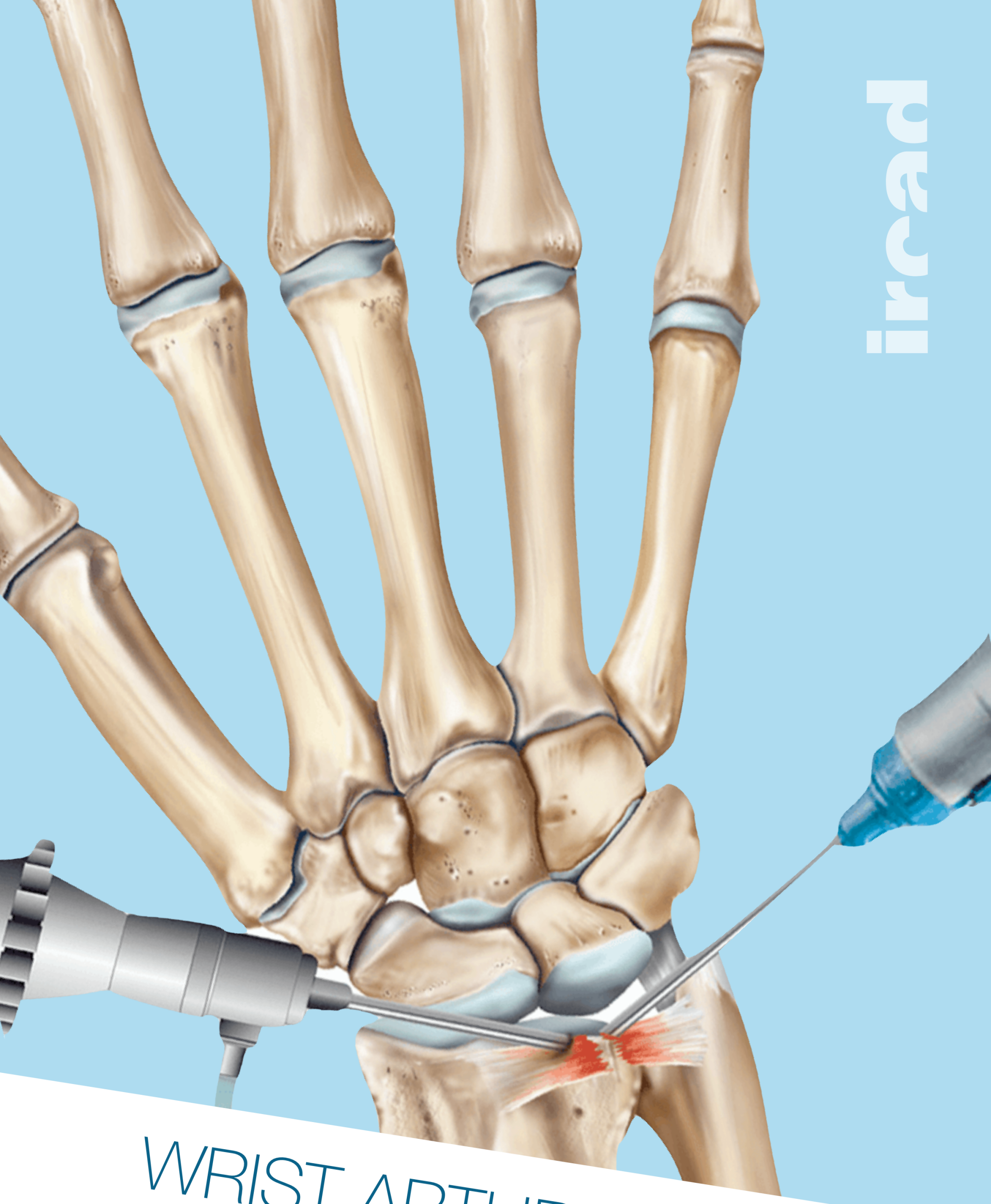

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WRIST ARTHROSCOPY

SURGICAL TECHNIQUES

by Christophe Mathoulin

Edited by WebSurg

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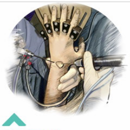
WRIST BASECAMP

The treatment of wrist pathologies has been revolutionized by the advent and development of wrist arthroscopy.

Since then, many indications have been modified and others are developed every day. Sometimes absent from the surgical philosophy of some centers, wrist arthroscopy remains an indispensable tool for any modern wrist surgeons, regardless of their practice location. The objective of senior surgeons is to pass on their experience to novice students who are curious about learning new techniques.

Each year, numerous hands-on training programs on cadavers are organized by different scientific societies with a predominance of courses organized by the IRCAD-IWC worldwide, in close partnership with IWAS, EWAS, and APWA. However, although they represent the most effective way to learn arthroscopy, such courses on cadavers are still geographically complicated for many students.

Since March 2020, virtual training, e-learning, and other means of online education are breaking records and seem to be a novel and highly satisfactory learning solution. It is subsequently mandatory to encourage the teaching of wrist arthroscopy and to allow learners to



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In this module, you will learn the basics of wrist arthroscopy.

CAMP TWO
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This module will address ligaments and ganglia.

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This module will address the triangular fibrocartilage complex (TFCC).

CAMP FOUR
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This module will address bones and trauma.

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This module will address Osteoarthritis and arthrodesis.

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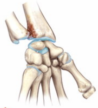


CAMP SEVEN
DRUJ
This module will address the distal radioulnar joint (DRUJ).

train anytime, anywhere, at a lower cost. It is why IRCAD-IWC, in partnership with IWAS and APWA, offers a completely charge-free online educational program:

the WRIST ARTHROSCOPY BASECAMP. In this new methodological resource, a large number of surgical techniques are grouped thematically, including lectures given by faculty experts regarding wrist pathologies. Self-assessment tests allow to validate continuing professional development at the European level (CME credits).

This educational platform will represent a hub to share experience, methodology, and new techniques in the armamentarium of wrist arthroscopists.

The Brussels-based European Union of Medical Specialists (UEMS-EACCME) has accredited 4 e-learning modules (ELMs) included in the WRIST ARTHROSCOPY BASECAMP, allowing learners to earn 4 European CME credits (ECMECs): https://websurg.com/fr/basecamp/wrist:

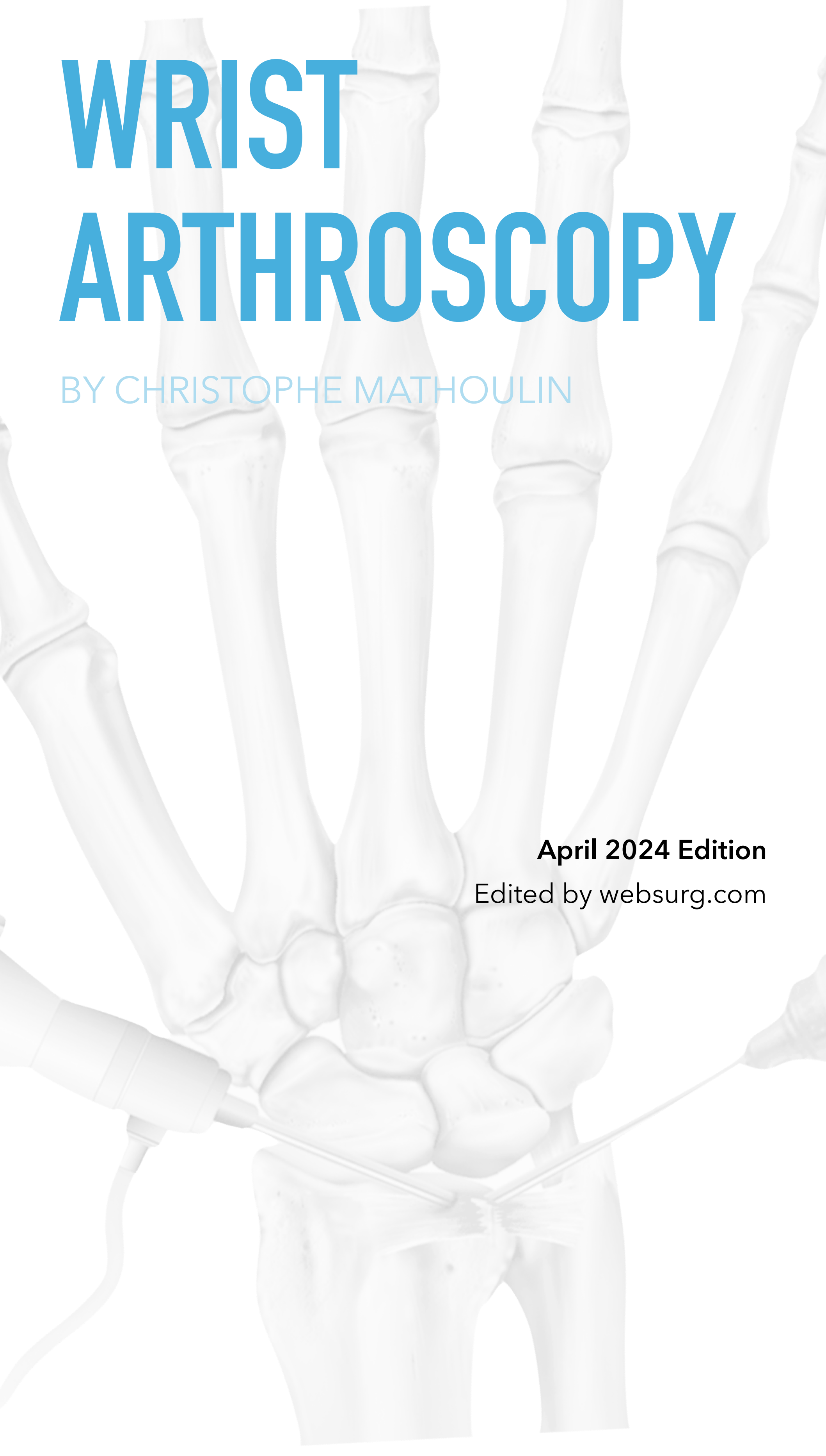
- Bone and trauma - 1 ECMEC
- TFCC and DRUJ - 1 ECMEC
- Ligaments and lymph nodes - 1 ECMEC
- Basics of arthroscopic anatomy - 1 ECMEC

A major milestone for IRCAD-IWC

www.ircad-iwc.org

WRIST ARTHROSCOPY

BY CHRISTOPHE MATHOULIN



April 2024 Edition
Edited by websurg.com

FOREWORD

It is a privilege to be asked to write a foreword for this magnificent e-textbook. Exceptional video content propels this 3rd edition far beyond the original version. I am humbled by Professor Christophe Mathoulin and the contributing authors who have invited me to provide an introduction to this display of their academic achievements. For many of them, it seems that I have become known as "the grandfather of wrist arthroscopy." I do hope that it at least suggests a seasoned perspective for arthroscopic techniques.

Surgeons have a conundrum. Surgical repair or reconstruction of tissues subjects a patient to additional iatrogenic trauma. Any rearrangement of a patient's anatomy requires surgeons to take a recuperative step backward before progressing forward. For patients candidates for surgery, it is the proverbial quid pro quo. Balancing the "cost:benefit" ratio for surgery is challenging. Ensuring a patient's benefit, the surgeon's judgment, skills, and compassion will exceed the patient's test costs.

This e-textbook will guide such judgment and aims to enhance our surgical skills. Conceived, designed, and largely written by Professor Mathoulin, this textbook offers pioneering and novel state-of-the-art surgical approaches and solutions to many common pathologies of the wrist. It displays innovative wrist surgical procedures with brief descriptions, outstanding illustrations, and video demonstrations. The e-book format makes the text uniquely accessible and portable.

It can be either studied or used as a reference by surgeons preparing for sound, precise, and logical surgical wrist arthroscopy procedures.

This e-textbook boosts wrist surgery enormously. It does not only attempt to be comprehensive in addressing every wrist injury, congenital deformity, and degenerative condition, but it is also a practical, if not essential, resource for wrist surgeons who have basic competence with wrist arthroscopy when they deal with challenging cases. Professor Mathoulin is a creative thinker and an innovative surgeon. His personal surgical experience is rife and his keen interest in surgical education, most particularly regarding the wrist, has become an internationally known phenomenon.

Wrist arthroscopy techniques will both educate and challenge wrist surgeons of all levels worldwide. It will help us to broaden our surgical prowess and enhance our understanding of many wrist disorders. Wrist anatomy is complex, and its functional anatomy is even more so. Wrist biomechanics are uneasy to fully comprehend. This text elucidates many of such puzzles.

Over the past years, I composed this triplet for progress and success, whether for research and development or for complex and complicated surgical challenges:

- Trust your imagination,
- Believe in possibility,
- Seize opportunities.

Professor Mathoulin fulfils this mantra. In devising innovative surgical approaches to unsolved wrist pathologies, many of which are described in this text, he has demonstrated a leadership role for progress and success in wrist surgery. He has become a wrist surgery evangelist. His passion for teaching gains new expression with this unique and elaborate e-textbook. The reader will surely use it often and enjoy it.

The conundrum of the trauma of surgery must be substantiated by therapeutic results. Wrist arthroscopy techniques truly help to ensure such outcomes. Arthroscopic or minimally invasive surgical approaches to the wrist contribute to preserve normal anatomy. Uninjured by the surgery, protected tissues do not have to recover or be rehabilitated postoperatively. Reparative and reconstructive procedures described in this text are logical, have been practiced and proven, and address patient discomfort or dysfunctioning in a prudent and expeditious manner.

I am confident that this compendium of arthroscopic surgical techniques for the wrist will be greatly beneficial to patients and surgeons throughout the world, for a long time to come.

Terry L. Whipple, MD, FAOA

PREFACE

Wrist arthroscopy is a much newer field than knee or shoulder arthroscopy, although Watanabe first explored the wrist arthroscopically in the early 1970s. More than 10 years went by before wrist arthroscopy was used for diagnostic purposes, and more than 20 years before feasible and reproducible treatments could be realistically contemplated.

I started to perform wrist arthroscopy in 1985. At that time, the scopes were not well-suited to the small size of the wrist joint. Many of us abandoned this instrument in favor of CT arthrography and MRI to diagnose wrist injuries. However, the limitations of such imaging modalities and the introduction of smaller scopes for the wrist joint soon led to a resurgence of interest in wrist arthroscopy, which is currently more than just a diagnostic tool.

With a group of colleagues and the support of KARL STORZ Endoscopy, the European Wrist Arthroscopy Society (EWAS) was created in 2005. It is the only scientific organization committed to developing and teaching wrist arthroscopy. The society immediately took off and its membership continues to grow. It gathers together surgeons interested in technology progress from the world over. Within a span of 10 years, the EWAS has become an internationally renowned organization with its own peer-reviewed journal (*Journal of Wrist Surgery, JWS*) and has been invited to participate in many scientific meetings. This success leads to logically evolve toward an international society, with the transformation of

EWAS into IWAS (International Wrist Arthroscopy Society).

With so many surgical techniques currently available, performing wrist surgery without a mastery of arthroscopy seems inconceivable.

The first edition, published in 2015, which I had written with Dr. Mathilde Gras, was a real success. However, some techniques have evolved, and with Dr. Jan Ragnar Haugstvedt, and with the contribution of new international authors, all experts in wrist arthroscopy, we have decided to create a new e-book, with many videos, which communicate much more than simple images, thanks to the help of the WebSurg team (IRCAD France).

This e-book evolves over the years, getting enriched by new chapters, and even sees some being relinquished.

I would especially like to thank Terry Whipple, who was a teacher to all of us, having largely conceived most of the arthroscopic wrist procedures, and who remains actively involved in the EWAS and keeps supporting us.

I hope this e-book will help you to perform groundbreaking techniques or at least inspires you to try them!

Christophe Mathoulin, MD, FMH

ACKNOWLEDGMENTS

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Special thanks go to:

The entire WebSurg team for providing us with videos, modeling this e-book, and making it available to everyone.

SUMMARY

1.
ARTHROSCOPIC ANATOMY

CLEMENT PRÉNAUD

AHLAM ARNAOUT

Introduction

The anatomy of the wrist is currently well-known, and many anatomical sources describe the components of this complex, functional, and well-organized joint. However, arthroscopic anatomy is particular in that the arthroscope provides vision “inside” the joint, and one must learn to analyze the view of the bones and ligaments from inside the wrist joint so that the brain can reconstruct the global wrist structure. The first step is to examine diagrams and dissections with the distal end of the wrist **(Figure 1, Figure 2, Figure 3)**, as most arthroscopy procedures are performed with axis translation with the hand in the “American position” (i.e., the fingers pointing toward the ceiling). Another critical particularity is that traction creates new anatomical spaces, allowing the arthroscope to enter the wrist.

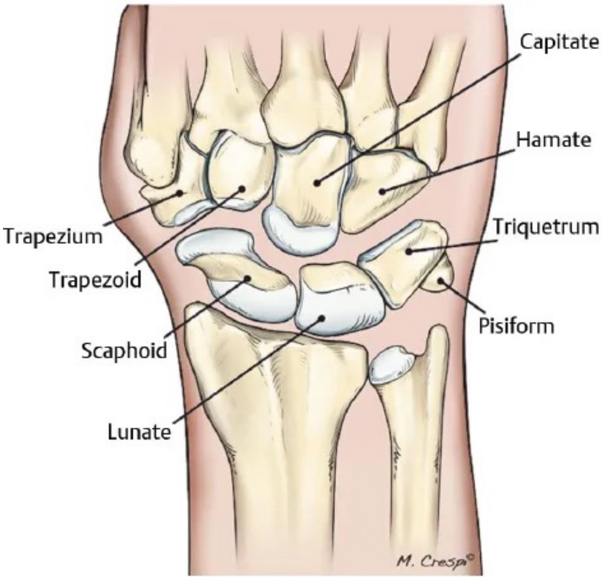


Figure 1.

Diagram of first and second carpal rows, with traction on the wrist creating sufficient space to allow passage of the scope and instruments.

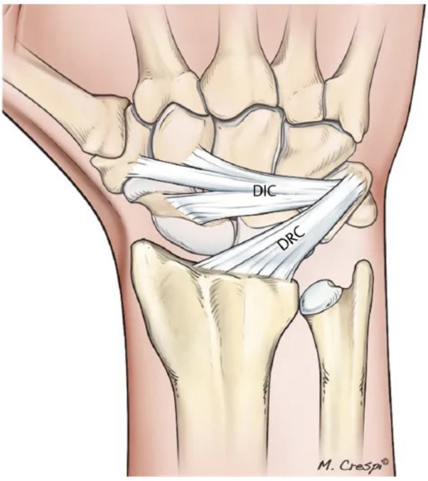


Figure 2.

Diagram showing the dorsal extrinsic ligaments: dorsal intercarpal (DIC) and dorsal radiocarpal (DRC).

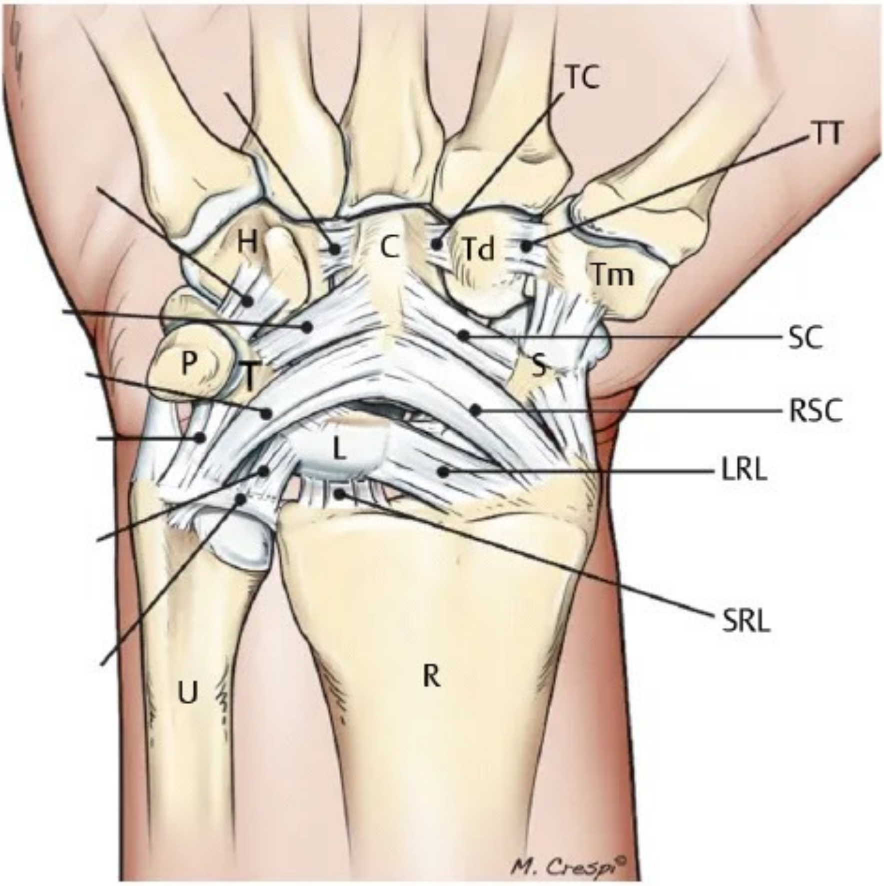


Figure 3.

Diagram showing the palmar extrinsic ligaments.

H, hamate
C, capitate
Td, trapezoid
Tm, trapezium
P, pisiform
T, triquetrum
L, lunate
S, scaphoid
U, ulna
R, radius

RSC, radioscaphocapitate ligament
LRL, long radiolunate ligament
SRL, short radiolunate ligament
UL, ulnolunate ligament
UT, ulnotriquetral ligament
UC, ulnocapitate ligament
TC, trapezocapitate ligament
SC, scaphocapitate ligament
PRU, volar part of the TFCC

Exploration

1. Principles of exploration

Traction in the axis of the wrist creates space between the radius and the first carpal row—the radiocarpal space and between both carpal rows—the midcarpal space. Saline injection can help to distend these potential spaces.

Entry into the joint is achieved using blunt-ended clips so as not to injure the "noble structures" (i.e., nerves, veins, and tendons), using the conventional arthroscopic portals.

The basic exploration of the wrist systematically includes a radiocarpal and midcarpal exploration. The objective is first to identify and evaluate the ligamentous and cartilaginous structures **(Figure 4)**.

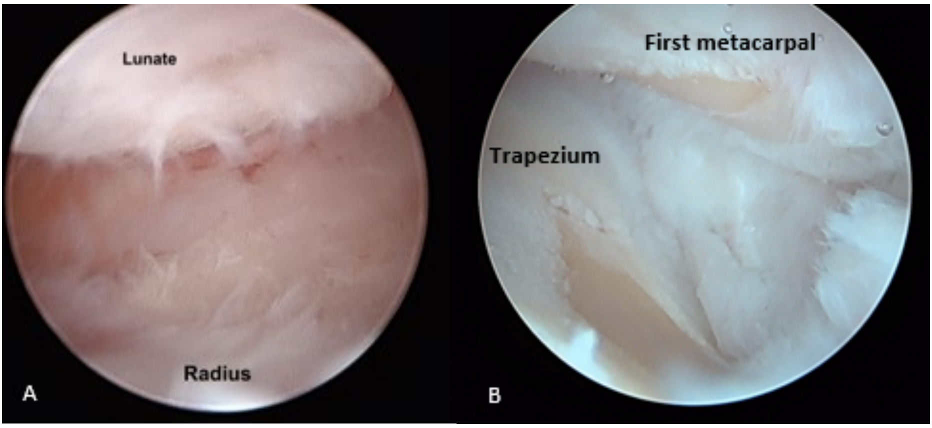


Figure 4.

Views of cartilaginous lesions during radiocarpal exploration (A) and carpometacarpal joint exploration (B).

