

SURGICAL TECHNIQUE

Correction of Malunited Intra-Articular Distal Radius Fractures With an Inside-Out Osteotomy Technique

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Purpose: To present an inside-out osteotomy technique under arthroscopic guidance to correct an intra-articular malunion.

Methods: The joint is explored with a 2.7-mm arthroscope through the standard portals without infusing any water. To allow room to introduce the curettes and the osteotomes (4-mm wide), the instrumentation portals are made slightly larger than usual. Malunited fragments are cut with the osteotomes from inside the joint and advanced out. Fragments are mobilized, and granulating tissue and/or new bone is removed with curettes and synoviotomes. After disimpaction and reduction, fixation with plates or screws via the appropriate open approach is performed under arthroscopic control. No water is used throughout the procedure except at the end of the surgery to clear out debris.

Results: Steps were corrected to 0 mm in all patients. Gaps of less than 1 mm were common.

Conclusions: This procedure allows us to define each cartilage-containing fragment and to re-create the original articular fracture line without the fear of creating new fracture lines on the articular surface. This technique can be used for patients with irregularly defined fragments that are not amenable to classic techniques. The key to the procedure is to perform the arthroscopic exploration without water infusion (dry technique). (*J Hand Surg* 2006;31A:1029–1034. Copyright © 2006 by the American Society for Surgery of the Hand.)

Key words: Distal radius malunion, intra-articular osteotomy, wrist arthroscopy, wrist fracture.



Rapid radiocarpal degeneration is expected to occur after intra-articular malunion of the distal radius in young active individuals.^{1–3} Although this requires immediate correction, there are only a few reports that deal with this problem.^{2,4–6} Recently Ring et al⁶ reported good results by using a direct open approach. The technique is difficult, however, and there is a risk of causing additional damage because of limited access. Furthermore, fragment devascularization is possible because the fragments occasionally need to be detached from the soft-tissue connections.

We have had a limited but very positive experience with an arthroscopic-guided inside-out osteot-

omy for intra-articular distal radius malunions. With this technique, the surgeon has virtual assurance of cutting through the original fracture lines with minimal interference to ligament attachments and hence with the blood supply of the osteotomized fragment.

Our experience is limited to 4 patients, all with intra-articular malunions of a short duration (5 wk to 3 mo). Two patients had a single fragment mobilized (1 anteromedial fragment, 1 styloid fragment) and the other 2 patients had 2 or more fragments mobilized (both C31 fractures of the AO classification). Gaps (<1 mm) were unavoidable after the surgery (see Discussion section), but steps were reduced to 0 mm (from a maximum of 5 mm).



Figure 1. Instruments required for the procedure (from left to right): impactor, osteotome, strong-angled curette, shoulder probe, and a small joint arthroscopic guide.

Surgical Technique

The arm is exsanguinated with an Esmarch bandage, and the tourniquet is inflated. Before suspending the patient's hand, the proposed site of fixation is prepared with the patient's arm on the hand table. A limited volar–ulnar incision is used for volar shearing malunion. A limited Henry approach is used if there is a radial styloid or multipiece malunion. A

plate then is placed and held in position with a single screw through its stem.

The hand then is placed in traction from a bow with a custom-made system (discussed later). The standard 3-4 and 6R portals are developed; however, transverse skin incisions (≈ 1 cm) on the dorsum of the wrist are preferred because they heal with minimal scarring. To avoid lacerating any nerve or tendon, only the skin is incised with a number 15 blade. A hemostat is used to widen the portal to permit the smooth entrance of the osteotomes and other instruments required (Fig. 1). Apart from dorsal portals, a volar radial portal always is used. If a Henry-type incision is planned, then the portal is developed as recommended by Levy and Glickel,⁷ otherwise we follow the technique of Doi et al.⁸

Initially, the scope is introduced through the 3-4 portal and the joint is palpated (for this we prefer the stronger shoulder probe). The consistency of the cartilage and the presence and location of steps are assessed. The preoperative computed tomography scan is invaluable for helping to establish orientation because joint disruption can be misleading (Fig. 2). A shaver can be helpful to remove the synovitis and fibrin that is present and which obscures the view. Air should flow freely into the joint when the suction

