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**Abstract**

The development of wrist arthroscopy was the natural evolution of the successful application of arthroscopy to the other joints of the human body.
# Wrist Arthroscopy in Traumatic and Post-Traumatic Injuries

Ferdinando Battistella, Grzegorz Adamczyk, Maciej Miszczak, Christophe Rizzo, Christophe Mathoulin, Eva-M Baur, Nicolas Dauphin, Didier Fontès, Riccardo Luchetti, Jane C. Messina, Andrea Atzei, and Federica Braidotti

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## 12.1 Introduction

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## 12.2 Clinical Results of Wrist Arthroscopic Assistance in Articular Distal Radius Fractures

Ferdinando Battistella

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## 12.3 Wrist Arthroscopy in Distal Radius Fractures with Associated Lesions

Grzegorz Adamczyk and Maciej Miszczak

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## 12.4 Outcome of Arthroscopically Assisted Percutaneous Fixation of Scaphoid Fractures

Christophe Rizzo and Christophe Mathoulin

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## 12.5 Wrist Arthroscopy in Acute TFCC Tears

Eva-M Baur

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## 12.6 Arthroscopy in the Treatment of Acute Scapholunate Ligament Lesions

Nicolas Dauphin

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## 12.7 Arthroscopic Management of Bennet’s Fractures

Didier Fontès and Riccardo Luchetti

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## 12.8 Treatment of Scaphoid Fractures Associated with Scapholunate Ligament Lesions

Jane C. Messina and Riccardo Luchetti

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## 12.9 Innovative Procedures in Wrist Arthroscopy

Andrea Atzei, Federica Braidotti and Riccardo Luchetti

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## References
The development of wrist arthroscopy was the natural evolution of the successful application of arthroscopy to the other joints of the human body.

In the recent years there has been considerable growth since pioneers such as Terry L. Whipple, Gary Poehling, and Lee Osterman reported their original description of the technique.

Although wrist arthroscopy was first introduced in 1979, it did not become an accepted method of diagnosis until the mid-1980s. As the surgical technique and technology improved, wrist arthroscopy became a therapeutic modality as well as a diagnostic one.

The complex anatomy of the carpus made of eight carpal bones with their cartilaginous facets tightly connected by intrinsic and extrinsic ligaments is being revealed day by day by the different arthroscopic views. At first the dorsal portal was described, then the volar, which is more rarely used.

Wrist arthroscopy has greatly improved our knowledge and understanding of these complex joints, and has allowed treating a variety of wrist pathologies with a minimally invasive approach, such as TFCC lesions, ganglia, loose bodies, arthritis of the wrist and trapeziometacarpal joint, scapholunate and other ligament lesions, and instability. More recently, it has been used in the treatment of fractures, such as scaphoid fractures, articular fractures of the hand, and distal radius fractures.

As we will see, this technique is still developing, and an increasing number of wrist problems are now being solved by the arthroscopic approach alone or to assist with an open approach.
12.2 Clinical Results of Wrist Arthroscopic Assistance in Articular Distal Radius Fractures

Ferdinando Battistella

12.2.1 Background

Recent advances in wrist arthroscopic surgical techniques and instrumentation have enabled the surgeon to improve the treatment of intraarticular distal radius fractures, but no clinical studies have been published yet that provide clear evidence of advantages of the arthroscopic technique over more traditional techniques.

12.2.2 The Arthroscopic-Assisted Technique Offers Several Theoretical Advantages

1. It allows for the evaluation of the articular reduction under a bright light and magnification. Particularly, rotation of the fracture fragments, which is difficult to judge under fluoroscopy, can be detected arthroscopically and corrected.

2. Washing out fracture hematoma and debris potentially allows for an improved range of motion.

3. It allows for detection and management of associated soft tissue and chondral lesions.

4. It is a minimally invasive technique causing less tissue damage, and fewer fracture fragments will be devitalized.

5. The fracture reduction is carried out with a traction tower, so it is possible to control the amount of radial shortening.

12.2.3 Purpose

The purpose was to determine the clinical results and usefulness of arthroscopic assistance in articular distal radius fractures. The study design was a double-blind clinical study in a prospective case series (group A) with a control group (group B).

12.2.4 Methods

From 2005 to 2009, we treated 40 patients with intra-articular fractures with arthroscopic assistance: 18 fractures had two fragments (Figs. 12.1 and 12.2), 12 fractures had three fragments (Fig. 12.3), and 10 had four fragments (Figs. 12.3 and 12.4). The fractures were classified according to the Doi classification into two-, three- and
four-part types, according to the number of main fracture fragments in the distal radial aspect on the basis of preoperative 3D CT scanning. Patient inclusion criteria were: articular step-off or gap formation greater than 2 mm after closed reduction, age less than 60 years old, and an associated evident lesion of the intercarpal liga-
mament or distal radioulnar joint (DRUJ). Patient exclusion criteria were: open fractures, initial carpal tunnel syndrome, or compartment syn-
drome. The control group comprised 40 patients with the same fracture type treated without arthroscopic assistance.

12.2.5 Technique

Reduction of articular congruity was initiated by arthroscopic elevation of the die-punched fragments and depression of the articular surface. Then the fracture was reduced using a five-step algorithm: (1) traction and closed manipulation; (2) percutaneous K-wire manipulation; (3) arthroscopic manipulation; (4) limited open techniques (Figs. 12.1, 12.2, 12.3 and 12.4). These are required if the above pro-
cedures are unsuccessful or are potentially unsafe for elevation of the die-punched fragments and depression of the bulging surface. (5) The last step is open procedures. If all of the above techniques have not succeeded, then an open reduction is required. At the end of the procedure, the associated lesions of the intercarpal ligaments or triangular fibrocartilage complex (TFCC) were treated.

