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DRY ARTHROSCOPY OF THE WRIST: ITS ROLE IN THE MANAGEMENT OF ARTICULAR DISTAL RADIUS FRACTURE

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INTRODUCTION

"If a method produces better results, one must master any difficulty it presents and learn to do it well." Nicholas Barton. J Hand Surg 1997; 22B:153

Articular congruity is the most important prognostic factor when dealing with an articular fracture. The fluoroscope has been shown to be inaccurate to control articular step-offs in distal radius fractures (1, 2). The arthroscope, on the other hand, allows seeing inside a joint. Hence this instrument, not the fluoroscope, seems to be the appropriate tool to control articular congruency in distal radius fractures.

Despite growing literature supporting its role (3–9), many surgeons are reluctant to systematically use the arthroscope when treating distal radius fractures. The possibility of compartment syndrome, the technical difficulties due to loss of vision and cumbersomeness without much benefit, are some of the arguments. However, the benefit of seeing inside a joint may be enormous when assessing congruency, associated ligament injuries, distal radio-ulnar joint instability and/or malunions.

The aim of this paper is to present the logistics and technical hints as the way we manage distal radius fracture. By keeping the order presented, the procedure can be much more "friendly" than expected. A key factor in the procedure is not infusing water inside the joint during the arthroscopy, the so-called "dry technique" (10).

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THE DRY TECHNIQUE

Most arthroscopies in the body are carried out infusing water to create an optical working cavity. Under those conditions we found the management of distal radius fractures quite cumbersome, not to say that compartment syndrome risk did exist (11). Furthermore, when we used to use water to distend the joint, performing semi-open operations such as osteotomies, or distal radio-ulnar joint reconstructions, were impracticable. Extrapolating that in other "scopies" in the human body, such as laparoscopy or thoracoscopy, water was not used to maintain the optic cavity, we realized that traction through the fingers was sufficient to maintain the wrist open. Main advantages were that soft tissue extravasation was eliminated, much facilitating any combined open surgery as the tissues maintained their original properties.

The dry technique, which in essence is similar to the classic technique but without infusing water, introduces a new set of difficulties derived from vision loss secondary to splashes of blood or soft-tissue debris that may stick to the scope tip. Removing the scope and wiping off the lens with a wet sponge is efficacious but time consuming. Moreover, poor vision quality or being immersed in a "red sea" may make the surgeon abandon this technique that has a lot to offer. This is particularly true for distal radius fractures. Based on our experience with more than 300 dry wrist arthroscopies we have found the following technical tips helpful:

- If the arthroscopy is carried out immediately after elevating the tourniquet, vision can be poor, improving as the operation proceeds. We realized the vision impairment was caused by condensation at the tip of the scope as a consequence of the different temperatures (the joint still was warm and the scope at room temperature). As time goes by vision improves as the exanguinated limb cools down. This is easily overcome by immersing the tip of the scope tip in warm saline for few minutes before beginning the surgery.

- If there is blood or blood clots (as after a fracture) you can clear any debris by injecting with 5 to 10 cc of saline through the side valve of the scope and then aspirating with the synoviotome. This in general should provide a clean field and sufficiently dry.
- If an absolute dry field is needed, as to see a gap or a step, we then recommend to dry out the joint. For this we use small (13 × 13 mm) or medium (25 × 25 mm) surgical patties (Ref: 800–04000. size: ½″ × ½″, Ref: 800–04003. size:1′ × 1′ (25 × 25 mm) Neuray™, Xomed, Jacksonville, FL.). The small patty can directly be rolled and directly introduced into the joint by a grasper. The large patties have to be slightly modified by cutting them into the shape of a triangle which facilitates removal from the joint. If the patties become entangled, they can be removed pulling on the tail or by retrieval with a grasper. Actually, we now rarely resort to this technique, again in order to reduce operative time.
- Avoid getting too close with the tip of the scope when working with burs or osteotomes in order to avert splashes that might block your vision. It is preferable to first inspect the area of interest and then slightly pull the scope back prior to inserting your working instrument. For the same reason avoid touching the tip of the scope with your instruments (probe, synoviotomes…).
- If you get a minor splash at the tip of your scope, you can remove it by gently rubbing the tip of scope on the local soft tissue (capsule, fat….). This maneuver will clear the view sufficiently.
- The synoviotome, burr or any other instruments connected to a suction machine can clog because the aspirated debride dries out. This requires frequent clearing by injecting saline through the tubing. This can be minimized by periodic saline aspiration from an external basin.
- Finally, one must understand that a most times the vision will never be completely clear but still sufficient to safely accomplish the goals of the procedure. Having a completely clear field except for specific times during the procedure is unnecessary and wastes valuable time. Actually, most of the times, particularly in fractures, we do irrigate with 3–5 cc, aspirate, and then work for sometime without any difficulty. Once the joint is again with blood we repeat the cycle. …So we have moved from the wet arthroscopy, to the dry and now somewhat "moist arthroscopy".

