Introduction

Wrist arthroscopy has steadily grown from a mostly diagnostic tool to a valuable adjunctive procedure in the treatment of distal radius fractures. The ability to visualize the fracture fragments under high power magnification enables the surgeon to anatomically reduce the articular surface with minimally invasive percutaneous techniques. Many studies have demonstrated the superiority of an arthroscopic-assisted reduction of a displaced intraarticular fracture over a fluoroscopic reduction which has been shown to correlate with improved wrist motion and grip strength. Doi and coworkers performed a prospective study comparing 34 intraarticular distal radius fractures treated with arthroscopic reduction, pinning (ARIF), and external fixation vs. 48 fractures treated with open plate fixation (ORIF) or with pinning ± external fixation. At an average follow-up of 31 months, the ARIF group had significantly better ranges of flexion-extension, radial-ulnar deviation, and grip strength ($p<0.05$). Radiographically, the ARIF group had better reduction of volar tilt, ulnar variance, and articular gap reduction [8]. Ruch et al. compared the functional and radiologic outcomes of arthroscopically-assisted (AA) percutaneous pinning and external fixation vs. fluoroscopically-assisted (FA) pinning and external fixation of 30 patients with comminuted intraarticular distal radius fractures. Patients who underwent AA surgery had significantly improved supination compared with those who underwent FA surgery (88 vs. 73°). AA reduction also resulted in improved wrist extension (77 vs. 69°) and wrist flexion (78 vs. 59°) [18]. The following chapter will discuss the portal placement and methodology of wrist arthroscopy along with its application in the treatment of distal radius fractures.

Relevant Anatomy

The standard portals for wrist arthroscopy are mostly dorsal. This is in part due to the relative lack of neurovascular structures on the dorsum of the wrist as well as the initial emphasis on assessing the volar wrist ligaments. The dorsal portals which allow access to the radiocarpal joint are so named in relation to the tendons of the dorsal extensor compartments. For example, the 1–2 portal lies between the first extensor compartment tendons which include the extensor pollicis brevis (EPB) and the abductor pollicus longus (APL), and the second extensor compartment which contains the extensor carpi radialis brevis and longus (ECRB/L). The 3–4 portal is named for the interval between the third dorsal extensor compartment which contains the extensor pollicus longus tendon (EPL) and the fourth extensor compartment which contains the extensor digitorum communis (EDC) tendons. In a similar vein, the 4–5 portal is located between the EDC and the extensor digiti minimi (EDM). The 6R portal is located on the radial side of the extensor carpi ulnaris (ECU) tendon as compared to the 6U portal which is located on the ulnar side (Fig. 2.1a–c).

The midcarpal joint is assessed through two portals, which allow triangulation of the arthroscope and the instrumentation. The midcarpal radial portal (MCR) is located 1 cm distal to the 3–4 portal and is bounded radially by the ECRB and ulnarly by the EDC. The
Dorsal Portals

Dorsal Radiocarpal Portals

Abrams and coworkers performed anatomical dissections on 23 unembalmed fresh cadaver extremities and measured the distances between the standard dorsal portals and the contiguous neurovascular structures [1]. The 1–2 portal was found to be the most perilous. The radial sensory nerve exits from under the brachioradialis approximately 5 cm proximal to the radial styloid and bifurcates into a major volar and a major dorsal branch at a mean distance of 4.2 cm proximal to the radial styloid [24]. Branches of the superficial radial nerve (SRN) that were radial to the portal were within a mean of 3 mm (range 1–6 mm), whereas, branches that were ulnar to the portal were at a mean of 5 mm (range 2–12 mm) (Fig. 2.2). The radial artery was found at an average of 3 mm radial to the portal (range 1–5 mm). Up to 75% of the time, there occurs either partial or complete overlap of the lateral antebrachial cutaneous nerve (LABCN) with the SRN[13]. In an anatomical study by Steinberg et al., the LABCN was present within the anatomic snuffbox in 9 of 20

Dorsal Midcarpal Portal (MCU) is similarly located 1–12 cm distal to the 4–5 portal and is bounded by the EDC and the EDM.

The relative safety of the portals has been studied by the way of cadaver dissection. Although some artifact is inescapable due to the displacement of neurovascular structures postmortem, this research provides some useful guidelines. In the clinical situation, distortion of the topographical anatomy due to fracture/dislocation or swelling as well as the use of intraoperative traction may increase the potential for harm; hence, a standardized method for establishing each portal is useful.