The fractures were pinned in 25 cases, and in 6 cases external fixation was used; in 9 cases open reduction and internal fixation were performed, and 18 patients were treated for associated lesions [scapholunate ligament (SL), TFCC].

Range of motion, grip strength, VAS, Mayo modified wrist score, DASH questionnaire and standard radiographs were registered at 1, 3, 6 and 12 month after the treatment. All patients were matched to control group B of 40 patients for fracture pattern, age and gender treated with conventional procedures. For the statistical meth-
ods, data from both groups were compared using Student’s t test for continuous variables, and the level of significance was set to $p < 0.05$. 

Fig. 12.2 Reduction with percutaneous k-wire used as Joy-stick of a two part fracture with vertical rim. In this case reduction by ligamentotaxis was not successful
Fig. 12.3  Reduction of a three part fracture with k-wires used as joy-stick or with the use of a compass
Fig. 12.4 In multifragmentary fractures, reduction is performed under arthroscopy, then internal fixation with plate and screws may be necessary to stabilize the fragments.
12.2.6 Results

No perioperative complications occurred. The scores for overall outcome demonstrated that group A had better outcomes and better ranges of motion and grip strength \((p<0.05)\) than group B. The radiographic results showed that the group A patients had better reduction of volar tilt, ulnar variance, and articular displacement than group B patients.

12.2.7 Conclusion

On the basis of our prospective comparative study, we found that the arthroscopically guided procedure was superior to the conventional open procedure.
12.3 Wrist Arthroscopy in Distal Radius Fractures with Associated Lesions

Grzegorz Adamczyk and Maciej Miszczak

12.3.1

Distal radius fracture takes first place on the epidemiological lists of fractures, in some classifications comprising 17.5% of all fractures.

Long-term results of distal radius fractures are a matter of discussion, but at 32-year follow-up, fully symptomatic osteoarthritis had developed in 40.5% of patients. Open reduction brings much better short- and better long-term results than splinting, and great initial displacement predisposes to a greater remaining displacement – most patients lose the reduction at 2 weeks, which becomes unacceptable.

Poor reduction is connected with pain and decreased grip strength.

The average age of distal radius fracture patients is slightly connected with the mechanism of injury: among patients over 64 years, it is a simple fall; in those between 48 and 64 years, frequently a fall from height; in those younger than 32 years, usually a sport.

Active young people always demand faster and better help, so short- and long-term results are their point of interest. Having a remaining step-off of 2 mm after reduction, among young patients, may lead to painful arthrosis [1]. The problem is how to measure the step-off. One third of patients with poor intraarticular reduction are evaluated by fluoroscopy as perfectly reduced [2].

One of the most useful tools seems to be arthroscopy.

The confusing elements when the technique was developed were fluid effusion, technical problems, nerve compression syndromes, compression syndromes, problems with visualization and edema, as well as problems with skin closure.

The solution seems to be the “dry arthroscopy” technique [3].

12.3.2 The Role of Arthroscopy in Distal Radius Intraarticular Fractures

Indications are:

- Articular fractures of the distal radius, enhancement of open surgery
- Removal of loose bodies
- Reduction of the articular surface
- Evaluation of the TFCC and SL
- Radial and ulnar styloid fracture
- Fracture of the medial column of radius
- Three- and four-part fractures
- Extraarticular fractures with signs of instability (DRUJ, PLI).

In more than 80% of cases of complex intraarticular fractures of the radius, other lesions that are invisible on X-ray, but manageable, are visualized: TFCC lesions (>50%), SLs, LTs (ca. 30%), dorsal ligaments, chondral lesions, styloid fractures and loose bodies.

Contraindications:

- Large hand edema, forearm compartment syndrome
- Severe soft tissue injury with contamination
- Open fractures and infection (relative)

12.3.3 Technique

Surgery can be performed immediately after injury, optimally 2–4 days after injury (up to 7–10 days). After 3 weeks the fragments have consolidated, and an osteotome is needed to displace them. The operation is done under regional or general anesthesia, with i.v. antibiotics, vertical traction of 2–4 kg and rarely horizontal traction. Low-weight long-term traction makes closed reduction easier.

In my opinion, computer tomography is mandatory in all cases of intraarticular fractures with scans of less than 1 mm; 3D reconstruction might be helpful, but is often misleading.

The open question is whether to start from arthroscopy or start with the open technique?

I start from the incision, in the majority of cases volar, and install a volar plate with LCP.
screws, provisionally locked to the shaft of the radius. Often if a large fragment is visible on the volar side, I also reduce and stabilize it. Sometimes at the beginning I use shorter screws so as not to interfere with later reduction. In some cases I also make a limited dorsal incision and stabilize the volar bony defect with a frozen bone graft (I never use artificial substances).

Then, the patient’s arm is positioned as is typical for arthroscopy, and standard portals are made. The fluid (10–20 ccm) is given by syringe, just to keep the tissue moist. The scope’s valve is kept open to let the suction work. The tips are perfectly described by del Pinal [4].

We start with the elevation of large fragments, temporary stabilization, sometimes with K-wires, and bone loss grafting. Reduction is performed with the hook, and often the K-wire serves as a “joystick” in transcortaneous reduction. The needle is introduced into the joint parallel to the expected final position of the fragment, then an assistant introduces the K-wire 8 mm below, elevates the fragment, and fixes it with wire.

For SL, LT and TFCC lesions, when there are indications, always try to stabilize them. One of the advantages of arthroscopy is verification of the DRUJ. Arthroscopic stabilization of the SLIL might be ARASL as described by Slusky [5]. Early versus delayed carpal ligament treatment shows better results according to Geissler [6].