2. Radiocarpal exploration

We usually start through the 3–4 radiocarpal portal and immediately find the scapholunate ligament, a shiny valley between the 2 promontories of the lunate and scaphoid. We then push the scope to find the ligament of Testut at the junction between the palmar part of the scapholunate ligament and the anterior capsule of the wrist. The scope is directed laterally, and the lateral distal part of the radiocarpal joint is visualized (i.e., the distal pole of the scaphoid above, and the scaphoid fossa and radial styloid below). The entire convexity of the scaphoid and radial cartilages can be assessed. If the scope is pushed forward, the anterolateral extrinsic ligaments can be seen: the radioscaphocapitate ligament (RSC), and the long radiolunate ligament (LRL). These ligaments are better seen on arthroscopy than in cadaveric dissection since they are intracapsular and extrasynovial. Their tension can be tested either by moving the wrist in ulnar and radial deviation or by using a probe inserted through the 6R or 4–5 portal. The zone of origin of palmar wrist ganglia lies between these extrinsic ligaments.

The scope is then slid from lateral to medial following the scaphoid convexity to find the scapholunate ligament depression, a concave furrow extending from the cartilages of the two bones: the proximal pole of the scaphoid and the proximal aspect of the lunate. The scapholunate ligament can be visualized entirely, from its palmar aspect to its dorsal side. The radioscapholunate ligament of Testut should not be mistaken for pathological synovitis; it can be more or less vascularized. Not a real ligament, it is rather a vessel and a proprioceptive nerve carrier for the SL ligament, with no stabilizer role. It is the direct prolongation of the anterior vessels and the anterior interosseous nerve. On the anterior aspect of the carpus, and just medial to the ligament of Testut, lies the short radiolunate (SRL) ligament, which is more difficult to see.

By drawing the scope slightly backward, the distal surface of the radius can be assessed, with the scaphoid fossa laterally and the lunate fossa medially separated by a bony ridge related to the SL ligament.

We then move medially to the radiocarpal joint. We follow the proximal surface of the lunate. The lunotriquetral ligament can be seen above as a valley between the lunate laterally and the triquetrum medially. The triquetrum is less often seen through the 3–4 portal. Medially to the short radiolunate ligament (SRL) is the ulnolunate ligament (UL), which joins the anterior part of the TFCC and the lunate, and then the ulnotriquetral ligament (UT), which joins the anterior part of the TFCC and the triquetrum.

The key to assess the medial radiocarpal joint is the triangular fibrocartilage complex (TFCC) exploration. The TFCC is a fibrocartilage disc, normally tense, with a medial insertion showing a regular anatomical perforation called the styloid recess. Its peripheral insertions on the palmar and the dorsal capsule and on the radius can be assessed, as well as its foveal insertion on the ulnar head **(Figure 5)**.

Figure 5.

Anatomical cut showing the TFCC with its foveal insertion.

A hook introduced through the dorsal 6R portal can be used to assess all insertions and test the trampoline effect (the hook should spring back briskly when this ligament is stretched and tensed, and it should return to normal upon release).

To complete the radiocarpal joint exploration and "see" specific zones, the scope position may be swapped (in the 6R portal) with the instruments (in the 3–4 portal). The assessment of the triquetrum, the lunotriquetral ligament, and of the lunate is easier in this position. It is the only approach through which the dorsal “cul de sac” can be seen between the reflection of the dorsal capsule and the first carpal row, especially the attachment of the dorsal portion of the scapholunate ligament to the dorsal capsuloscapholunate septum (DCSS), one of the first zones affected in scapholunate instability **(Figure 6, Figure 7)**.

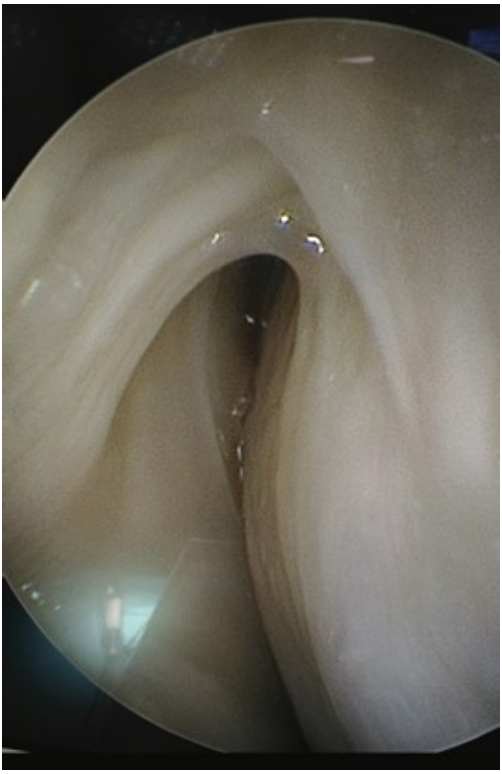


Figure 6.

Radiocarpal arthroscopic view showing the dorsal capsuloligamentous insertion of the scapholunate ligament (dorsal capsuloscapholunate septums, DCSS).

Figure 7.

Anatomical section showing the dorsal capsuloligamentous septum (DCSS), between the dorsal portion of the scapholunate and the dorsal capsule (DIC).

In normal conditions, the DCSS presents a shape of cathedral arches. Its status could be graded in 4 stages according to the trampoline aspect and to the fiber attachment **(Figure 8)**.

Stage 0: The DCSS presents an intact aspect.

Stage 1: The DCSS is loosened when palpated with a probe. It presents partial detachments on its distal insertion with >50% of continuous fibers.

Stage 2: The DCSS is loosened when palpated with a probe. It presents partial detachments on its distal insertion with <50% of continuous fibers.

Stage 3: The DCSS is totally torn.

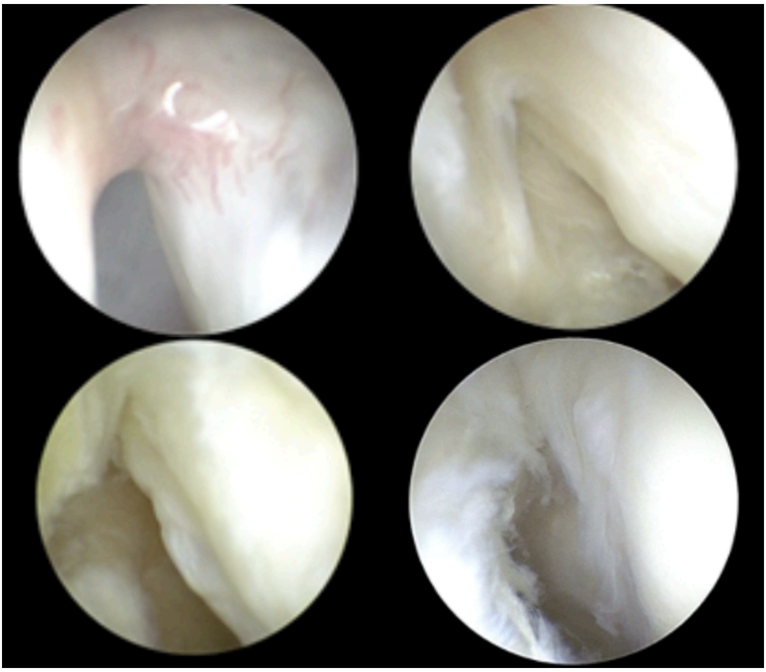


Figure 8.

Views of the different stages of the DCSS.
A, Stage 0, B, Stage 1, C, Stage 2, D, Stage 3
L, Lunatum.

3. Midcarpal exploration

The midcarpal joint is first explored through the ulnar midcarpal MCU portal. It is easily localized at the depression between the four medial bones. Due to the direction of the scope, the first zone visualized is the distal scapholunate space. Normally, it is an interval between the scaphoid laterally and the distal concave surface of the lunate medially. A probe is inserted through the radial midcarpal portal (RMC) to test this joint.

The scope is slid medially in the midcarpal joint and the bony structures are assessed. Above, one can see the rounded cartilaginous surface of the capitate head, and medially the head of the hamate, and the interval between the two bones are also visible. We can follow the distal hamate medially. Below, we follow the concave aspect of the lunate, as well as its two palmar and dorsal horns, and then the interval between the lunate and the triquetrum.

The geometry of this joint depends on the shape of the lunate, which offers two possibilities: the surface is smooth between the two bones (Viegas type 1), or shows a ridge on the distal medial part of the lunate forming a valley where the head of the hamate articulates (Viegas type 2). The hamate does not form an inverted glenoid cavity; it is more like a trochlear joint.

It is possible to see the distal part of the great extrinsic palmar radiocarpal ligaments once the synovium has been cleaned away to better distinguish the different ligaments. Laterally, we can see the scaphocapitate portion of the RSC ligament, and medially the ulnotriquetrocapitate (UTC) ligament; both form the arcuate ligament, the rupture of which causes palmar midcarpal instability **(Figure 9)**. Below and medially, we can see the RSC and the distal terminal part of the LRL ligament.

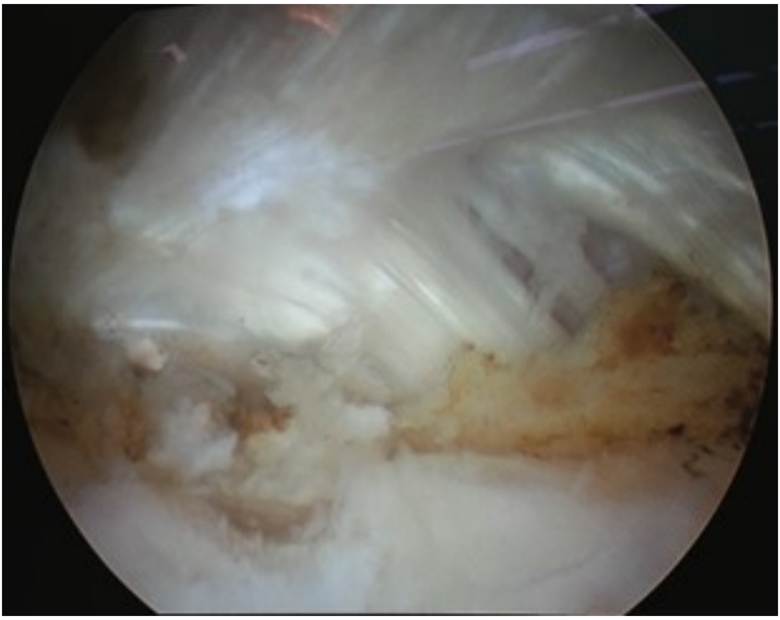


Figure 9.

Midcarpal arthroscopic view showing, after cleaning and excision of the synovium, the internal view of palmar extrinsic ligaments: the arcuate ligament formed by the union of the ulnocapitate ligament on the left and the radioscaphocapitate ligament on the right. Proximally, the long radiolunate ligament can be seen.

Swapping the position of the scope to use the RMC shows the medial portion of this joint, as well as the dorsal capsule, using the combined effect of the obliqueness of the camera and the triangulation effect. It is the only suitable approach to study the medial distal aspect of the scaphoid or the scaphotrapezotrapezoid joint (STT).

By moving the scope laterally and distally, we follow the scaphoid and the lateral aspect of the capitate medially to see the STT joint distally. The synovium can be debrided using a shaver through a 1–2 midcarpal portal. With the scope in this portal, and assisted by means of traction on the thumb, the STT can be entered and seen completely. We can then follow the distal dorsal medial portion of the joint and check the dorsal aspect of the capitate up to the carpometacarpal joint.

Tips & tricks

- Using a shaver, it is essential to perform a synovectomy and clean the joint of any debris for a better visualization.
- The deep side of the TFCC can be explored through the distal radioulnar portal (DRU) up to the foveal insertion and the sigmoid fossa of the radius.
- Another way to have a direct access to the fovea is to use the direct foveal portal (DF), which allows for a direct exploration of the foveal insertion of the TFCC.
- With the scope position in the 6R portal, with the instruments through the 3–4 radiocarpal portal, the assessment of the triquetrum, the lunotriquetral ligament, and of the lunate is easier.
- The evaluation of the DCSS is achieved with a hook probe introduced through the 3–4 radiocarpal portal.

- To see the DCSS, the scope can be introduced into the 6R portal or the 1-2 portal.
- Moving aside the dorsal capsule with the probe allows to adequately visualize the DCSS.

Conclusion

A thorough knowledge of the conventional anatomy is essential to understand the arthroscopic anatomy of the wrist.

Both radial and midcarpal joints are complex. Although arthroscopy is no longer used for diagnostic exploration exclusively, the first step of every arthroscopy should be dedicated to analyze the different anatomical structures, which can be directly seen perfectly. Additionally, a sound knowledge of this “arthroscopic” anatomy can bring to light new anatomical structures (e.g., the dorsal capsuloscapholunate septum [DCSS]). It can also help to understand specific pathologies such as midcarpal instability, and allow some procedures such as dorsal capsuloligamentous suturing.

Video 1: Wrist Arthroscopic Anatomy
https://vimeo.com/917902436

2.
MATERIALS AND SET-UP

MATHILDE GRAS

Introduction

Knee and shoulder arthroscopies have been performed for a long time. Wrist arthroscopy has been developed more recently, especially for surgical techniques. The wrist is particularly mobile, with very little space between its constituent radiocarpal, midcarpal, and distal radioulnar joints. An adequate set-up maintains joint position, and produces axial traction to create sufficient space for the instruments.

Materials

1. Arthroscopy Unit

The arthroscopy unit is similar for all broadcasted surgeries. It includes a monitor, a video camera, and a light source. A compact camera head is the most adapted one to the small camera used. Xenon or LED lamps are replacing halogen lamps since they last longer and provide a better quality lighting. Additionally, image or video recording devices are usually available for record keeping, publication, or teaching purposes. The video camera, the light source, and video exporting are integrated within the same compact box. Nowadays, advances in light sources and recording technologies allow for the integration of a video camera, a light source, and video exporting within the same compact box. The use of a printer is no longer necessary due to electronic exporting systems. However, immediate printing is still a simple method to show the operation report to the patient and file a record in the patient's notes.

2. Arthroscope

A small arthroscope (1.9–2.7mm) is usually used for the wrist, with a camera angulated at 30 degrees **(Figure 1)**. The arthroscope is short (60–80mm) to adapt to the size of the wrist and to the depth of the surgery zone, and to prevent obstruction of instruments outside of the wrist. The sheath includes a connector for irrigation, and the trocar must be blunt to prevent cartilaginous lesions.

Figure 1.

Arthroscope with camera angulated at 30 degrees, 1.9mm in size, and 2.4mm in diameter.

3. Instruments (figure 2)

The instruments are also designed for precision and to limit the magnitude of external movements. Curved mosquito forceps are used to create the portals and to grasp structures. The probe is a basic instrument for joint exploration. Fine instruments such as graspers and resection forceps may be used. Angulated instruments can provide access to certain structures that would otherwise be inaccessible through the small joint intervals. A motor is fitted with abrasive instruments, such as shavers for synovial resection or burrs for bone resection, of appropriate sizes (2–3mm in diameter and 6–8cm long). A cannulated wide-bore needle is used for the passage of sutures, and mini anchors are used for ligament repair.

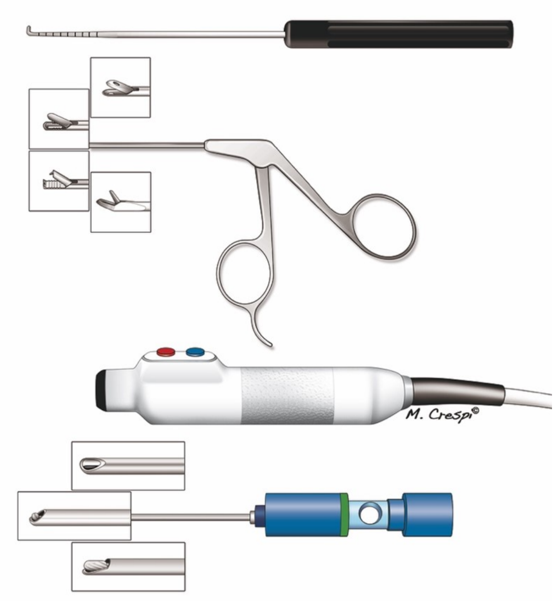


Figure 2.

Basic instruments (i.e.,probe, basket grasper, mini motor with shaver and burr).

4. Traction

The wrist is a tiny joint. Traction is necessary in order to create a space for the insertion of the scope and instruments and to prevent cartilage damage. The traction applied is usually 5 to 7 kg, but it can be only 2 to 3 kg, such as for the thumb. Traction is vertical in the axis of the forearm and allows for the stabilization of the limb for surgery. The arm is fixed on the table horizontally, and the elbow is flexed at 90 degrees with the hand pointing upward. This traction can be maintained using weights connected to a cable supported by either stands or sterilizable towers **(Figures 3 and 4)**, which allow to orientate the joint during arthroscopy. Traction is applied to the hand using either Chinese finger traps or a traction hand. New adapted tables are currently available, facilitating the set-up.

Figure 3.

Set-up with vertical traction using a stand.

Figure 4.

Set-up with vertical traction using a traction tower.

5. Irrigation

Not all surgeons use irrigation; some prefer "dry arthroscopy." However, irrigation is frequently useful to clean the joint, and it is mandatory when using radiofrequency waves where the heat that is generated may cause burns. Irrigation in the wrist joint is unnecessary for joint dilatation; it is maintained via traction. It is subsequently possible to use a low pressure, which limits the diffusion of saline into the tissues.

Wrist arthroscopy can be performed either wet or dry. In case of wet arthroscopy, physiological saline is used with low pressure, without arthropump. The fluid pack is placed 50cm above the level of the wrist. Irrigation inflow takes place through the sheath of the arthroscope. A trocar is not necessary for outflow since saline is evacuated through the portals used. The suction provided by the shaver is used for joint cleaning. Constant rinsing of the joint provides a better visualization and eliminates debris from intra-articular procedures, thereby reducing the risk of infection. It also prevents tissue heating with the use of motorized instruments and diathermy or vaporization. If there is no tourniquet, irrigation contributes to limit bleeding by increasing intra-articular pressure. However, if not controlled, irrigation may infiltrate the surrounding tissues.

Set-up

Arthroscopy is usually performed under a locoregional anesthesia with a tourniquet on the distal arm close to the elbow. The elbow is fixed to the arm table, which prevents movement between the fixed area and the elbow during traction **(Figure 5)**. An axillary block is the anesthesia of choice for wrist arthroscopy since it causes complete muscle relaxation, makes the tourniquet better tolerated, and ensures postoperative analgesia. It also shortens the length of hospital stay. A tourniquet is usually used to obtain a bloodless field, although some authors currently advocate arthroscopy under local anesthesia without a tourniquet (1).

Figure 5.

Countertraction placed on the tourniquet.

The patient lies supine with the shoulder at a 90-degree abduction. If a traction tower is used, it is placed on the arm table. The surgeon stands at the head of the patient with the assistant beside or facing the surgeon. The arthroscopy unit may be on the other side of the patient facing the surgeon, or sometimes facing the arm table **(Figure 6)**.

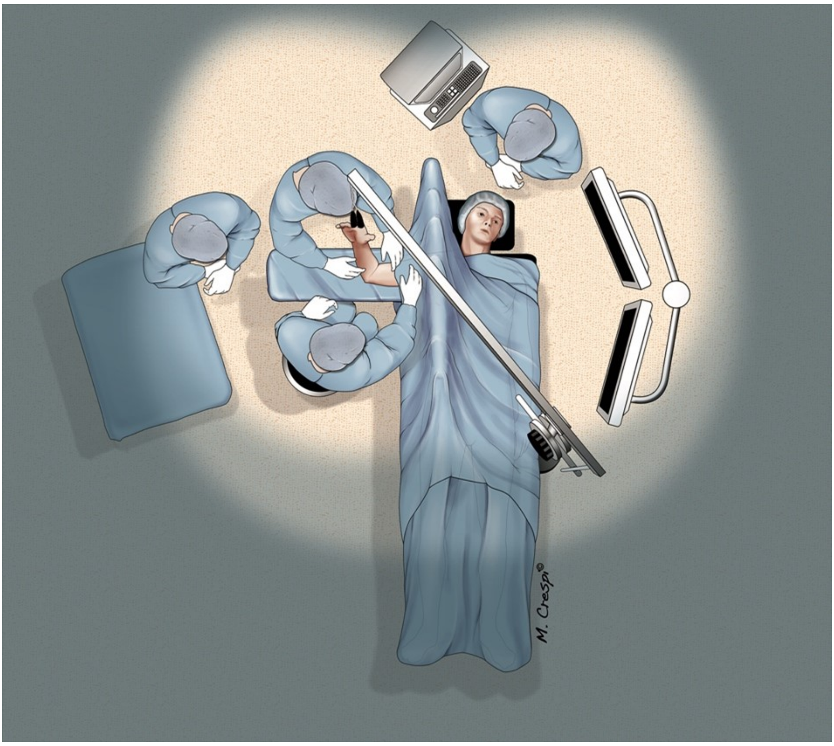


Figure 6.

Diagram showing the patient lying with traction on the arm vertically, surgeon at the head, and assistant facing the surgeon.

Tips & tricks

- Vaporization is not recommended in the wrist.
- Countertraction has to be as close as possible to the elbow, on the tourniquet.
- When traction is put in place, one must control that the counter-support has not moved.
- Wet arthroscopy allows for a better vision and cleaning of the joint.

Conclusion

Wrist arthroscopy requires a thorough knowledge of the wrist, set-up, and small instruments adapted to the wrist due to the complicated anatomy and narrowness of the joints. Special attention must be paid to set-up in order to allow for adequate technical gestures and maneuvers.

Video 2: Wrist Arthroscopy Materials and Set-up
https://vimeo.com/917903137

3.
SURGICAL APPROACHES

JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

Arthroscopic surgery avoids the joint exposure that results from extensive surgical approaches. Conventional wrist surgery incisions are known to cause fibrosis and stiffness. As a result, arthroscopic approaches are as small as possible. This chapter describes the main arthroscopic approaches, knowing that other possibilities exist, depending on the surgeon, the amount of exposure required, and variations in anatomical configuration.

General principles for approaches

The incisions are horizontal, following the skin creases, and they are left to granulate to achieve a cosmetically pleasing scar. A No. 15 blade is used. No. 11 blades are used for other joints such as the shoulder or the hip, but not for the wrist where noble structures, such as tendons, vessels, and nerves, lie just beneath the skin and are at risk of injury **(Figure 1)**.

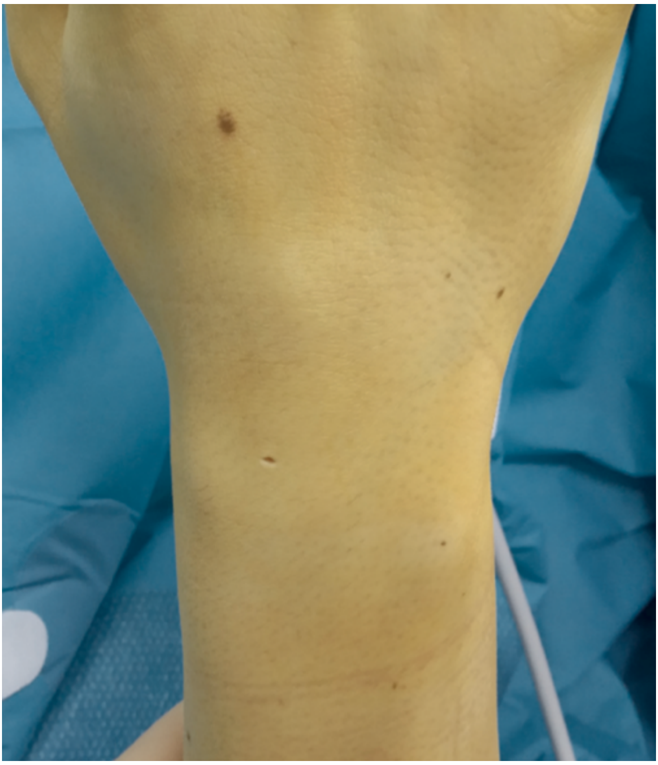


Figure 1.

Operating view of a 3–4 portal. The approach is a small horizontal skin incision allowing for the introduction of instruments and scope.

The steps to establish an approach or portal are always the following ones:

- Finger palpation of the zone,
- Placement of a needle in the exact location of the portal, taking into account bony anatomy and the required angle,
- Short incisions of 1 to 2mm using No. 15 blade,
- Breaching of the skin and the capsule using a blunt mosquito clip to push any noble structures away without injuring them.