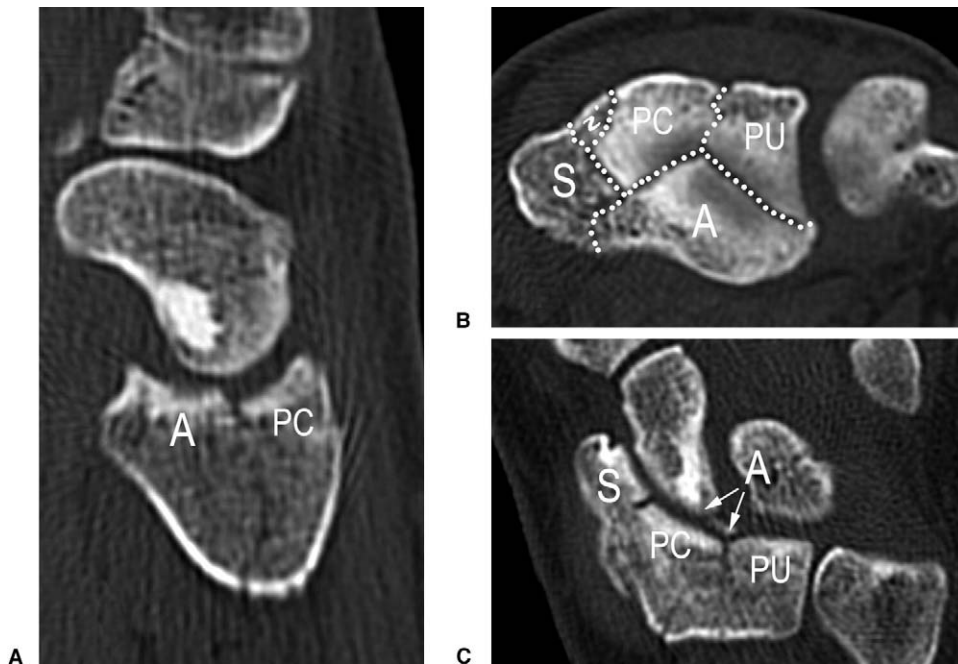


Figure 2. Preoperative computed tomography scan of a C3.1 fracture. (A) A 3.5-mm step-off on the scaphoid fossa (A, anterior fragment; PC, postero-central). (B) Corresponding axial view showing a multipiece fracture. The styloid (S), postero-central (PC), and a small (i) intermiddle fragment are depressed in relation to the anterior fragment (A) and the postero-ulnar fragment (PU) (see panel C). (C) Coronal computed tomography scan showing the depression of the styloid (S) and postero-central (PC) in relation to the postero-ulnar (PU) and anterior (A) fragments. Only the depressed fragments (PC and S) will require correction.

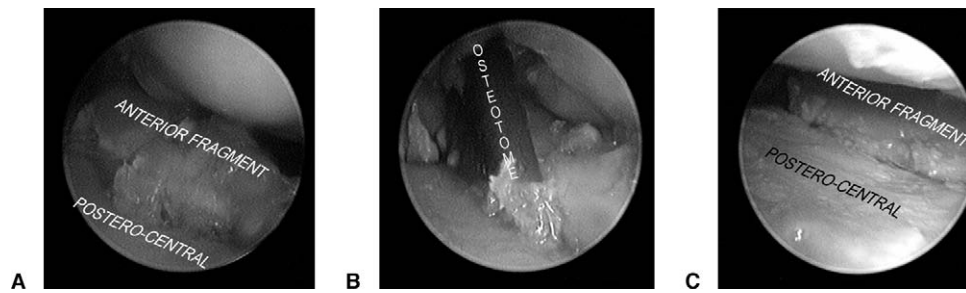


Figure 3. Correction of a step-off in the same patient as shown in Figure 2. The right wrist is shown; the arthroscope is in the 6R portal viewing radially. The radial styloid is at the very far upper left corner. (A) Step-off on the scaphoid fossa. (B) The osteotome (entering the joint through the volar radial portal) separates the malunited fragments. (C) Corresponding view after reduction.

of the synoviotome or burr is working, otherwise the suction will suck the capsule in, which will obscure the view. A sufficient amount of air enters through the side tube of the arthroscope's sheath. The surgeon should keep the valve open throughout the entire procedure.