MANAGEMENT OF THE RADIUS FRACTURE

Surgery was carried out as soon as the CT scan was available (immediately to some days after the accident). Fractures with a delay in treatment longer that three weeks are considered healed (12) and were managed by arthroscopic assisted osteotomy (13).

Except in some specific fractures, such as radial styloid, that were managed with cannulated screws though a transverse incision in the styloid (needless to say under arthroscopic control), all the rest were managed with the following protocol.

SURGICAL TECHNIQUE

The radius is approached between the FCR and the radial artery. The pronator quadratus is reflected ulnarly. A preliminary reduction is done by standard maneuvers. A volar locking plate is provisionally applied and stabilized by inserting only the screw into the elliptical hole on the stem of the plate. The dorsal fragments are manually compressed to the plate that acts as a mold. Customarily several attempts and maneuvers are needed before the "best" reduction is obtained as judged by fluoroscopic views, and by direct observation of the metaphyseal component of the fracture. The articular fragments are then secured to the plate by inserting Kirschner wires (K-wire) through the auxiliary holes of the transverse component of the plate. Once considered that the reduction is ideal and/or that no improvement is attainable without proceeding to an arthrotomy, the arthroscopic part of the operation begins.

The hand is suspended from a bow, the fingers pointing to the ceiling, with a custom made system that allows easy connection and disconnection from the bow without losing sterility (13).

Traction is carried out on all fingers with a countertraction of 7–9 Kg. A small transverse incision is made just distal to Lister´s tubercle and the scope (2.7 mm; 30º angle) is introduced and directed ulnarly. An ulnar portal is now established. I prefer the 6R, which is located immediately radial to the extensor carpi ulnaris tendon. This is best carried out under arthroscopic guidance by inserting a needle percutaneously, in the expected 6R position. This step is important, as sometimes desinsertion of the ulnar attachment of the TFC directs the surgeon to the ulnocarpal instead of the radiocarpal joint. Although vision at this stage may also be obscured by blood, in general it is possible to see the needle introduced in 6R, certifying that one stays distal to the TFC. A straight hemostat is used to dilate the portal. Alternatively, the surgeon should go blindly making the portal radial to the ECU, just proximal to the triquetrum, and directing the hemostat radially inside the joint.

The blood and debris are aspirated by a 2.9 mm shaver inserted in 6R. The valve on the arthroscope sheath should be left open at all times as to allow the air to circulate freely in the joint and avoid capsular collapse while suctioning. Despite the fact that the whole operation is done without water (dry technique) the joint can be washed of blood at the beginning or as required during the procedure as explained above. The negative pressure exerted by the shaver will suck the water from the syringe without any extravasation of fluid outside the joint.

Once the elements that need to be mobilized are identified, the scope is swapped to 6R, where it will stay until the entire fixation is done. In this position, on top of the ulnar head, the scope will have a steady point to rest upon, and will not impede reduction or displace reduced fragments.