After the reduction of fragments, fluoroscopic control is performed with a 23° tilt of the distal radius for better visualizations of the screws. At the end, the arm is again positioned on a table, fixation of the plate is completed, and sometimes some K wires are left. The forearm is then put in a cast for a minimum of 4 weeks.

12.3.4 Results and Conclusions

- This is a technically demanding procedure and should be used in well-selected cases of articular fractures.
- A very good assisting surgeon is needed (this is not a “one man show”).
- One should expect the procedure to last 2 h.

The reported results are good when we take into consideration that we are dealing with complex lesions.

This procedure allows a better range of motion (ROM) (F and E ca. 60°), recovery in 95%, and full PS grip strength with a 23% decrease. A quick return to work (2 months) is possible according to Osterman [7].

Luchetti and Atzei reported the results of 22 cases (20–104 months follow-up), with 21 excellent and 1 good result [8].

I have changed my technique. From January 2009 until December 2010, I performed 12 fixations under dry arthroscopy. My preliminary results were satisfactory. We did not observe any loss of reduction, once we had to remove the metal work, and no tendon lesions occurred. In all the cases bone union was obtained between 6 and 8 weeks postoperatively. Twice we had to perform arthrolysis to obtain a better ROM. The average ROM was 63°–40°.
Classically, it was considered that consolidation of scaphoid fractures could be achieved without surgery. However, for many years, open reduction and internal fixation have been the recommended and well-accepted treatment for displaced and unstable intraarticular fractures. This trend has also influenced the therapy of scaphoid fractures. Furthermore, the inconvenience of conservative treatment, with its unpredictable economic consequences due to the long duration of immobilization, and increasing demands of patients have been reasons for surgery. The complex morphology and small size of the scaphoid bone have resulted in the development of numerous sophisticated techniques to achieve an anatomic and stable fixation. In 1984, Herbert [9] reported his experience using a cannulated screw, which originally was not developed for fixation of scaphoid fractures. In the early 1990s, the first article was published [10] reporting the insertion of cannulated screws with a minimally invasive technique. The main principle was to preserve the surrounding ligaments of the carpal bones in order to avoid a destabilization of the reduction and to protect the fragile vascularity of the scaphoid bone [11]. Whipple [12, 13] was the first who presented a method with percutaneous screw fixation using a modified Herbert screw combined with image intensifier control and arthroscopic examination of the wrist. This technique allows controlling the exact fracture reduction, maintaining the fixation under compression, avoiding an intraarticular penetration of the screw and assessing potential associated lesions.

Furthermore, this makes an early return to activities of daily living possible.

The purpose of this study was to report our experience and results of scaphoid fractures treated with an arthroscopically assisted percutaneous screw fixation technique using a cannulated Herbert type screw in a consecutive series of patients (Table 12.1).

### 12.4.2 Materials and Methods

Between April 2001 and December 2004, 24 consecutive patients with scaphoid fractures underwent arthroscopically assisted percutaneous screw fixation at a mean age of 35 years (range, 17–55 years). Two patients could not be reviewed with a follow-up of at least 24 months (follow-up of 10 months and 16 months, respectively) and were excluded from the study. The remaining 22 patients comprise the study population. In the 17 men and 5 women, the dominant side was involved in 16 cases. There were only acute fractures (type B according to the classification of Herbert [9]) and mainly corpus fractures (type III in 13 patients and type IV in 7 patients according to the classification of Schernberg [14]). Fractures of the proximal pole were not included. In 16 cases the fracture was non-displaced; in six cases the fracture was minimally displaced (articular step of 1 mm or less). The mean delay from trauma to surgery was 10 days (range, 1–21 days).

### 12.4.3 Operative Technique

Under ambulatory conditions the operation is performed under locoregional anesthesia. The patient is placed in the supine position on a special arm table with a tourniquet on the arm applied as proximally as possible. During the critical parts of the operation the forearm can be

### Table 12.1 Classification of scaphoid fractures according to Schernberg [14]

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relatively extended using a pad underneath the wrist. Another possibility is to put the wrist under traction with a traction device, which is placed outside the arm table, still allowing positioning of the image intensifier. A retrograde (from distal to proximal) screw fixation is the aim. At the beginning, the fracture is visualized under arthroscopy using standard portals, leaving the forearm free on the table. Then, a 1-mm pin is placed through a small (5-mm) incision to the distal tuberosity of the scaphoid in a retrograde fashion (Fig. 12.5). The wrist is put under traction, allowing arthroscopic control to verify the exact reduction of the scaphoid. The arthroscope is then introduced through a radial mediocarpal portal through which the fracture can be assessed very easily. If necessary, a debridement of the articulation can be done with the shaver while cleaning the medial surface of the scaphoid. If the fracture is displaced, reduction of the fragments is possible with a small retractor introduced through a 1–2 mediocarpal portal. Under arthroscopic control, the fracture fixation pin is pulled back slightly beyond the fracture line; then the fracture is reduced and the pin replaced into the proximal fragment (Figs. 12.6 and 12.7). As soon as a satisfying reduction has been achieved, the hand is removed from the traction device, and the wrist is positioned on a pad on the arm table. Under fluoroscopic control, the hole for the screw is then tapped (Fig. 12.8). The screw is then inserted over the guide wire (Fig. 12.9). Again under arthroscopic control the radiocarpal compartment is visualized through a 3–4 radiocarpal portal. This allows verifying the absence of an intraarticular penetration of the screw head at the level of the proximal pole. Then the entire radio-carpal compartment is inspected to assess potential associated lesions. Mediocarpal exploration allows the inspection of the fracture line to the medial articular surface of the
12.4.3.1 Postoperative Protocol

Postoperatively, the wrist is left unprotected; a simple anterior splint can be applied after the first dressing just for analgesic reasons.