Once major cartilage destruction has been ruled out (see Discussion section) and the fragments to be mobilized are defined, then the scope is moved to the 6R portal and the 3-4 and volar radial portals are used for instrumentation. We use periosteal elevators, which are available commercially for shoulder surgery (Artrex AR-1342-30°, Artrex AR-1342-15°; Artrex, Naples, FL) to cut the fragments. These elevators have a 4-mm width and are strong enough to cut the fragments by gently tapping them with a hammer. To avoid the risk of lacerating extensor tendons when introducing the osteotomes through the 3-4 portal, the blade of the osteotome should be introduced parallel to the tendon. The articular surface first is defined fully with the osteotome and then the osteotome is advanced to cut the external callus. Gentle maneuvers are necessary because there is a risk of cutting the tendons if the osteotome is plunged volarly or dorsally.

The displaced fragments are mobilized fully by carefully prying them out with the osteotome. In most cases, the fragments are disimpacted and elevated easily by hooking them with the strong shoulder probe and pulling upward. On one occasion, we had to resort to pushing up the fragment from outside the joint by using a Steinmann pin, which was advanced into the exact spot with the help of a small arthroscopic guide (Ref 4291; Dyonics, Smith & Nephew Inc., Andover, MA).

Many times scarring and new bone formation between the fragments impedes full reduction. This should be resected with the help of small curettes or burrs introduced through the portals. Once the reduc-

tion is thought to be the best possible (Fig. 3), then 1 surgeon maintains the bones in position while the other inserts the distal screws of the plate. In 1 patient, we used a single screw to secure a volar-ulnar fragment and, in another patient, we used a 2.7-buttress plate to stabilize a styloid fragment. In the most common 4-part or more fragments situation, a plate with locking distal pegs is preferred (DVR; Hand Innovations, Miami, FL). The joint then is irrigated with 10 to 30 mL of saline that is introduced through the scope's side tube, and a shaver is used to remove all of the debris. The rest of the plate is secured in the standard manner with the hand flat (Fig. 4). Fluoroscopy controls can be performed throughout the procedure as many times as required (see later).

The portals are closed with paper tape or a single stitch, and the wrist is placed in a removable splint. In all of our patients, the fixation was sufficiently stable as to start protected range of motion on the first preoperative visit (~48 h).

The surgeon may be inconvenienced by 2 factors during the procedure: blurred vision and hand positioning. The following technical tips have been found to be of great help.

Blurred Vision

Splashes of blood or soft-tissue debris may obscure the surgeon's vision by sticking to the scope tip. Removing the scope and wiping off the lens with a wet sponge is efficacious but time consuming. We recommend other alternatives. If debris is obscuring the surgeon's vision, then the optic can be cleaned off easily by gently wiping its tip on the capsule or any neighboring soft tissue. Ideally, blood should be dried from the surgical field with a sponge. Because there is no such thing as an arthro sponge, we have used small (13 mm × 13 mm) surgical patties for this purpose (Ref: 80-04000, size: 0.5 in × 0.5 in;



Figure 4. Same patient as in Figures 2 and 3. (A) Preoperative x-ray shows the depressed fragments highlighted by black dots. (B) Restoration of the articular line (at 6 wk).

Neuray, Xomed, Jacksonville, FL). The patty is rolled and introduced into the joint by a grasper. At times it can become entangled, and pulling from the tail (or with the grasper) can help to remove it. This is the method we used most often (including for acute distal radius fractures). Alternatively the joint can be washed out with 5 mL to 10 mL of water infused through the sheath of the arthroscope while aspirating with a synoviotome. Although effective, this is quite time consuming because the joint has to be dried out with a sponge to obtain a clear view. (As in microsurgery, the field can be either absolutely dry or immersed in water; however, working with a small amount of water tends to be quite annoying.)

