Arthroscopic-assisted Distal Radius Fracture Fixation for Dorsoulnar Corner Fragments Using a Locked, Hooked Kirschner-Wire Technique

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Abstract

Background: Distal radius fractures with dorso-ulnar corner fragments (DUC) pose a surgical challenge due to limited visualization and the risk of hardware prominence. Traditional approaches often result in inadequate reduction and fixation, leading to suboptimal clinical outcomes.

Description of Technique: In this study, we introduce an arthroscopic-assisted approach for the fixation of distal radius fractures with DUC fragments. The technique utilizes locked, hooked K-wires to provide a low-profile dorsal capturing mechanism. We outline the step-by-step procedure, which includes pre-operative planning, volar plate application, and arthroscopic reduction of DUC fragments.

Patients and Methods: We applied this technique to a 60-year-old female patient with an unstable intra-articular distal radius fracture and a DUC fragment. Closed reduction was initially attempted, followed by arthroscopic-assisted reduction and internal fixation using the locked, hooked K-wire technique.

Results: Our technique has demonstrated its ability to withstand early movement rehabilitation protocols without fixation loss, enabling early mobilization. A custom thermoplastic splint was worn for 6 weeks, with favorable supination/pronation and wrist flexion/extension outcomes at clinical review.

Conclusions: Arthroscopic-assisted fixation with locked, hooked K-wires offers a reliable solution for accurately reducing challenging DUC fragments in distal radius fractures. This approach complements standard distal radius fixation systems, providing a low-profile dorsal capturing mechanism and addressing the issue of hardware prominence, ultimately improving clinical outcomes.

Keywords
- wrist
- radius
- fracture
- arthroscopic
- dorsoulnar corner

Berger[1] described the various ligamentous attachments of the distal radius, ulnar, and carpus, and over time the understanding of their contribution to fracture patterns of the distal radius has been advancing. Mandziak et al[2] recognized the link between these structures and the relative frequency of common fragment patterns in complex intra-articular injuries

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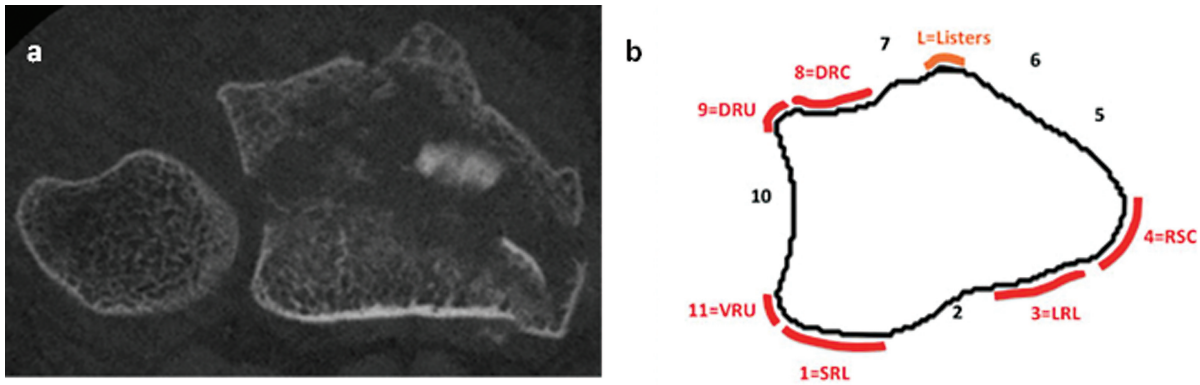

Fig. 1 (a) An axial CT slice showing a comminuted intra-articular distal radius fracture with dorsoulnar corner fragment. (b) Corresponding diagram of key osseo-ligamentous units highlighting the attachments of the dorsal radioulnar (DRU) ligament and dorsal radiocarpal ligament (DRC) to the dorsoulnar fragment region of the distal radius. Reproduced with permission from Bain et al[3] and Thieme Medical Publishers, Inc. VRU: volar radioulnar. SRL: short radiolunate ligament. RSC: radioscaphocapitate ligament. LRL: long radiolunate ligament.

(Arbeitsgemeinschaft Für Osteosynthesefragen (AO) types C2 and C3). Bain et al[3] further confirmed the relevance of osseo-ligamentous units and the ways in which fragments are generated with injuries to the wrist (►**Fig. 1**).