In simpler cases where only a single fragment remains unreduced, the fragment is freed by backing out the specific K-wire that kept it secured to the plate. **Depressed fragments** are lifted by hooking

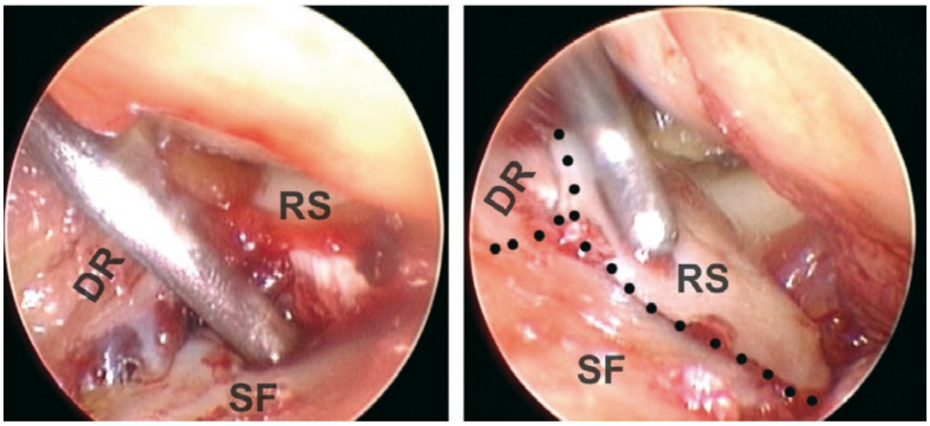

Fig. 1. Reduction of a 3 mm depressed fragment in the scaphoid fossa. The shoulder probe is hooking the fragment. On the right the depressed fragment is now leveled. (RS: Radial styloid; DR: Dorsal rim; SF: Scaphoid fossa. Scope in 6R, viewing radially in a right wrist.)

them with the tip of a shoulder or knee arthroscopy probe introduced from 3–4, or in rare cases from 4–5 portals (Fig. 1). **Elevated fragments** nearly always correspond to rim fragments that due to the effect of traction are overdistracted. They are easily repositioned by the assistant decreasing traction while the surgeon levels them with the probe or a Freer elevator. Once the fragment is reduced, it is held in position with a bone tenaculum, and stabilized by pushing the corresponding K-wire in the plate again. **Free osteochondral fragments** are extremely unstable and when repositioned, sink into the metaphyseal void. To avoid this we create a supporting hammock where they can lie. This is done by inserting the distal layer of pegs in the plate, while keeping these fragments slightly overreduced. Then, they are impacted by using a Freer elevator or by releasing the traction and using the corresponding carpal bone as a mold. A grasper can be useful to grab and twist a severely displaced fragment.

Only in the most comminuted cases, will several fragments continue to be displaced after the fluoroscopic part of the operation. Backing out all the K-wires and attempting to reduce and fix all fragments at the same time, is an impossible endeavor in our hands. We recommend a step by step procedure beginning from the least comminuted part of the fracture. This keystone area is reduced as explained above (backing out the corresponding K-wire, arthroscopic reduction and pushing in the K-wire), building up the rest of the articular surface to this foundation. Whether one begins the reduction from ulnar to radial, or the opposite way, is entirely dependent on where the comminution is located.

Still under arthroscopic control, locking pegs are inserted in the plate by the other surgeon in critical spots, so as to make the articular surface stable to probe palpation. This part of the operation is quite awkward as the flexor tendons are in tension blocking the vision of the plate. Retracting ulnarly the tendons with a Farabeuf, and reducing the traction to release the flexor tendons, may ease the task. As soon as the major articular fragments are stabilized, the hand is put flat on the operating table, as in this position the rest of pegs and screws can be inserted expeditiously.

Once the radius fixation is over, the distal radioulnar joint and the midcarpal joints are assessed for instability or ligament damage. (See below) If nothing else is found, the joint is washed with saline injected through the side valve of the scope (as explained before) and the intraarticular debris is sucked with the synoviotome.

Bone graft was not used in any of these patients, as it is our belief that a locking plate provides sufficient support.