The dorsal radiocarpal portals are named for the dorsal extensor compartments in between, so that the 3–4 portal lies between the 3rd and 4th compartments and the 6R portal is radial to the 6th compartment, and so on.

Radiocarpal portals

Radiocarpal portals are named according to their positions in relation to the dorsal extensor compartments **(Figure 2)**.

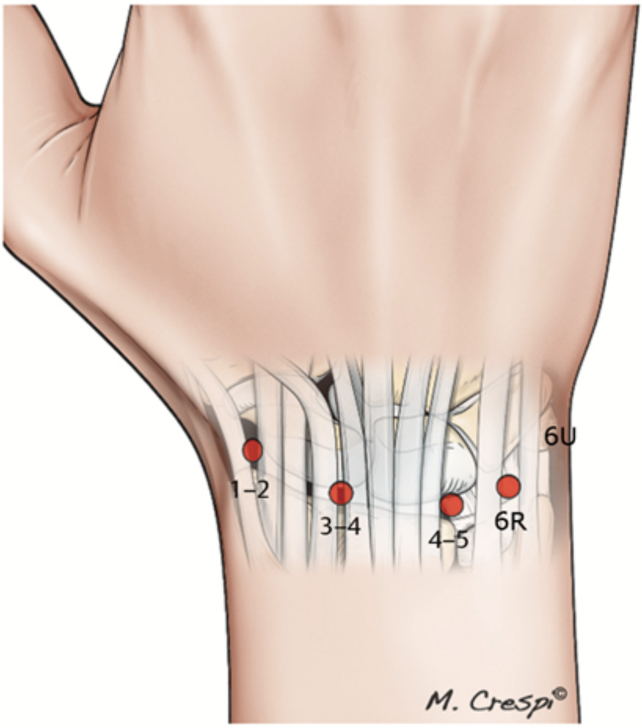


Figure 2.

Diagram showing conventional radiocarpal portals named according to their position in relation to dorsal extensor compartments.

1. 3-4 radiocarpal portal

This portal is the real key to wrist exploration and the easiest one to identify. The first method of identification uses the 'three circles' technique: a circle is drawn over the tubercle of Lister, two identical circles of the same size are marked distally, and the portal is located at the center of the third circle. In the second technique, the thumb is held vertically against the wrist so that the pulp feels the tubercle of Lister and the tip is at the distal end of the tubercle, the thumb is rolled toward the distal end of the wrist, the second phalanx of the thumb (P2) passing from a vertical to a horizontal position, and the tip falls into the dip of the radial radiocarpal joint. The 3–4 portal is located just over the nail.

Once the position has been marked, the needle is inserted, respecting the radial slope from dorsal to palmar and from lateral to medial. Once the needle has been correctly placed (i.e., felt freely within the joint), the portal is established as usual using a blunt mosquito forceps.

One way to know if you have entered the joint through the 3-4 portal is to turn the scope in the ulnar direction and see if it holds itself, resting on the TFCC. Careful dissection must be performed before perforating the capsule since the risk (although very rare) of this approach is injury to the posterior interosseous nerve.

2. 6R radiocarpal portal

This portal is easy to find once the 3–4 radiocarpal portal has been established. The scope in the 3–4 portal is directed ulnarward and when facing the triangular fibrocartilage complex (TFCC), the spot for the 6R portal is seen through transillumination. Its correct position is controlled using the needle in the joint.

3. 4-5 Radiocarpal portal

This portal is less frequently used, as the previous two portals are sufficient to explore the wrist. However, it may be useful for specific techniques. With the scope in the 3–4 portal, a needle is used to locate this portal situated between the 4th and the 5th compartments, 1cm laterally to the 6R portal.

4. 6U radiocarpal portal

This portal was conventionally used for outflow. It is often associated with a direct foveal distal radioulnar portal for the foveal reinsertion of the TFCC.

The 6U radiocarpal portal is ulnar to the extensor carpi ulnaris tendon (ECU) on the medial aspect of the wrist.

The scope in position 3–4 is pushed ulnarward and placed at the TFCC, facing the styloid recess. The intramuscular needle must emerge in the middle of the styloid recess.

This approach is risky due to the association with the dorsal sensory branch of the ulnar nerve. Extra care is required to prevent injury to this sensory nerve. This portal is more palmar than one would think.

5. 1-2 radiocarpal portal

This portal is located between the 1st and the 2nd compartments above the radial styloid. The depression distal to the styloid is used to locate it, using the thumb and transillumination: the scope in a 3–4 position is directed radially toward the styloid.

The needle is placed by respecting the radial slope and it is checked intra-articularly. The approach may be horizontal for a styloidectomy, or an extended vertical approach may be used to place an implant and prevent injury to the cutaneous sensory branches of the radial nerve. A lesion of the radial nerve could ruin all the benefits expected from surgery. It is the reason why we insist upon a very careful dissection. To do so, one should not hesitate to widen the skin incision by opening the skin only.

Midcarpal portals

There are three conventional midcarpal portals, namely the midcarpal ulnar (MCU) portal, the radial midcarpal (MCR) portal, and the scaphotrapeziotrapezoid (STT) portal **(Figure 3)**.

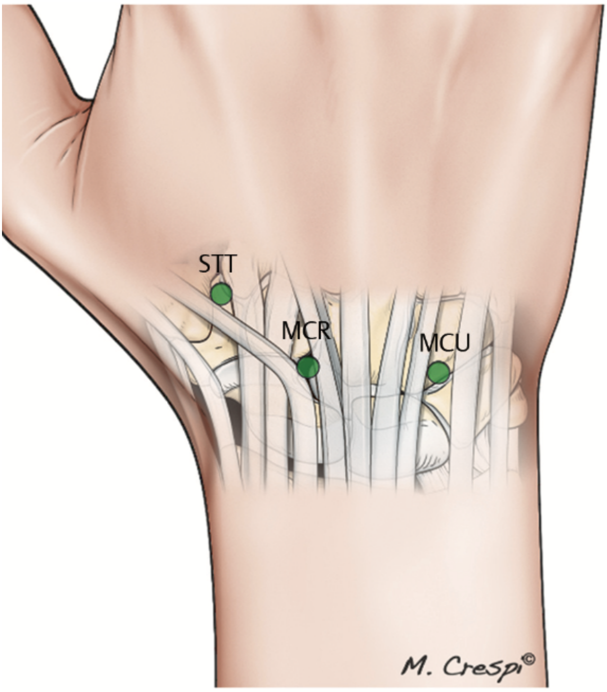


Figure 3.

Diagram showing conventional midcarpal portals: STT: scaphotrapezotrapezoid portal, MCR: radial midcarpal portal between compartments 3 and 4, and MCU: midcarpal ulnar portal conventionally between compartments 4 and 5, but sometimes crossing compartment 4.

1. Midcarpal ulnar portal

The MCU is the simplest arthroscopic approach to the midcarpal joint. The midcarpal joint depression situated between the medial four wrist bones is easily palpable and it is called the "crucifixion fossa." An intramuscular injection needle helps to locate the exact orientation of this portal. It should be placed following the slope of the first and of the second carpal rows and directed from ulnar to radial. A tip is used to introduce the introducer straight and very horizontal.

2. Midcarpal radial portal

This portal is not very simple to locate. It is located about 1cm distal to the 3–4 radiocarpal portal and more central. The space between the scaphoid and the head of the capitate is very tight, and the curve of the two bones is prominent. Lesions of the cartilage are not uncommon, if this is used as the primary approach to the midcarpal joint.

After the MCU portal has been established, it is easier to introduce the scope into the joint and direct it toward the dorsal aspect of the scaphoid just after the scapholunate joint to locate this portal through transillumination.

3. STT midcarpal portal

This portal is located between the flexor carpi radialis (FCR) laterally and the extensor carpi radialis (ECR) medially at the STT joint just radial to the index extensors **(Figure 4)**. Localization is not simple. Transillumination may be used, directing the scope toward the STT joint. To do so, the arthroscope must be introduced through the 3–4 portal following the medial aspect of the scaphoid distally until the STT is reached. An easy way to locate the entry point is to aim at the point of convergence between the tendon of the extensor digitorum longus of the thumb and the radial border of the second metacarpal.

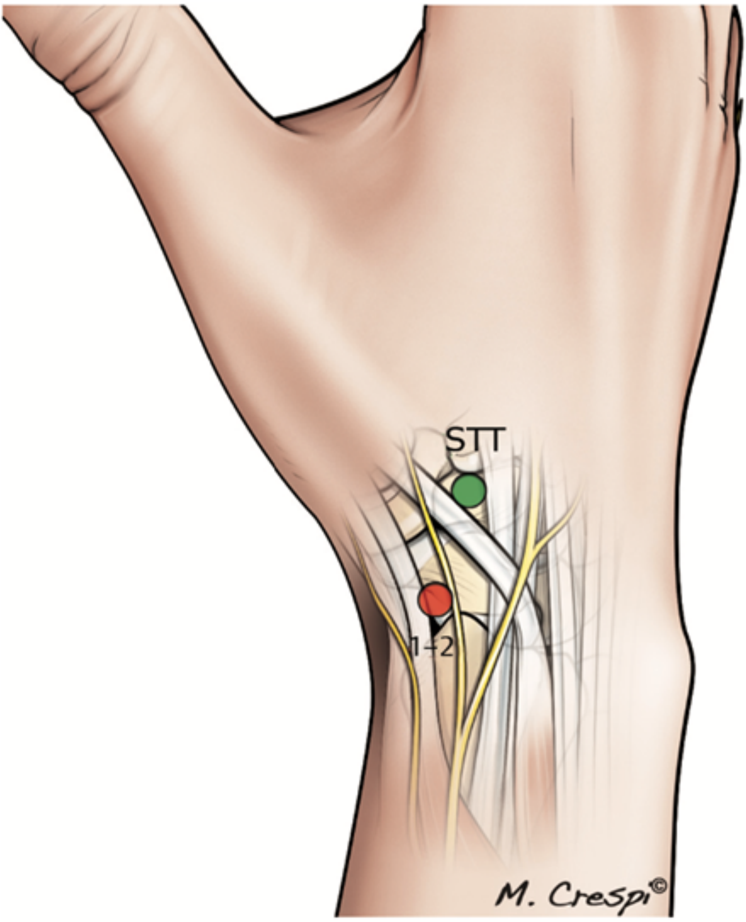


Figure 4.

Diagram showing the two radial portals: the 1–2 radiocarpal portal and the STT midcarpal portal above between the FPL and the ECR.

Distal radioulnar portals

1. Distal radioulnar portal

There are three distal radioulnar portals, namely the distal radioulnar (DRU) portal, the direct foveal portal, and the proximal “distal radioulnar” portal **(Figure 5)**.

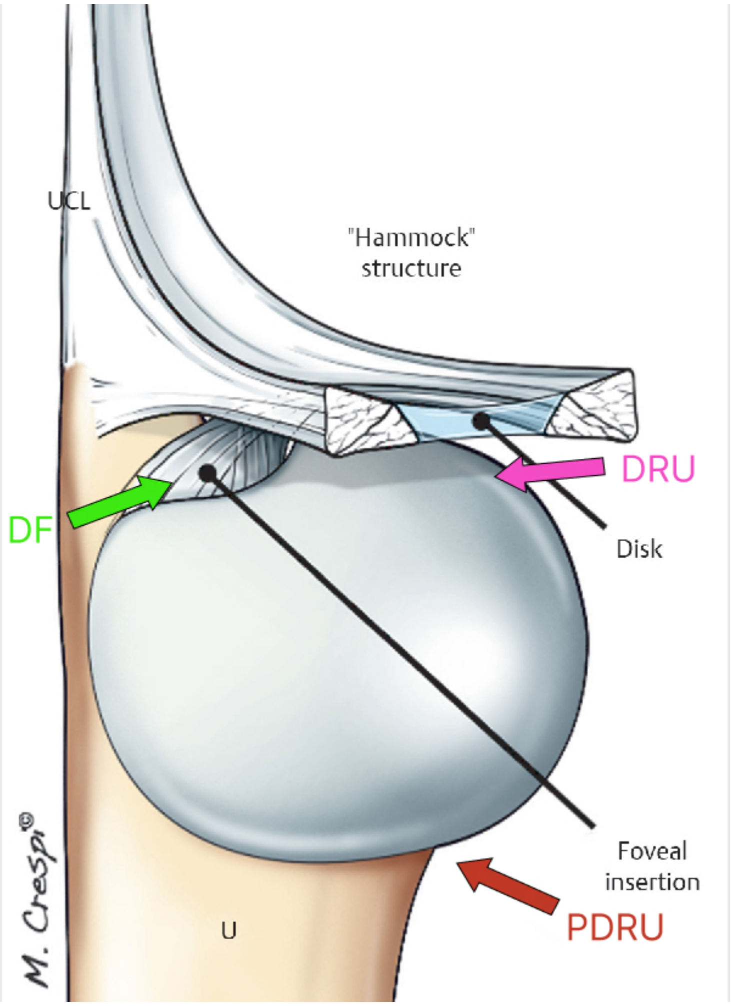


Figure 5.

Diagram showing the three distal radioulnar portals: DF (direct foveal), DRU (distal radioulnar), and PDRU (proximal distal radioulnar).

This portal is located below the TFCC precisely at the apex of an isoceles triangle, the base of which is the line joining the 4–5 and the 6R portals. In order to find it, the scope is placed in the 3–4 portal with the camera facing the TFCC. The needle must be inserted into the interval between the radius and the ulna, and it is used to lift the center of the TFCC from below under direct vision. The deep side of the TFCC can be explored through this portal up to the foveal insertion and to the sigmoid fossa of the radius. To facilitate the introduction of instruments and to prevent creating false paths, once the needle is adequately positioned, an injection of saline solution allows the TFCC to be lifted and the instruments to be introduced more easily into this narrow space.

2. Direct foveal portal

This portal has been recently described by Atzei. It allows to directly explore the foveal insertion of the TFCC. The supinated hand is placed under traction. The pit anterior to the ulnar styloid and above the ulnar head is palpated **(Figure 6)**. The scope is placed in the DRU with the camera facing the fovea. A needle is then inserted through this depression until it becomes visible.

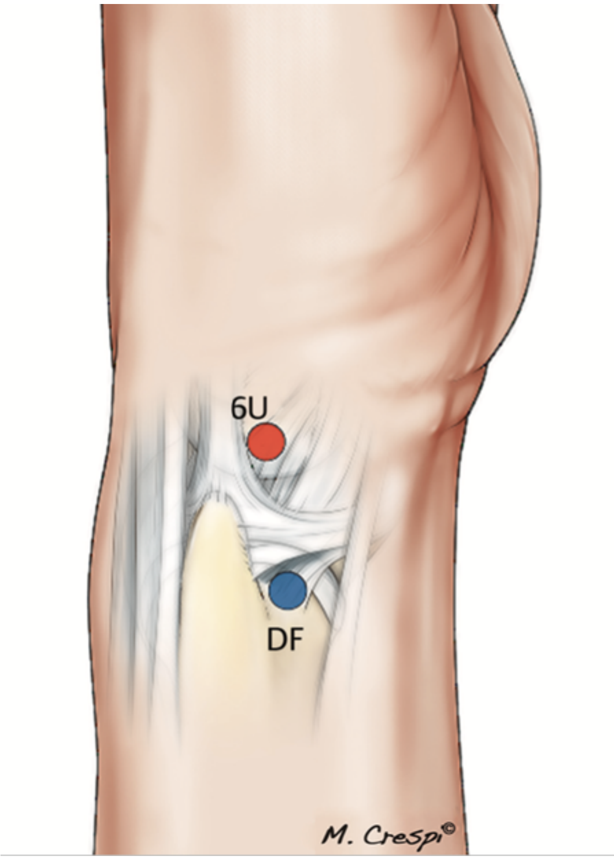


Figure 6.

Diagram showing the two medial portals: the 6U radiocarpal portal and the direct foveal (DF) portal. The direct foveal portal lies above the ulnar head and anteriorly to the ulnar styloid.

3. Proximal distal radioulnar portal

This portal is located 1cm proximally to the DRU portal and it is seldom used. It allows for the exploration of the proximal ulnar head and the proximal part of the ulnar notch.

Tips & tricks

- Palpation is a major step that should not be neglected as it will allow you to identify your landmarks.
- The capsule is sometimes too thick and does not allow for the insertion of instruments or makes the procedure very difficult. If patients are warned of the risk of open conversion, they will be less surprised.
- Soft tissue dissections in high-risk areas (1-2, 6U, etc.) are essential for the success of the procedure. An enlargement of skin incisions is a safe option.
- Performing approaches after the joint is swollen or the procedure has been underway for some time can make it difficult to create portals since palpable landmarks are disturbed. Marking the palpable edges with a felt-tip pen helps to maintain the landmarks.
- One should not hesitate to multiply the approaches, and especially to switch the positions of the instruments. One must make sure that the structures are not in the same direction.
- Accessory approaches can be added by creating another needle approach. Generally, such approaches are specific to a procedure. You will find them in the different chapters of this book.

Conclusion

The approach to the wrist is easy to perform, but there are rules to follow. Because of the narrow space of the joint, landmarks and a good anatomical knowledge are essential. We recommend to start with the most standard approaches, followed by the more complicated ones as soon as conventional approaches are better mastered.

Video 3: Wrist Arthroscopy Portals
https://vimeo.com/917903353

4.
VOLAR PORTALS

LORENZO MERLINI

Introduction

Most of the current wrist arthroscopic procedures can be performed with only dorsal portals (such as 3-4, 6R, MCR, MCU). However, it is sometimes necessary to use volar portals, especially to visualize dorsal elements, or for procedures involving volar passage such as ligamentoplasties.

Naturally, the main danger is represented by noble elements such as the median nerve, radial and ulnar arteries, and flexor tendons.

There are two ways to create volar portals, namely inside-out or outside-in.

Almost every procedure necessitating a volar portal can be performed with the radial volar radiocarpal portal, which is usually performed in an inside-out fashion, and through the central volar portal, performed outside-in and giving access to both radiocarpal and midcarpal joints.

Operative techniques

1. Radial Volar Radiocarpal Portal

It is the simplest volar portal to create. In a standard dorsal set-up, with the scope in the 6R portal, the blunt trocar is inserted into the 3-4 portal and pushed volarly through the RSC and LRL ligaments, all the way through the skin. The orientation will reproduce a Henry approach, passing between the radial artery and the flexor tendons/median nerve. A small incision is made on the skin where the trocar is pointing. The trocar is then pushed through and exteriorized volarly. The scope cannula can be inserted into the joint **(Figures 1a and 1b)**. This portal will offer a complete view of the dorsal aspect of the radiocarpal joint, and the dorsal rim of the radius, which can be very helpful when performing a radial styloidectomy.

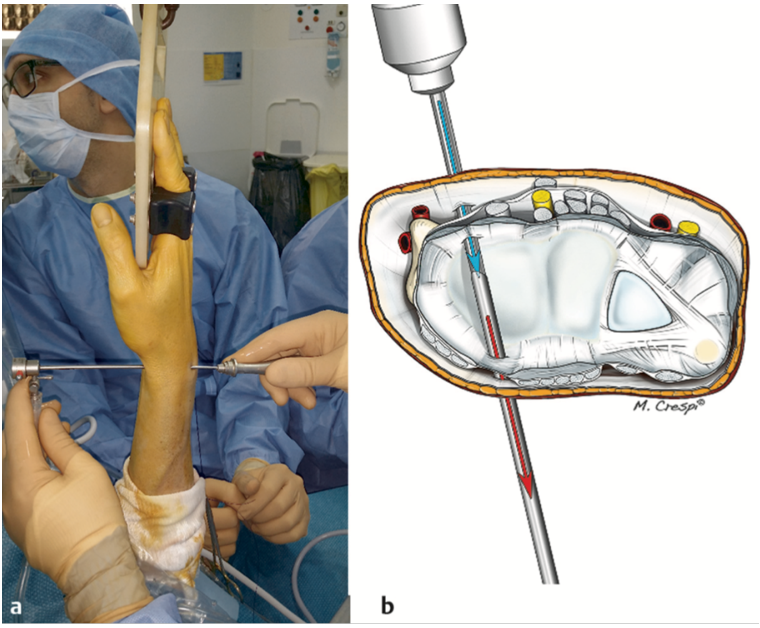


Figure 1.

2. Volar Central Portal

This volar central portal requires a minimally invasive approach. However, it provides a nice exposure and visualization of the whole dorsal articular aspect of the wrist. In addition, it allows for a radiocarpal and midcarpal exploration, through the same skin incision, but using two different capsular portals, one above and one underneath the lunate.

The skin incision is performed volarly, between the proximal and the distal volar creases of the wrist (over approximately 10mm), in the axis of the third metacarpal space **(Figure 2)**.

Figure 2.

First, the flexor superficialis tendons are identified and retracted radially. The fourth and fifth flexor digitorum profundus tendons are then retracted ulnarly while the third and second tendons are retracted radially. The volar central midcarpal portal is performed under direct vision just over the anterior horn of the lunate through the space of Poirier **(Figure 3)**.

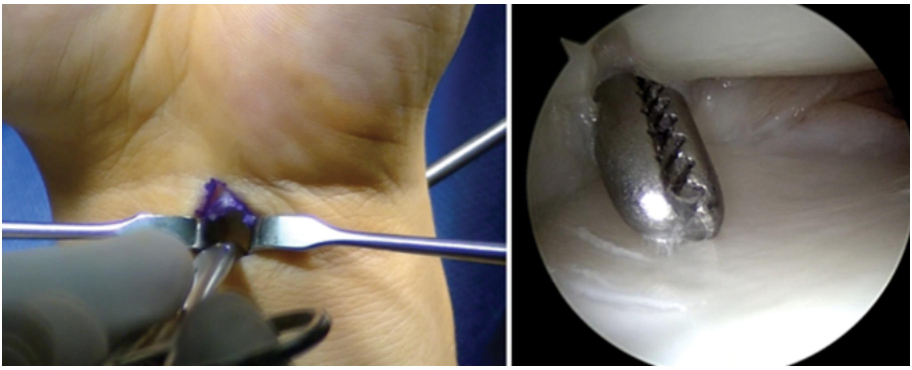


Figure 3.

The volar central radiocarpal portal is created under the lunate through the interval between the ulnocarpal ligaments and the short radioulnar ligament.

Tips & tricks

Volar portals have a bad reputation for no good reason whatsoever. If properly performed, they are harmless and allow for a safer and a more reliable execution of the procedure.

The radial radiocarpal portal is very easy to perform under direct arthroscopic visualization, without any risk for noble anterior structures.

The volar central portal is more demanding in its creation and requires a good exposure with retractors. Performing the volar central portal with the scope positioned dorsally is facilitated via transillumination, which helps to have a good direct view on the capsule with the minimally invasive incision, and a correct positioning of the radiocarpal and midcarpal portals under arthroscopic control.

However, excessive traction on the retractors may be damaging for the median nerve and it should always be controlled.

Conclusion

An exclusive dorsal approach in wrist arthroscopy is becoming old-fashioned and increasingly insufficient not only for complex procedures such as ligament reconstruction, but also for simpler ones requiring optimal visualization of the dorsal aspect of the joint.

Volar portals are safe if they are correctly performed. Caution remains the rule when noble elements stand on the way.

Video 4: Wrist Arthroscopy Palmar Approach & Portals
https://vimeo.com/917903900

5. DORSAL WRIST GANGLION RESECTION

LORENZO MERLINI

Introduction

A dorsal wrist ganglion or a synovial cyst is a benign tumor, which can disappear spontaneously. Surgery is reserved for painful ganglia, or large ones with cosmetic repercussion. The recurrence rate of radiology-guided procedures and postoperative complications of open surgery, such as stiffness in flexion and unattractive scars, are well-known. Arthroscopic resection is a simple minimally invasive technique, which seems to have a lower recurrence rate, without open approach-related complications.

Operative techniques

1. Midcarpal exploration

Dorsal ganglion resection is one of the rare occasions where it is useful to start the exploration at the midcarpal joint.

Indeed, most frequently, the origin of the ganglion will be located inside the midcarpal joint, regarding the scapholunate complex **(Figures 1 and 2)**.