12.4.4 Results

12.4.4.1 Intra- and Peroperative Results

The duration of surgery averaged 30 min (range, 15–45 min). The last case had the shortest duration, documenting the learning curve of this technique.

In displaced fractures the reduction could be held with intraarticular arthroscopic maneuvers. All 22 Herbert screws were inserted retrogradely from distal to proximal. Arthroscopic control was used systematically, independent of the perioperative fluoroscopic control. Although there was a satisfying intraoperative fluoroscopic result, wrist arthroscopy revealed an overlength of the screw tip due to an intraarticular break out at the proximal pole of the scaphoid in three cases. The screws had to be changed to shorter ones.

In our series we found only a few associated lesions. In one patient a central perforation of the TFCC was debrided with the shaver. In another case a lesion of the anterior part of the scapholunate ligament without dynamic instability was observed, which did not have any therapeutic consequences. In a third case the associated lesion was a distal comminuted T-shaped radius fracture, which was treated with ORIF (palmar plating) during the same surgery.

12.4.4.2 Complications

There were no postoperative complications, especially no infections and no nerve lesions.

12.4.4.3 Clinical Results

The mean follow-up was 35 months (range, 24–53 months). All patients were very satisfied or satisfied with the results. None of the patients regretted choosing this method. The main reason for this high satisfaction rate was the fast functional recovery and the absence of postoperative immobilization. Furthermore, patients appreciated the small scars, an observation regularly made after most of the endoscopic and arthroscopic procedures.

According to the Mayo Modified Wrist score, 13 patients had excellent, 6 patients good and 3 patients fair functional results. Two of the three patients with a fair result had an associated lesion.
The mean Mayo Modified Wrist score was 91.5 points (range, 65–100 points).

At final follow-up, 30 of the 34 wrists reached 90% and more of the mobility compared to the contralateral side. Average wrist flexion was 67° (range, 35°–85°), extension was 69° (range, 40°–90°), radial abduction was 22° (range, 0°–40°), and ulnar abduction was 37° (range, 20°–50°).

Average grip strength measured with the Jamar® dynamometer was 40.7 kg (range, 20–60 kg) and reached 91% of the healthy contralateral side.

Patients returned to work after a mean duration of 23 days (range, 1–93 days). Twelve patients could return to work immediately after surgery. Only the patient with the associated radial fracture returned to work after 3 months. Most patients either had an independent occupation or were professional high-level athletes.

### 12.4.4.4 Radiographic Results

All 22 fractures healed primarily; non-union or malunion was not observed. The mean duration of consolidation was 6 weeks (range, 4–8 weeks). Whereas the mean duration in originally displaced fractures was 64 days, it was 45 days in originally non-displaced fractures.

### 12.4.5 Discussion

Numerous recent studies have shown the capability of a percutaneous fixation of scaphoid fractures using cannulated screws [10, 15–17], which competes with the classical conservative method of forearm immobilization for 3 months. Several studies confirm the increased rate of fracture consolidation with percutaneous screw fixation [15–18]. Especially in non-displaced fractures consolidation seems to be shorter. Bond and Shin reported (percutaneous screw fixations vs. conservative treatment) a consolidation time of 4–5 weeks after percutaneous screw fixation in their randomized study [18]. In our study the average radiological consolidation period was less than 2 months for non-displaced fractures, which confirms this statement.

In various series return to professional activities were earlier after screw fixation [16, 18, 19]. In our study the functional recovery was also exceptionally fast. This might be also due to a patient selection bias because many of our patients chosen this method with regard to their professional and personnel duties. We are very well aware of the fact that this is a special patient collective: It seems to be more logical to propose the percutaneous screw fixation for a motivated and well-informed patient, especially when conservative treatment has the risk of failure, e.g., in unstable fractures. The failure rate in terms of consolidation can reach up to 15% after cast immobilization of 3 months [20, 21]. In our series there were no non-unions.

Wrist arthroscopy combined with percutaneous screw fixation allows avoiding certain complications that are relatively frequent in fracture fixation of the scaphoid. Filan and Herbert [21] found 14 intraarticular (Herbert) screw penetrations in their series of 431 patients. In our series, after final arthroscopic control of the radiocarpal joint, we had to change three screws because of break out of the screw tip out of the scaphoid. Arthroscopic mediocarpal examination also allows assessing the quality of fracture reduction after screw fixation. In our series there were no problems in terms of reduction, and all the displaced scaphoid fractures could be reduced and maintained under arthroscopic control (Fig. 12.9).

We only performed screw removal in the case of persistent anterior wrist pain. A longer follow-up is necessary to evaluate the potential development of secondary osteoarthritis.
12.5 Wrist Arthroscopy in Acute TFCC Tears

Eva-M Baur

Arthroscopy has gained increasing importance for treating traumatic lesions of the TFCC in the last 15 years. Now it seems the most powerful tool for the diagnosis and treatment of TFCC lesions.

In 1989 Palmer introduced a classification of acute (traumatic) and degenerative lesions [22] (Fig. 12.10).

12.5.1 Palmer Class I: Traumatic (Acute)

A Central perforation
B Ulnar avulsion
   With styloid fracture
   Without styloid fracture
C Distal avulsion (from the carpus)
D Radial avulsion
   With sigmoid notch fracture
   Without sigmoid notch fracture

12.5.2 Treatment of Acute TFCC Tears

12.5.2.1 Class IA Tears
Arthroscopic debridement is sometimes combined with a wafer or ulnar shortening procedure (Fig. 12.11).

12.5.2.2 Class IB Tears
There is a discrepancy between the anatomical description of Palmer class IB and the clinical finding of a variety of IB lesions, with different treatment requirements. Therefore, A. Atzei described a subclassification of class IB. Sometimes, proximal unstable TFCC lesions in the fovea are not easy to detect.