Fig. 2.1 Dorsal portal anatomy. (a) Cadaver dissection of the dorsal aspect of a left wrist demonstrating the relative positions of the dorsoradial portals. EDC extensor digitorum communis; EPL extensor pollicis longus; SRN superficial radial nerve.

Lister’s tubercle = asterisk. (b) Relative positions of the dorsoulnar portals. EDM extensor digiti minimi; DCBUN dorsal cutaneous branch of the ulnar nerve. (c) Positions of the 6R and 6U portals (Copyright by Dr. Slutsky [23])

Fig. 2.2 Branches of the superficial radial nerve (SRN). SR1 minor dorsal branch; SR2 major dorsal branch; SR3 major palmar branch (Copyright by Dr. Slutsky [23])
(45%) specimens. Based on these findings, they recommended a more palmar, proximal portal in the snuffbox that was no more than 4.5 mm dorsal to the first extensor compartment and within 4.5 mm of the radial styloid [24].

Branches of the SRN that were radial to the 3–4 portal were located at a mean distance of 16 mm (range, 5–22 mm). In one specimen, an ulnar branch of the SRN was found 6 mm ulnar to the portal. The distance to the radial artery was a mean of 26.3 mm (range 20–30 mm). Sensory nerves were remote to the 4–5 portal, except in one case, where an aberrant SRN branch was found 4 mm radial to the portal.

The dorsal cutaneous branch of the ulnar nerve (DCBUN) arises from the ulnar nerve on an average of 6.4 cm (SD = 2.3 cm) proximal to the ulnar head and becomes subcutaneous 5 cm proximal to the pisiform. It crosses the ulnar snuffbox and gives off 3–9 branches that supply the dorsoulnar aspect of the carpus, small finger, and ulnar ring finger [4]. The mean distance of the DCBUN to the 6R portal was 8.2 mm (range 0–14 mm). Transverse branches of the DCBUN were found in 12/19 specimens and were noted to be within 2 mm of the portal (range 0–6 mm). The mean distance of the branches of the DCBUN that were radial to the 6U portal was 4.5 mm (range 2–10 mm), while branches that were ulnar to the portal ranged from 1.9 to 4.8 mm on an average. Any transverse branches of the DCBUN were generally proximal to the portal at an average of 2.5 mm.

**Dorsal Midcarpal Portals**

Branches of the SRN were found radial to the MCR portal at a mean of 7.2 mm (range 2–12 mm; SD = 2.7). Two specimens contained SRN branches ulnar to the portal at 2 and 4 mm. Branches of the SRN were generally remote from the MCU portal except in one specimen (1 mm). Branches of the DCBUN were found at a mean distance of 15.1 mm (range 0–25 mm; SD = 4.6).

**Triquetro-Hamate (TH) Portal**

This portal enters the midcarpal joint at the level of the TH joint ulnar to the ECU tendon. The entry site is both ulnar and distal to the MCU. Branches of the DCBUN are most at risk (Fig. 2.3).

**Dorsal Radioulnar Portals**

These portals lie between the ECU and the EDM tendons. Transverse branches of the DCBUN were the only sensory nerves in proximity to the dorsal radioulnar portal at a mean of 17.5 mm distally (range 10–20 mm) (Fig. 2.4a).

