Technical Note

Arthroscopic-Assisted Distal Radius Fracture Fixation Using the NanoScope System

Abby Choke, M.B.B.S., M.R.C.S. (Edin.),
Sin Fah Chung, M.B.B.S., M.Med., F.R.C.P.S. (Glasgow), and
Sze Ryn Chung, M.B.B. Ch. B.A.O. (Hons), M.R.C.S. (Edin), M.Med. (Surg), F.A.M.S. (Hand)

Abstract: Intra-articular distal radius fractures with significant articular step-off and gapping are associated with high risk of developing symptomatic arthritis and poor functional outcome. The use of arthroscopy for distal radius fixation had been well published in the literature. It allows the surgeon to fine-tune intra-articular fragments to achieve articular congruency, address ligamentous disruption, and check for screw penetration within the joint. Various techniques have been reported, including volar locking plate presetting to aid in arthroscopic reduction. Here, we demonstrate our arthroscopic-assisted distal radius fixation technique using a 1.9-mm miniature scope NanoScope (Arthrex, Naples, FL).

In the last 20 years, arthroscopy has become increasingly popular for intra-articular distal radius fracture (DRF) fixation.[1,2] Knirk and Jupiter[3] found that patients with intra-articular DRF with an articular step-off of more than 2 mm had an increased risk of developing arthritis, 93% of whom were symptomatic. Later studies have shown that the articular threshold has been reduced to 1 mm.[4,5] Although conventional fluoroscopic-assisted DRF fixation can effectively restore radial height, inclination, and volar tilt, the extent of articular step and gap deformity often is underestimated.[2,6,7]

On the basis of a study comparing arthroscopic-assisted distal radius fixation (AADRF) and fluoroscopic-assisted DRF fixation, arthroscopy improves postoperative step-off and enables a more comprehensive assessment of associated soft-tissue injuries.[8] In the acute setting, arthroscopy can aid in the removal of intra-articular hematomas and detect fragments that compromise the reduction of intra-articular fragments.[9,10] Intra-articular screw penetration also can be assessed using the arthroscope during the fixation.[10-12] Moreover, the severity of the intra-articular step is directly correlated with the degree of postoperative intra-articular fibrous tissue formation, ultimately resulting in restricted wrist movement.[13] Koo et al.[14] found statistical improvements in functional outcomes (range of motion, grip strength, Mayo wrist score, and Disabilities of the Arm, Shoulder, and Hand, short version, score) as well as articular steps and gaps in AADRF compared with fluoroscopic-assisted DRF. Here, we demonstrate a surgical technique for AADRF using the NanoScope (Arthrex, Naples, FL) system in a left intra-articular distal radius fracture (AO type C3; Video 1).

Surgical Technique

Preoperative Planning

Radiographs of the injured wrists and computed tomography scans are helpful to delineate the different fracture fragments and orientation. A 3-dimensional computed tomography scan with carpal subtraction allows us to better appreciate the die-punch fragments of the radiocarpal articulation from an axial perspective (Fig 1). Surgery should be performed within the first week of injury, as organized hematoma can impede fracture reduction. If the surgery occurs 3 weeks or

From the Department of Hand & Reconstructive Microsurgery, Singapore General Hospital, Singapore (A.C., S.R.C.); and Royal College of Medicine Perak, University Kuala Lumpur, Kuala Lumpur, Malaysia (S.F.C).

Received January 11, 2024; accepted April 1, 2024.