According to the literature the foveal reconstruction of TFCC lesions has gained increasing importance over the last 10 years [23–28]. The most common reconstruction is still suturing the TFCC to the floor of the sixth extensor tendon compartment, but this is not the place where the detachment took place. Thus, the attachment back to the bone is the crucial element of the reconstruction.

In addition to arthroscopic refixation of the TFCC to the fovea using an anchor technique, other techniques are described – arthroscopically assisted or only arthroscopically (Figs. 12.12 and 12.13).
Also the completely open technique of suturing or anchoring the TFCC is very common. In any case, refixation of the TFCC back to the fovea is most important for DRUJ stability. To reach the diagnosis the MRI scan or arthro-CT scan can be helpful (provided they are of good quality). However, the most important tool is wrist arthroscopy, which provides the opportunity to diagnose and treat the patient in the same procedure.

Nakamura describes the necessity and also a technique to fix the foveal insertion of the TFCC back to the ulna arthroscopically. But he only uses and recommends this technique for acute and subacute lesions [23]. G. Tuennerhoff reported good results in chronic lesions as well, using a slightly different technique.

**12.5.2.3 Class IC Tears**

These tears consist of a rupture along the volar attachment of the TFCC and ulnocarpal ligaments. Culp and colleagues described an arthroscopic refixation [27].

**12.5.2.4 Class ID Tears**

Osterman presented his results on a retrospective study of 19 patients with Palmer class ID TFCC lesions without DRUJ instability that compared the clinical outcomes after TFCC reattachment versus debridement, obtaining the same results for both. But lesions with instability require a refixation to the radius, open or arthroscopic [28].
12.6  Arthroscopy in the Treatment of Acute Scapholunate Ligament Lesions

Nicolas Dauphin

12.6.1  Introduction

Scapholunate ligament lesions are mostly seen in wrist trauma with the wrist in extension and supination. The lesion can also be associated with a distal radius fracture. Scapholunate tears lead to chronic instability and secondary carpal arthritis. Arthroscopy is the most valuable tool in the early diagnosis of acute lesions. Treatment can also been done arthroscopically or with arthroscopic assistance.

The scapholunate ligament is composed of three parts: the dorsal part is actually the strongest part and is firmly attached to the dorsal wrist capsule near the dorsal scaphotrapezial ligament and the dorsal intracarpal ligament. The intermediate part is fibro-cartilaginous and not vascularized, and can therefore not be repaired. The palmar part is in relationship with the palmar capsule. The dorsal and the palmar part are components of the extra-articular system and thus are vascularized. The scapholunate ligament is the main joint stabilizer, especially the strong dorsal part.

The scapholunate joint has flat joint surfaces and is particularly sensitive to metallic fixation through the joint. This leads to important secondary arthrofibrosis that can stabilize the proximal pole of the scaphoid. This is the principle of the K-wire fixation of the scapholunate joint as described by T. Whipple [29].

12.6.2  Patients and Technique

We present a series with 42 patients presenting an acute SL lesion (<2 months) (Fig. 12.14). Thirty-five men and 7 women with a mean age of 34 years underwent operations. Mean follow-up was 37 months. Ninety-two percent of the patients achieved good to excellent results according to the Mayo wrist score [30].

Arthroscopy is performed as outpatient surgery under axillary bloc and a tourniquet. Distraction is achieved by traction of 3–5 kg with a wrist arthroscopy tower. Standard arthroscopic portals are used for exploration of the radiocarpal joint (3–4, 6R) and the midcarpal joint (MCR, MCU). The radiocarpal joint is explored first, and the SL ligament inspected and palpated.

The lesion is refreshed by shaving the remnants of the ligament. The scaphoid is then reduced by external and internal maneuvers under arthroscopic control in the mid-carpal joint. Two 1 to 1.2-mm K-wires are used under fluoroscopic and arthroscopic control (Fig. 12.15).

12.6.3  Discussion

The staging is done according to Garcia-Elias in six stages [31]. Stage 1 is an acute or chronic partial lesion with the dorsal part being intact. We prefer conservative treatment with an 8-week...
cast. In certain stages, we now associate an arthroscopic dorsal wrist capsuloplasty with the K-wire treatment in order to recreate a relationship between the dorsal wrist capsule and the dorsal remnants of the ruptured scapholunate ligament [32]. The new arthroscopic dorsal wrist capsuloplasty attaches the two remnants of the SL ligament to the overlying dorsal wrist capsule. This is done by arthroscopy as described in our technique. Stage 2 according to Garcia-Elias’ suggestion is a complete lesion with the ligament being repairable. In this stage we recommend K-wires through the SL interval or arthroscopic dorsal capsuloplasty without K-wires. In stage 3, the ligament cannot be repaired, and dorsal capsuloplasty is used. In stage 4, the carpal bones are malaligned, and they have to be reduced. In this case, we recommend K-wires combined with dorsal capsuloplasty [32].

**Fig. 12.15** Pinning of SL space under arthroscopy
12.7 Arthroscopic Management of Bennett’s Fractures

Didier Fontès and Riccardo Luchetti

12.7.1

This type of fracture dislocation of the base of the first metacarpal was first described in the British Medical Journal in 1885 by Edward H. Bennett. It is an avulsion fracture of the volar and ulnar portion of the first metacarpal base. Figure 12.1 shows the Gedda classification (Fig. 12.16).

The surgical management remains controversial (percutaneous screw or wire fixation) and is sometimes difficult. The accuracy of fluoroscopic reduction control is doubtful. There can be problems of associated ligamentous lesions and late arthritis changes. Basal joint articulation is not plane but complex (saddle), so in comparison with distal articular radius fractures, only arthroscopic control makes it possible to evaluate the reduction accurately. Peroperative fluoroscopy is insufficient, and the basal joint saddle is more complex than the radial epiphysis. In numerous series, after arthroscopic control of the radial articulation reduction, a second procedure is carried out in 70–100% of cases.