**Volar Portals**

**Volar Radial Portal**

An anatomic study was performed on five fresh frozen cadaver arms to determine the safe landmarks for a volar radial (VR) portal after arterial injection studies to highlight the vascular anatomy [20]. The proximal and distal wrist creases were marked. The volar skin was then removed and the flexor carpi radialis tendon (FCR) sheath was divided. The tendon was retracted ulnarly and a trochar was inserted into the radiocarpal joint at the level of the proximal wrist crease. The trochar was noted to enter the radiocarpal joint between the radioscapohamate ligament (RSC) and the long radiolunate ligament (LRL) in four specimens and through the LRL ligament in one specimen. The median nerve was 8 mm (6–10 mm) ulnar to the VR portal, while the palmar cutaneous branch passed...
4 mm (3–5 mm) ulnar to the portal. The radial artery was 5.8 mm (4–6 mm) radial to the portal and its superficial palmar branch was located 10.6 mm (6–16 mm) distal to the portal. The SRN lay 15.6 mm (12–19 mm) radial to the portal. The portal was 12.8 mm (12–14 mm) distal to the border of the pronator quadratus, which roughly corresponds to the palmar radiocarpal arch [9]. The palmar cutaneous branch was the closest in proximity but always lies to the ulnar side of the FCR [5, 14]. The superficial palmar branch of the radial artery passed through the subcutaneous tissue over the tuberosity of the scaphoid and was out of harm’s way with an incision at the proximal wrist crease [10, 17]. When the trochar was placed through the floor of the FCR tendon sheath at the proximal palmar crease, the carpal canal was not violated. It was thus apparent that there was a safe zone comprising the width of the FCR tendon plus at least 3 mm or more in all directions, that was free of any neurovascular structures.

**Volar Radial Midcarpal (VRM) Portal**

The volar aspect of the midcarpal joint was identified with a 22 gauge needle through the same skin incision and a blunt trochar was inserted. It was necessary to angle the trochar in a distal and ulnar direction (approximately 5°) in order to access the midcarpal joint through the same skin incision. The trochar passed closer but still deep to the superficial palmar branch of the radial artery, which coursed more superficially over the scaphoid tuberosity at that level. The distance between the volar radiocarpal and volar midcarpal entry sites averaged 11 mm (7–12 mm).

**Volar Ulnar Portal**

In a companion study, a volar ulnar (VU) portal was established via a 2 cm longitudinal incision made along the ulnar edge of the finger flexor tendons at the proximal wrist crease [22]. The flexor tendons were retracted radially and a trochar was introduced into the radiocarpal joint. The ulnar styloid marked the proximal point of the VU portal, approximately 2 cm distal to the pronator quadratus. The portal was in the same sagittal plane as the ECU subsheath and penetrated the ulnolunate ligament (ULL) adjacent to the radial insertion of the triangular fibrocartilage. The ulnar nerve and artery were generally more than 5 mm from the trochar, provided the capsular entry point was deep to the ulnar edge of the profundus tendons. The palmar cutaneous branch of the ulnar nerve (nerve of Henlé) was highly variable and not present in every specimen. This inconstant branch provides sensory fibers to the skin in the
distal ulnar and volar part of the forearm to a level of 3 cm distal to the wrist crease. Its territory may extend radially beyond the palmaris longus tendon [3]. This branch tends to lie just to the ulnar side of the axis of the fourth ray, but it was absent in 43% of specimens in one study [15]. Martin et al. demonstrated that there was no true internervous plane due to the presence of multiple ulnar-based cutaneous nerves to the palm, which puts them at risk with any ulnar incision [14]. Since there is no true safe zone, careful dissection and wound spread technique should be observed.

**Volar Distal Radioulnar (VDRU) Portal [21]**

The topographical landmarks and establishment of the portal are identical to those of the VU portal. The same risks also apply. The capsular entry point for the VDRU lies 5 mm to 1 cm proximal to the ulnocarpal entry point (Fig. 2.5a, b).

**Field of View**

The following describes the typical field of view as seen through a 2.7 mm arthroscope under ideal conditions. Synovitis, fractures, ligament tears, and a tight wrist joint may limit the field of view which necessitates the use of more portals to adequately assess the entire wrist [19].

**1–2 portal:** Structures visualized are limited to the radial aspect of the wrist.

Radius: scaphoid and lunate fossa, dorsal rim of radius.

Carpus: proximal and radial scaphoid, proximal lunate.

Volar capsule: oblique views of the radioscapoholunate (RSC) ligament, long radiolunate ligament (LRL), short radiolunate ligament (SRL).

Dorsal capsule: oblique views of the dorsal radiocarpal ligament (DRCL).

TFC: poorly visualized.

**3–4 portal:** almost a complete panoramic view of the entire volar radiocarpal joint

Radius: scaphoid and lunate fossa, volar rim of radius.

Carpus: proximal scaphoid and lunate, dorsal and membranous scapholunate interosseous ligament (SLIL).

Volar capsule: RSC, radioscapoholunate ligament (RSL), LRL, ulnolunate ligament (ULL).

Dorsal capsule: oblique views of the DRCL insertion onto the dorsal SLIL.