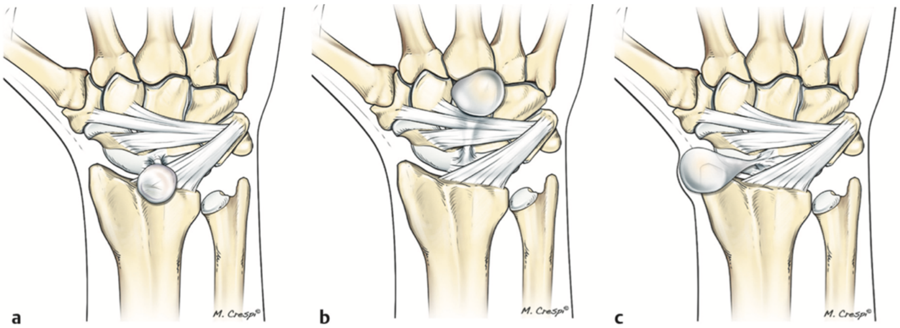


Figure 1.

The first step is to eliminate an associated SL instability, which would require a dorsal capsuloligamentous repair after resection, if it is found.

If there is no SL instability, everything can usually be performed through the midcarpal joint.

In almost all cases, the MCR portal will be performed in a transcystic fashion, which does not cause any problem. The shaver is inserted into the MCR portal under direct arthroscopic control from the MCU portal.

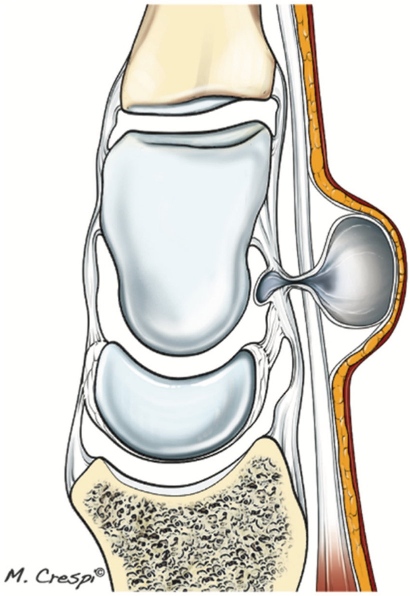


Figure 2.

2. Ganglion resection

Direct vision will allow to identify the pathological capsule, with mucoid dysplasia herniating into the joint. The resection of this tissue is very easy and fast, opposite to the normal adjacent capsule that will be harder to debride **(Figure 3)**.

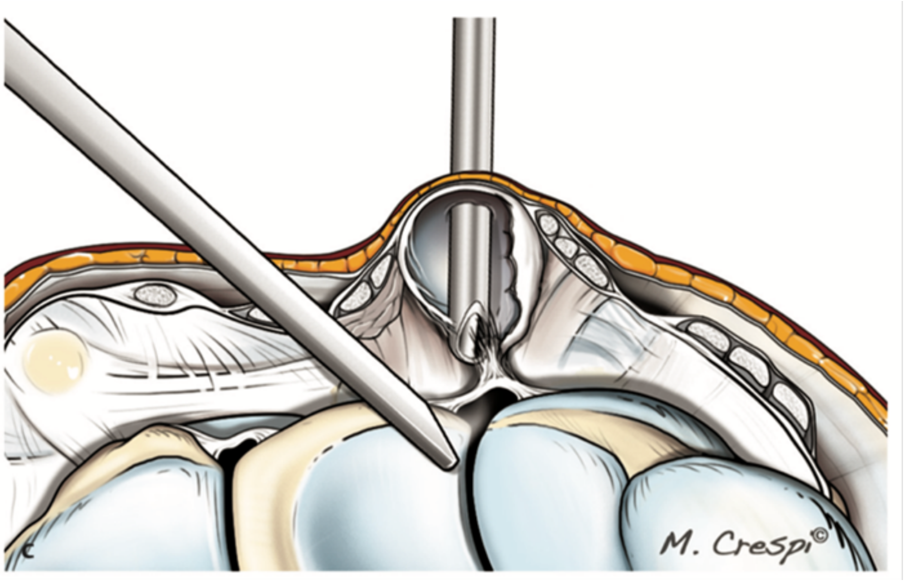


Figure 3.

Once the pathological capsule has been resected, there will be a fairly large hole in the dorsal capsule, usually just proximally to the DIC ligament. At that time, a direct "cystoscopy" can be performed by moving the scope inside the ganglion, which will have drained back into the joint. The remnants of the ganglion wall can be resected until extensor tendons are visualized.

3. Closure and postoperative care

In the absence of SL instability, the procedure may stop there. The incision can be closed via a simple application of Steri-strips (recommended for cosmetic reasons in the absence of splint maintaining wrist extension that will automatically close the skin).

Immediate mobilization is encouraged, without any forced constraints during 3 to 4 weeks.

Some authors recommend a systematic wide arthroscopic dorsal capsuloligamentous repair (WADCLR) after ganglion resection, in order to decrease the recurrence rate. This strategy will require a 6-week splinting, followed by rehabilitation.

Tips & tricks

SL instability must be first assessed during midcarpal exploration and must lead to a WADCLR procedure in the event of significant findings. The patient must be prepared in anticipation.

Shaving the pathological capsule is quite easy. However, resecting the ganglion wall can be trickier and is particularly at risk for extensor tendons. When performing a "cystoscopy", direct arthroscopic control is crucial and must be obtained using triangulation and scope angulation at their maximal capacity.

Special attention must be paid to the DIC ligament, which should not be harmed during the resection of the pathological dorsal tissue.

Some surgeons use ink coloration to easily find the ganglion and resect the pathological tissue from the ganglion. This trick may be helpful, especially in the learning curve.

Conclusion

Dorsal ganglion resection is a perfect indication under arthroscopy, provided that cautious resection is performed under permanent visualization.

Video 5: Dorsal wrist ganglion: Arthroscopic resection
https://vimeo.com/917905042

6.
ARTHROSCOPIC VOLAR GANGLION EXCISION

AHLAM ARNAOUT

Introduction

Volar wrist ganglia are less common than dorsal ones. They are benign tumors, such as dorsal ganglia, originating either from the radiocarpal joint, or more rarely from the midcarpal joint as a part of the STT arthritis syndrome.

An arthroscopic resection procedure is currently preferred, considering that the intracapsular origin of the ganglion is away from the noble structures that can be injured in the open technique (e.g., flexor tendons, radial artery).

Operative technique

1. Set-up and instrumentation

The procedure is an outpatient surgery under locoregional anesthesia, using a tourniquet.

A traction of 5 to 7 kg is applied to the wrist positioned supine.

Wet or semi-dry arthroscopy is preferred to prevent the burning of surrounding tissues and of safe cartilages while using the shaver.

A shaver (2.4 to 2.9mm) is required for the procedure.

2. Portals

The 3-4 portal is used for the scope, and the 1-2 portal to introduce the instruments. A 6R or a 4-5 portal can be useful at the end of the procedure.

Before initiating the surgery, the ganglion is outlined with a skin marker on the volar aspect of the wrist as a landmark used to make sure that the entire cyst fluid has been removed at the end **(Figure 1)**.

Figure 1.

Volar cyst outlined before starting the surgery.

3. Exploration and intra-articular opening of the ganglion

The scope is introduced into the 3-4 portal and the shaver into the 1-2 portal.

As a first step, a synovectomy is performed to clear the view if necessary, and associated lesions are controlled.

The assistant holds the scope. The surgeon holds the shaver in one hand and uses the other hand to push the ganglion toward the radiocarpal joint.

The scope is placed in front of the hiatus between the radioscaphocapitate (RSC) and long radiolunate (LRL) ligaments **(Figure 2)**. The volar ganglion resection area is localized, as hypertrophic synovial bulges out in this area, while the operator presses on the outlined ganglion with a finger on the volar crease of the wrist.

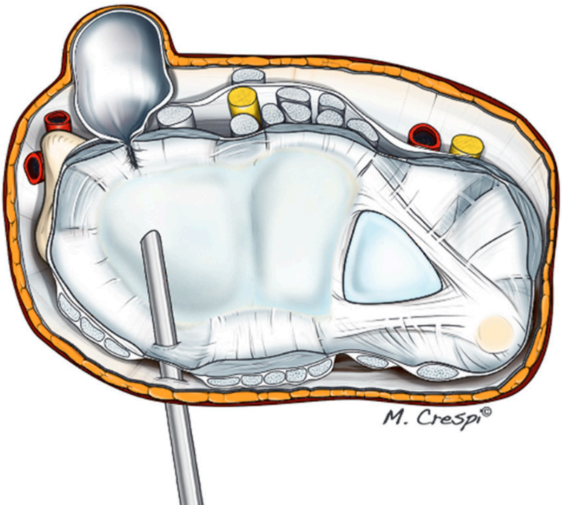


Figure 2.

Scope inserted into the 3-4 portal, to locate the volar cyst stalk, between RSC and LRL ligaments.

4. Ganglion resection

Resection is performed with the shaver from inside the joint:

- The ganglion stalk is first resected in the opening RSC/LRL **(Figure 3)**.
- Resection progresses gradually and deeper toward the volar side.
- Volar pressure on the ganglion may facilitate resection **(Figure 4)**.
- The presence of adipose fragments (small yellow flakes) indicates that the cyst has been opened.
- The resection is complete and can be stopped, and the flexor tendons are sometimes clearly visible **(Figure 5)**.

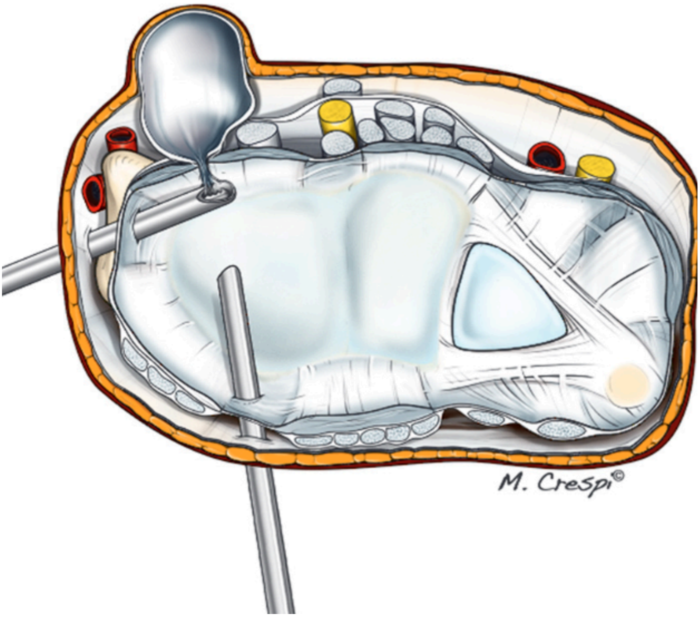


Figure 3.

Foot ganglion resection. The scope is in the 3-4 portal, and the shaver in the 1-2 portal.

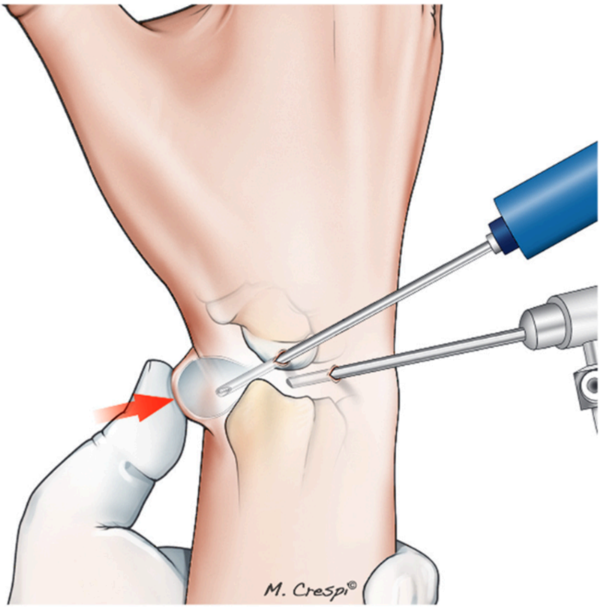


Figure 4.

Surgeon pressing with his/her finger on the ganglion at the volar aspect of the wrist to facilitate resection.

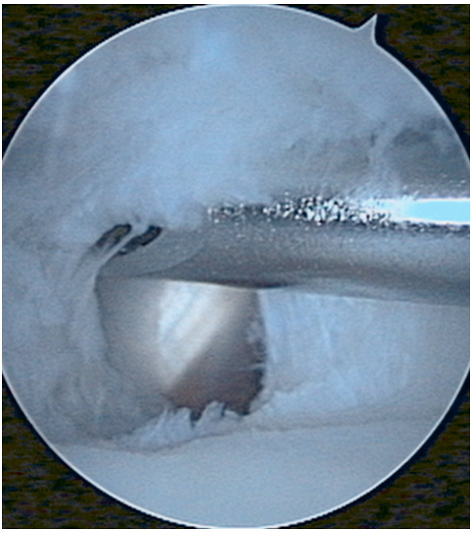


Figure 5.

End of the procedure: the Flexor Pollicis Longus is visible. The RSC and the LRL are intact.

Tips & tricks

- Once the capsule has been breached, visibility will be reduced due to the inflow of mucus into the joint, which indicates a broken ganglion wall.
- At the end of the procedure, using a 6R or 4-5 portal may be useful. The shaver is placed in the 3–4 portal, directly over the space between the RSC and LRL ligaments, to complete the resection and make sure that all synovial tissues have been removed **(Figure 6)**.
- It is unnecessary to remove the entire ganglion wall.
- The shaver should not be moved outside of the joint due to the risk of damaging the radial artery and the median nerve.

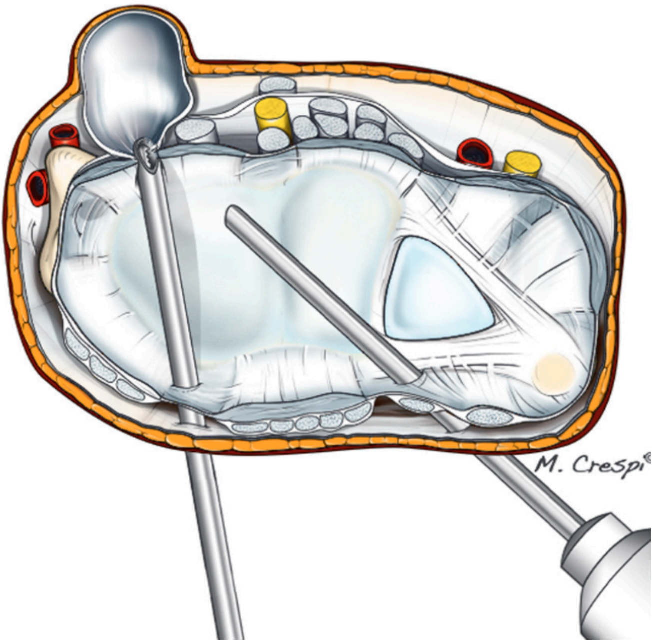


Figure 6.

Scope in the 6R portal and shaver in the 3-4 portal. Useful configuration to complete resection at the end of the procedure.

Conclusion

The surgical treatment of a common radiocarpal volar ganglion is indicated when it is painful or unsightly.

Arthroscopic resection is a reproducible and effective technique when the different steps are respected. The recurrence rate is equivalent to the one of open resection with a decreased risk of injury to noble elements (especially to the radial artery and flexor tendons), and with the benefits of the minimally invasive techniques (e.g., faster functional recovery, no scar).

Video 6: Palmar wrist ganglion: arthroscopic resection
https://vimeo.com/917904830

7.
ARTHROSCOPIC RADIAL STYLOIDECTOMY

JANE MESSINA

Introduction

Radial styloidectomy is a technique used to increase radial deviation in the early stages of wrist osteoarthritis and particularly in scapholunate advanced collapse (SLAC) stage I and scaphoid nonunion advanced collapse (SNAC) stage I. This technique has been used for many years and can be used as an isolated palliative technique or associated with a reconstructive technique such as scaphoid bone grafting in scaphoid nonunion in SNAC stage I. It can be also associated with a salvage procedure in order to increase radial deviation.

While a large incision is required in open styloidectomy, with the risk of ligament damage, an arthroscopic technique offers the advantage of being minimally invasive with less trauma and less risk of damage to ligamentous structures. Radial styloid resection has to be lower than 5mm in order to preserve wrist stability.

Positioning

The surgical procedure is performed in regional anesthesia with a tourniquet positioned at arm level. The arm is fixed to the table, the elbow flexed at 90 degrees, and a traction of 6 kg (5 to 7 kg) is applied to the forearm using Chinese finger traps.

Operative technique

The 3-4 , 1-2, 6 R, volar radial portals are mainly used. Portals are performed inserting a kneedle into the portals first in order to locate the joint, then making a skin incision and introducing a blunt mosquito forceps to prevent damage to tendon, vessels, and nerves up to capsular level. The capsule is then perforated and a trocar is introduced.

1. Exploration of the joint

With the scope in the 3-4 portal, an exploration of the radiocarpal joint is performed and the radial styloid is visualized. There, an area of chondropathy is seen at the styloid and dorsal portion of the scaphoid fossa. The 6R and 1-2 portals are then created.

2. Synovium resection

With the scope in 6R with the portal directed toward the radial styloid and a 2.5mm shaver in the 3-4 portal, soft tissues are resected around the radial styloid, and a similar procedure is then performed with the camera in the 3-4 portal (always directed toward the radial styloid) and the shaver in the 1-2 portal. Cleaning of the synovium is useful in order to visualize and expose the bony edge of the radial styloid and facilitate bone resection.

3. Bone resection

The osteophytes are located at the tip and dorsal part of the radial styloid. After resection of the synovium, a 3mm burr is used to resect the residual cartilage and the bone of the radial styloid. The burr can be introduced from the 1-2 portal (with the camera in the 3-4 or 6R portal) **(Figures 1 & 2)**, or through the 3-4 portal (with the camera in the 6R portal, see Figure 3). The cartilage and subchondral bone are resected up to 4-5mm **(Figure 3)**. It is crucial to preserve the radioscaphocapitate ligament (RSC) volarly and the dorsoradial ligament dorsally (DRC).

In order to better visualize the dorsal part of the scaphoid fossa of the radius, the volar radial portal can be used while the 1-2 and 3-4 portals are used for the burr to perform the resection **(Figure 4)**.

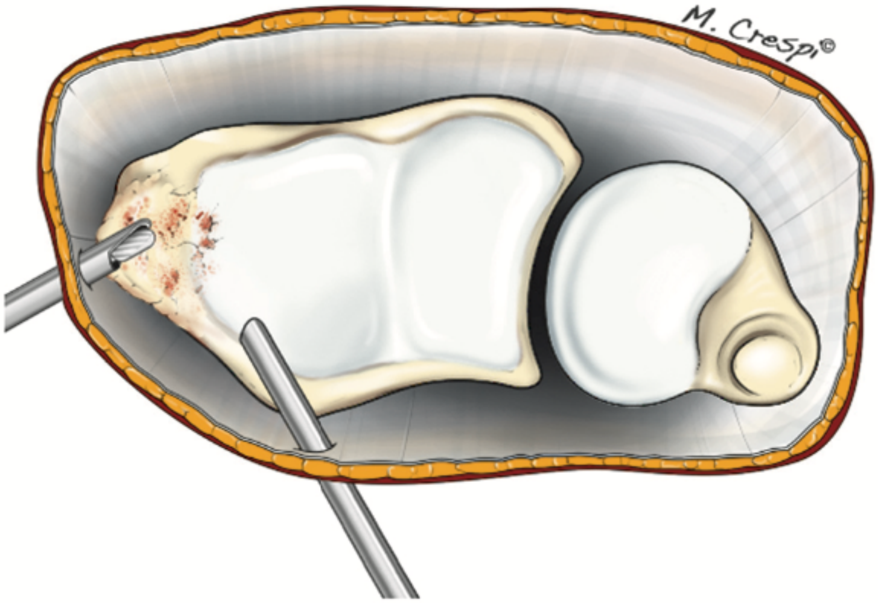


Figure 1.

Drawing showing the scope through the 3–4 portal and the burr through the 1–2 portal.

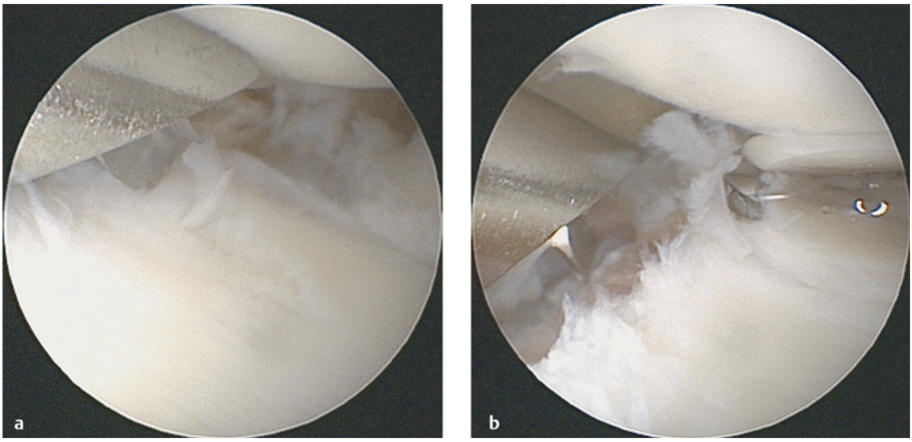


Figure 2.

(a) Intra-articular view showing the burr at the beginning of a styloidectomy, placed at the zone of chondropathy of the radial styloid. (b) Intra-articular view showing the burr at the zone of styloidectomy.

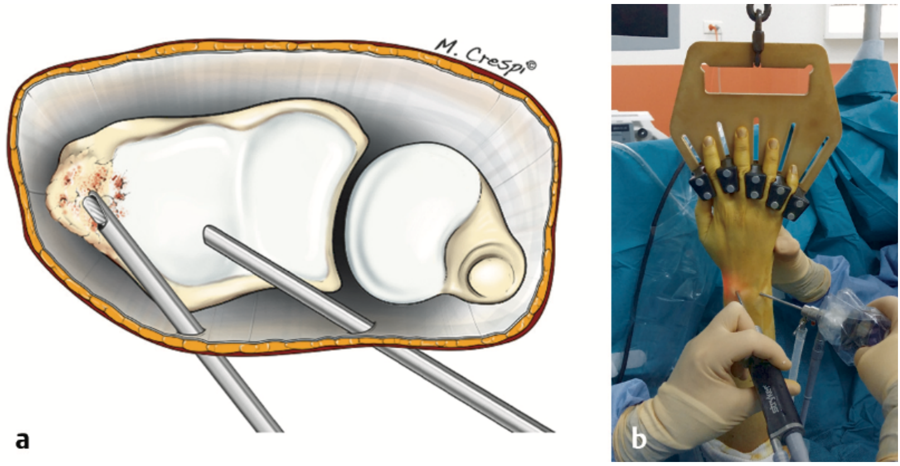


Figure 3.

(a) Drawing showing the scope introduced through the 6R portal and the burr through the 3–4 portal. (b) Operative view showing the scope introduced through the 6R portal and the burr through the 3–4 portal.

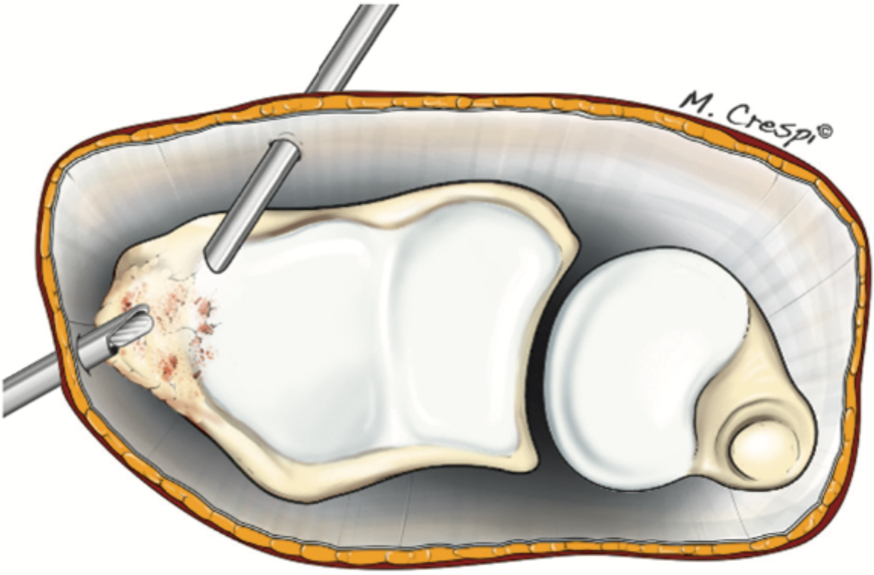


Figure 4.