The displacement mechanism of these fractures is a trauma with axial compression with bone crushing. The abductor pollicis longus has a subluxation function, and associated ligamentous lesions are possible.

12.7.2

Historically, small joint arthroscopy was first developed by Masaki Watanabe (1970–1972) and Terry Whipple (1985). CMC basal joint-specific endoscopic exploration was developed by several authors [33–39]:

- J MENON [33]
- RA BERGER [34]
- MA ORELLANA, J CHOW [35]
- D. FONTÈS [36, 37]
- EF WALSH et al. [38]
- A BADIA [39]

Fig. 12.16 Gedda classification of Bennett’s fractures
12.7.3 Instrumentation for First CMC Arthroscopy

First of all we need a traction tower (Whipple) or shoulder holder, then an assistant is needed to stabilization the forearm (Fig. 12.17). Single thumb finger traps are required (5-8-lb traction).

Mini-fluoroscopy is used for X-ray control, using a short-barrel optical and smooth trocar, diameter: 1.9 mm.

Specific miniaturized instruments are necessary as probes, dissectors, graspers, baskets, power shavers and burs. Cautery or radiofrequency ablation probes (mini VAPR) are available.

The 1R, 1U and/or thenar portals are used (Fig. 12.18). Caution should be used concerning the superficial nerves, radial artery and tendons.

The extrinsic ligaments have a controversial physiology. The cartilage and bones form a double saddle-shaped joint.

12.7.4 Materials and Methods

This was a multicentric study, with simultaneous evaluation of different strategies examining a few cases per center.

There were two cases of malunion and 16 fractures. All patients had preoperative plain X-rays (A. Kapandji incidences) and 3D CT scans.

12.7.5 Technique

Under horizontal arthroscopy (Fig. 12.19), debridement of bloody tissues and articular free fragments was obtained. Reduction of articular fragments was obtained, and inter-metacarpal pinning was performed under fluoroscopic check.

Osteosynthesis was performed by

- Direct or extra-articular pinning
- Headless screwing
Arthroscopy allowed the management of associated lesions.

12.7.6 Results

This was a small, multicentric series with no uniformity of fracture management. It was possible to treat associated lesions. No specific complications were recorded. We obtained good cosmetic appearances, good anatomical reductions, and excellent function and return to activities. All patients recovered key pinch and grasp strength. There was an early return to sport competition at the same level as preoperatively.

12.7.7 Conclusions

Our procedure for Bennett’s fractures is arthroscopic control, which means a minimally invasive procedure. No specific complications were recorded in trained hands. Accurate articular reduction for the Gedda type of fracture was obtained, with testing of the stability and management of the frequently associated lesions. Nevertheless, we need larger prospective series for definitive results.
12.8 Treatment of Scaphoid Fractures Associated with Scapholunate Ligament Lesions

Jane C. Messina and Riccardo Luchetti

12.8.1 Introduction

The simultaneous occurrence of a scaphoid fracture and scapholunate ligament (SL) lesion has been described for many years. Although rare, it usually occurs in high-energy trauma with a transscaphoid palmar perilunate fracture dislocation [40–43]. An undisplaced fracture of the scaphoid would traditionally exclude the occurrence of an associated ligamentous lesions in the wrist and so be treated alone. The diagnosis of associated scapholunate (SL) lesions relies on radiographic investigations (Fig. 12.20) and on surgical findings during open surgical procedures using the dorsal approach. With the development of wrist arthroscopy several previously unknown associations of lesions have been described [44, 45] (Fig. 12.21). In particular, the use of arthroscopic assistance in scaphoid internal fixation has allowed finding the association between scaphoid fractures and SL lesions in a high percentage of cases, ranging from 10 to 75% [46–52]. Among these, we nevertheless have to distinguish the rate of occurrence of clinically relevant scapholunate ligament tears (especially Geissler stages III-IV), which need to be repaired effectively. The recently described EWAS (European Wrist Arthroscopy Society) Classification seems to be more accurate in distinguishing the severity of SL lesions, as partial lesions are better identified and distinguished in partial anterior, partial posterior and complete SLIOL lesions (Table 12.2) [53, 54].

Fig. 12.20 (a, b) Patient of 28 years old, preoperative XRay of a fracture of the waist of scaphoid associated to scapholunate lesion
scaphoid and reconstruction of the SL ligament. According to some authors, the presence of an SL lesion may interfere with the scaphoid union [55, 56]. In acute lesions a simultaneous treatment of the two lesions, possibly under arthroscopy, is advisable with a screw fixation of the scaphoid (open or arthroscopic) and a pin fixation of the SL interval [30, 48, 50]. If the SL lesion is severe (Geissler/EWAS stage IV), a simultaneous open treatment of the SL lesion is suggested (SL ligament repair with dorsal capsulodesis) [57–59]. In chronic lesions a two-stage procedure with scaphoid screw fixation (with a bone graft) and subsequent capsulodesis or another reconstruction technique to repair the scapholunate ligament is preferable [57–59].

12.8.2 Materials and Methods

Seven patients affected by scaphoid fracture and SL ligament lesions have been treated since 2008 (Figs. 12.20, 12.21, and 12.22). All were males, and the mean age was 29 years old [21–39]. There were four chronic injuries and three acute (operated within 3 weeks from trauma). All patients had standard X-rays with oblique scaphoid views. X-rays documented the scaphoid fracture in all cases: a waist fracture was shown in five cases, a proximal pole fracture in one case and a distal pole fracture in one case. MRI scans performed in all cases confirmed the scapholunate-associated lesion (Fig. 12.21). All patients were examined under arthroscopy. The treatment of acute injuries was arthroscopic examination of the wrist, screwing of the scaphoid fracture associated to pinning of the SL joint or dorsal capsulodesis [19]. In the chronic cases arthroscopy was used to

Table 12.2 Arthroscopic classifications of scapho-lunate ligament tears (simplified).