TFC: radial insertion, central portion, ulnar attachment, palmar and dorsal radioulnar ligaments (PRUL, DRUL), prestyloid recess ± pisotriquetral orifice.

**4–5 portal:** this portal gives improved views of the ulnar aspect of the radiocarpal joint including TFCC
and is useful for instrumentation when combined with the 6R.
Radius: lunate fossa, volar rim of radius.
Carpus: proximal lunate, triquetrum, dorsal and membranous lunotriquetral ligament (LTIL).
Volar capsule: RSL, LRL, ULL.
Dorsal capsule: poorly seen.
TFC: radial insertion, central portion, ulnar attachment, PRUL, pre styloid recess ± pisotriquetral orifice.

6R portal: This gives a more direct line of sight with the dorsal LTIL and is typically used for instrumentation or outflow.
Radius: poorly seen.
Carpus: proximal lunate, triquetrum, dorsal and membranous LTIL.
Volar capsule: ULL and ulnotriquetral ligament (UTL).
Dorsal capsule: poorly seen.
TFC: radial insertion, central portion, ulnar attachment, PRUL, pre styloid recess ± pisotriquetral orifice.

6U portal: This is also mostly used for outflow, but it is also useful for instrumentation for debridement of palmar LTIL tears in combination with the VU portal.
Radius: sigmoid notch.
Carpus: proximal triquetrum, membranous LTIL.
Volar capsule: oblique views of the ULL and ULT.
Dorsal capsule: oblique views of the DRCL.
TFC: dorsal rim and radial attachment.

VR portal: This portal is mostly indicated to assess the palmar SLIL and the DRCL. It is also of use for AA fixation of distal radius fractures due to the direct line of sight with the dorsal rim fragments [8].
Radius: scaphoid and lunate fossa, dorsal rim of radius.
Carpus: proximal palmar scaphoid and lunate, palmar, and membranous SLIL.
Volar capsule: oblique views of the RSL, LRL, ULL.
Dorsal capsule: oblique views of the DRCL.
TFC: oblique views of the radial insertion, central portion, ulnar attachment, PRUL and DRUL.

VU portal: This portal is mostly indicated to assess the palmar LTIL and the dorsal ulnar capsule. It is also of use for debridement of palmar LTIL tears.
Radius: sigmoid notch region of lunate fossa.
Carpus: proximal palmar lunate and triquetrum, palmar and membranous LTIL.
Volar capsule: poorly seen.
Dorsal capsule: direct in-line views of the dorsoulnar capsule including the ECU subshetah.
TFC: radial insertion, central portion, ulnar attachment, DRUL.

Radial Midcarpal Portal
Volar: continuation of the RSC ligament.
Radial: scaphotrapezial-trapezoidal (STT) joint and distal scaphoid pole.
Proximal: SLIL joint, LTIL joint, distal scaphoid, distal lunate.
Distal: proximal capitate, capitolunate ligament, oblique views of proximal hamate.

Ulnar Midcarpal Portal
Volar: continuation of the volar ulnocarpal ligament (important in midcarpal instability).
Radial: distal articular surface of the lunate and triquetrum and partial scaphoid.
Proximal: LTIL joint, SLIL joint.
Distal: proximal hamate, capitolunate ligament, oblique views of proximal capitate.

Dorsal DRUJ Portals: Proximal and Distal
Volar: palmar radioulnar ligament
Radial: sigmoid notch, radial attachment of TFC
Ulnar: limited view of DRUL
Distal: proximal surface of articular disc (AD)

Volar DRUJ Portal
Volar: DRUL
Radial: sigmoid notch, radial attachment of TFC
Ulnar: foveal attachment of deep fibers of TFCC
Distal: proximal surface of AD