Address correspondence to Abby Choke, M.B.B.S., M.R.C.S. (Edin.), Department of Hand and Reconstructive Microsurgery, Singapore General Hospital, 20 College Rd, Academia Level 4, Singapore, 169856, Singapore. E-mail: abbyc29@gmail.com

2212-6287/2442
https://doi.org/10.1016/j.eats.2024.103033

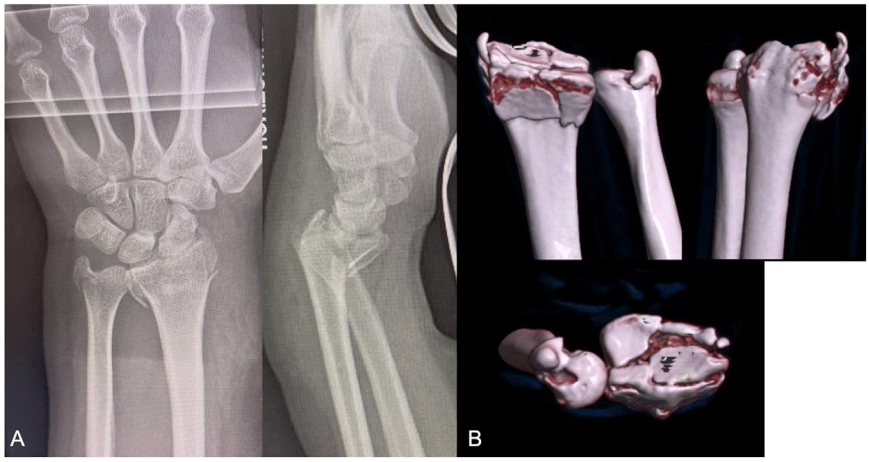

Fig 1. (A) Radiograph (anteroposterior and lateral views) showing an intra-articular distal radius fracture of the left wrist with central die-punch and volar shear fragments. (B) The degree of articular involvement can be better appreciated on computed tomography. The axial cuts provide valuable details about the articular surface, including the pattern and degree of displacement.

later, healed impacted fragments may require an osteotomy.[15] For the implant, we prefer a variable-angled volar locking plate for preliminary reduction.

Exposure of DRF

The procedure is performed with the patient under regional or general anesthesia using a pneumatic tourniquet. We employed the trans-flexor carpi radialis approach to expose the fracture site (Fig 2). The flexor carpi radialis sheath is incised, and the tendon is retracted ulnarly, protecting the median nerve. The floor of the sheath is then incised to access the deeper forearm structures, and the flexor tendons are retracted to expose the pronator quadratus muscle. The pronator quadratus is elevated subperiosteally from its distal and lateral borders to expose the fracture site. Care is taken not to violate the volar radiocarpal ligaments. The brachioradialis tendon is routinely released at its distal insertion to aid in reduction.

Fracture Reduction and Plate Presetting

Fresh fractures less than 10 days old can be managed with longitudinal traction through ligamentotaxis. The aim is to realign the volar cortex and "jig-saw" the fracture back into its anatomic position. In cases involving severe metaphyseal comminution, especially in subacute fractures, our preferred approach is to hyperextend the wrist to enhance fracture-site visibility