The operations are carried out as outpatient procedures. Twenty-four to forty-eight hours later the splint is removed and self-directed active and assisted exercises are encouraged. A removable plastic splint is made, to be worn only when at risk of further trauma. Exceptions are made in the cases of additional fixation required for scapho-lunate or dorsal rim fixation.

We have operated more than 100 articular distal radius fractures with arthroscopic control. None of our cases was considered a failure nor did the arthroscopy have to be abandoned. In order to test the feasibility and outcome of the above protocol, we extracted a subgroup of the 16 consecutive most comminuted fractures. They all had “explosion fractures”: more than five articular fragments and/or a free osteochondral fragment. At a minimum of one year they were called back for the purpose of this study (14). Except in one case that the extra-articular reduction was lost in the rest the radiographic parameters were satisfactorily maintained. Range of motion was 105 º of flexo-extension. Grip strength 85% of the contralateral, and a DASH of 6. This study confirms that (dry) arthroscopy is feasible in the most severely articular comminuted C3 fractures, and our results compare favorably with to other similar case series (15, 16).

LIGAMENTOUS INJURY

It should be underscored that although some types of fractures, such as those where the fracture line crosses in the vicinity of the interfossal sulcus, are probably more prone to involve the scapho-lunate (S-L) ligament, any wrist fracture can be associated to a carpal

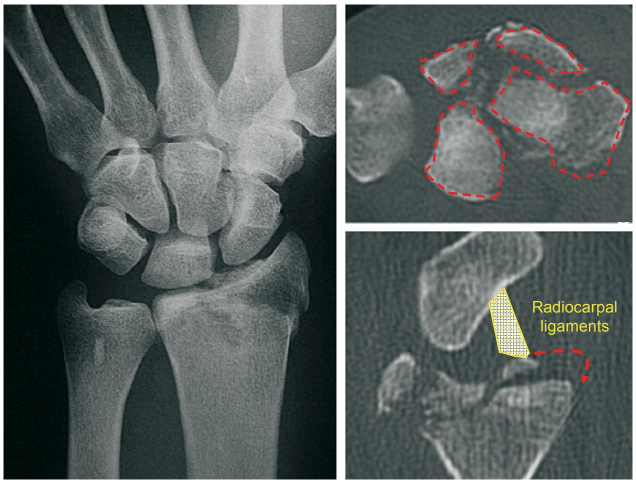

Fig. 2A–C. Intra-articular five-plus fragment fracture. A fragment containing the short radio-lunate ligament has been avulsed from the volar rim of the radius, and is responsible for dorsal radio-carpal dislocation.

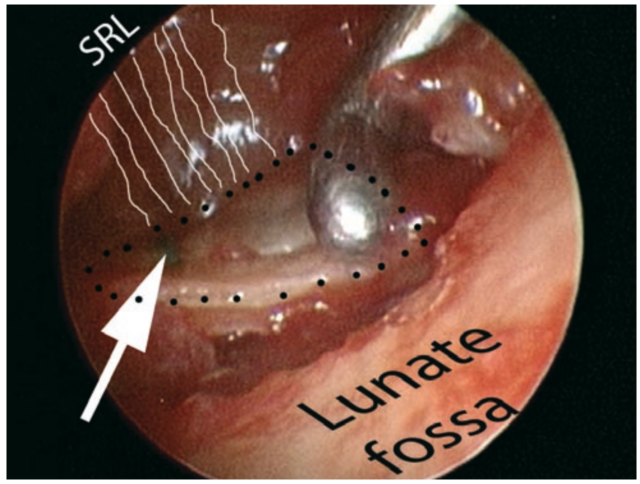

Fig. 2 D. Intraoperative view. The fragment containing the short radio-lunate (RSL) has now been reduced and sutured with a mattress stitch (arrow).