Methodology: Diagnostic Survey
The patient is positioned supine under general anesthesia with the arm abducted under tourniquet control. A 2.7 mm 30° angled scope along with a camera
attachment is used along with some method of overhead traction. The structures that should be visualized as a part of a standard exam include the radius articular surface, the proximal scaphoid and lunate, the volar carpal ligaments, the scapholunate (SLIL) and lunotriquetral (LTIL) interosseous ligaments, and the triangular fibrocartilaginous complex (TFCC). It is the author’s practice to establish the dorsal portals first and then start the arthroscopic examination with the VR portal in order to visualize the palmar SLIL and the DRCL to minimize artifact secondary to iatrogenic trauma to the dorsal capsular structures. The VU portal is utilized to assess the palmar LTIL and DRUL, ECU subshaeath and radial TFCC attachment. The scope is then inserted in the 3–4 portal followed by various combinations of the 4–5 portal and 6R portal. The 6U portal is mostly used for outflow, but it may be used for instrumentation when debriding palmar LTIL tears. Midcarpal arthroscopy is performed next to assess the integrity of the intercarpal ligaments and to inspect for chondral lesions or loose bodies in the midcarpal joint. The special use portals such as the dorsal and volar distal radioulnar joint (DRUJ) portals and the 1–2 portal are used as needed.

3–4 Portal

The surgeon is initially seated facing the dorsal surface of the wrist. The concavity overlying the lunate between the EPL and the EDC is located just distal to Lister’s tubercle, in line with the second webspace. The radiocarpal joint is identified with a 22 gauge needle that is sloped 10° palmar to account for the volar inclination of the radius. The joint is injected with 5 mL of saline. A shallow skin incision is made to avoid injuring small branches of the SRN or superficial veins. Tenotomy scissors or blunt forceps are then used to spread the soft tissue and pierce the dorsal capsule. This technique is repeated for each portal. The vascular tuft of the RSL is directly in line with this portal. Superior to the RSL is the membranous portion of the SLIL. The insertion of the dorsal capsular attachment can often be visualized by rotating the scope dorsally while looking ulnarwards. The radioscapholunate (RSL) and LRL are radial to the portal and can be probed with a hook in the 4–5 portal. The SRL, TFCC and ulnolunate (ULL) and lunotriquetral (ULT) ligaments are ulnar to the portal.

4–5 Portal

The interval for the 4–5 portal is identified with a 22 gauge needle inserted between the EDC tendons and the EDM, in line with the ring metacarpal. Due to the normal radial inclination of the distal radius, this portal lies slightly proximal and about 1 cm ulnar to the 3–4 portal. Views of the ulnar half of the lunate are obtained by moving the scope radially, whereas the triquetrum is seen by angling the scope in a superior and ulnar direction. The LTIL is often difficult to differentiate from the carpal bones without probing. The ULL and ULT can be seen on the far end of the joint. Proximally, the radial insertion of the TFCC blends imperceptibly with the sigmoid notch of the radius, but it can be palpated with a hook probe in either the 3–4 or 6R portal. The peripheral insertion of the TFCC slopes upwards into the ulnar capsule. The volar and DRULs can be probed for laxity/tears, but they are not seen as distinct structures since they blend with the TFCC. The pisotriquetral orifice (PTO) is just distal and anterior to the prestyloid recess and is found within the substance of the ULT just anterior to the proximal articular surface of the triquetrum.

6R, 6U Portals

The 6R portal is identified on the radial side of the ECU tendon, just distal to the ulnar head. The scope should be angled 10° proximally to avoid hitting the triquetrum. The TFCC is immediately below the entry site. The LTIL is located radially and superiorly, whereas the ulnar capsule is immediately adjacent to the scope. The 6U portal is located ulnar to the ECU tendon. This portal can be used to view the dorsal rim of the TFCC or for instrumentation when debriding the palmar LTIL.

Midcarpal Portals

The midcarpal radial (MCR) portal is found 1 cm distal to the 3–4 portal. The (STT) joint lies radially and can be seen by rotating the scope dorsally. The scapholunate (SL) articulation which is proximal to this portal can be probed for instability or step-off. By moving the scope in an ulnar direction, the lunotriquetral (LT) articulation
D. J. Slutsky

comes into view. Superiorly, the proximal surface of the capitate, the interosseous ligament, and the hamate are seen. The midcarpal ulnar (MCU) portal is located 1 cm distal to the 4–5 portal or 1.5 cm ulnar and slightly proximal to the MCR portal, in line with the ring metacarpal axis. Normally, there is very little step-off between the distal articular surfaces. When there is any doubt, the traction should be released and the SL joint should be viewed with the scope in the MCU, whereas the LT joint should be viewed with the scope in the MCR.