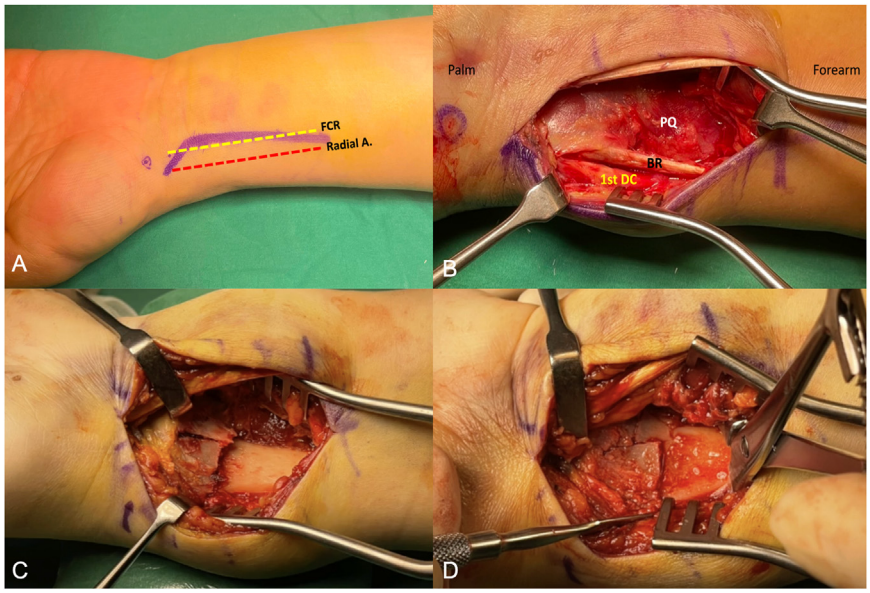

Fig 2. (A) Surface marking of the radial artery (red dotted line) and flexor carpi radialis (FCR) tendon (yellow dotted line.) on a left wrist. A trans-FCR approach is employed in this case. (B) Exposure of the pronator quadratus (PQ) muscle, brachioradialis (BR), and first dorsal compartment (1st DC) tendons. (C) The PQ is elevated subperiosteally up to the watershed ridge for exposure of the fracture site. (D) The volar cortex is realigned and jig-sawed back into anatomical position by manual reduction and pronation with a bone clamp on the proximally (Orbay maneuver).

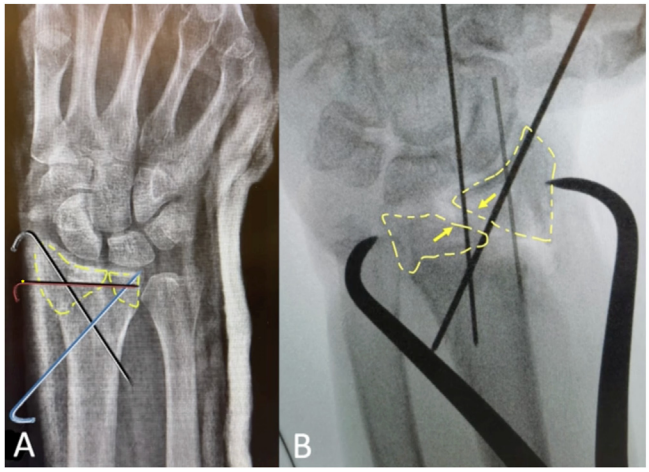

Fig 3. (A) This figure illustrates the different directions Kirschner wires can be used to reduce the fragments. The first wire (black) stabilizes the radial styloid to the metaphysis. The second wire (red) can be employed when there is a sagittal split. The third wire (blue) is useful when there is an isolated volar or dorsal lunate fragment. (B) In a widely splayed sagittal split, a bone tenaculum clamp can be placed between the radius styloid and ulnar bone to compress the gap.

and subsequently employ the Orbay maneuver, which entails releasing the proximal radial fragment subperiosteally and mobilizing it into pronation with a bone clamp (Fig 2D).[16] This allows dorsal metaphysis access for debridement of fracture calluses or placement of bone grafts. In patients with extensive metaphyseal comminution, we routinely pack in sufficient amount of allograft cancellous bone chips into the fracture site to elevate the subchondral fragment. Next, the fracture is reduced through longitudinal traction, palmar flexion, and supination of the proximal fragment back into position to realign the volar cortex. Depending on the fracture configuration, provisional intrafocal or extrafocal Kirshner wires can be used to hold the reduction under fluoroscopic guidance (Fig 3).

We prefer to use a variable-angled volar locking plate in most cases of AO-type C DRFs. The plate is positioned under fluoroscopic guidance and is secured by placing a cortical screw in the elliptical hole of the plate (Fig 4). The screw is partially secured to allow the plate to slide distally and proximally. The distal screw holes are left free for manipulation of the articular fragments during arthroscopy. Ensure that the plate is not positioned distal to the watershed ridge. One may place multiple subchondral supporting Kirshner wires distal to the plate as a joystick wire before the arthroscopy setup.