Drawing showing the scope through the radial palmar radiocarpal portal and the burr through the 1–2 portal.

Postoperative care

Skin closure of these small approaches is unnecessary. A semi-compressive bandage is applied for 7 to 10 days, followed by an application of a light bandage until skin healing **(Figure 5)**. If a simple styloidectomy is performed, this technique allows for an early mobilization. It is advised to avoid efforts for 20 to 30 days. If it is associated with another procedure, postoperative care is similar to the main procedure.

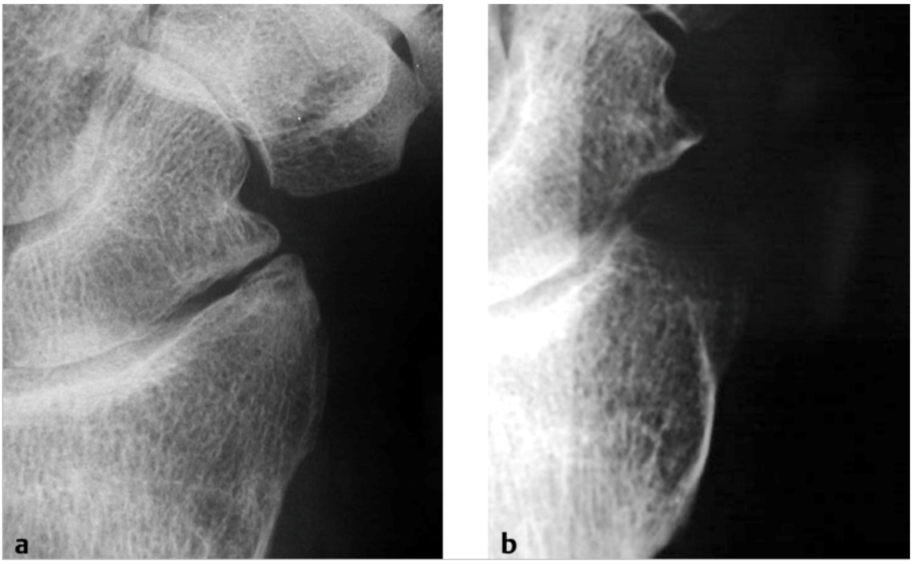


Figure 5.

(a) Clinical case showing radial styloid arthritis SLAC stage I in a 65-year-old man following an old rupture of the scapholunate ligament. (b) Same patient case after styloidectomy, which was chosen as the sole treatment in this case, with immediate postoperative recovery of mobility.

Tips & tricks

- The 1-2 portal is crucial as it allows to perfectly visualize the triangular-shaped radial styloid and to resect the dorsal and volar part of the radial styloid.
- The volar radial portal is useful to better visualize the dorsal radial rim in case we want to improve the resection of the dorsal portion of the radial styloid.
- It is crucial to switch the portals in order to have a complete view of the area to be resected and of the resected area at the end of the procedure.
- A control radiography can be performed during the operation in order to check the amount of resected bone **(Figure 5)**.

Conclusions

Although the open approach has been abandoned as it was too invasive, arthroscopic styloidectomy is a minimally invasive procedure, which allows to gain wrist motion in radial deviation either as an isolated procedure or associated with other procedures.

Video 7: Arthroscopic styloidectomy
https://vimeo.com/917910390

8.
WAFER PROCEDURE

AHLAM ARNAOUT

Introduction

Ulnocarpal impaction is the abutment of the distal ulna against the TFCC and the ulnar compartment of the carpus.

It often occurs after distal radius fracture and it is mainly associated with positive ulnar variance (UV) **(Figure 1)** even though it was also described with negative variance.

The natural evolution of the lesions ranges from the central perforation of the TFCC to eventually degenerative lunotriquetral tear **(Figure 2)**.

The distal ulna resection procedure is one of the gold standard surgical techniques to treat the abutment. It was first described by Feldon in 1992, as an open "en tranche" resection (WAFER procedure).

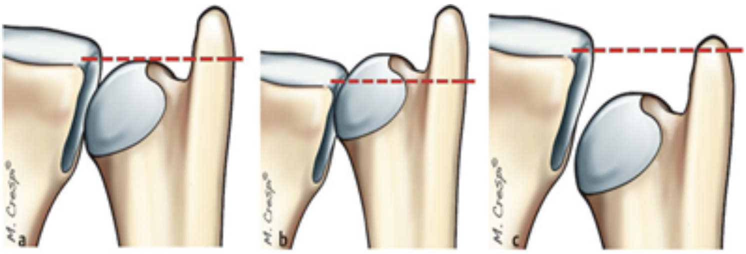


Figure 1.

Ulnar variance patterns. a: neutral. b: positive. c: negative.

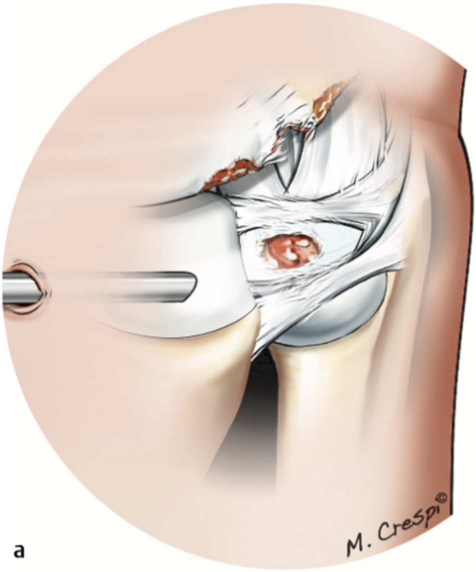


Figure 2.

Natural evolution of the lesions in ulnocarpal syndrome abutment. Central perforation of the TFCC, ulnar head chondromalacia, chondromalacia of the medial aspect of the lunate, triquetral chondromalacia, and degenerative lunotriquetral instability.

Operative technique

1. Set-up and instrumentation

The procedure is an outpatient surgery, under locoregional anesthesia, using a tourniquet.

A traction of 5 to 6 kg is applied to the wrist positioned supine.

Wet arthroscopy is preferred to prevent the burning of surrounding tissues and of safe cartilages while using the shaver and the burr.

A shaver (2.4 to 2.9mm) and a motorized burr (3.5mm) are necessary to perform the procedure.

2. Portals

Usual arthroscopic dorsal radiocarpal portals are used, 3-4 for the scope, and 6-R (or 4-5) as an instrumental portal.

3. Exploration and debridement

Extensive synovectomy in the ulnar compartment is first performed to clear the view.

The stage of the abutment and associated lesions are diagnosed: TFCC foveal disinsertion, degenerative lunotriquetral tear, etc.

Debridement and widening of the central perforation of the TFCC are performed, with the shaver and/or a clamp basket to ensure a good exposure of the resection area.

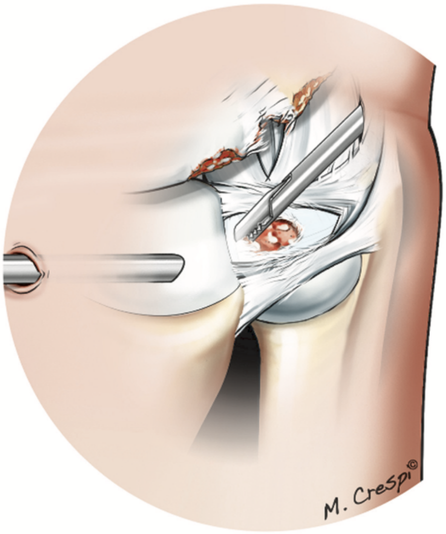


Figure 3.

Widening of central tear of the TFCC using a basket clamp.

4. Distal ulna resection: oblique helicoidal osteotomy

The ulnar head is rather oval-shaped than spherical with a relatively increased positive ulnar variance (UV) in pronation. Bone resection is performed with the burr from maximal pronation to maximal supination, with the help of the assistant to obtain a complete resection.

The entire visible portion of the ulnar head jutting out above the radius is resected as long as new bulges appear.

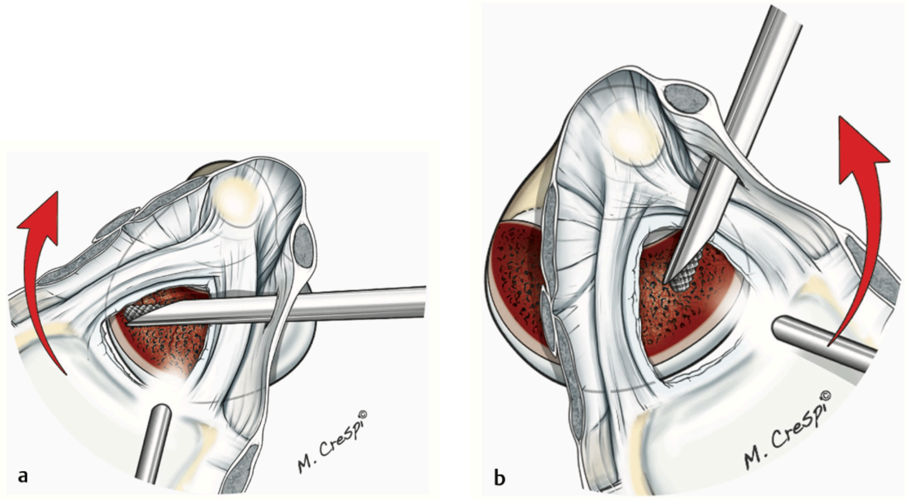


Figure 5.

Continued resection of the ulnar head during wrist pronation (a) and supination (b).

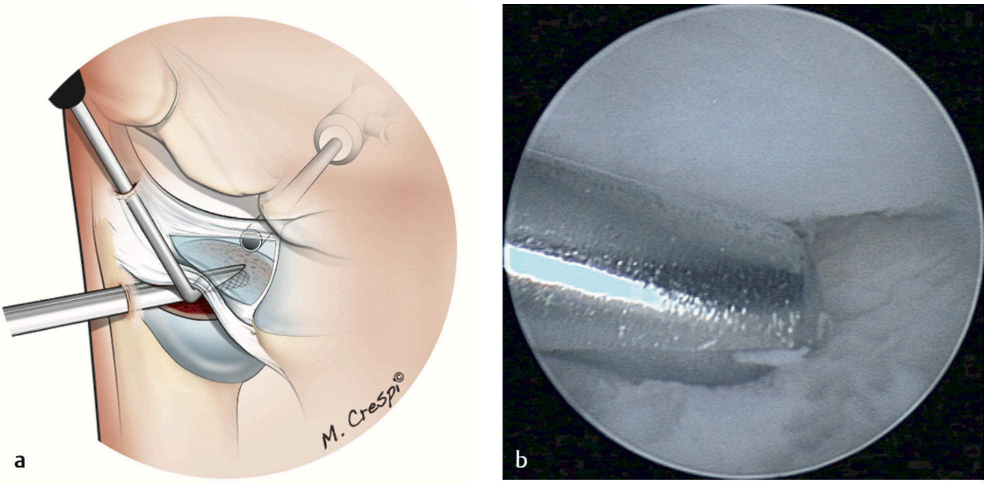


Figure 6.

Ulnar head resection when the TFCC is intact. The scope is placed in the distal radioulnar portal and the shaver inserted through the direct foveal portal so that it lies under the TFCC. The probe (or skin hook), inserted through the 6R portal, is used to lift the TFCC. (b) Arthroscopic view of the shaver under the TFCC.

Specific case: intact TFCC (Figure 6)

In rare cases (young patients), the TFCC is intact. A sub-TFCC approach can be used to avoid perforating and injuring the TFCC when exposing the ulnar head. A distal radioulnar portal is created to introduce the scope, and the instruments are inserted through the direct foveal portal.

Resection is performed as described earlier, with the assistant pronating and supinating the wrist. It can be useful to reverse the scope and the burr positions to put the finishing touches on the osteotomy.

Tips & tricks

- During this resection step, it is essential to preserve the DRUJ.
- Check the intact DRUJ at the end of the procedure. The outcome will depend on this **(Figure 7)**.
- TFCC foveal reinsertion can be associated with distal ulna resection.
- Fluoroscopy can be used to control that a sufficient amount of bone has been removed with negative ulnar variance (UV).

Figure 7.

Preserved distal radioulnar joint once the ulnar head has been resected.

Conclusion

It is a safe and simple procedure, and one of the gold standards to treat ulnocarpal impingement. It allows for an early mobilization without postoperative splinting.

It has similar outcomes to an ulnar shortening osteotomy, for UV less than 3 to 4mm and intact DRUJ, without the complications of the hardware and the bone consolidation issues.

Video 8: WAFER procedure
https://vimeo.com/917911892

9.
ARTHROSCOPIC PARTIAL RESECTION OF THE STYLOID PROCESS OF THE ULNA

MARKUS PÄÄKKÖNEN

Introduction

Ulnar styloid impaction syndrome (USIS) is a rare syndrome caused by impaction between the triquetrum and an abnormally large (>6mm) ulnar styloid process (PSU). The patient seeks medical attention due to ulnar wrist pain exacerbated in wrist ulnar deviation. Initial therapy consists of NSAID medication and splinting of the wrist. Wrist X-ray shows an enlarged PSU with ratio of the length of PSU to the length of the capitate exceeding 0.23. Signs of irritation and soft tissue wear between the triquetrum and PSU are identified in MRI. Surgery is considered in cases recalcitrant to conservative therapy.

Operative technique

1. Arthroscopic exploration

This procedure is usually performed under regional anesthesia with the arm secured to a traction device with an upward traction of 4.5-7 kg (10-15 lbs) applied to the wrist. A standard diagnostic arthroscopy of the midcarpal and radiocarpal joints is performed to rule out any other cause of ulnar wrist pain. Any soft tissue tear at the tip of the PSU is identified and photographed.

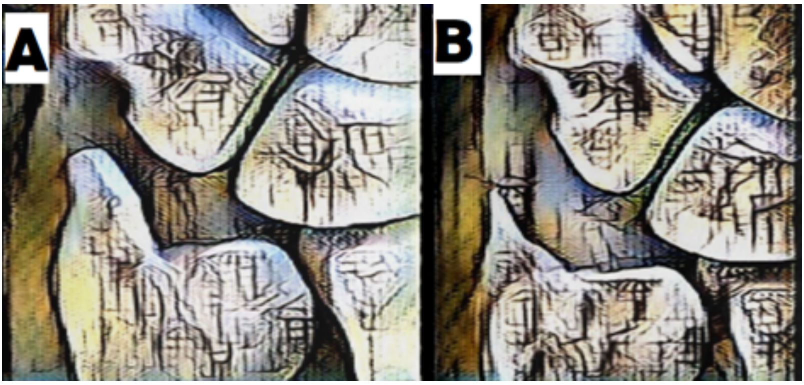


Figure 1.

*An enlarged PSU **(A)**. Oblique resection of the distal and radial PSU has been performed **(B)**.*

Two portals are generally used during this procedure:

- a standard 3-4 portal for the scope,
- the 6R portal for the shaver/burr.

The scope is inserted into the 3-4 portal for visualization. A shaver is used to debride any synovitis or cartilage debris. In advanced cases, the enlarged PSU is readily visualized through the soft tissue deficit caused by the shearing between the tip of the PSU and the triquetrum. If it is not the case, an arthroscopy hook may be used to palpate the tip of the PSU. It is also an option to insert a hypodermic needle into the joint to identify the tip of the PSU using fluoroscopy. It is advisable to insert the needle from a dorsal-ulnar angle to prevent iatrogenic injury to the dorsal sensory branch of the ulnar nerve.

2. Partial ulnar styloid excision

Wet arthroscopy and continuous irrigation are used for this procedure. The tip and the radial side of the PSU are exposed with a soft tissue shaver. Care is taken not to cause injury to the TFCC. Using a 3.5mm burr, approximately 3mm of the tip and the radial side of the PSU is resected at a 45-degree angle. Most of the ulnar rim of the PSU and the corresponding ligament insertions are left intact. Fluoroscopy is useful in evaluating the extent of the resection. TFCC is evaluated by the hook test at the end of procedure, and DRUJ stability is assessed by the DRUJ ballottement test without traction. In cases with TFCC tear and DRUJ instability, a standard TFCC repair using the method of choice of the operating surgeon is performed. Wound closure is achieved by means of a tape or sutures. When used, the sutures are removed after one week.

3. Postoperative care

The soft dressing is removed after 3 days and the wrist is immediately mobilized. A wrist X-ray examination is included in the postoperative outpatient visit. The patient may return to heavy manual work after approximately 4 weeks.

Tips & tricks

Although an enlarged PSU with advanced soft tissue tears is immediately obvious, this may not always be the case. It is prudent to have a fluoroscope readily available to identify the PSU and to evaluate the extent of the resection.

It is essential to evaluate DRUJ stability at the beginning and at the end of the procedure to detect concomitant TFCC tear and to rule out any iatrogenic ulnar TFCC tear.

If there is a concomitant extensor carpi ulnaris (ECU) tendon pathology, the tendon can be readily exposed by using a soft tissue shaver at the 6R portal to excise the wall of the 6th extensor compartment.

Conclusion

Arthroscopic partial excision of the PSU is a simple and reliable technique with low morbidity. In cases with isolated USPI, full pain relief may be expected. The technique allows to preserve the ulnar border of the PSU and the corresponding ligament insertions.

10.
HALT SYNDROME

JEAN-MICHEL COGNET

Introduction

When the apex of the hamate is prominent (Viegas type II hamate), chondritis lesions may occur. There is often a history of a traumatic fall of the wrist in extension and chronic pain on the dorso-ulnar side of the wrist. The diagnosis of the lesion requires an arthro-CT, as the radiographs are most often normal. This condition is known as the HALT (Hamate Arthrosis Lunotriquetral Tear) syndrome. Arthroscopic resection of the proximal pole of the hamate allows the impingement to be removed while keeping the extrinsic ligamentous planes intact.

Surgical technique

The patient is positioned in a dorsal decubitus, elbow bent at 90 degrees, support on the arm and traction by turn of traction (3 to 5 kg).

The approaches are midcarpal (MCR and MCU). However, in principle, they are associated with radiocarpal approaches allowing for the complete exploration of the wrist joints.

The procedure starts by exploring the radiocarpal to ensure that there is no associated lesion that would have gone unnoticed on intraoperative imaging. We then proceed to the exploration of the midcarpal region. The scope is introduced via the MCR route and the probe hook via the MCU route. The area of chondritis, which may be more or less extensive, is easily identified. A mirror image should be searched for on the lunate. The other bones of the carpus should also be checked. Resection is performed with a shaver and an arthroscopic burr, with the camera in MCR and the instrumentation in MCU. The resection should be performed similarly to the ulnar head resection, taking care not to damage the other carpal bones.

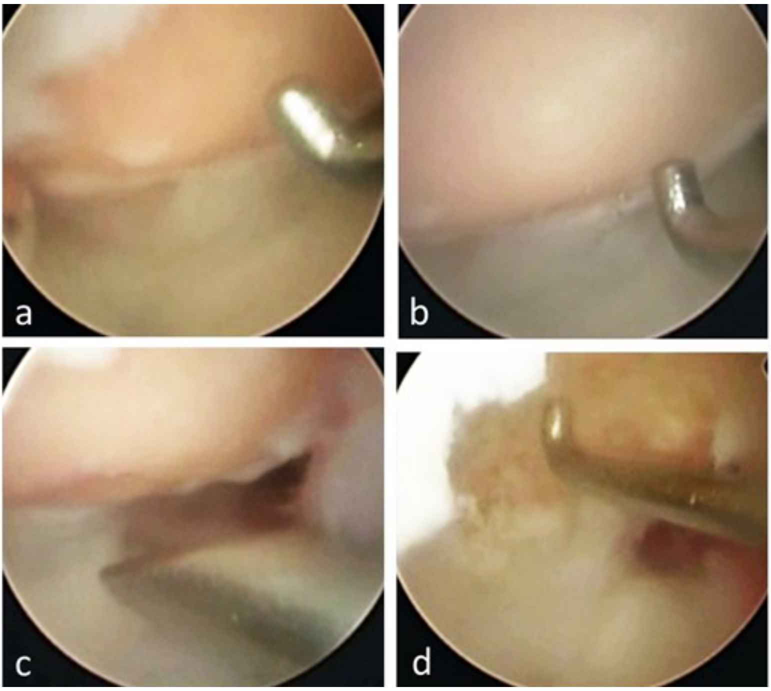


Figure 1.

The chondritis area is clearly visualized at the proximal pole of the hamate (a and b). This area of chondritis is resected with a motorized burr (c), hence obtaining a cavity.

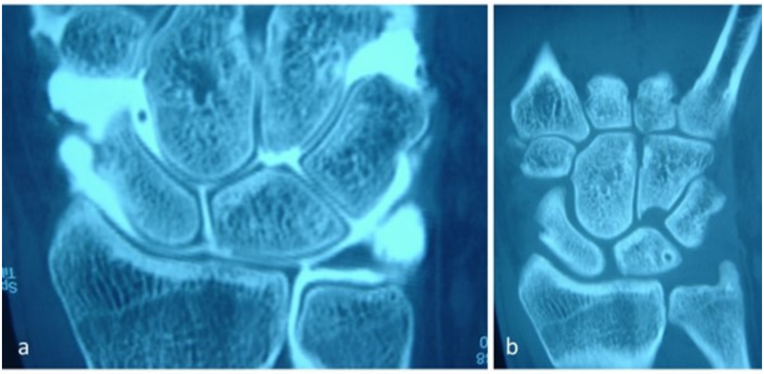


Figure 2.

Appearance of the chondritis area on the proximal pole of the hamate on arthro-CT (a). Postoperative CT-scan showing the resection performed (b).

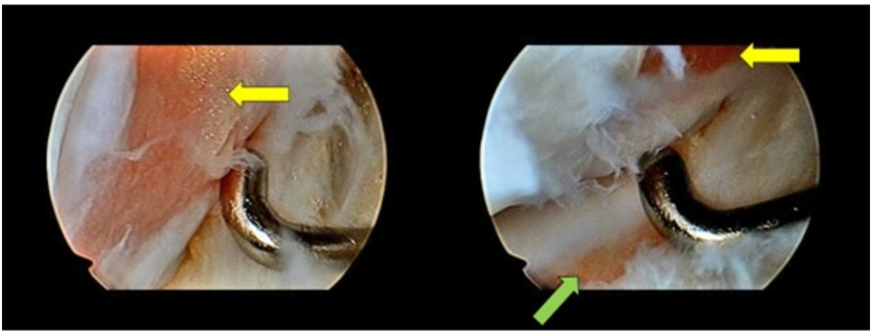


Figure 3.

Arthroscopic exploration reveals an area of extensive chondritis (yellow arrow) over half the articular surface of the hamate with a mirror image (green arrow) on the lunate.

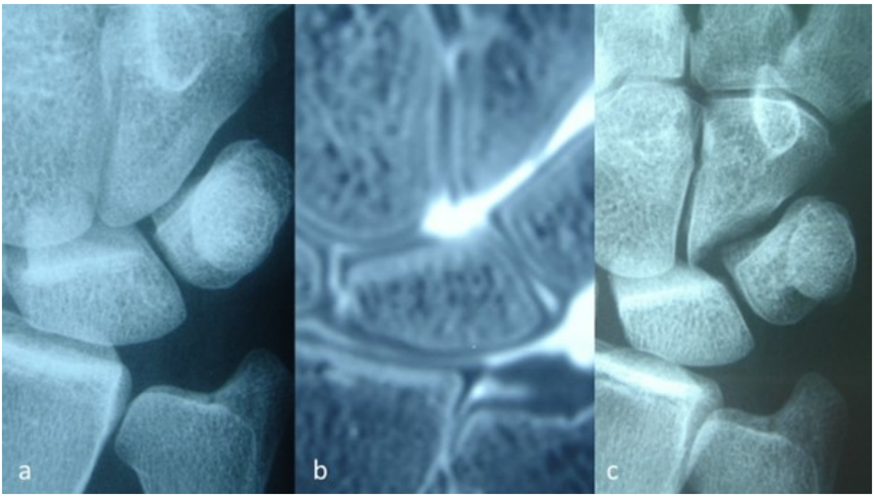


Figure 4.