Volar Portals

To establish the VR radial portal, the surgeon is seated facing the volar aspect of the wrist. A 2 cm transverse or longitudinal incision is made in the proximal wrist crease overlying the FCR tendon. It is not necessary to specifically identify the adjacent neurovascular structures, provided the anatomical landmarks are adhered to. The tendon sheath is divided and the FCR tendon is retracted ulnarly. The radiocarpal joint space is identified with a 22 gauge needle and distended with 5 mL of saline. Tenotomy scissors or forceps are used to pierce the volar capsule. A blunt obturator and trochar are then introduced followed by the arthroscope. The midcarpal joint can be accessed through the same skin incision by angling the trochar 1 cm distally and approximately 5° ulnarswards. A hook probe is inserted through the 3–4 portal and it is used to assess the palmar aspect of the SLIL and the DRCL. A useful landmark when viewing from the VR portal is the intersulcal ridge between the scaphoid and lunate fossae. The origin of the DRCL is seen immediately ulnar to this ridge, just proximal to the lunate. The VU portal is established via a 2 cm longitudinal incision centered over the proximal wrist crease along the ulnar edge of the finger flexor tendons. The tendons are retracted to the radial side and the radiocarpal joint space is identified with a 22 gauge needle (Fig. 2.6a–c). Blunt tenotomy scissors or forceps are used to pierce the volar capsule, followed by insertion of a cannula and blunt trochar, then the arthroscope. The ulnar nerve is protected by use of the cannula and a more radial entry site. The median nerve is protected by the adjacent flexor tendons. The palmar region of the LTIL can usually be seen slightly distal and radial to the portal. A hook probe is inserted through the 6R or 6U portal.

DRUJ Portals

The dorsal aspect of the DRUJ joint can be accessed through a proximal and distal portal. The proximal portal is mostly for outflow and can be identified by inserting a 22 gauge needle horizontally at the neck of the distal ulna. The distal portal (DDRUJ) is identified just proximal to the 6R portal, underneath the DRUL. This portal can be used for outflow drainage or for instrumentation. It lies on top of the ulnar head, but underneath the TFCC.

The topographical landmarks and establishment of the VDRU portal are identical to those of the VU portal. The capsular entry point lies 5–10 mm proximally [21]. There is more room on the volar ulnar aspect of the DRUJ for the insertion of an arthroscope with relatively

**Fig. 2.6** Technique for VU portal. (a) Skin incision for VU portal. FCR flexor carpi radialis tendon; FDS flexor digitorum sublimus. (b) FDS retracted, saline injection of radiocarpal joint. (c) Insertion of cannula through capsule deep to FDS tendons (Copyright by Dr. Slutsky [23])
unimpeded views of the proximal articular disk and the foveal attachments. The VDRU portal is accessed through the VU skin incision. A 1.9 mm small joint arthroscope can be used since gaining access to the DRUJ can be difficult, especially in a small wrist, but a standard 2.7 mm scope provides a better field of view. It is useful to leave a needle or cannula in the ulnocarpal joint for reference. The DRUJ is located by angling a 22 gauge needle 45° proximally, and then injecting the DRUJ with saline. Once the correct plane is identified, the volar DRUJ capsule is pierced with tenotomy scissors followed by a cannula with a blunt trochar and then the arthroscope. Alternatively, a probe can be placed in the DDRUJ portal and advanced through the palmar incision to help locate the joint space. It can then be used as a switching stick over which the cannula is introduced. Initially, the DRUJ space appears quite confined, but over the course of 3–5 min, the fluid irrigation expands the joint space, which improves visibility. A burr or thermal probe can be substituted for the 3 mm hook probe through the DDRUJ as necessary.

Contraindications

Large capsular tears which carry the risk of marked fluid extravasation, active infection, neurovascular compromise, and distorted anatomy are some typical contraindications. Marked metaphyseal comminution, shear fractures and a volar rim fractures require open treatment, although the arthroscope can be inserted to check the adequacy of the joint reduction. Due to the risk of late collapse, adjuvant internal fixation with locking plates is advised in elderly and osteopenic patients since fracture site settling may occur for up to 6 months [7].