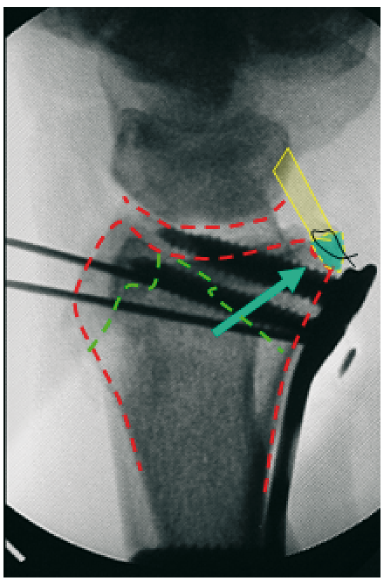

Fig. 2 E. Fluoroscopic view shows schematically the procedure and how the lunate is reduced.

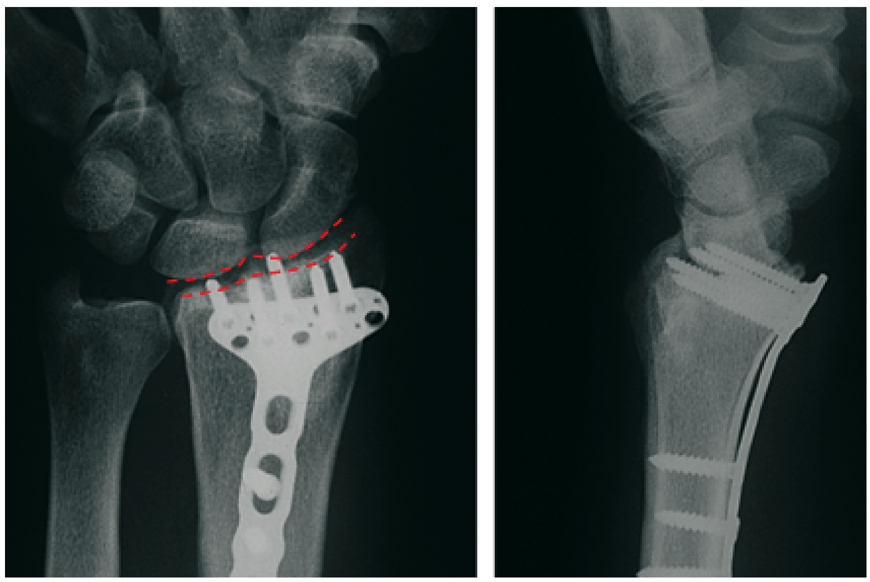

Fig. 2 F–G. A-P and lateral view at 2 years. The joint spaces are well maintained. The patient achieved a 120º flexo-extension arch and nearly full prono-supination.

fracture or a ligamentous injury. Not only will major ("static") ligamentous injuries be a source of pain, but even lesser ligamentous injuries may also be symptomatic in the long-term (17).

Traditionally, fluoroscopy or plain radiograms have been used to diagnose S-L ligament injuries. However, there are two problems when one relies on radiograms, traction radiograms, or CT scan. Firstly, some patients may not have at presentation any radiological sign of S-L ligament injury until after some months have elapsed. This group may become larger by modern treatment modalities that promote early mobilization, as minor degrees of ligamentous injuries might progress to complete ruptures. Obviously it is critical to have a clear diagnosis to know whom should be mobilized and when.

By the same token, open repair or even percutaneous pinning of an S-L dissociation is not without consequences: stiffness is in fact quite common in our experience. We have found several patients that despite the fact that the radiograms showed an S-L gap, this turned out to be normal for such a patient. This in general is bilateral, a preoperative contralateral X-ray may help, but the arthroscopic exploration is definitive. (Fig. 3).

The arthroscope is an excellent tool to sort out the degree of damage and instability in any wrist ligament. Most wrist arthroscopists use Geissler's classification to grade ligamentous injury in the wrist (3). Grade I: hemorrhage/ Grade II: Attenuation of the ligament. The probe can pass through the S-L space/ Grade III: major attenuation. In general the anterior part of the S-L ligament is torn and the probe can be twisted in the space/ Grade IV: complete rupture. The 2.7 mm scope can pass through the space. Although the grading system is not perfect, all classifications available are also somewhat subjective (18, 19).