Two such fragments, both involving the sigmoid notch and one the volar rim and the other the dorsoulnar corner (DUC) of the radius, are now well reported in the literature.[4,5] The DUC, a part of the lunate facet, has both the dorsal distal radioulnar and the dorsal radiocarpal ligaments attached to it.[1] Failure to stabilize large fragments in this region can lead to fragment escape, loss of sagittal plane alignment, carpal subluxation and distal radioulnar joint (DRUJ), and proximal carpal row instability with subsequent poor clinical outcomes.[4–6]

Fracture fragments of the DUC of the distal radius pose a particularly difficult area to fix surgically. Access is not permitted to this region through volar approaches and capture of these fragments relies on indirect reduction and fixation using suboptimal standard intraoperative fluoroscopy.[4] This may result in failure to capture the DUC adequately, malreduction or screw prominence utilizing only volar approaches.[5,7]

The risk of hardware prominence and tendon irritation or rupture from dorsal fixation elements is well reported.[4,8] Surgeons have attempted to overcome this issue with a variety of techniques and prostheses that both provide resolute fixation of DUC fragments and are low profile, aiming to mitigate the risk of tendon complications.[9–16]

We describe, here, an arthroscopic-assisted approach to distal radius fracture fixation that utilizes the successes of volar plating, provides a low profile, simple method of reducing and stabilizing DUC fragments and overcomes the issues of visualization of fractures in this region of the joint and their safe reduction with ultra-low-profile fixation.

Surgical Technique

A fine-slice CT scan to assess fragment size and displacement is first reviewed to assist with operative planning. A tourniquet is applied. We use a volar approach through the bed of flexor carpi radialis elevating pronator quadratus from the metadiaphysis to expose the fracture. Volar fragments are reduced using traction and digital manipulation under direct vision and if required with assistance of elevators such as a Freer, via a "shoehorn" technique as described by Del Piñal.[17]

A volar locking plate is sized and applied to the radial volar cortex, proximal to the watershed line if appropriate to reduce tendon irritation.[8,18] Fluoroscopy is used to confirm plate position and early reduction in the coronal and sagittal planes and once satisfactory, the proximal shaft screws are inserted.

Kirschner-wire(K-wire) guides (NewClip Technics, Nantes, France) are attached to each of the two rows of distal locking holes. These also aid in retraction of soft tissues. One-millimeter thick K-wires are passed through each guide to enter the volar cortex only (►**Fig. 2**). K-wire guides are not exclusive to this Newclip plate and are available for many volar locking plate systems and if placed centrally, K-wires may be used without such guides if they are not available.

Then, arthroscopy is performed. Our preference is dry to assist visualization[19] and either vertical or horizontal traction. Entry to the joint is through the standard dorsal ¾, ½ , and 6R portals and switching between these two to view, debride, and reduce fragments (►**Fig. 3**).

The DUC fragment is generally left until after the rest of the articular surface has been restored. Reduction is rehearsed with manipulation using either the surgeon's thumb externally, or a Freer's elevator or probe via an arthroscopy portal, or a percutaneous K-wire in joystick mode. Once satisfactory, the fragment is then released to allow the fracture gap to open again. The K-wires in the volar cortex are advanced until the tip of one is seen in the DUC fracture. It is reversed slightly, reduction performed, and K-wire advanced passing through the DUC until it tents the skin dorsally (►**Fig. 4**). Open reduction of the DUC may be performed in difficult cases.

A 1- to 2-cm incision is made over the tip of the wire. The tendons and posterior interosseous nerve are protected and the K-wire advanced approximately 5 cm and bent to a hook and cut. Three-point benders are available to simplify bending. It is then gently impacted from dorsal to volar until the