Preoperative radiographic appearance on X-ray (a) and arthro-CT (b) showing the extent of cartilage destruction. Radiographic appearance after resection of the chondritis area (c).

Tips & tricks

The midcarpal joint is sometimes tight. As a result, resection should be started with a motorized knife in order to create a working space before using a motorized burr, the diameter of which is larger and could well create iatrogenic lesions.

It is the CT-scan that allows to check the resection area at a distance from the surgery: it is also a good way to show the patient what has been done.

Conclusion

The HALT syndrome is rare. However, it is critical to know how to think about it when faced with a painful wrist. Arthro-CT can make the diagnosis better than simple radiographs. The arthroscopic management with the resection of the chondritis area is simple, efficient, and not very iatrogenic.

11.
TFCC EXAMINATION

CHRISTOPHE MATHOULIN
JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

The triangular fibrocartilage complex (TFCC) is one of the intrinsic ligaments of the wrist. It is often injured due to a fall on an outstretched hand or in association with distal radius fractures, and central perforations are commonly seen in degenerative processes during aging. It contributes to the stability of the distal radioulnar joint and to that of the ulnocarpal joint. The nomenclature–Triangular FibroCartilage Complex–is apt since it reflects both structure and anatomical shape. Many recent cadaver and arthroscopic studies have elucidated its exact anatomy and function. This knowledge is of great help to understand the biomechanical role of the TFCC and to manage TFCC tears arthroscopically.

Histology

The TFCC is composed of two histologically different types of tissues. The central fibrocartilage disc makes up for 80% of the area of the TFCC. It is avascular and comprised of collagen type 1 fibers, which are orientated according to tensile forces and grouped in bundles, with fusiform chondrocytes in the matrix. This central disc is attached to the hyaline cartilage that covers the distal radius and extends as a meniscus homologue. The peripheral 20% of the disc is vascularized, as are its extensions: the ulnocarpal ligaments (volar), and the sheath of the extensor carpi ulnaris (ECU) (dorsal). These structures are composed of loose vascularized connective tissue, with fibroblasts that secrete proteoglycans and extracellular matrix. They are interspersed in a gelatinous matrix composed of collagen fibers and elastin fibers. The TFCC is inserted on the fovea of the ulna by Sharpey's fibers, which are vertically orientated. At the base of the ulnar styloid, the fibers are orientated horizontally. The ECU tendon subsheath is also firmly attached to the dorsal aspect of the fovea by Sharpey's fibers. In contrast, the ulnocarpal ligaments do not have any Sharpey's fibers.

Consequently, the TFCC is composed of two distinct parts: a vascularized portion and a non-vascularized portion. Vascularization is supplied from branches of the posterior interosseous artery, the ulnar artery, and medullary arteries of the head of the ulna at the fovea. This histological difference explains the pathophysiology of TFCC lesions. The central disc and its radial insertion are avascular and cannot heal spontaneously. The peripheral portion of the TFCC is well-vascularized and has a good healing potential. Macroscopically, it is often difficult to distinguish between the fibrocartilaginous and the ligamentous parts.

Anatomy

The TFCC is located between the ulna and the proximal carpal row (opposite to the lunate and the triquetrum). It subsequently supports the distal radioulnar joint (DRUJ) in its proximal portion. The DRUJ is formed by the articulation between the concave sigmoid notch located on the medial aspect of the distal end of the radius and the articular surface of the ulnar head **(Figure 1)**.

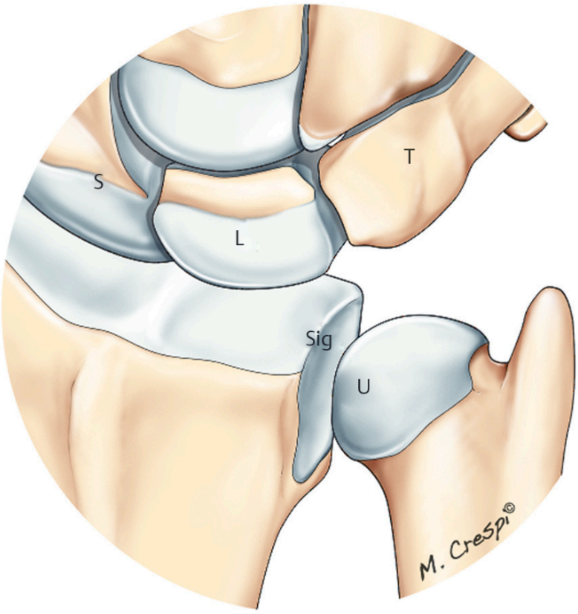


Figure 1.

*Schematic diagram of the distal radioulnar joint. **S**, scaphoid; **L**, lunate; **T**, triquetrum; **Sig**, sigmoid notch of radius; **U**, distal articular surface of the ulnar head.*

The DRUJ is stabilized by dorsal and volar radioulnar ligaments, the TFCC, and the joint capsule.

The TFCC consists of the following 5 parts:

1. The fibrocartilaginous disc and the meniscal homologue,
2. The ulnocarpal ligaments on the volar aspect (the ulnolunate and the ulnotriquetral ligaments) **(Figure 2)**,
3. The dorsal and volar radioulnar ligaments (each with a superficial and deep part) **(Figure 3)**,
4. The ulnar collateral ligament,
5. The floor of the fibrous 5th and 6th extensor compartments **(Figure 4)**.

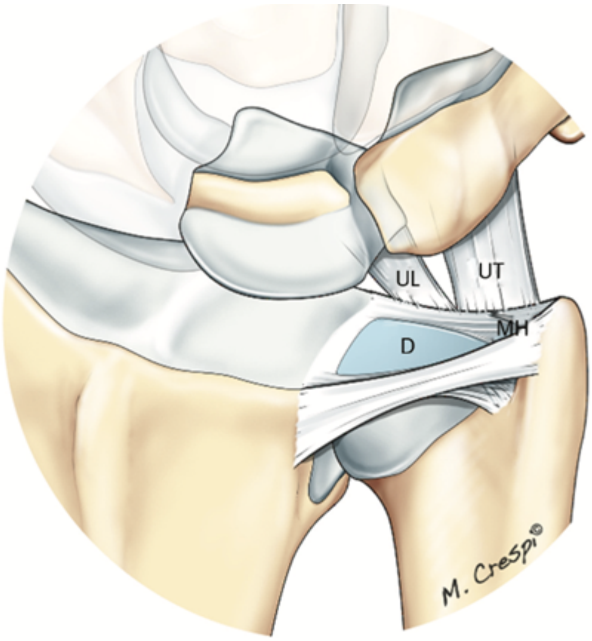


Figure 2.

Drawing of the distal portion of the TFCC. D, disk; MH, meniscal homologue; UL, ulnolunate ligament; UT, ulnotriquetral ligament.

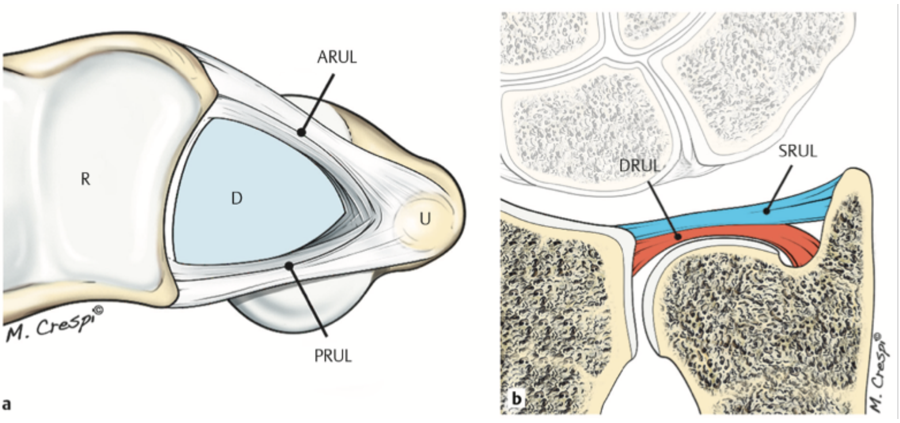


Figure 3.

Left (a) : Drawing view of the distal portion of the TFCC. R, radius; D, disc; U, ulna; ARUL, anterior radioulnar ligament; PRUL, posterior radioulnar ligament. Right (b) : Drawing section showing a portion of the radioulnar ligament composing the TFCC. DRUL, deep radioulnar ligament; SRUL, superficial radioulnar ligament.

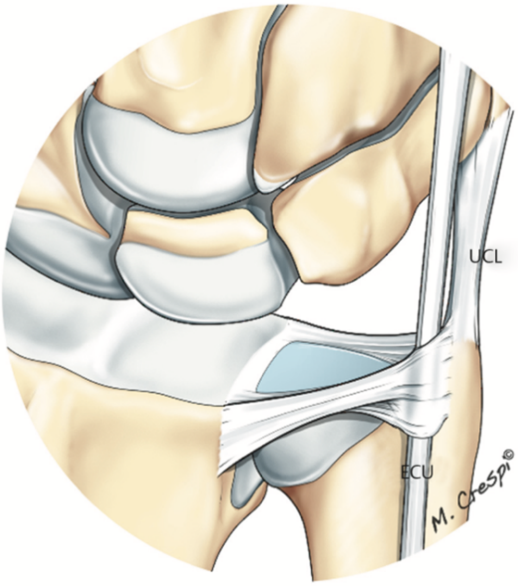


Figure 4.

Drawing of the dorsal and medial portion of the TFCC. ECU, extensor carpi ulnaris tendon; UCL, ulnar collateral ligament.

The central disc is a robust fibrocartilaginous structure extending between the ulna and the radius. The base of the disc is attached to the sigmoid notch of the radius, whereas the apex is attached to the fovea at the base of the ulnar styloid on the head of the ulna. The foveal insertion of the TFCC is not seen during wrist arthroscopy using standard radiocarpal portals.

This essential part of the TFCC is best visualized using the DRUJ portals. These fibers are part of the "iceberg" concept propagated by Atzei. The central fibrocartilaginous disc continues medially and volarly to merge with the ulnar collateral ligament and the ulnocarpal ligaments, respectively.

The ulnocarpal ligaments (the ulnolunate and the ulnotriquetral ligaments) do not insert onto the ulna, but are derived from the anterior part of the TFCC, and they connect the carpus (lunate, triquetrum, and capitate) to the ulna via the palmar portion of the radioulnar ligament at its origin—the fovea.

The radioulnar ligaments (dorsal and volar) arise from the medial aspect of the distal radius. They insert at different points onto the ulna (the deep fibers insert onto the fovea, whereas the superficial fibers insert onto the styloid process).

Palmer had a two-dimensional view of the TFCC. However, since the studies conducted by Nakamura, it is valuable to understand the dynamic function and analyze the TFCC in its three-dimensional structure. As a result, one can schematically separate the TFCC into 3 zones: a proximal zone corresponding to the insertion of the triangular foveal ligament, a distal region corresponding to the "hammock," and an outer area corresponding to the ulnar collateral ligament **(Figure 5)**.

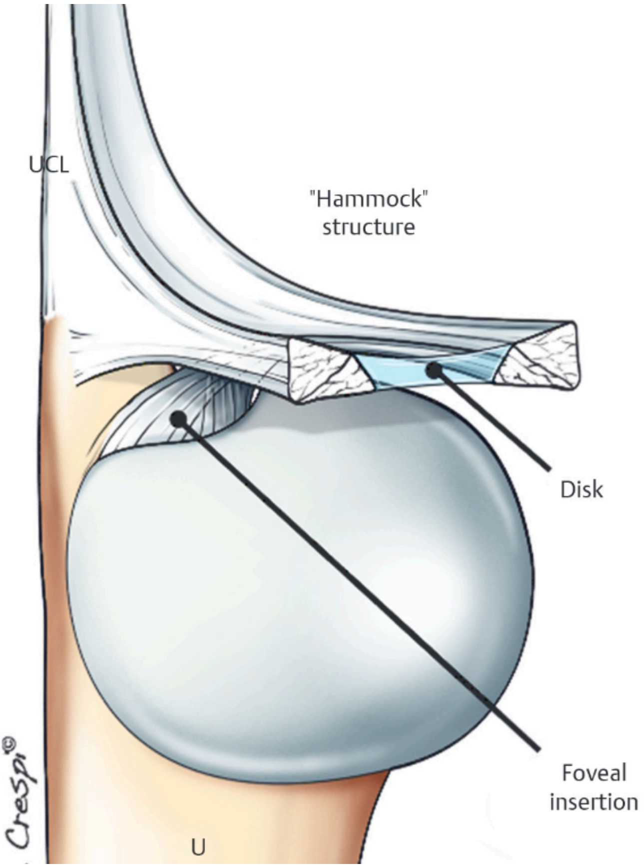


Figure 5.

Three-dimensional structure of the TFCC described by Nakamura (concept of "hammock") UCL, ulnar collateral ligament; U, ulna.

Biomechanics

The TFCC plays a major role in the biomechanics of the carpus and DRUJ. It stabilizes the DRUJ and the ulnocarpal joint. The TFCC allows the transmission and distribution of forces from the wrist onto the ulna and provides a gliding surface for the carpus during complex movements of the wrist. The central disc is crucial for the distribution of mechanical stresses on the proximal part of the triquetrum and the lunate. The TFCC and its components differentiate humans from primates and allow 6 degrees of movements at the wrist joint, namely flexion, extension, supination, pronation, ulnar, and radial deviation. The proximal part of the TFCC stabilizes the DRUJ, whereas the distal portion, resembling a hammock, supports the ulnar carpus. During pronation and supination, the central disc deforms only slightly **(Figure 6)**, whereas the triangular ligament twists significantly at its insertion on the fovea of the ulna.

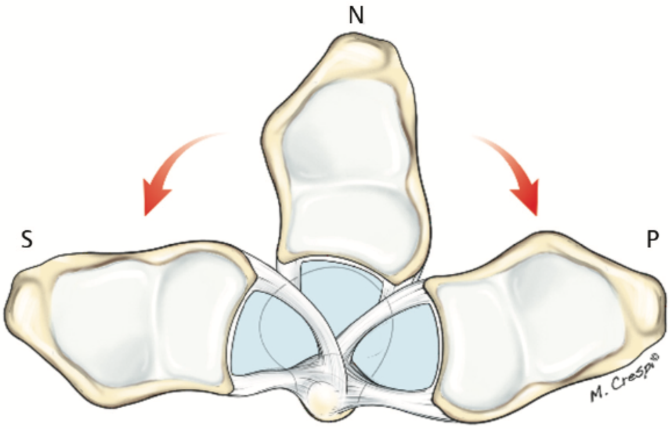


Figure 6.

Drawing showing the dynamic changes of the disc during rotation of the wrist. P, pronation; S, supination; N, neutral, minor changes according to Nakamura.

The ulnar collateral ligament is also deformed during pronation and supination. The relationship between the radius and the ulna changes with pronosupination: in supination, the head of the ulna is relatively volar to the radius, whereas, in pronation, it is dorsal to the distal radius. In fact, in supination, it is the radius that translates dorsally and causes certain fibers of the TFCC to tighten, namely the superficial fibers of the volar radioulnar ligament and the deep fibers of the dorsal radioulnar ligament. In pronation, conversely, the radius translates into the volar position: it is then the superficial fibers of the dorsal radioulnar ligament and deep fibers of the volar radioulnar ligament that are stretched out **(Figure 7)**.

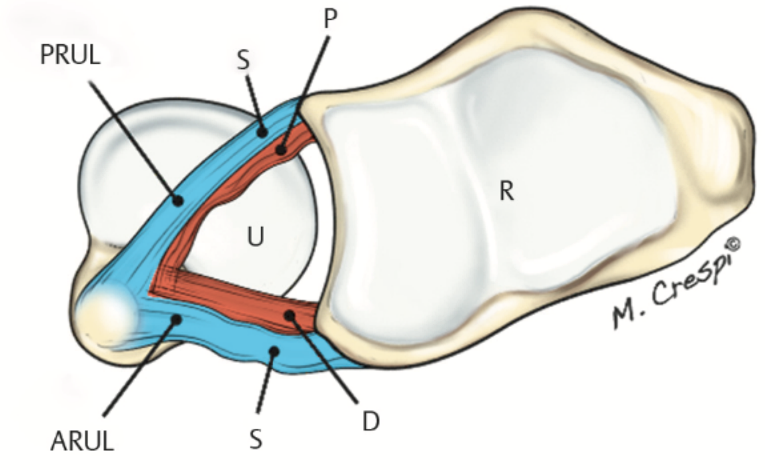


Figure 7.

Drawing showing the position of the fibers of radioulnar ligaments in wrist pronation. We note that the superficial fibers of the radioulnar ligament are stretched and posterior root fibers of the posterior ligament radioulnar are loose, whereas the reverse is true with the radioulnar ligament. ARUL, anterior radioulnar ligament; PRUL, posterior radioulnar ligament; S, superficial fibers; D, deep fibers; U, ulna; R, radius.

It is subsequently imperative to move the DRUJ through the entire range of pronosupination when exploring the TFCC arthroscopically.

The TFCC plays a key role in the intrinsic stability of the DRUJ. Extrinsic stability is provided by the ECU subsheath, the distal fibers of the interosseous membrane, and the pronator quadratus muscle. In extreme movements, the DRUJ capsule prevents dislocation of the joint.

Arthroscopic examination

The following 3 arthroscopic tests are used to check the type of TFCC lesion:

1. The “trampoline sign”: This test is used to assess for the overall loss of elasticity of the TFCC. Normally, the TFCC is as taut as a trampoline. A loss of the “trampoline” effect is seen in complete avulsion injuries of the proximal and distal portions of the TFCC. It may be negative in isolated proximal lesions and equivocal in partial distal lesions **(Figure 8)**.

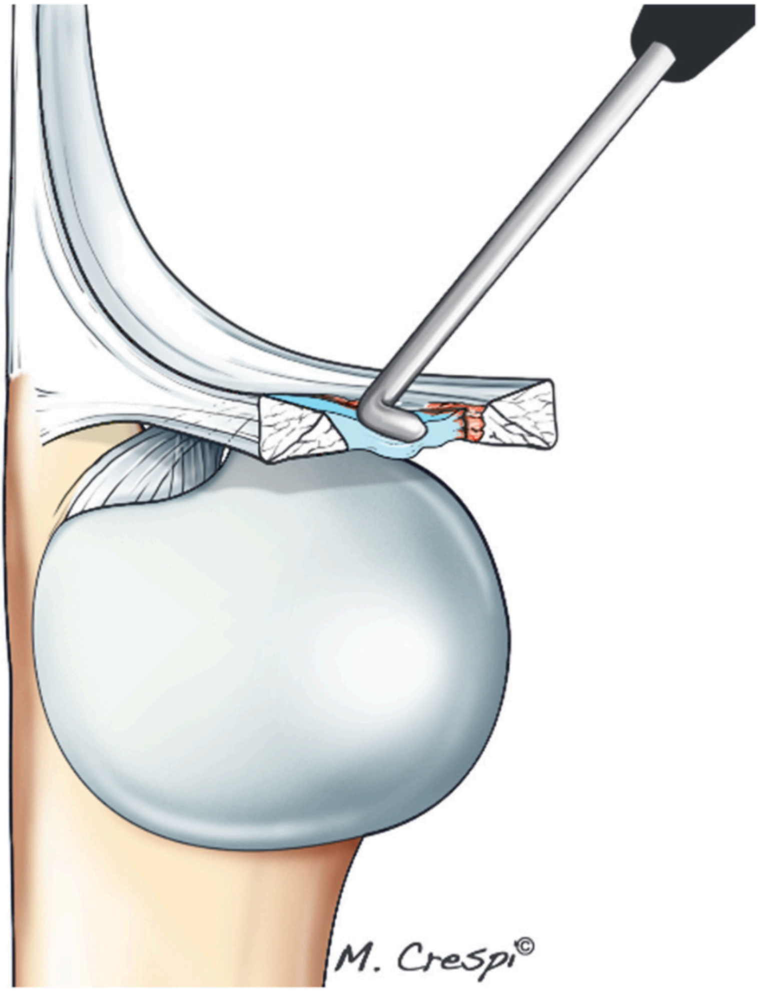


Figure 8.

*Drawing of the "trampoline sign" looking for an overall loss of elasticity of the TFCC.
The probe is placed in the 6R portal and will test the resilience of the TFCC.*

2. The "hook sign" (of Atzei): While performing the "hook test," a ripple effect can be seen by pushing the ulnar attachment of the TFCC toward the radius. It is positive in complete tears of the TFCC and negative in other cases. The hook probe is introduced at the foveal region. It then passes underneath the TFCC. The TFCC is then pulled up, applying traction with the hook probe from underneath the TFCC. In case of avulsion of its foveal insertion and of the superficial portion, the probe creates a ripple effect on the TFCC. The test is then considered positive **(Figure 9)**.

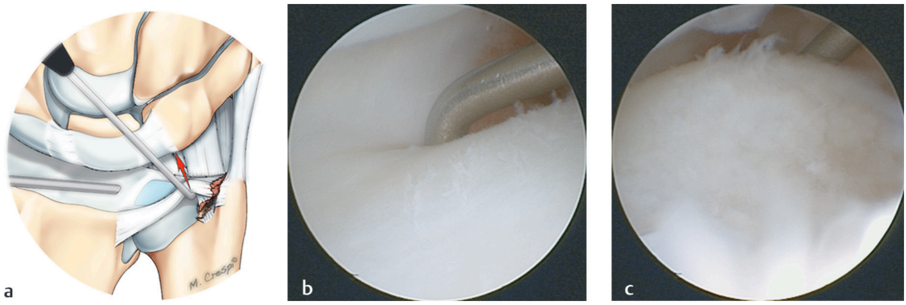


Figure 9.

Drawing of the "hook sign" looking for a wave effect in repelling the ulnar attachment of the triangular complex to the radius.
The probe introduced into 6R is positioned at the styloid recess and "pushes" the TFCC to the radial side. In case of a break, a raised ripple effect is visible. (b) Arthroscopic view showing the sensor positioned at the styloid recess. (c) Arthroscopic view showing the creation of the "ripple" when the probe pushes the TFCC toward the radius.

3. The “ghost sign” characterizes a “reverse trampoline sign” by inserting the hook into the DRUJ and seeking a “ghost” effect observed on the radiocarpal aspect of the TFCC. This indicates an avulsion of the deep fibers of the TFCC. It is negative in distal lesions and positive in isolated proximal lesions, which differs from the hook sign **(Figure 10)**.

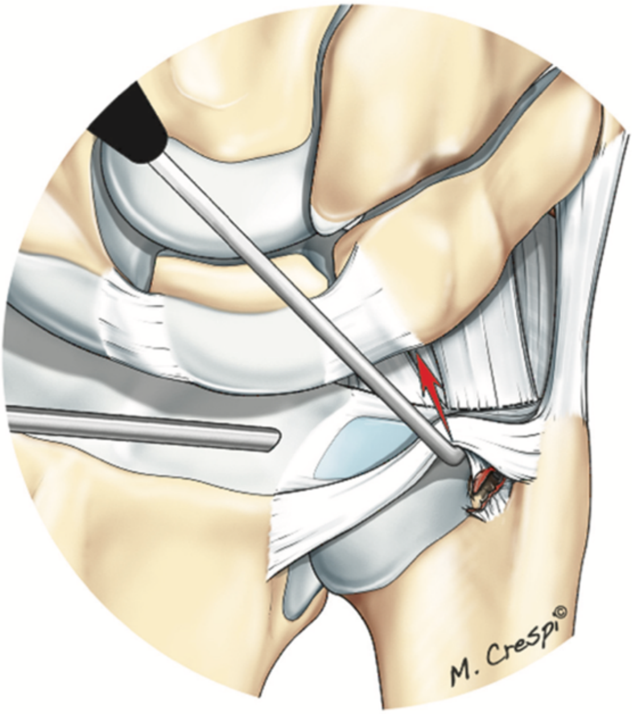


Figure 10.