One should take care not to overdiagnose (and overtreat) ligamentous injuries (6, 20, 21), as one must understand that the carpal bones may move quite a lot in some patients (22). For this reason, when we find S-L ligament injuries grades I or II, we just debride the edges of the membranous portion of the S-L ligament, and do not modify the aftercare of the fracture. In the cases of grade III S-L injuries, if the joint maintains the congruency during the arthroscopy we keep those patients in a cast for 4–6 weeks to allow the ligament to heal (irrespective of whether the distal radius fracture was stable enough to move). This is much preferred to pinning, which is associated to stiffness, and is reserved in our protocol to treat the more severe grades IV.

From a logistic standpoint we first treat the distal radius fracture (in most cases with a volar plate), and then, the S-L dissociation. The protocol is reversed when a scaphoid fracture is present. In this latter case we prefer to stabilize first the scaphoid in order to avoid further displacement caused by traction.

With the hand lying on the table, and through a small transverse incision just distal to the radial styloid, the radial nerve branches are retracted with a Ragnell. A 2mm soft tissue protector guide (from the AO instruments set) is laid over the scaphoid and two or preferably three 1.25 mm K-wires are inserted into the scaphoid and directed (2) to the scapho-lunate space and (1) to the capitate. These wires are introduced with fluoroscopic control and left flush with the scaphoid. The hand is again placed in traction and under arthroscopic guidance the scaphoid is reduced to the lunate by exerting external pressure on the tubercle and using the probe, in the radial midcarpal portal, to reduce it. If a considerable amount of instability exists, a joystick K-wire (1.5 mm) is inserted into the lunate through the dorsal skin, allowing direct control of this bone. Once the reduction of the S-L interval is achieved, another surgeon advances the pins across the intercarpal space. The hand is released from traction and the midcarpal joint is blocked by pushing the K-wire into the capitate. The wrist is then immobilized for 6 weeks and then progressive range of motion allowed.

DISTAL RADIO-ULNAR JOINT TEARS AND INSTABILITY

Abraham Colles already warned that most problems secondary to a radius fracture will be located in the ulnar part of the wrist. It is amazing that we have been unable to change this, more than 100 years later (23).

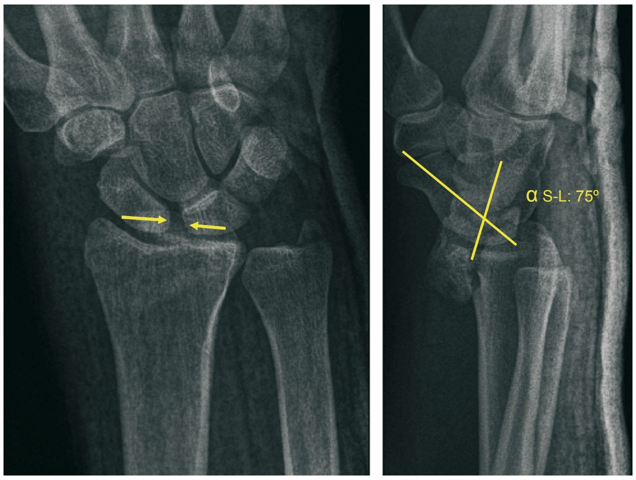

Fig. 3. Apparent scapho-lunate dissociation after a styloid fracture. During arthroscopy the S-L space was tight. Immediate range of motion was begun. At six weeks the patient had a full range of motion and could return to sports activity. The S-L gap has not progressed.

Part of the reason for this comes from the fact that the ulnar anatomy has been ill-defined until recently. Nakamura et al's (24, 25) anatomical studies clearly showed that most distal radio-ulnar ligaments insert into the fovea rather than into the styloid. This has tremendous implications as a patient may have instability regardless of the presence of an ulnar styloid fracture. Not surprisingly, Lindau et al (26) proved that patients with untreated TFCC tears did worse than those without them, irrespective of the presence of an ulnar styloid fracture (Fig. 4). It is hence important to recognize TFCC tears, to identify the unstable group, and to appropriately treat each entity in the setting of a distal radius fracture.