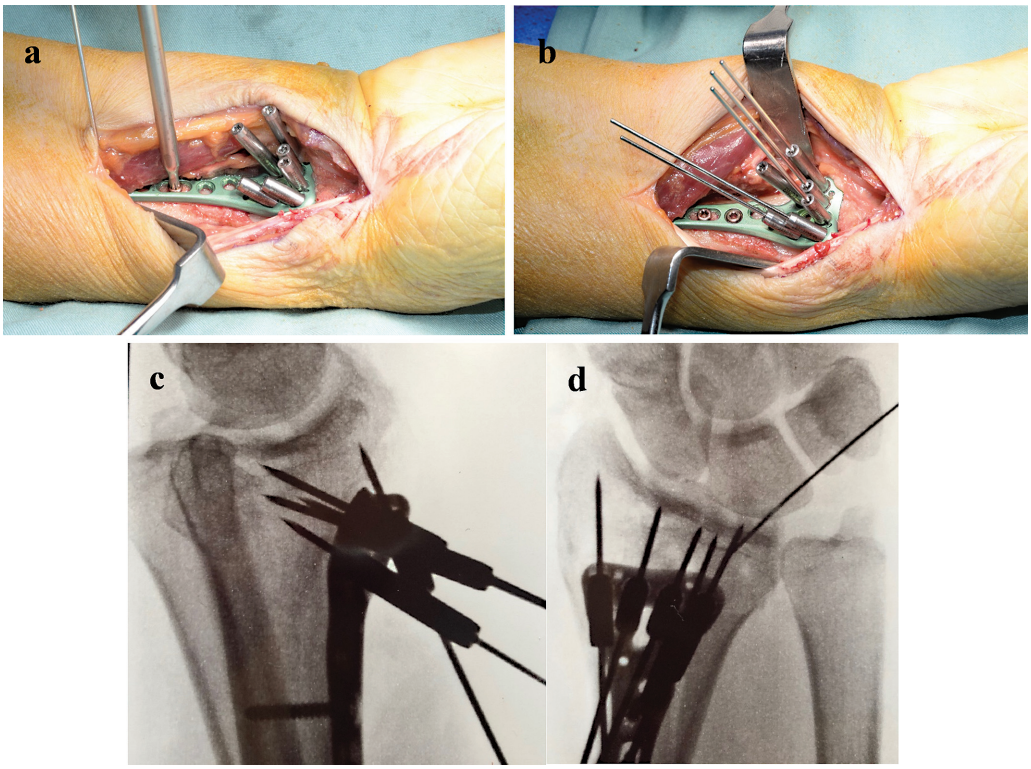

Fig. 2 (**a**) Insertion of the volar plate, proximally stabilized and with K-wire guides attached aiding soft tissue retraction. (**b**) K-wires inserted into volar cortex of the fracture. (**c, d**) Fluoroscopic confirmation of K-wire length, position, and volar reduction. K-wire, Kirschner-wire.

Fig. 3 Showing fluoroscopic and arthroscopic viewing screens during intra-articular fragment reduction attempts.

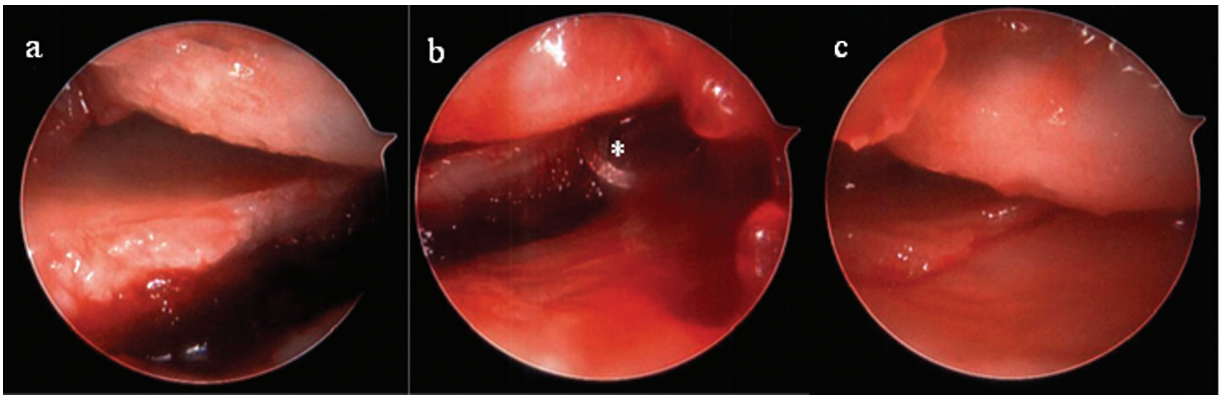

Fig. 4 (**a**) Arthroscopy showing displaced intra-articular dorsoulnar corner fragment with large intra-articular step/gap. (**b**) Passage of a volar K-wire until the tip is seen in the fracture (tip marked by asterisk). (**c**) Reduction of step and passage of the K-wire to stabilize. K-wire, Kirschner-wire.