Wrist Arthroscopy and Hematoma Washout

Next, a standard wrist arthroscopy setup is employed with 12 pounds of traction (Fig 5). A 1.9-mm NanoScope (Arthrex, Naples, FL) was used in this case. The 3-4 and 6-R portals are employed to assess the radiocarpal joint, whereas the midcarpal radial and midcarpal ulnar portals are used to evaluate the midcarpal joint. We begin our arthroscopy with the 3-4 portal as the viewing portal and the 6-R portal as the working portal. We prefer to use dry arthroscopy with intermittent saline irrigation, as described by Del Piñal.[17] Synovectomy of the ulnocarpal joint is performed

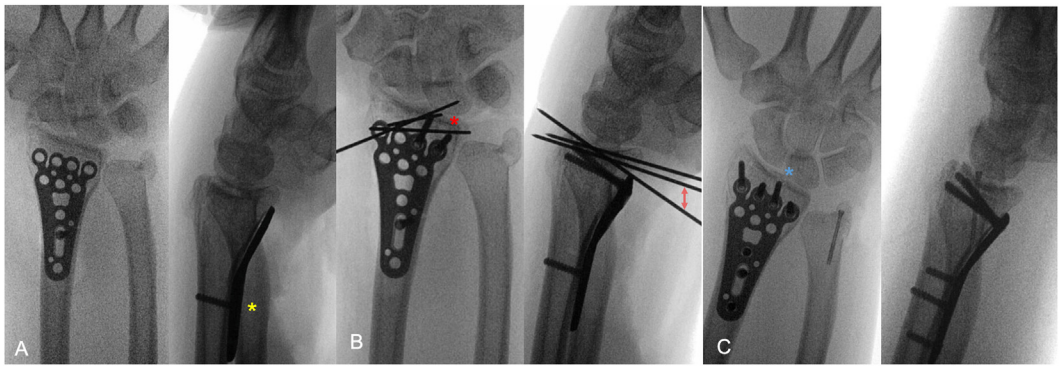

Fig 4. (A) A demonstration of a left intra-articular distal radius fracture preliminary volar locking plate (VLP) fixation using the Medartis 2.5 mm distal radius plate (Medartis, Basel, Switzerland) before scope setup. A cortical shaft screw is inserted at the proximal oval hole (yellow asterisk). The plate serves as a buttress to the volar cortex for arthroscopic manipulation later. (B) Small 1.0-or 1.2-mm Kirschner wires are inserted in the subchondral aspect of the volar ulnar fragment (red asterisk) as a joystick for fine-tuning of the articular surface. Under arthroscopic guidance, the wire is backed out halfway, adjusted by downward levering (red arrow) to align the articular surface, and then advanced back into the dorsal fragment. The intermediate column fragment is first stabilized to restore the sigmoid notch congruency, followed by the radial column. (C) Once the articular reduction is satisfactory, distal locking screws are filled in. In this case example, the third radial distal screw is directed more distally to support the ulnar corner fragment (blue asterisk).

Fig 5. Arthroscopy setup for a left distal radius fracture using the wrist traction tower and finger traps. A pneumatic tourniquet is applied as well.

using an arthroscopic shaver. The camera is then rapidly swapped to the 6-R portal and the shaver to the 3-4 portal. Soft callus and hematoma around and between the fracture site are debrided until adequate exposure is achieved (Fig 6). It is important to identify and remove any loose bodies trapped within the fracture gap.

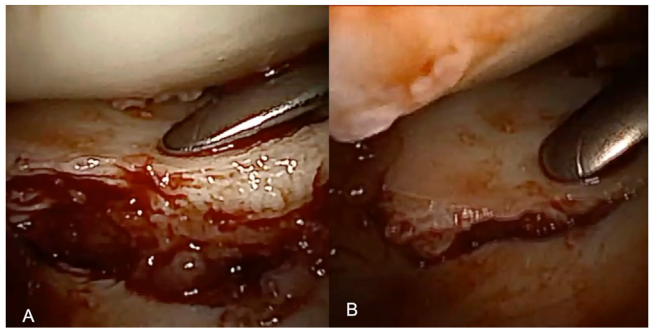

Fig 7. (A) A Freer elevator is a narrow instrument with a flat broad surface that can be used to press down elevated fragments. In this figure, the elevator is used to depress the dorsal ulnar fragment. (B) Sometimes, when the fragment does not yield to direct pressure alone, it may be necessary to release the vertical traction to counter overdistraction.