Changing Hand Positioning Under Sterile Conditions

During surgery most surgeons⁹ will place the hand suspended with the fingers pointing upward. Fluoroscopy is extremely cumbersome with the hand in this position; ideally the hand should lay flat. Furthermore during some parts of the surgery the surgeon may want the hand on the operating table, not suspended. Changing the position of the hand from a suspended position to a flat position can be performed easily when using a traction tower. If one is using a classic bow, however, the hand cannot be released from the bow except by preparing the fingers again. To solve this inconvenience we suggest a

method that expeditiously allows the hand to be engaged and disengaged from the bow while maintaining sterility at all times (Fig. 5).

Discussion

The technique presented in this article is drawn from experience with malunions of a relatively short duration (5 wk to 3 mo). It may be argued that the fragments can be easily defined this early by simply breaking the external callus. As early as 3 to 4 weeks, however, impacted fractures have healed soundly, to the point that an osteotome is required to redefine the cartilage-containing fragments.^{10,11} Piecemeal fragmentation can occur if the mobilization is not performed carefully. The arthroscope allows us to follow the exact line of the chondral fracture with magnified vision and to restore the cartilaginous surface anatomy.

There are benefits to early correction of extra-articular distal radius fractures.¹² Logically a greater benefit would be expected in cases of intra-articular malunion because this prevents further damage by altered joint mechanics.¹³ We have no experience in osteotomies of longer than 3 months' duration. It may be that after 3 months the cartilage is worn out and/or that arthrofibrosis might impede the arthroscopic procedure to be performed, but we have no data to support either statement. Certainly a loss of cartilage would preclude this surgery; we