Arthroscopic-Assisted Fixation: Distal Radius

Indications

More than 2 mm of articular displacement or gap are typical indications for surgical treatment. Isolated radial styloid fractures and simple three-part fractures are most suited to this technique. Displaced intraarticular fractures of the distal radius are often associated with unrecognized intraarticular soft tissue injuries [11] (Fig. 2.7); hence, a suspicion of a significant acute SLIL or LTIL tear or DRUJ instability due to a suspected TFCC tear are additional indications. Traction views will help to sort out the fracture anatomy. It is my preference to perform a CT scan along with coronal views to rule out an unrecognized sagittal split as well as to assess the congruency of the sigmoid notch.

Equipment and Implants

In general, a 2.7 mm 30° angled scope along with a camera attachment is used. A fiberoptic light source, video monitor, and printer have become the standard of care. Digital systems allow direct writing to a CD and superior video quality as compared to analog cameras. A 3 mm hook probe is needed for palpation of intracarpal

![Fig. 2.7](image) Soft tissue injuries associated with distal radius fractures. (a) Avulsed radioscaphocapitate (RSC) and long radiolunate ligaments (LRL) viewed from the 3–4 portal. (b) Avulsed ulnolunate ligament (*asterisks*) seen from the 4–5 portal (Copyright by Dr. Slutsky [23])
structures. Some method of overhead traction is useful. This may include a traction from the overhead lights or a shoulder holder along with 3–5 Kg sand bags attached to an arm sling. A traction tower such as the Linvatec tower (Conmed – Linvatec Corporation, Largo, FL) or the ARC traction tower (Arc Surgical LLC, Hillsboro, OR) greatly facilitates instrumentation. The use of a motorized shaver or diathermy unit such as the Oratec probe (Smith and Nephew, NY) is useful for débride-ment. A motorized 2.9 mm burr is needed for bony resection. A variety of Steinman pins and small eleva-tors are useful for the elevation of bony fragments. A K-wire driver and intraoperative fluoroscopy are integral to the procedure. A distal radius locking plate set should be available as per surgeon preference.

Optional

There are a variety of commercially available suture repair kits including the TFC repair kit by Arthrex (manufacturer) or Linvatec (Conmed – Linvatec Corporation). Ligament repairs can also be facilitated by the use of a Tuohy needle which is generally found in any anesthesia cart. Specially designed jigs have been made to facilitate repair of radial TFC tears although Trumble et al. have described a method with meniscal repair needles passed through a suction cannula in the 6U portal [26].

Surgical Technique

Intraoperative fluoroscopy is used frequently through-out the case, with the C-arm positioned horizontal to the floor. It is preferable to wait for 3–5 days to allow the initial intraarticular bleeding to stop. The author has found it useful to perform much of the procedure without fluid irrigation using the dry technique of del Piñal [6] which eliminates the worry of fluid extravasa-tion. If fluid irrigation is used, inflow is through a large bore cannula in the 4–5 or 6U portal with the outflow through the arthroscope cannula. The working portals include the VR and 6R portal for fracture visu-alization and the 3–4 portal for instrumentation – but all of the portals are used interchangeably. Lactated Ringer’s solution is preferred over saline, and the fore-arm is wrapped with coban to limit extravasation. The fracture hematoma and debris are lavaged and any early granulation tissue is debrided with a resector. Mehta and colleagues described a 5 level algorithm for reducing the fracture fragments [16]. This included the “London technique” where the K-wires were advanced through the distal ulna into the subchondral distal radius and withdrawn from the radial aspect so that they do not encroach on the DRUJ.

Radial Styloid Fractures

It is easiest to obtain the reduction through ligamento-taxis while the arm is suspended in the traction tower. A Freer elevator may also be placed in the fracture site to facilitate this step. A 1 cm incision is made over the styloid to prevent injury to the SRN, and two 1.5 mm K-wires are inserted for manipulation of the styloid fragment. The fracture site is best assessed by viewing across the wrist with the scope in the 6R portal, in order to gauge the rotation of the styloid. The K-wires are used as joysticks to manipulate the fragment, and then, one K-wire is driven forward to capture the reduction. One or two cannulated screws are used to stabilize the fracture fragment.