Reduction of Intra-articular Fragments and Fixation

We prefer stabilizing the lunate facet first to ensure sigmoid notch congruity, followed by the scaphoid facet. Reduction maneuvers include hooking the depressed fragment with a arthroscopic probe or dental hook or pushing down an elevated fragment with a Freer elevator (Fig 7). Overdistracted fragments can also be managed by partially releasing the traction. One may also use the subchondral joystick wires to adjust the intra-articular fragments. The joystick wire used to secure the fracture is backed out halfway, the alignment of fracture is adjusted, and then the wire is advanced into the dorsal fragment with the surgeon's thumb pushing against the dorsal cortex from the exterior (Figs 8 and 9). We recommend 'over-elevating' the dorsal fragment just before the screw insertion as when the screw engages there is a natural tendency to fall back into the anatomical position. In fractures with a coronal or sagittal split, a bone tenaculum clamp can temporarily secure the reduction (Fig 3B). It is not uncommon for large dorsal fragments to appear elevated from the arthroscope when the volar-ulnar

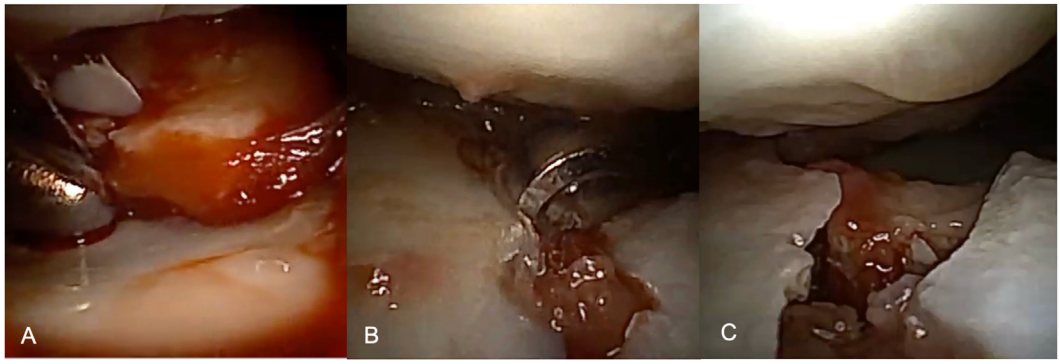

Fig 6. (A) Arthroscopic view demonstrating synovectomy and debridement of hematoma using an arthroscopy shaver. (B) A 2.2-mm arthroscopic debrider allows entry into the articular gap. Precise and careful debridement is essential to avoid shaving the off articular cartilage. (C) Accurate identification of different fragments is possible when debridement is adequate.