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<td>MC: normal</td>
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<td>II</td>
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<td>IV</td>
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confirm and stage the SL lesion, and classify it according to the Geissler and EWAS classifications (Fig. 12.22). The chronic patients underwent open surgery, screwing of the scaphoid (through a small volar approach or dorsal approach) and reconstruction of the SL ligament by capsulodesis according to Berger using the dorsal approach (Figs. 12.23 and 12.24). Capsulodeses were performed in the same intervention or secondarily in a second operation.

All patients were evaluated at a mean follow-up of 18 months (range 10–30 months). The Mayo wrist score was used to evaluate the patients at follow-up.

### 12.8.3 Results

Arthroscopy documented Geissler stage III in six patients and stage II in one patient (EWAS stages IIIC in six cases and EWAS IIIB in one case).

At follow-up X-rays documented healing of the fracture in all cases. The results were excellent in five and good in two cases according to the Mayo Wrist Score. Grip strength was comparable to the contralateral side in these patients, and the patients returned to their previous work. One patient...
patient reported occasional pain under load-bearing at follow-up. Two patients treated with dorsal capsulodesis had a slight reduction of flexion of the wrist. No complications were documented in the treated patients.

12.8.4 Discussion and Conclusions

The diagnosis of a ligamentous lesions in the wrist associated with scaphoid fracture has been evolving in the last years with the diffusion of wrist arthroscopy, which allows the identification of associated lesions. The association of scaphoid fracture and evident carpal instability has been described in the past, and traditionally these lesions were thought to be part of a perilunate dislocation type injury due to a high-energy trauma. Nowadays, we know that a spectrum of different ligament lesions can occur, and they can be associated in different ways, which are still being defined. Some authors have identified up to 75% of scapholunate tears associated with scaphoid fracture, in 25% of cases referred as complete ruptures [49]. Nevertheless, the lesions were not staged according to Geissler or other arthroscopic classifications, so it is difficult to evaluate the real percentage of cases that really needed surgical treatment of the scapholunate injury (at least 25%).

The routine use of wrist arthroscopy allows the detection of a variety of different lesions (bone fractures, ligament tears, cartilage damage, TFCC lesions). Wrist arthroscopy can also be performed with the dry technique, which has the advantage of avoiding fluid extravasation during the procedure. It is advisable to describe all the lesions in the operative report of each patient and if possible to treat them at the same time. Some are more severe or chronic, or require too much time to treat at the same time, and may require a subsequent surgical treatment. However, sometimes there are minor lesions (i.e., SL lesions, Geissler/EWAS stage I, II) that the surgeon can...
choose to leave alone or to select the best treatment option for the patient.

Our experience with the treated cases demonstrated that both lesions can be treated at the same time. A single dorsal approach or a double approach can be used depending on the type of scaphoid lesion. In acute cases without fragment displacement, the scaphoid fracture fixation can be performed percutaneously (under arthroscopic assistance) or through a short volar approach. Pinning of the SL space can be added to this procedure (Geissler stages II - III). The traditional volar approach is mainly used when the scaphoid fracture is displaced and needs to be reduced. The dorsal approach can also be used to fix the scaphoid in association with the treatment of the SL lesion. Chronic SL lesions, or acute ones in severe cases (Geissler/EWAS stage IV), are generally treated by a traditional dorsal approach: the SL ligament is identified and sutured with a bone anchor, and a capsulodesis is added as an augmentation technique using a radially based dorsal intercarpal ligament flap [57–59]. In chronic cases the choice of surgical approach to treat the scaphoid fracture depends on the condition of the scaphoid itself. If the scaphoid non-union has a humpback deformity, and a DISI is present, a cortical bone graft will be needed, and the volar approach will be mandatory; the dorsal approach can be adopted if there is no scaphoid deformity or carpal malalignment. The SL lesion can be treated at the same time by the dorsal approach, as previously described. With the development of new arthroscopic techniques, such as arthroscopic dorsal capsulo-ligamentodesis, it should now be possible to treat the fresh fracture and the scapholunate tear arthroscopically at the same time, which should simplify the technique [32, 58].

Our preliminary results are excellent and good; a longer follow-up is needed to evaluate the results correctly in the long term. According to our experience, lesions needing treatment do not occur frequently, but we cannot exclude that they are still underdiagnosed in clinical practice. We have to remind physicians that in perspective a residual carpal instability can lead to degenerative arthritis and an SLAC wrist, emphasizing the importance of early treatment of the SL lesions, especially in the young patient. The lack of identification of these lesions could also explain some of the not completely satisfactory results, even when the scaphoid fracture has been correctly treated and healed [50].
12.9 Innovative Procedures in Wrist Arthroscopy

Andrea Atzei, Federica Braidotti and Riccardo Luchetti

[AL08] 12.9.1

The introduction of the arthroscopic approach has provided tremendous improvement in the management of wrist disorders. Both diagnosis and surgical repair have improved in terms of accuracy and specificity, so that many surgeons use “all-arthroscopic” treatment, which allows results comparable or even superior to traditional surgical techniques.

As a mini-invasive procedure, arthroscopy has the advantage of reduced capsular damage and scarring; thus, joint mechanoreceptors are potentially preserved, and wrist proprioception can be subjected to the least alteration after the surgical procedure [60].

For this reason, a number of procedures have been proposed for the treatment of wrist ligamentous disorders, especially of the ulnar compartment and distal radioulnar joint (DRUJ), since this area is very narrow and difficult to reach by the open approach, and there are many important structures to protect.