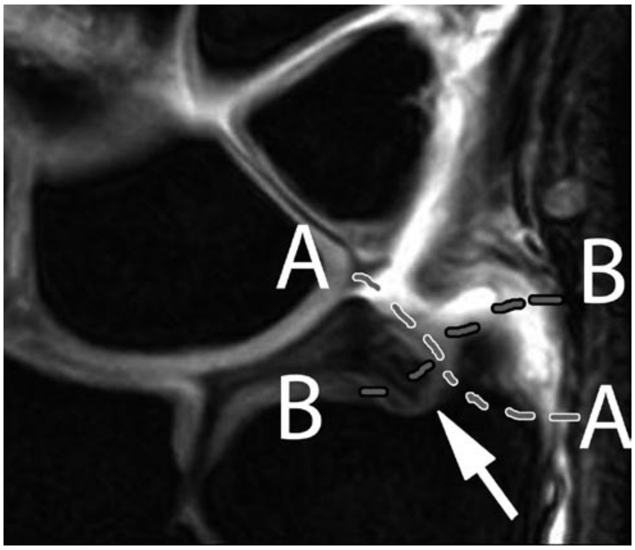

Fig. 4. Most distal radio-ulnar ligaments insert into the fovea (arrow). Whereas path B will cause a major instability without a styloid base fracture, path A will cause no such instability, despite being associated to a fracture of the styloid base.

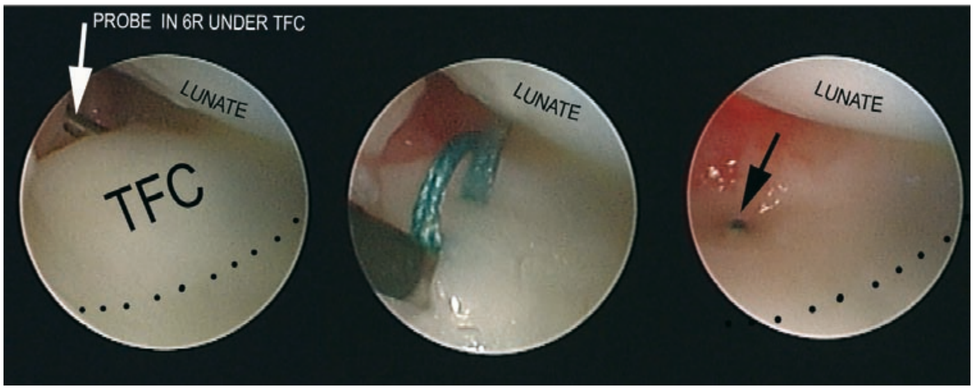

Fig. 5. TFC reinsertion at the fovea. Complete detachment of the TFC (left). A bone anchor has been inserted at the fovea and a mattress stitch (black arrow) is now attaching the TFC. Semiopen procedures are greatly facilitated by using the Dry Technique.

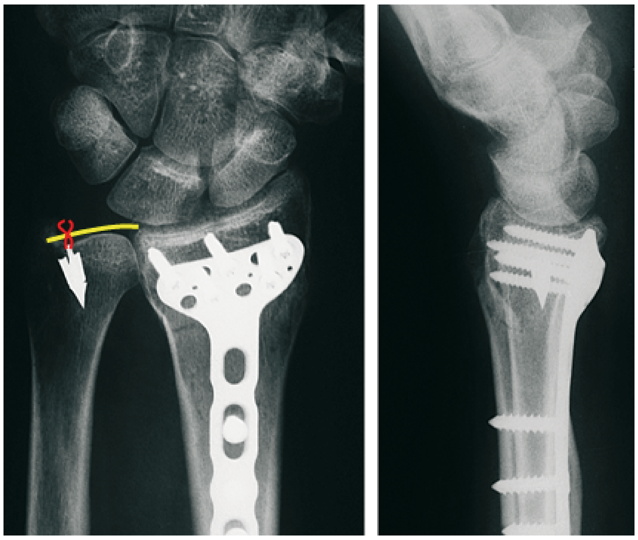

Fig. 6. This patient had a complete foveal detachment with distal radio-ulnar joint instability despite not having an ulnar styloid fracture. After reanchoring the TFCC to the fovea, the distal radio-ulnar joint became congruent and stability restored.