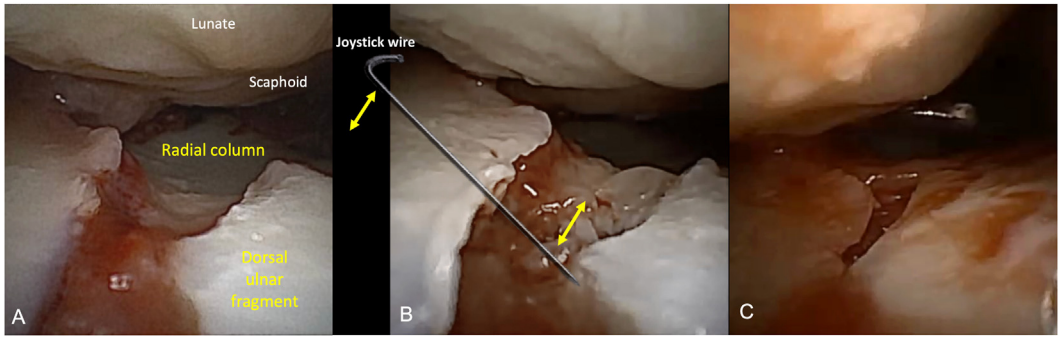

Fig 8. (A) Arthroscopic view from the 6-R portal, showing the lunate and scaphoid superiorly and the distal radius articular surface interiorly. The radial column is depressed in relation to the ulnar column. (B) The joystick wire is inserted from a volar to dorsal direction. The wire is levered to elevate the radial column. (C) The wire is backout and redirected until satisfactory reduction of the articular surface is achieved.

fragments are rotated dorsally (reduced "teardrop" angle).[18] Therefore, it is imperative to align the volar-ulnar fragment by rotating it anteriorly. Graspers may be necessary to maneuver free-floating malrotated fragments. The subchondra locking screws function as a hammock, providing support to the free-floating fragments.

Upon satisfactory reduction of the joint, the fixation is completed with the remaining screws (Fig 4C). Final scope surveillance is performed to assess articular congruity, screw penetration, and associated ligamentous injuries. All Kirshner wires are removed. The wound is closed in layers after irrigation and hemostasis. A volar plaster slab is applied to keep the wrist neutral and fingers free for motion.

Postoperative Care and Rehabilitation

The wrist is immobilized in a plaster slab for 1 week, then converted to a resting wrist splint. Progressive, gentle active motion is initiated for 3 weeks. In the fourth week, passive wrist motion and gradual strengthening are introduced, with the splint removal scheduled for the sixth week.

Discussion

Arthroscopy is a gold standard modality to assess the articular surface of the wrist joint. With direct visualization, the fracture articular surface can be matched as accurately as possible. In addition, it facilitates a better understanding of the fracture pattern and enables surgeons to assess associated injuries, such as carpal bone fractures, carpal ligaments, or triangular fibrocartilage complex tears.

Systematic reviews, such as Smeraglia et al. 2016,[19] do not demonstrate a significant improvement in outcomes with AADRF. However, the available outcome data are mixed, and there is a shortage of high-quality randomized controlled trials. Our experience highlights its value as an adjunct in specific fracture subtypes, especially in multifragmentary fractures with central

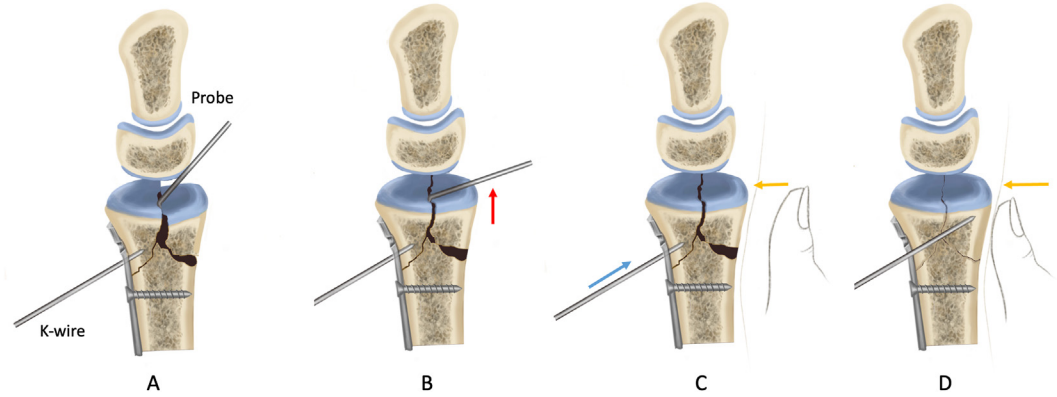

Fig 9. Arthroscopic reduction maneuver using a joystick wire. (A) A joystick wire is parked in the volar fragment. With the scope in the 6-R portal, an arthroscopic probe is introduced from the 3-4 portal and used to hook on the depressed dorsal articular fragment. (B) The fragment is hooked upward and dorsally (red arrow) to align the articular cartilage. (C) With the aid of the thumb pressure on the dorsal aspect on the Lister's tubercle (yellow arrow), the joystick wire is advanced forward by the surgeon assistant to secure the reduction (blue arrow). (D) The thumb pressure is maintained throughout the wire placement. Screw insertion is then followed once articular congruency is confirmed.