hook engages the cortex of the reduced DUC and is flush (►**Fig. 5**). Care is taken not to overcompress the hooked wire head, preventing fragmentation of the DUC and overpenetration. The joint is assessed arthroscopically once more and the stability tested.

More than one K-wire can be used for larger fragments. The remainder of the K-wires in the central and radial part of the plate are exchanged for locking screws/pegs. The hooked K-wire is cut flush to the plate surface with specific K-wire cutters (►**Fig. 6**) and secured to the plate with a polyaxial K-wire locking system (K-lock, Newclip Technics, Nantes, France) (►**Fig. 7**). This K-wire locking device was a proof-of-concept design for the hooked K-wire technique and is currently only available for this Newclip plating system. A polyaxial K-wire locking nut could be adapted to any locking plate technology.

Patients and Methods

Case Example

A 60-year-old female had a heavy fall and sustained an unstable intra-articular distal radius fracture with DUC fragment (►**Fig. 8**). Initial treatment involved closed reduction in the emergency department. Arthroscopic-assisted reduction and internal fixation was performed the following day using the locked, hooked K-wire technique (►**Figs. 9** and **10**).

Results

The technique has shown itself capable of withstanding the forces reported in early movement rehabilitation protocols without loss of fixation allowing commencement of early mobilization (►**Fig. 11**).[15] A custom thermoplastic splint was

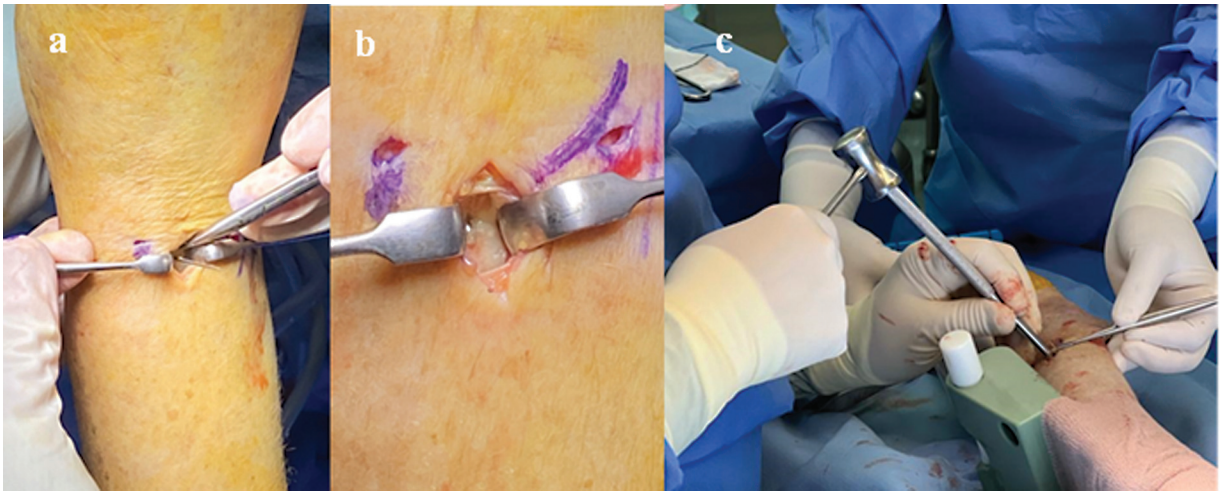

Fig. 5 (**a**) Advancement of the K-wire through a dorsal mini-incision made at the point of protuberance of the skin as it was advanced. (**b**) The trimmed and hooked end of the K-wire tapped back down flush to the dorsal cortex of the DUC fragment. (**c**) A 10-mm dorsal incision to impact hook free of extensor tendons. DUC, dorsoulnar corner; K-wire, Kirschner-wire.