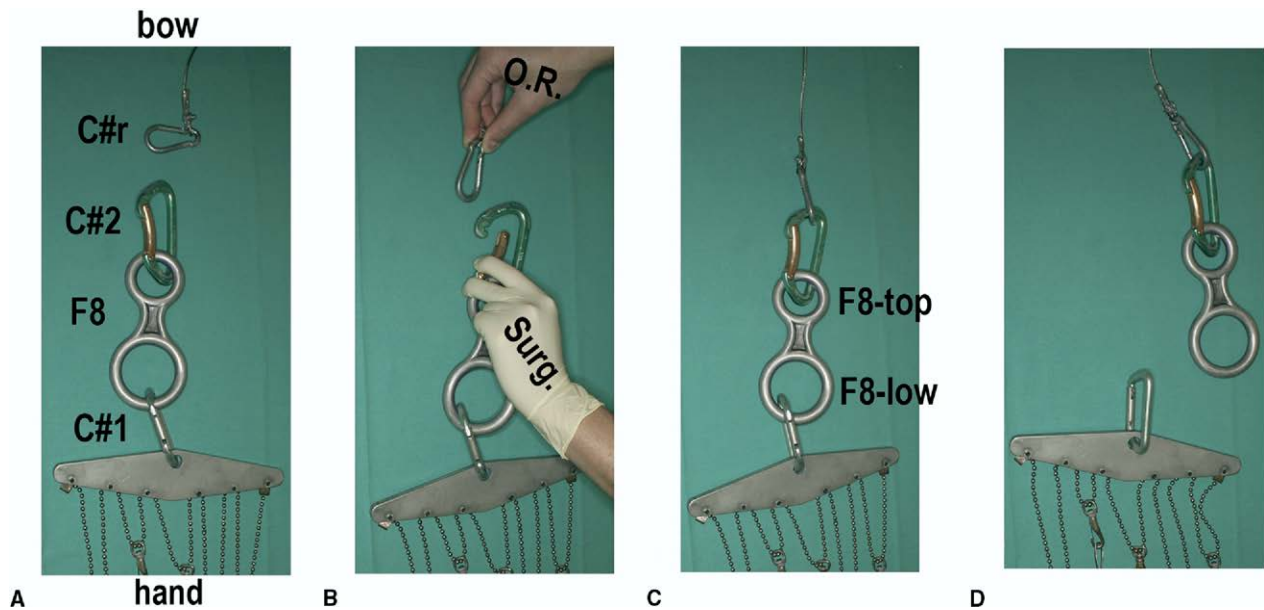


Figure 5. Method for maintaining sterility when changing from a vertical traction position, suitable for arthroscopy, to a standard surgical position, with the hand flat on the table. (A) The hand, held with Chinese traps, hangs from “carabiner 1” (c #1), a figure of eight descender (F8), “carabiner 2” (c #2), and the “bow’s rope carabiner” (c#r). (B) (Carabiners and figure of eight descenders can be purchased at any climbing shop.) The surgeon, under sterile conditions, connects c#2 to c#r, which is held by the operating room personnel. (C) During arthroscopy, only the lower hole of F8 is considered sterile (F8-LOW) because the other hole (F8-TOP) comes into indirect contact with c#r. (D) To transfer the hand to a horizontal position, the surgeon unfastens c#1. To put the hand into traction again, the surgeon needs only to fasten c#1 to F8-LOW, which will maintain sterility at all times. All but c#r are sterile.

then would switch to a reconstructive osteochondral graft procedure¹⁴ or a partial arthrodesis.^{15,16} For this reason, an exploratory arthroscopy before plating would be our choice in older malunions (>3 mo).

The whole arthroscopic procedure is performed without water (what we call the dry technique) except at the very end to flush out the debris or to clear the field of blood as explained earlier. The dry technique avoids the cumbersome run-off of water through the (large) portals, the dangerous extravasation to surrounding soft tissues, but more importantly it is much easier than the standard (wet) technique. We in fact have moved away from the wet (classic) arthroscopic technique to perform the procedure nearly always without water (ulnar head recession or ganglion removal can be performed easily). Water is likely to be needed if a laser or electrocautery is going to be used, but we do not have experience with either of these techniques.

The inside-out technique is a minimally invasive technique that allows full assessment of the deformity, accurate osteotomy, and mobilization of the displaced fragments. Even irregular fragments that are not amenable to other techniques can be dealt with by this procedure. Correction of step-offs was achieved in every patient with an accuracy of 0

mm; however, residual gaps of about 1 mm were common as a result of cartilage loss, interposition of newly formed bone, and presumably cartilage destruction from the original injury. The procedure can be incorporated easily by any surgeon familiar with arthroscopy (video 1; this video may be viewed at the *Journal’s* Web site, www.jhandsurg.org).

The authors would like to thank Mr. Robert Jenkins for his help during the English translation of this article. The arthroscopic dry technique was developed as an input from other specialties and specialists. The mechanics of a laparoscopy procedure was a flash of inspiration; no water is used except for diluting blood clots; the water is, however, aspirated as the optic cavity is maintained by air at all times. The authors would like to recognize Drs. Atzei and Luchetti (from Italy), who shared with us that they were not infusing water in some of the steps of the arthroscopy exploration. Similarly the authors heard Dr. C. Zaidenberg (from Argentina) say at the Annual Meeting of the American Association for Hand Surgery (Cancún, Mexico, January 9–14, 2002) that during arthroscopic resection of wrist ganglions that no water was used until after the ganglion stem was identified.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

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Erratum

In the article by Dr. Yoshitaka Hamada, et al, that appeared in the April 2006 issue of the Journal (“Effects of monofilament nylon coated with basic fibroblast growth factor on endogenous intrasynovial flexor tendon healing.” Vol 31A, No 4, pp 530–540), the authors were listed incorrectly. The correct author listing is as follows: Yoshitaka Hamada, Shinsuke Katoh, Naohito Hibino, Hirohumi Kosaka, Daisuke Hamada, and Natsuo Yasui from University of Tokushima; and Makoto Ozeki, Yu Kimura, and Yasuhiko Tabata from Kyoto University.