Table 1. Pearls and Pitfalls in Arthroscopic-Assisted Distal Radius Fixation (AADRF)

Pearls
- A computed tomography scan accurately evaluates the pattern of fracture comminution and the presence of loose osteochondral fragments.
- Accurate manual or fluoroscopic reduction is vital for restoring gross extra-articular alignment, whereas arthroscopy is used to fine-tune intra-articular fragments.
- Dry arthroscopy with intermittent irrigation is preferred to reduce extravasation and soft-tissue edema compared with wet arthroscopy.
- The 6-R portal optimally visualizes intra-articular distal radius fixation by placing the scope over the ulnar head, providing a stable point and minimizing interference with fracture fragments.
- Joystick wires (1.2-mm diameter) can be placed before or during wrist traction for easy manipulation.
- We prioritize stabilizing ulnar fragments to restore the DRUJ relatioship before addressing radial fragments. This is especially important when reducing the explosive type AO C3 fractures.
Pitfalls
- This procedure has a steep learning curve, and initial surgeries may require extended operating time, especially for those new to the procedure.
- An experienced surgical assistant is necessary to help in the drilling and screw placement from the volar side.
- Heat-generating devices might be contraindicated in dry arthroscopy. However, regular intermittent irrigation can alleviate this concern for those who prefer using burrs or vaporizers for other reasons.
- The surgeon's thumb on the dorsal surface of the distal radius may be at risk of injury during Kirshner wire placement (Fig 9).

DRUJ, distal radioulnar joint.

depression. Abe and Fujii[20] reported that 9.3% of wrists in their series were found to have free fracture fragments that were not identified with preoperative imaging. The extended operating time and logistical complexities related to the arthroscopy setup can be discouraging for many surgeons. We favor the use of the NanoScope because of its lightweight nature, easy setup, and maneuverability compared with conventional arthroscopes.

Numerous techniques for performing AADRFs are available in the literature. Our recommendation involves achieving an anatomical reduction of the volar cortex with plate presetting without traction. Subsequently, intra-articular fragments are fine-tuned, and fractures are stabilized sequentially during traction. A reliable assistant is crucial to aid in accurate screw placement. We prefer a transverse dorsal capsulotomy to access the intra-articular fragments in cases necessitating a dorsal approach. Alternatively, a scope with transverse traction and weights hanging off the edge of the table can be employed. The pearls and pitfalls are discussed in Table 1.

In conclusion, AADRF is an effective adjunct, offering direct visualization for reduction of articular fragments. Despite clinical outcomes being comparable with non-arthroscopic fixation from a recently published randomized controlled trial,[21] the primary advantage of arthroscopy lies in the ability to meticulously restore articular congruency, preventing the development of symptomatic posttraumatic osteoarthritis. Although some may question its value, mastering the technique makes it a valuable adjunct for achieving precise anatomical fracture alignment.

Disclosures

All authors (A.C., S.F.C., and S.R.C.) declare that they have no known competing financial interests or personal relationships that could have appeared to influence the work reported in this paper.

Acknowledgments

The authors thank Dr. Nah Jie Hui for the illustration provided in Figure 9.