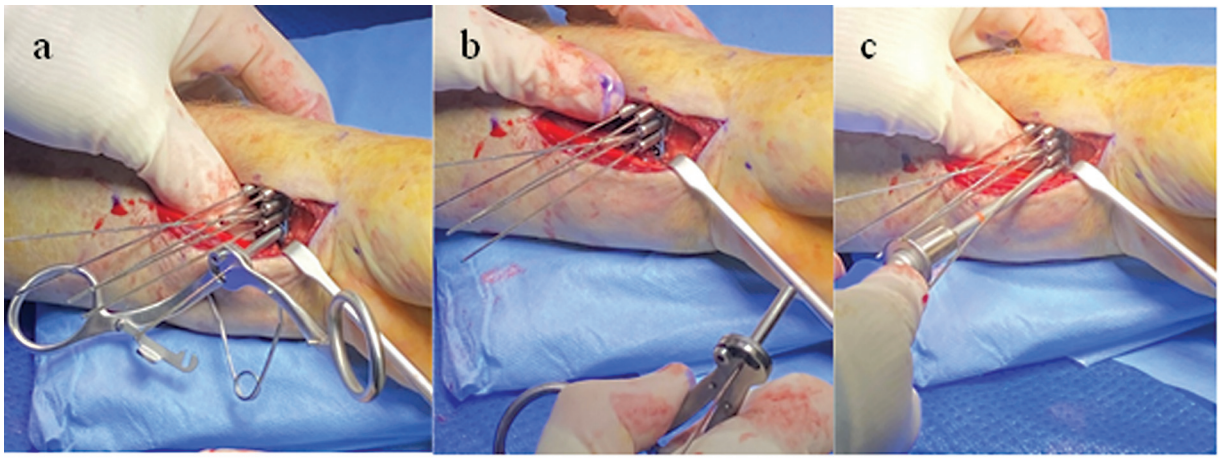

Fig. 6 (**a**) K-wire cutter in situ over DUC K-wire. (**b**) Cut K-wire flush to the plate in the center of the locking hole. (**c**) Cannulated screwdriver engaging the K-wire locking device into the plate locking hole. DUC, dorsoulnar corner; K-wire, Kirschner-wire.

Fig. 7 Example of Kirschner-wire locking device being inserted into a plate.

Fig. 8 Case Example: A 60-year-old female with unstable intra-articular distal radius fracture (DRF) with dorsoulnar corner (DUC) fragment. Preoperative radiograph and CT.

worn for 6 weeks, except for nonloaded activities of daily living and active range of motion where it was removed. Supination/pronation was recorded as 70/75 degrees and wrist flexion/extension was 40/50 degrees at clinical review 7 weeks postoperatively.

Discussion

Prominent dorsal hardware remains a challenge surgically in distal radius fracture fixation and this technique is a new method that aims to address this issue. The hooked K-wire head captures the DUC cortex and aligns flush with it, while being secured to the volar plate with length and angular stability. Fracture fragments of the distal radius DUC are difficult to access due to limited visualization and using volar approaches and intraoperative fluoroscopy alone may result in inadequate reduction or fixation and metalware prominence.

The absolute size of DUC fragments that benefit from this technique is not well defined and certainly not all DUC fractures require fixation.[10] However, failing to fix these