Schematic of the “ghost sign,” looking for a “ghost” effect of the foveal side of the TFCC by inserting the hook into the RUD and pushing the probe up and down the radius. In case of an isolated fracture of the foveal insertion of the TFCC, a rising “ghost wave” can be seen.

Conclusion

A good knowledge of the histological differences of the TFCC components, especially regarding their vascularization, is crucial to understand the healing potential of different TFCC lesions. Understanding the complex anatomy of the TFCC (its 3D structure and insertions) is helpful to identify lesions, which were unknown, or little understood before the advent of arthroscopy, especially avulsion of the TFCC at its foveal insertion on the head of the ulna.

Video 9: TFCC Arthroscopic examination
https://vimeo.com/917905687

12.
TFCC PERIPHERAL SUTURE

LORENZO MERLINI

Introduction

The triangular fibrocartilage (TFCC) is one of the most frequently injured elements of the wrist, and particularly so regarding its dorsal peripheral and medial component. This type of lesion does not cause instability of the distal radioulnar joint (DRUJ). However, it often causes very annoying pain with any strenuous activities, especially sports (e.g., tennis, golf, fencing, basketball), but also daily life activities, especially involving pronosupination. Arthroscopy has quickly become the gold standard for treating such lesions, allowing for a better visualization and understanding, as well as easy repairs in a minimally invasive fashion.

Operative technique

1. Exploration

By positioning the scope in the 3-4 portal and instrumentation in the 6R portal, probing and testing if the TFCC can easily be performed, looking for the classical signs of rupture:

- Loss of the trampoline effect, indicating a peripheral lesion, but which can often be considered as false negative in small peripheral tears, or false positive in central degenerative perforation.
- Passage of the probe underneath the TFCC from its peripheral insertion, indicating a peripheral tear or an insufficient healing of a previous one **(Figure 1)**.
- Pull test from the styloid recess, indicating a foveal detachment if positive.
- "Ghost sign", usually stronger in foveal detachment.

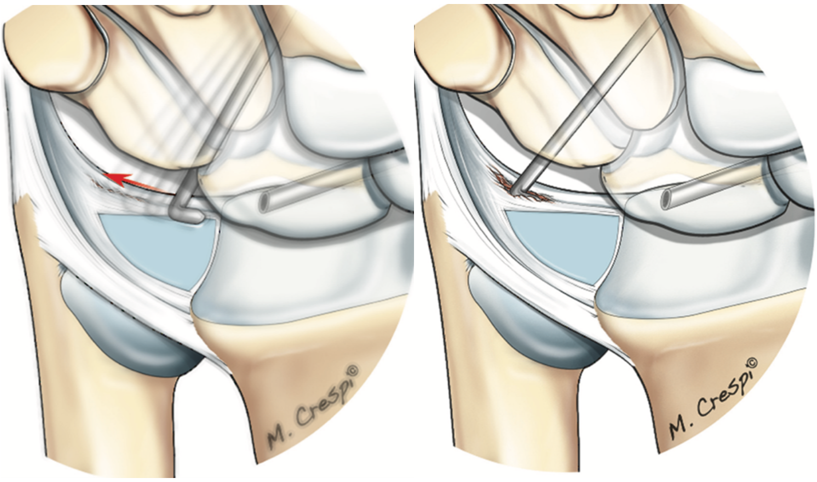


Figure 1.

2. Performing the distal DRUJ portal

In order to repair the peripheral portion of the TFCC, the sutures have to pass through the capsular structures and the TFCC, and back again. This kind of U-shaped repair is very easy to perform. Creating a distal DRUJ portal will allow the sutures to come from underneath in a relatively oblique orientation, which will help the transfixation of the TFCC with the needles. This portal is usually located 1cm proximally to the 6R portal. However, its exact position is to be confirmed via needle try-out first.

3. Repair of the TFCC

Absorbable monofilament such as 3/0 PDS (Ethicon) is the preferred suture to use. A suture loop is placed in a 21-Gauge hypodermic needle, and a straight suture is placed in another 21-Gauge needle. First, the loop is passed via the DRUJ portal through the capsule and then forward and through the TFCC on the radial side of the tear. The needle is withdrawn leaving the suture loop in place within the joint. The second single suture is then passed through the capsule and at the medial portion of the TFCC, if possible through the foveal insertion, in order to strengthen the suture **(Figures 2 and 3)**.

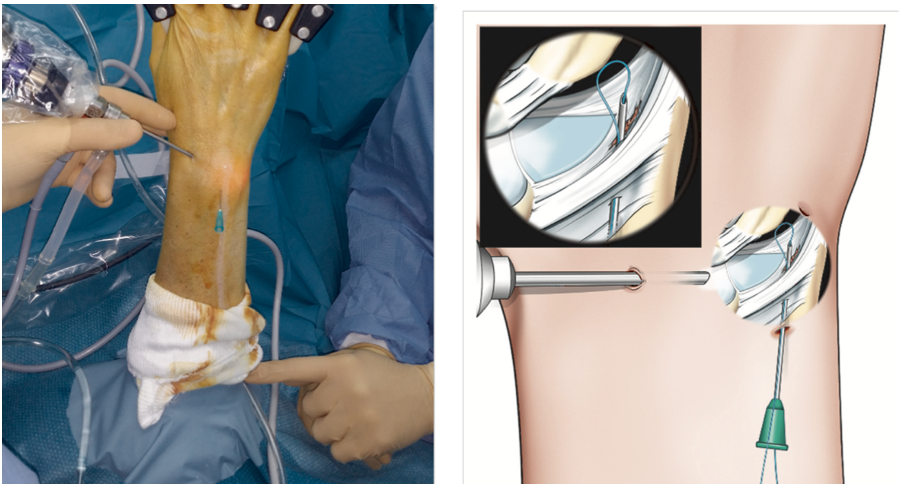


Figure 2

Using a fine hemostat forceps, both sutures are brought out through the 6R portal.

On the outside, the single suture is passed through the loop, and the loop is then pulled out of the DRUJ portal. In this manner, the single suture is pulled back across the TFCC and the articular capsule, to make a single intra-articular horizontal mattress suture, closing the peripheral TFCC tears. Both strands of the absorbable suture are then brought out together through the DRUJ portal.

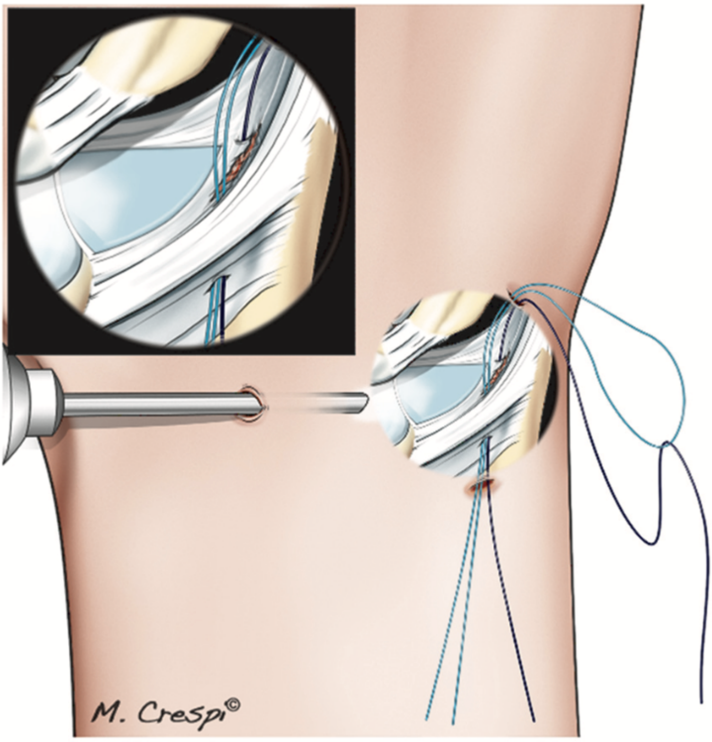


Figure 3.

4. Final suture and postoperative care

After removing the traction, the wrist is placed in extension and ulnar deviation, the suture is placed under tension, and a surgeon's knot is tied between the two strands. The knot is then buried subcutaneously. The portals can be left open to heal by means of scar formation.

The wrist is immobilized in extension and ulnar deviation in a below-the-elbow plaster cast for a period of 6 weeks. Some surgeons prefer a elbow restraining splint, such as sugartongue immobilization. Rehabilitation is started at the sixth week. The suture usually resorbs within 3 to 6 months. It can sometimes cause temporary irritation and the patient should be informed of this.

Tips & tricks

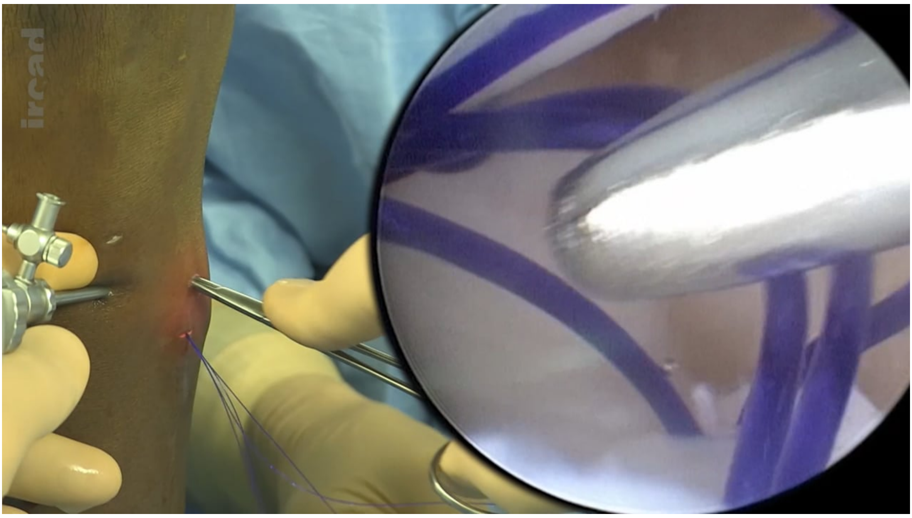
Good visualization of the TFCC is crucial and it requires the scope to be placed in the 3-4 portal but underneath the lunate, otherwise the lunate will prevent a good view of the TFCC. In order to have an optimal positioning of the scope, it is helpful to place the blunt trocar already in the right position, with an ulnar and oblique orientation allowing to pass underneath the lunate without creating any cartilage damage, and only then put the scope into its cannula.

Transfixation of the TFCC is easier with relatively vertical needles; consequently, the distal DRUJ portal must be performed 10 to 15mm to the 6R portal.

Sometimes, the TFCC will be so loose that passing the sutures through it can be a difficult step. Placing a probe or a forceps to maintain a flat and tensed TFCC through the 6R portal can help.

Conclusion

TFCC peripheral repair is one the most common arthroscopic procedures in our field, and it is very accessible even at the beginning of the learning curve. However, it requires a proper positioning of the portals and correct orientation of the needles to facilitate the repair.



Video 10: TFCC Arthroscopic suture
https://vimeo.com/917905771

13. DOUBLE LOOP SUTURES IN LARGE PERIPHERAL TEARS OF THE TFC

AHLAM ARNAOUT

CHRISTOPHE MATHOULIN

Introduction

There are three described components of the TFCC: the proximal part inserted into the fovea, the distal portion ("hammock-like structure "), and the ulnar collateral ligament (extrinsic ligaments insertions).

Massive peripheral lesions, with TFCC dorsal tears extending from the styloid process up to its distal insertion on the radius can be seen. They are often associated with middle DRUJ instability, even though the foveal insertion is intact.

A "double loop "suture is one of the possible techniques to address this specific pattern.

Operative technique

1. Set-up and instrumentation

The procedure is an outpatient surgery, under locoregional anesthesia and using a tourniquet.

A traction of 5 to 7 kg is applied to the wrist positioned supine.

A shaver (2.4 to 2.9mm), hypodermic needles and absorbable 3.0 and/or 4.0 monofilament sutures are required for the procedure.

2. Portals

Usual arthroscopic dorsal radiocarpal portals are used: 3-4 for the scope, and 6R as an instrumental portal. A DRUJ portal is also necessary.

3. Exploration and debridement

The massive peripheral tear of the TFCC is easily identified with the scope introduced into the 3-4 portal and the probe into the 6R portal **(Figure 1)**. The trampoline test is generally positive (TFCC loosening), indicating a peripheral lesion. The "hook test" is negative in isolated peripheral lesions (the TFCC cannot be raised with the probe).

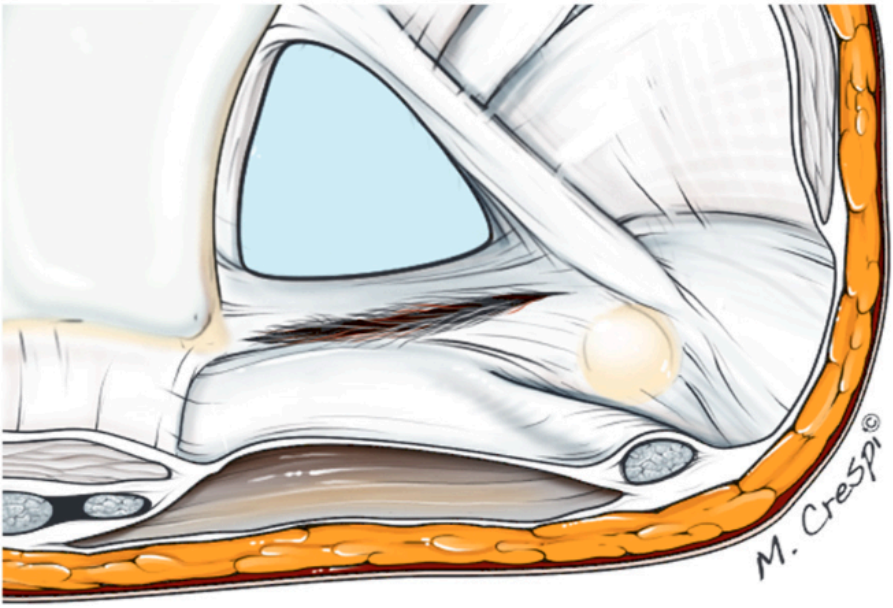


Figure 1.

Massive peripheral tear of the TFCC.

Synovectomy and debridement of the torn part of the TFCC are first performed with the shaver.

4. TFCC repair

Distal radioulnar portal

A needle is introduced obliquely through the capsule and directed toward the center of the TFCC tear. It is used as a landmark to create the distal radioulnar portal, which is usually located 1cm proximally to the 6R portal.

The "central" loop (Figure2)

A loop of a 3/0 PDS suture passed through a hypodermic needle is introduced into the capsule and into the center of the TFCC, at its dorsal insertion. The loop is retrieved with a mosquito forceps from the 6R portal.

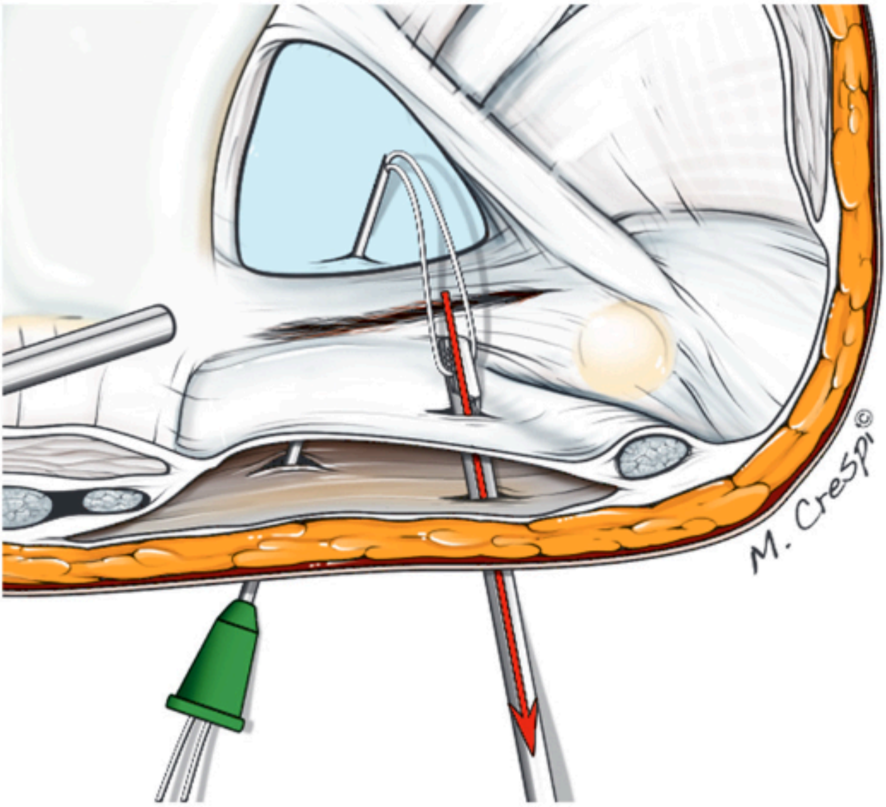


Figure 2.

Central loop crossing the center of the TFCC tear.

The first single suture (Figure 3)

A single suture (3/0 or 4/0, depending on wrist size) passed through a second hypodermic needle is introduced as described above, into the same DRUJ portal and the capsule, but exits near the ulnar insertion of the TFCC. This first suture is retrieved from the 6R portal.

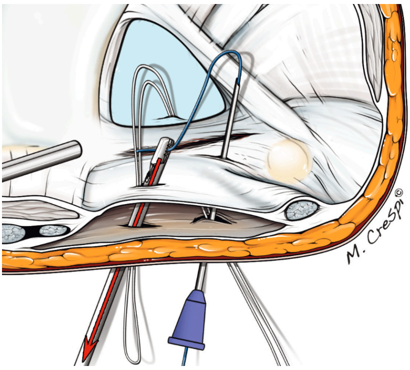


Figure 3.

First single suture retrieved from the 6R portal.

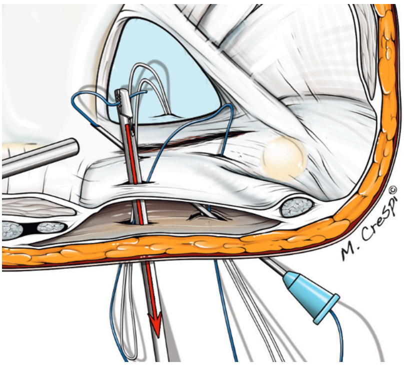


Figure 4.

Second single suture retrieved from the 6R portal.

The second single suture (Figure 4)

A second single suture passed through a third needle is introduced into the same radioulnar portal. This second suture is directed to properly reach the foveal insertion of the TFCC (the needle exits close to the styloid recess). The second suture is also retrieved from the 6R portal.

Achieving the "double loop" (Figures 5-7)

The central loop and the 2 sutures are passed through the DRUJ portal, the capsule, and the TFCC. They now emerge from the 6R portal outside of the joint.

The 2 single sutures are passed through the central loop outside the joint.

A proximal distal traction on the central loop is then performed at the DRUJ portal so that the 2 single sutures pass through the TFCC and exit at the DRUJ portal. Two loops securing the TFCC to the capsule are now created: one for the lateral portion, and another one for the medial one.

Figure 5.

Central loop and the two single sutures.

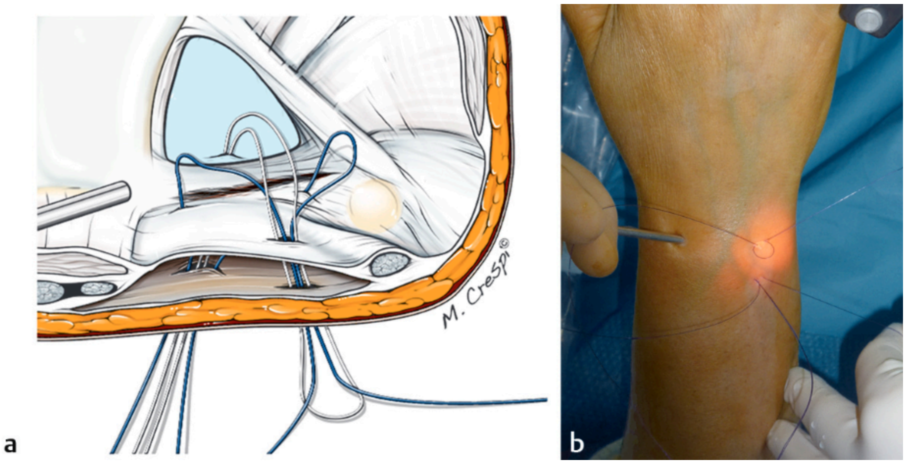


Figure 6.

The two single sutures are passed through the loop outside the joint.

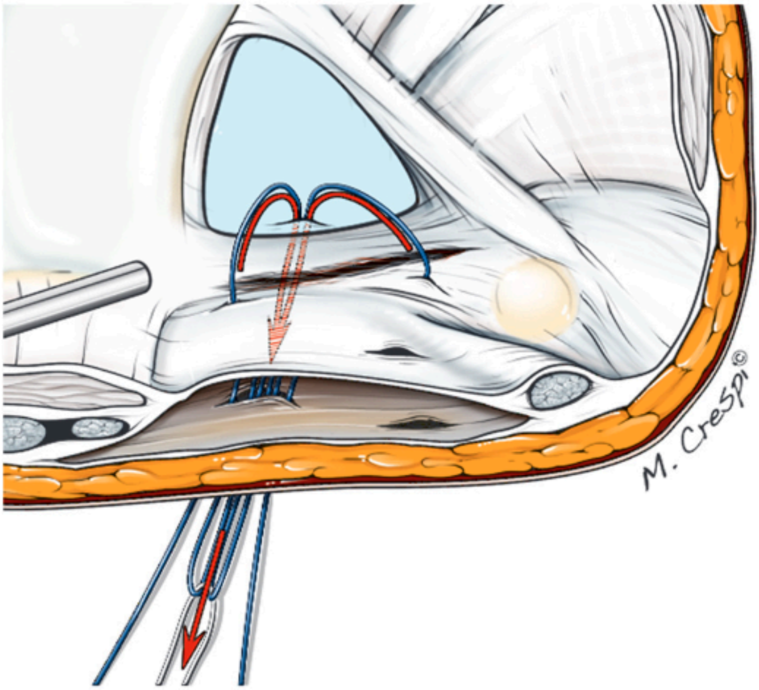


Figure 7.

Proximal distal traction on the loop, the 2 single sutures are retrieved from the DRUJ portal.

Final step: tightening the knot (Figure 8)

The traction is released, and the suture knot is tied subcutaneously while placing the wrist in extension and in ulnar deviation.

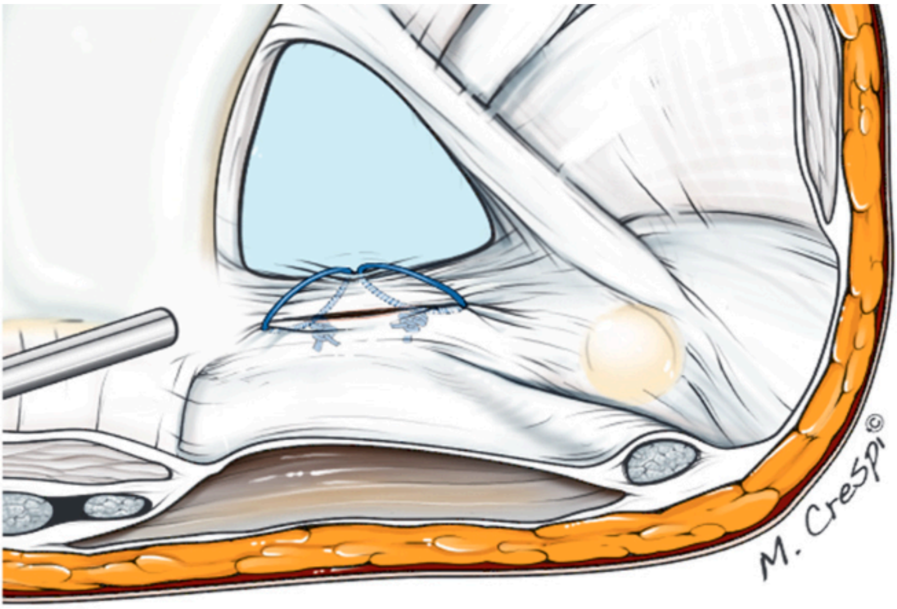


Figure 8.