Three-Part Fractures

Three-part fractures are comprised of a radial styloid fragment and a medial or lunate fragment. The radial styloid fracture is reduced and pinned as above. It is then used as a landmark to which the depressed lunate fragment is reduced. An elevator or large pin is inserted percutaneously to elevate the lunate fragment. Tenaculum forceps with large jaws are used to hold the reduction and to prevent crushing the SRN. The reduction is captured with horizontal subchondral K-wires, stopping short of the DRUJ. It is paramount to bone graft the metaphyseal defect through a small dorsal incision to prevent late collapse. The VR portal aids in the reduction of any dorsal die punch fragments. Once the reduction has been achieved, some type of neutral-ization device is desirable such as a bridging external fixator. More recently, volar locking plates and/or head-less cannulated screws have been used. It is my prefer-ence to use a nonbridging external fixator to allow early wrist motion (The Fragment Specific Fixator, South Bay Hand Surgery, LLC. Torrance, CA) (Fig. 2.8a–n).
Fig. 2.8 Arthroscopic-guided pinning and nonbridging external fixation. (a) Comminuted intraarticular distal radius fracture. (b) Lateral View. (c) Anteroposterior CT view reveals the extent of the intraarticular fragmentation. (d) Lateral CT highlights the small dorsal rim fragments. (e) Coronal CT view shows the sigmoid notch disruption. (f) Arthroscopic view of joint surface showing the degree of comminution. (g) A percutaneous is inserted through the ulna to capture and control the medial fragment. (h) Percutaneous reduction of dorsal tilt. (i) Fluoroscopic appearance.
Postoperative splinting in supination in between therapy helps prevent a pronation contracture.

**Four-Part Fractures**

In four-part fractures, the lunate facet is split into volar and dorsal fragments. The volarmedial fragment must usually be reduced through an open incision since wrist traction rotates this fragment and prevents reduction by closed means (Fig. 2.9). The radial styloid fragment is reduced with ligamentotaxis and temporarily held with K-wires. A standard volar approach or a limited volar ulnar incision can be made. The volarmedial fragment is reduced under direct observation by pinning it back to the shaft and the radial styloid fragment. A 2.4 mm volar locking plate is provisionally applied to hold the reduction. The reduction is checked through the 6R and VR portals. The dorsomedial fragment is then elevated back to the radial styloid and reduced to the volarmedial fragment, which is utilized as a landmark. A small locking dorsal plate can be applied at this point, or alternatively, the distal screws of the volar plate can be used to lag the volarmedial and dorsomedial fragments. In this event, one or more of the distal screws should be placed in a non-locking fashion to help compress the fragments. Wiesler et al. however have described a method for
treat four-part fractures arthroscopically. After a Freer elevator is introduced dorsally to disimpact the fragments, a nerve hook is used to reduce the volar lunate facet which is then pinned to the radial styloid. The remaining fragments are reduced with interfragmentary pin fixation, and the reconstructed articular surface is then pinned to the radial metaphysis [27].

Ulnar Styloid Fractures

Peripheral TFCC tears are assessed arthroscopically. In a study of arthroscopically-treated distal radius fractures, Lindau found that 10/11 with complete peripheral TFCC tears had DRUJ instability at the 1 year follow-up examination compared with 7 of the 32 patients with only partial or no peripheral tears. Patients with instability of the DRUJ had a worse Gartland and Werley wrist score [12]. In this regard, large TFCC tears may be repaired with open or arthroscopic technique at the preference of the surgeon. The diagnosis of a foveal detachment of the deep fibers of the TFCC requires a high index of suspicion. Arthroscopic confirmation is difficult, since the fovea cannot be seen through the standard radiocarpal portals. Berger has described using a probe to pull on the TFCC in multiple directions in an attempt to elicit the displacement of the triangular fibrocartilage which he believes is indicative of a foveal disruption [25]. Atzei and Luchetti describe the hook test which consists of applying traction to the ulnar-most border of the TFCC with the probe inserted through the 4–5 or 6-R portal. The test is positive when the TFCC can be pulled upwards and radially towards the center of the radiocarpal joint [2]. Basi-ulnar styloid fractures with initial displacement of more than 2 mm should be repaired if there is residual DRUJ instability following fixation of the radius. It is my preference to use either 2 K-wires with tension band wiring or headless screw fixation. (see also Chap. 6).

Summary

The use of wrist arthroscopy continues to expand the indications and treatment options for distal radius fractures. A systematic approach and a thorough understanding of the topographical and internal anatomy of the wrist are integral to minimizing complications while maximizing the chances for a successful outcome.

References

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