Many repair techniques have been described for all-inside suturing of peripheral TFCC tears [61] or for TFCC foveal refixation when the DRUJ is unstable [24, 62]; these have shown very rewarding results.

12.9.2 Complete Arthroscopic Reconstruction of the TFCC

Recently, an arthroscopic reconstruction technique using a tendon graft has been introduced for non-reparable TFCC tears.

This technique is a modification of the open procedure originally described by Mansat (1983), then popularized by Adams (2001), which uses a palmaris longus graft through a transosseous tunnel into the radius and ulna [63, 64]. It takes advantage of the magnified visualization and easy access to intra-articular structures of the ulnar wrist in order to improve the accuracy of the surgical reconstruction.

Although the arthroscopic approach requires three 2.5/3-cm skin incisions for tunnel preparation, it produces very little capsular damage, which is limited to the standard radiocarpal portals (3–4; 4–5; 6R/6U) and to a small piercing of the ulnocarpal ligament interval. This piercing between the interval between the ulnolunate and the ulnolunotriquetral ligaments, just distal to the remnants of the palmar DRUJ ligament, improves stabilization of the ulnar carpus and allows a real anatomic reconstruction of the radio-ulno-carpal ligamentous complex (Fig. 12.25). Because of the limited field of view, this passage is much more demanding with the open technique than with arthroscopy. The procedure is further improved from the original version with the use of a 4-mm absorbable interference screw to secure graft fixation into the ulnar tunnel. The wrist is immobilized in neutral rotation or slight supination in a long-arm cast for 3 weeks, followed by a further 4 weeks in a Münster-type splint, to regain elbow flexion/extension. Then the wrist is protected by a short splint for 2 more weeks, and rotation is recovered. Afterwards, progressive resisted wrist and hand strengthening exercises are started. My personal experience with this technique started in 2005, and I have operated on 13 patients since then. I had only one intraoperative complication because of an undisplaced fracture of the ulnar tunnel that healed uneventfully, and at early follow-up DRUJ stability had been restored in all patients. At follow-up longer than 3 years, DRUJ stability had been maintained in all seven patients. The range of motion increased from 85% to 95% on the contralateral side, and the grip strength increased from 65% to 87%. Pain decreased from 8.7 to 1.7 on a 10-point visual analogue scale.

The patients were very happy, especially with the reduced early postoperative pain, which eased the early postoperative rehabilitation phases. The modified Mayo Wrist Score was excellent in five patients and good in two. All patients were satisfied with the results of the procedure and resumed their previous manual activities; only one changed work for unrelated reasons.
An arthroscopic approach may be of benefit also in the treatment of some forms of midcarpal instability (MCI). MCI is still a poorly understood condition that is common in patients with congenital or acquired ligamentous laxity. It is characterized by an abnormal motion of the carpus, with sudden VISI subluxation of the proximal carpal row, which causes the typical “clunk.” Although treatment of the most severe clinical forms (with very frequent and painful spontaneous clunks) requires partial carpal arthrodesis, milder forms respond to conservative treatment of tendon strengthening. The reconstructive problem is for those intermediate forms with transient wrist dysfunction for which partial fusion may be an over-treatment, but physiotherapy is not enough to reduce symptoms. In 2007 Mason and Hargreaves suggested application of capsular thermal shrinkage in order to reproduce the open technique of dorsal capsular reefing described by Lichtman in 2003. A cautious approach to ligament thermal shrinkage should be recommended because of the high risk of thermal injuries to intra-capsular (mechanoceptors) and capsular-adjacent structures (tendons and nerves), due to the reduced thickness of the wrist ligaments, and because of the usual high rate of recurrence of laxity following this procedure even in larger joints. As an alternative, capsular reefing may be achieved with the use of strong non-resorbable sutures (Fig. 12.26). Two sutures are introduced through the 6U portal in a sewing-machine fashion, retrieved and secured with an intra-articular sliding knot through the MCU and MCR portal, respectively, after catching the dorsal radiotriquetral ligament and dorsal intercarpal ligament. Tightening of the dorsal ligaments produces a reduction of the VISI subluxation via a direct mechanical effect. We can also suppose the occurrence of a dynamic effect that is produced by the enhancement of the tone of the stabilizing periarticular muscles caused by the stimulation of the ligamentous mechanoceptors.
due to ligament stretching. Patients should wear a short arm splint for 3 weeks, then use a specifically designed hinged splint restricting radio-carpal motion for a further 3 weeks. Rehabilitation along the arc of the DTM is facilitated, and recovery of the complete arc of motion along other patterns is discouraged. Isometric co-contraction of the ECU and FUC and progressive proprioception exercises are started at 4 weeks. Forearm strengthening is not allowed before 3 months postoperatively. Return to work is allowed after recovery of adequate muscular strength, and patients are instructed how to maintain good ECU and FUC muscular tone. In my experience with four patients reviewed at an average follow-up of 1.7 years, this technique is very effective in preventing wrist clunking. All patients improved and returned to heavy work. The modified Mayo wrist score was excellent in two cases, good in one and fair in one, mainly because of the loss of range of motion.

### Conclusions

Wrist arthroscopy is a very useful tool to correctly evaluate traumatic and post-traumatic radiocarpal, midcarpal and hand injuries. Intracarpal lesions of the ligaments and TFCC can be directly visualized and repaired. Articular joint surfaces can be visualized and anatomically reduced. Nevertheless, the technique is demanding, and accurate training on cadaver specimens is necessary to learn the technical skills and to minimize the operating time.

The increased use of arthroscopic examination of the wrist is advisable in wrist trauma in order to establish a correct diagnosis, prognosis and treatment of all the patient’s lesions, possibly preventing the future development of degenerative arthritis.

### References


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