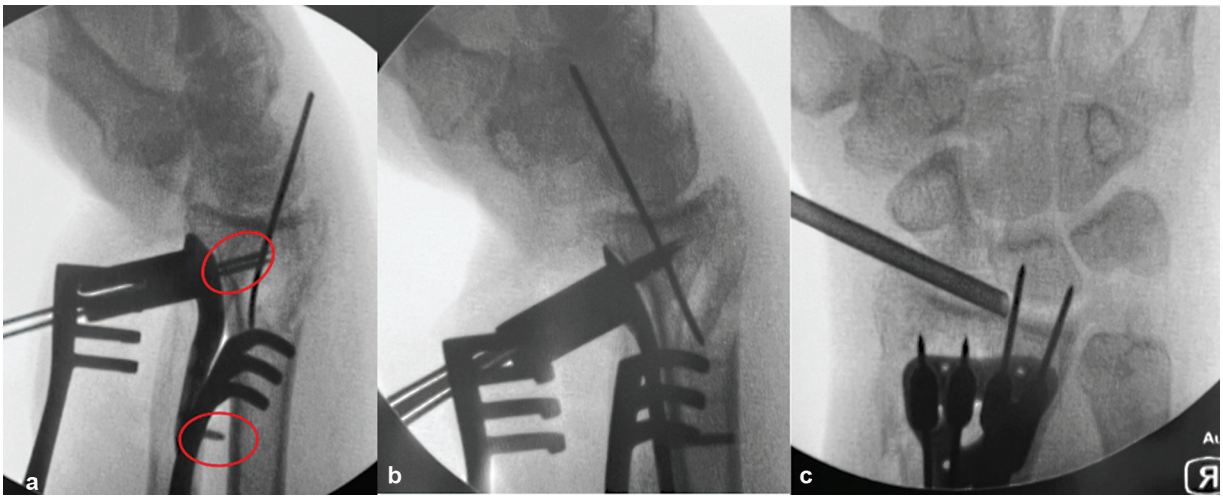

Fig. 9 Case Example: A 60-year-old female with unstable intra-articular DRF with DUC fragment. (**a**) Wires engage only volar fragments. Bottom circle is kickstand screw. (**b**) Volar tilt corrected by reducing plate to shaft. (**c**) DUC fragment reduced under arthroscopic control and K-wire advanced to stabilize. DRF, distal radius fracture; DUC, dorsoulnar corner; K-wire, Kirschner-wire.

Fig. 10 Case Example: A 60-year-old female with unstable intra-articular DRF with DUC fragment. Wire bent to form dorsal hook. DRF, distal radius fracture; DUC, dorsoulnar corner.

fragments with at least one capturing screw has been associated with an increased risk of loss of reduction.[5] Small fragments or rim fractures at the DUC that do not present with radio-lunate subluxation or dorsal tilt may not require more than standard volar plate approaches. However, fragments involving a significant proportion of the DRUJ and distal radial articular surface that have displaced more than 2 mm have the ability to lead to future arthrosis[20] and instability,[4,6] and are indications for this technique. Extensive dorsal comminution may not be suitable for this approach and dorsal/fragment-specific fixation may still be considered.

Single hooked K-wire fixation of larger fragments that extend further radially around the dorsal rim may be inadequate. Screws being larger, may comminute such fragments and the use of a second K-wire in the same method is our preferred option. Intra-articular screw or K-wire penetration is prevented with the arthroscopic-assisted nature of the technique. While there is potential for the K-wires to penetrate the posterior interosseous nerve and extensor tendons, a dorsal mini-incision confirms safe passage and K-wires can be adjusted if they impinge on structures by reversing the tip to the dorsal cortex and readvancing with tendons retracted. The dorsal K-wire head should be impacted gently to prevent penetration and fragmentation, as has been reported in prior techniques using integrated compression screws through volar locked plates.[11,14] Again, direct visualization ensures the hooked K-wire heads sit flush.

We have used this technique with volar rim plates to simultaneously treat volar and dorsal rim fractures. Since volar rim plates routinely require removal to prevent flexor tendon complications, we have had experience in removing

Fig. 11 Case Example: A 60-year-old female with unstable intra-articular DRF with DUC fragment. Wire cut off volar and locked and complete remainder of cannulated fixation. Posterior Anterior (PA) and Lateral final X-ray. DRF, distal radius fracture; DUC, dorsoulnar corner.

the hooked K-wire constructs. The polyaxial K-lock requires a specific cannulated screwdriver and must be preordered. The K-lock is disengaged like a standard locking screw, leaving the hooked K-wire exposed. Gentle antegrade tapping with a small bone punch and hammer ensures the hooked head becomes prominent dorsally allowing easy identification and removal with pliers through the same mini-incision scar as when it was put in.

Conclusion

Arthroscopic-assisted fixation provides a solution for accurately reducing challenging DUC fragments and this technique utilizing locked, hooked K-wires provides a low-profile dorsal capturing mechanism suitable for tackling difficult DUC fragments alongside standard distal radius fixation systems.

Ethical Review Committee Statement

No Independent Review Board (IRB) approval was required for this submission.

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Conflict of Interest

None declared.

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