References

1. Mathoulin C, Sbihi A, Panciera P. Intérêt de l'arthroscopie du poignet dans le traitement des fractures articulaires du 1/4 inférieur du radius: à propos de 27 cas [Interest in wrist arthroscopy for treatment of articular fractures of the distal radius: Report of 27 cases]. *Chir Main* 2001;20:342-350 [in French].
2. Edwards CC 2nd, Haraszti CJ, McGillivary GR, Gutow AP. Intra-articular distal radius fractures: Arthroscopic assessment of radiographically assisted reduction. *J Hand Surg Am* 2001;26:1036-1041.
3. Knirk JL, Jupiter JB. Intra-articular fractures of the distal end of the radius in young adults. *J Bone Joint Surg Am* 1986;68:647-659.
4. Fernandez DL, Geissler WB. Treatment of displaced articular fractures of the radius. *J Hand Surg Am* 1991;16:375-384.
5. Trumble TE, Schmitt SR, Vedder NB. Factors affecting functional outcome of displaced intra-articular distal radius fractures. *J Hand Surg Am* 1994;19:325-340.
6. Lutsky K, Boyer MI, Steffen JA, Goldfarb CA. Arthroscopic assessment of intra-articular distal radius fractures after open reduction and internal fixation from a volar approach. *J Hand Surg Am* 2008;33:476-484.
7. Ono H, Katayama T, Furuta K, Suzuki D, Fujitani R, Akahane M. Distal radial fracture arthroscopic intra-articular gap and step-off measurement after open reduction and internal fixation with a volar locked plate. *J Orthop Sci* 2012;17:443-449.
8. Shihab Z, Sivakumar B, Graham D, Del Piñal F. Outcomes of arthroscopic-assisted distal radius fracture volar plating: A meta-analysis. *J Hand Surg Am* 2022;47:330-340.

9. Richards RS, Bennett JD, Roth JH, et al. Arthroscopic diagnosis of intra-articular soft tissue injuries associated with distal radial fractures. *J Hand Surg Am* 1997;22:772-776.
10. Doi K, Hattori Y, Otsuka K, et al. Intra-articular fractures of the distal aspect of the radius: Arthroscopically assisted reduction compared with open reduction and internal fixation. *J Bone Joint Surg Am* 1999;81:1093-1110.
11. Lindau T. Arthroscopic evaluation of associated soft tissue injuries in distal radius fractures. *Hand Clin* 2017;33:651-658.
12. Abe Y, Yoshida K, Tominaga Y. Less invasive surgery with wrist arthroscopy for distal radius fracture. *J Orthop Sci* 2013;18:398-404.
13. Gabl M, Arora R, Klauser AS, Schmidle G. Characteristics of secondary arthrofibrosis after intra-articular distal radius fracture. *Arch Orthop Trauma Surg* 2016;136:1181-1188.
14. Koo SCJJ, Leung KYA, Chau WW, Ho PC. Comparing outcomes between arthroscopic-assisted reduction and fluoroscopic reduction in AO type C distal radius fracture treatment. *J Wrist Surg* 2021;10:102-110.
15. del Piñal F, García-Bernal FJ, Delgado J, Sanmartín M, Regalado J, Cerezal L. Correction of malunited intra-articular distal radius fractures with an inside-out osteotomy technique. *J Hand Surg Am* 2006;31:1029-1034.
16. Orbay JL, Badia A, Indriago IR, et al. The extended flexor carpi radialis approach: A new perspective for the distal radius fracture. *Tech Hand Up Extrem Surg* 2001;5:204-211.
17. Del Piñal F. Technical tips for (dry) arthroscopic reduction and internal fixation of distal radius fractures. *J Hand Surg Am* 2011;36:1694-1705.
18. Medoff RJ. Essential radiographic evaluation for distal radius fractures. *Hand Clin* 2005;21:279-288.
19. Smeraglia F, Del Buono A, Maffulli N. Wrist arthroscopy in the management of articular distal radius fractures. *Br Med Bull* 2016;119:157-165.
20. Abe Y, Fujii K. Arthroscopic-assisted reduction of intra-articular distal radius fracture. *Hand Clin* 2017;33:659-668.
21. Pérez-Úbeda MJ, Arribas P, Gimeno García-Andrade MD, et al. Adjuvant arthroscopy does not improve the functional outcome of volar locking plate for distal radius fractures: A randomized clinical trial. *Arthroscopy* 2024;40:305-317.