Most TFCC tears are located in the vicinity of the radial insertion and are named after Palmer classification as I-A (27). They are not associated to DRUJ (distal radio-ulnar joint) instability and the only treatment they require is debridement. This can be done by means of a shaver or angulated "basket" forceps.

When the ulnar attachments of the TFCC complex are torn the DRUJ becomes unstable (so-called IB tears according to Palmer's classification). Recognition and treatment of this group is vital, as it is a source of long-term sequelae (26). Excessive anteroposterior motion of the ulnar head, during the intraoperative exploration, points to a major detachment (28). Arthroscopically, there are two clues for the diagnosis: detachment of the TFC from the dorsal capsule, being the surgeon able to lift he TFC from the ulnar head, and loss of "trampoline effect" (29). The latter consists of the loss of resilience when the surgeon pushes down on the TFC with the probe in 6-R. Although quite popular, I find (perhaps because I always use the dry technique) the trampoline misleading, and prefer a modification in which the TFC is hooked with a needle (or the probe) and lifted distally attempting to stress its foveal insertion. Any lifting is diagnostic of rupture at the fovea, and requires reattachment.

Arthroscopic reattachment of the TFC to the capsule is quite popular (28, 30, 31) but leaves the most important foveal insertion untreated. Nakamura et al (32) and Garcia-Elias et al (33), both proposed an open approach in order to reinsert the TFC at the fovea. Atzei et al (34), and Atzei (35) devised a very effective technique of foveal reattachment of the TFCC under arthroscopy.

The technique of foveal reattachment with some modifications is as follows: The hand is kept under traction and **in supination**. In this position the fovea is easily reached through 1.5 cm oblique incision, just volar to the ulnar styloid. Small Ragnell's retractors should be used in order to protect the dorsal branch of the ulnar nerve. Spreading the soft tissues with scissors in the direction of the fibers of the extensor retinaculum, allows one to reach the fovea. The dome of the ulnar head is also apparent confirming that the distal radio-ulnar ligaments are detached. The fovea is freshened with a rongeur and one of the commercially available bone anchors is inserted making sure that is deeply set. An empty Toughy type needle (epidural anesthesia) is introduced at 4–5 portal and directed ulnarwards. The needle then pierces the TFC and exits in the vicinity of the fovea, where it is loaded with one of the extremes of the thread of the anchor. The needle is withdrawn until the tip is at the radiocarpal joint, and the pushed again towards the fovea, in order to place a mattress stitch on the TFC. By tightening the knot the TFC would be reinserted at the fovea restoring the anatomy.

Prono-supination should be blocked for 4–5 weeks, with a sugar-tong splint. The wrist, however, can be left free to move if the fixation of the radius proves stable, although some form of compressive dressing (Coban® like) should be wore, as otherwise distal edema and pain will ensue.

Finally instability can be due to complete avulsion of the distal radio-ulnar ligaments and TFC from the radius (so-called class ID tear) (27). If untreated, it can be a source of secondary instability and pain (36). Usually the radio-ulnar ligament is avulsed with a fleck of bone and reinsertion of it restores both congruency at the sigmoid notch and stability.

CONCLUSION

The dry technique allows us to see inside the joint without the problems of fluid extravasation and constant loss of vision. Additionally it allows semi-open procedures, such as osteotomies and foveal reattachments, which would be impracticable if water is used. The technique has a learning curve, but will be readily mastered by those already experienced in the classic arthroscopic techniques. Despite the fact that it may be considered another technical hindrance, I highly recommend using the arthroscope when dealing with acute distal radius fractures in order to see the articular reduction and the concomitant associated injuries.

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