlsen BT, Moran SL, Berger RA. The management of chronic distal radioulnar instability. Hand Clin 2010;26:517-28.
56. Fulkerson JP, Watson HK. Congenital anterior subluxation of the distal ulna. A case report. Clin Orthop Relat Res 1978;131:179-82.
57. Purisa H, Sezer I, Kabakas F, Tuncer S, Erturer E, Yazar M. Ligament reconstruction using the Fulkerson-Watson method to treat chronic isolated distal radioulnar joint instability: Short-term results. Acta Orthop Traumatol Turc 2011;45:168- 74.
58. Dy CJ, Ouellette EA, Makowski AL. Extensor retinaculum capsulorrhaphy for ulnocarpal and distal radioulnar instability: The Herbert sling. Tech Hand Up Extrem Surg 2009;13:19-22.
59. Stanley D, Herbert TJ. The Swanson ulnar head prosthesis for post-traumatic disorders of the distal radio-ulnar joint. J Hand Surg Br 1992;17:682-8.
60. Hui FC, Linscheid RL. Ulnotriquetral augmentation tenodesis: A reconstructive procedure for dorsal subluxation of the distal radioulnar joint. J Hand Surg Am 1982;7:230-6.
61. Scheker LR, Ozer K. Ligamentous stabilization of the distal radioulnar joint. Tech Hand Up Extrem Surg 2004;8:239-46.
62. Feldon P, Terrono AL, Belsky MR. Wafer distal ulna resection for triangular fibrocartilage tears and/or ulna impaction syndrome. J Hand Surg Am 1992;17:731-7.
63. Feldon P, Terrono AL, Belsky MR. The "wafer" procedure. Partial distal ulnar resection. Clin Orthop Relat Res 1992;275:124-9.
64. Milch H. Cuff resection of the ulna for malunited Colles' fracture. J Bone Joint Surg 1941;23:311-3.
65. Darrach W. Partial excision of lower shaft of the ulna for deformity following Colles's fracture. Ann Surg 1913;57:53-7.
66. Watson HK, Brown RE. Ulnar impingement syndrome after Darrach procedure: Treatment by advancement lengthening osteotomy of the ulna. J Hand Surg Am 1989;14(2 Pt 1):302-6.
67. Lluch A. The Sauve-Kapandji procedure: Indications and tips for surgical success. Hand Clin 2010;26:559-72.
68. Breen TF, Jupiter JB. Extensor carpi ulnaris and flexor carpi ulnaris tenodesis of the unstable distal ulna. J Hand Surg Am 1989;14:612-7.
69. Tsai TM, Stilwell JH. Repair of chronic subluxation of the distal radioulnar joint (ulnar dorsal) using flexor carpi ulnaris tendon. J Hand Surg Br 1984;9:289-94.
70. Sauve' L, Kapandji, M. Nouvelle technique de traitement chirurgical des luxations recidivantes isolees de l'extremite inferieure du cubitus. J Chirurgie 1936;47:589-94.
71. Bowers WH. Distal radioulnar joint arthroplasty: The hemiresection-interposition technique. J Hand Surg Am 1985;10:169-78.
72. Scheker LR. Implant arthroplasty for the distal radioulnar joint. J Hand Surg Am 2008;33:1639-44.

How to cite this article: Thomas BP, Sreekanth R. Distal radioulnar joint injuries. Indian J Orthop 2012;46:493-504.

Source of Support: Nil, **Conflict of Interest:** None.