Final position of the sutures.

Postoperative protocol

The wrist is immobilized in slight extension and ulnar deviation in a custom-made palmar orthosis.

The rehabilitation protocol is started at 6 weeks.

Tips & tricks

- Try to recover the 3 sutures in a single passage to prevent soft tissue entrapment between the sutures.
- The second suture should be passed through the foveal insertion of the TFCC to achieve a repair as robust as possible.
- Ask the assistant to maintain the proximal ends of the 2 sutures to avoid losing them while pulling on the central loop.
- Do not forget to assess the SL ligament complex. Massive peripheral tears of the TFCC are often associated with DCSS injuries.

Conclusion

Large tears of the entire dorsal aspect of the TFCC are not so rare and often associated with DCSS lesions.

The "double loop" suture technique allows for a complete repair, which is simple and easy to perform.

Video 11: TFCC Arthroscopic suture for large tear
https://vimeo.com/917906322

14. ARTHROSCOPY-ASSISTED FOVEAL REINSERTION OF THE TFCC

MARION BURNIER

TOSHIYASU NAKAMURA

Introduction

The triangular Fibrocartilage Complex (TFCC) is a 3-dimensional structure involved in distal radioulnar joint (DRUJ) stability.

When the radioulnar ligaments (RUL), also called reins, of the TFCC, are ruptured or detached at the fovea where the main inserting point of the RUL to the ulna is located, it results in severe distal radioulnar joint instability. The RUL should be reattached to the fovea. Different techniques have been described including arthroscopy-assisted transosseous reinsertion [1] or peripheral reinsertion.

This chapter describes the arthroscopy-assisted refixation method of the TFCC, including the RUL to the fovea using a wrist targeting guide.

Operative technique

1. Patient preparation

The procedure is performed on an inpatient basis under general anesthesia. The patient is positioned supine with a pneumatic tourniquet on the upper arm. The forearm is vertical in position with the traction tower and a 2 to 3 kg weight is applied on the upper arm for countertraction.

2. Exploration

Arthroscopic exploration helped us to redefine TFCC injuries by dividing them into three parts, including the disc, the wall, and the reins. Complete foveal TFCC tears are defined as 1B tear according to Palmer or Rein 1 according to Herzberg and colleagues.

Arthroscopy can be performed either with irrigation or dry. Our preference goes to dry arthroscopy as it makes it easier to test the ligament and to perform associated open procedures.

The arthroscopic "hook test" can be used to determine if there is a foveal detachment of the proximal component (deep portion) of radioulnar ligaments (RUL) representing a Palmer 1B-type lesion. It is performed by inserting a probe through the 6R portal and applying traction on the TFCC from an ulnar to a radial position. The test is considered positive for a tear if the ulnar aspect of the TFCC is able to be pulled radially and distally. The "suction sign" was recently described by Greene and Kakar and it is helpful when a peripheral 1B tear has scarred in and inhibits the hook test or to verify the successful repair of peripheral TFCC tears with restoration of its tension. The suction sign consists of applying suction with the shaver on the TFCC and in pathological cases, the TFCC will lift up toward the suction tip. A careful examination has to be performed to evaluate associated injuries such as lunotriquetral tear or dorsal peripheral tear of the TFCC.

DRUJ arthroscopy can directly visualize the foveal lesion **(Figure 1)**. In case of foveal detachment of the TFCC, the joint space of the DRUJ can be widely expanded because the RUL is loose. When the TFCC is completely to the ulna without any DRUJ instability, the foveal area is difficult to be visualized with DRUJ arthroscopy.

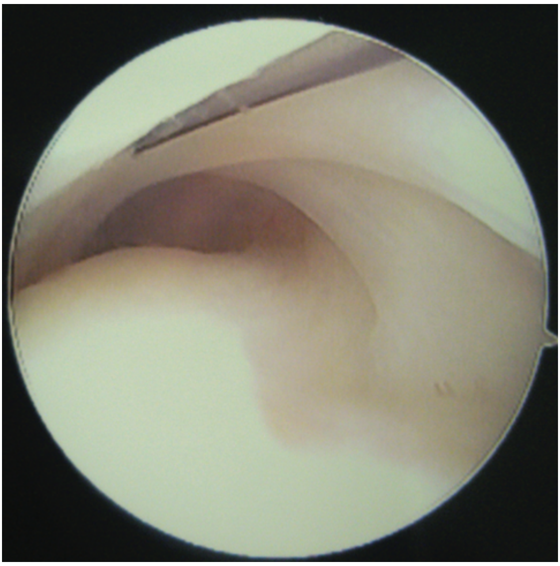


Figure 1.

DRUJ arthroscopy offers direct vision of the ulnar head, radial sigmoid notch, proximal surface of the TFCC, fovea, and RUL.

As a result, DRUJ arthroscopy can be a diagnostic tool for foveal detachment of the TFCC. When the ligament tissue can be seen in the RUL area, it is a candidate for arthroscopy-assisted foveal refixation, whereas severe scar tissue occupies the foveal area, and open exploration will then be recommended.

3. Arthroscopy-Assisted Transosseous Foveal Refixation of the TFCC

The fundamental concept of this technique is based on the anatomical characteristics of the TFCC, where the line between the ulnar half-area of the TFCC and the 10–15mm proximal point on the ulnar surface of the ulna from the ulnar styloid must pass through the center of the fovea **(Figure 2)**.

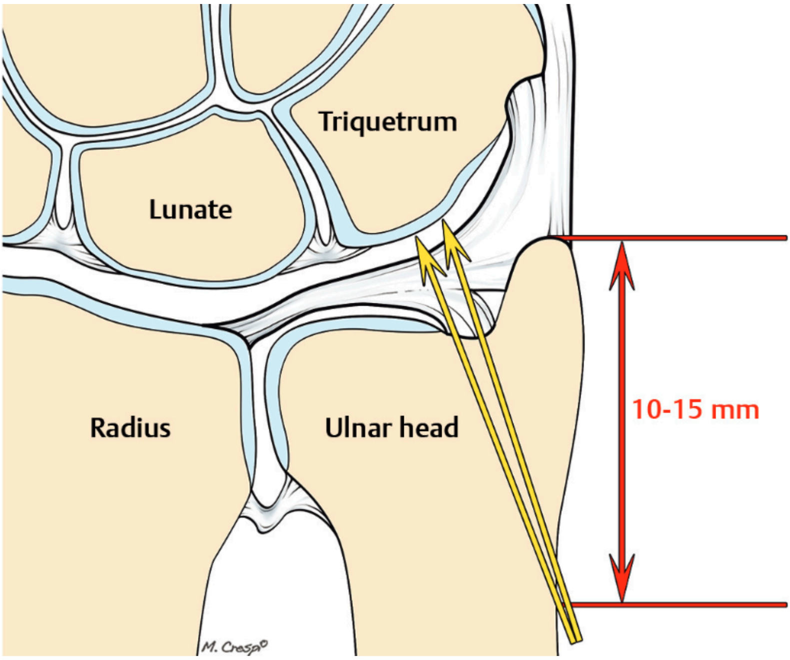


Figure 2.

Basic concept of the arthroscopic transosseous repair of the TFCC. The line between the point on the ulnar cortex of the ulnar shaft 10–15mm proximal from the tip of the ulnar styloid and ulnar half of the TFCC passes through the fovea theoretically.

After the foveal detachment of the TFCC has been confirmed, the original target device **(Figure 3)**

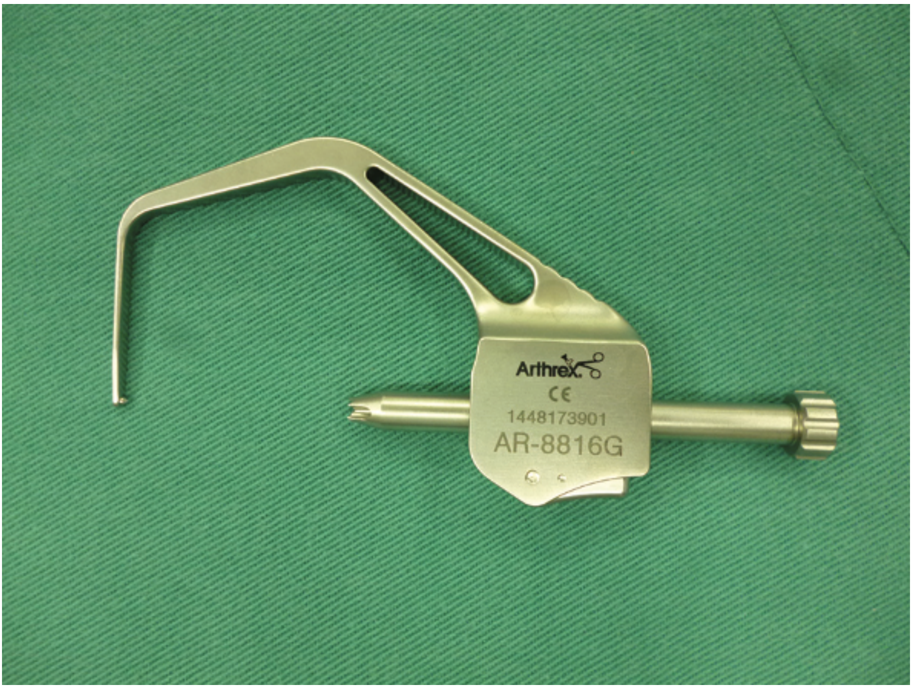


Figure 3.

Wrist drill guide.

Wrist Drill Guide (Arthrex, Naples, FL) was set through the 4-5 or 6R portal and an approximately 1cm longitudinal incision was made on the ulnar side of the ulnar cortex **(Figure 4)**, 10-15mm proximal from the tip of the ulnar styloid, with the periosteum elevated. A small spike on the target device is set on the ulnar half of the TFCC. Two separate small holes are made from the ulnar cortex of the ulna with a 1.2mm K-wire to the ulnar half portion of the TFCC **(Figure 5)**.

Figure 4.

Setting of the targeting device.

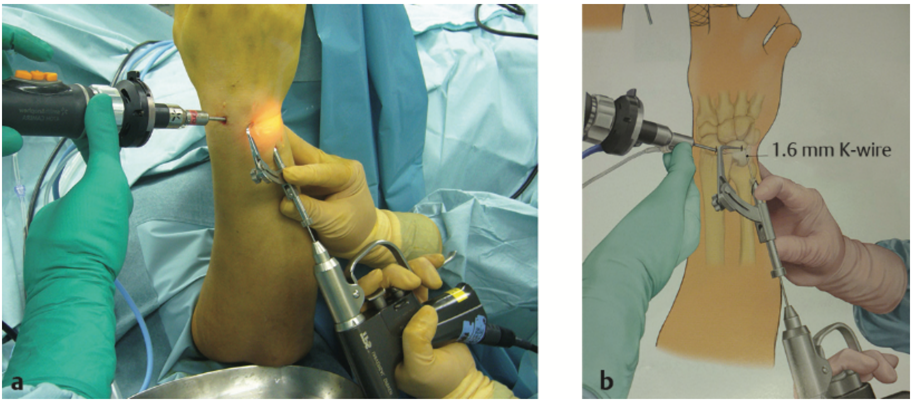


Figure 5.

Inserting K-wire to create a tunnel through the ulna and the TFCC. (a) Actual picture. (b) Drawing.

DRUJ arthroscopy may be helpful to confirm precise hole-making at the fovea. The 21-Gauge needle, in which the 4/0 nylon loop stitch was set, is passed through one tunnel from the outside **(Figure 6)**, and then is repeated through the other bone tunnel **(Figure 7)**.

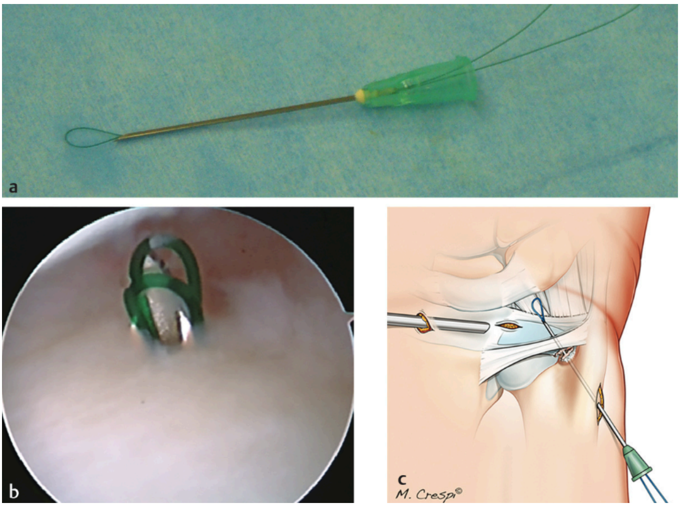


Figure 6.

21-Gauge needle with loop stitch (a) is passing through the TFCC (RC arthroscopy) (b). (c) Drawing of 21-Gauge needle passing through the ulna to the TFCC.

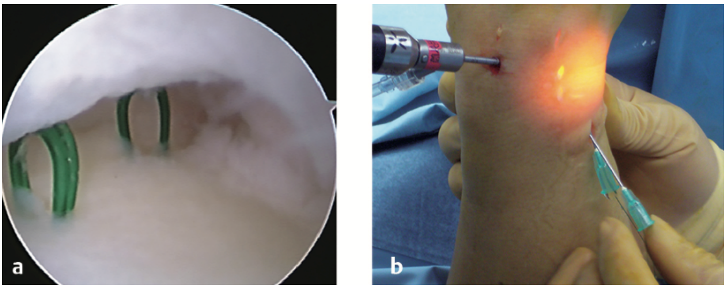


Figure 7.

(a) Two 21-Gauge needles are set through the TFCC. (b) Outside picture of two 21-Gauge needle settings.

From the 4–5 or 6R portal, the two loop stitches are once pulled out using a mosquito forceps **(Figure 8)**, and two non-absorbable 3/0 polyester stitches (Ti-Cron, Covidien, Mansfield, MA, United States) are introduced from the RC joint to the ulnar cortex of the ulna by loop stitches **(Figure 9)** to make an outside-in pullout suture of the TFCC to the fovea **(Figure 10)**.

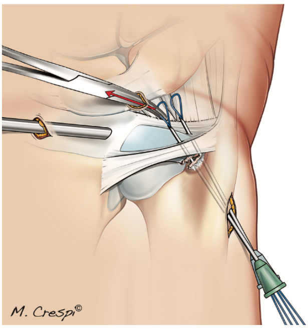


Figure 8.

Drawing indicates that the mosquito forceps, introduced into the radiocarpal joint through the 6R portal, picks up two loop stitches simultaneously.

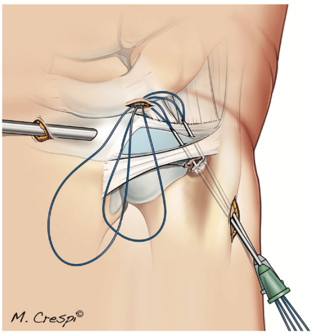


Figure 9.

Two loops were introduced outside through the 6R portal, since the working space for repair is wide as compared to inside the joint.

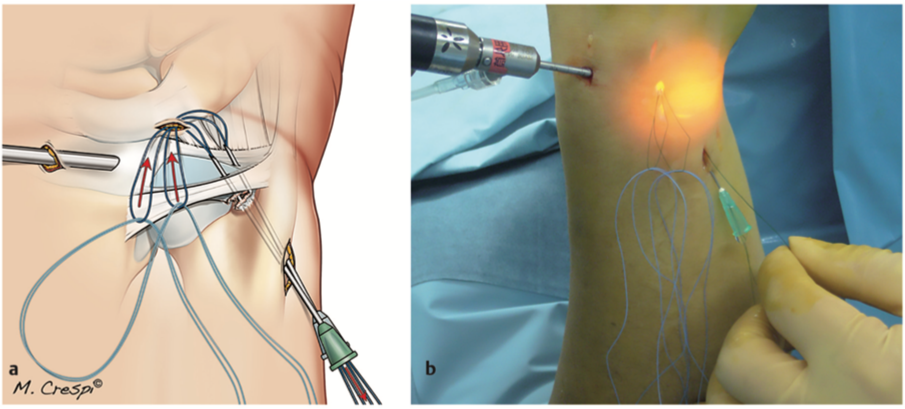


Figure 10.

(a) Two 3/0 polyester stitches are introduced from the RC joint into the ulnar cortex of the ulna using loop stitches. (b) Actual picture of two non-absorbable 3/0 polyester stitches introduced into the ulnar cortex of the ulna with loop stitches.

The TFCC is tightly anchored to the ulnar fovea with this technique **(Figure 11)**.

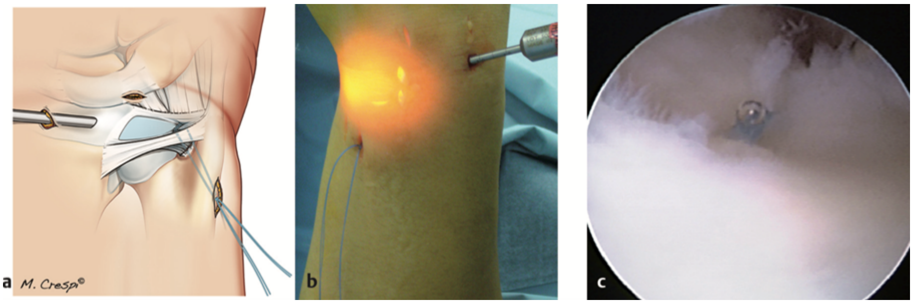


Figure 11.

Diagram of arthroscopic transosseous repair of the TFCC. (b) Outside view of after refixation of the TFCC. (c) Arthroscopic view after transosseous repair of the TFCC. Note that the detached TFCC is tightly anchored.

If the drill guide is unavailable, two needles can be introduced on both sides of the distal ulna, one volarly and another dorsally, to evaluate the trajectory of the ulnar bone tunnel. The radiocarpal arthroscopy can help to check the position of the needles through the TFCC and its appropriate foveal insertion.

Arthroscopy-Assisted Peripheral Foveal Refixation of the TFCC

A loop of 3/0 monofilament is inserted into an 18-Gauge needle after arthroscopic foveal shaving . The needle is introduced into the TFCC from the dorsal aspect of the ulnar styloid process through an ulnar skin incision proximal to the styloid process. The scope is located in the 3-4 portal **(Figure 12.A)**.

A second needle with a loop of PDS 2/0 is introduced into the TFCC from the palmar aspect of the ulnar styloid process.

The PDS loop is passed through the second loop and pulled out dorsally **(Figure 12.B)**. An anteroposterior bony tunnel with a K-wire is proximal to the styloid process and the two free limbs of the PDS material are passed through **(Figure 12.C)**. The « Nice Knot » is completed and applied to the ulnar cortical **(Figure 12.D)**.

The "Nice Knot" is a double-strand knot described by P. Boileau and Ruminian initially proposed for tuberosity osteosynthesis in proximal humerus fractures.

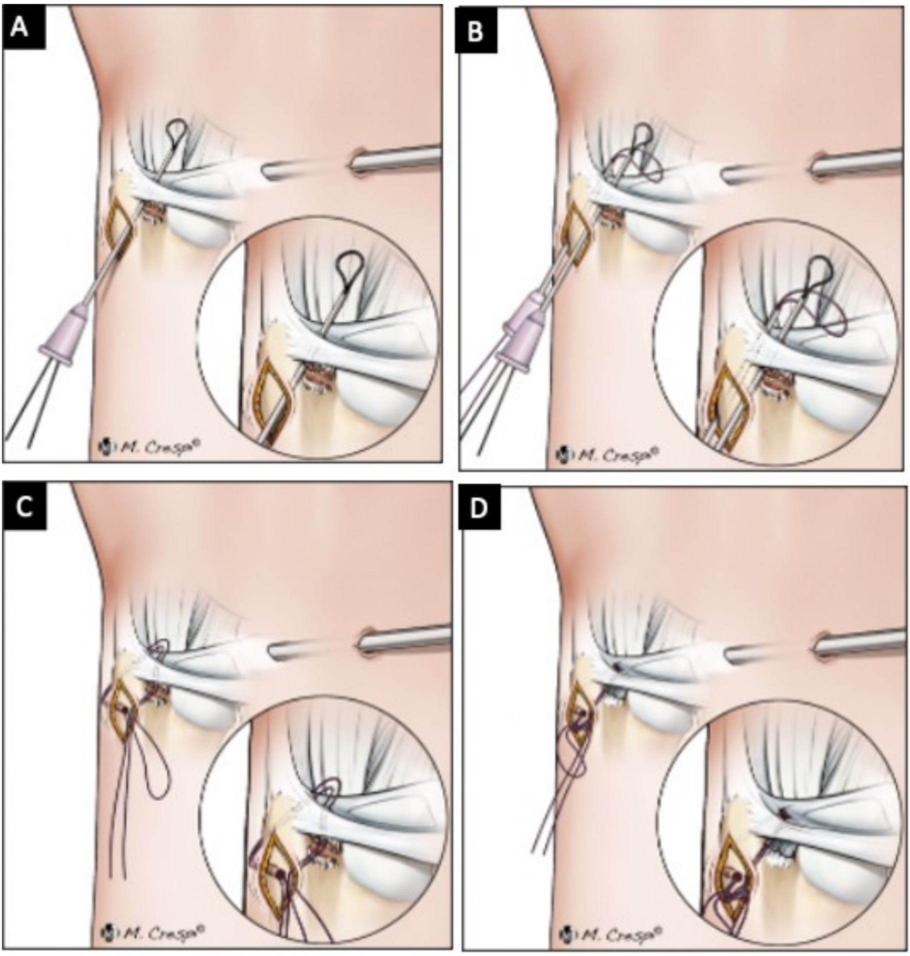


Figure 12.

The suture is doubled over itself to obtain 2 free limbs on one end and a loop on the other. The loop end is passed around or through the tissues to be fixed using a retriever or a needle. A simple square knot is realized using the loop on one hand and the 2 free limbs on the other (as in a simple undoubled suture).

Both free limbs are then passed through the loop. The knot is then shaped looking smaller. When the involved tissues are ready to be secured, the surgeon tightens down the sliding knot by pulling on the 2 free limbs.

Postoperative care

Two weeks of long arm casting, then 3 weeks of short arm casting are applied with the wrist and forearm in a n neutral position. After cast removal, rehabilitation is started. The patient may resume normal sports activities 6 months after the surgery.

Tips & tricks

- Dry arthroscopy can afford a more appropriate view and evaluation of dorsal peripheral associated tear of the TFCC.
- During arthroscopic evaluation of TFCC injuries, it is recommended to first start with the 3-4 radial portal and not to immediately perform the ulnar portal not to miss dorsal peripheral TFCC tears.
- As the direction of the ulnar bone tunnel can be difficult to achieve properly, it can be useful to find the appropriate direction of the fovea by mimicking the direction with both a volar and dorsal needle with an oblique direction from proximally to distally.
- Using the "Nice Knot" technique provides multiple advantages such as a double suture and theoretically increases suture strength; this knot is more accurate to adjust tensioning and it can undo if it has not been properly secured.

Conclusion

This approach is a very easy and reliable refixation technique of the avulsed TFCC (RUL) to the fovea. The targeting wrist guide is useful and time-saving to create two parallel bone tunnels to reattach the RUL to the precise anchoring point.

Video 12: TFCC Foveal tear: Arthroscopic repair
https://vimeo.com/917906672

15.
TFCC RECONSTRUCTION

MARION BURNIER

Introduction

Instability of the distal radioulnar joint (DRUJ) mainly results from triangular fibrocartilage complex (TFCC) injury, which plays a crucial role in maintaining DRUJ stability. The critical part of the TFCC is the foveal attachment of the reins accountable for DRUJ stability. The TFCC is usually repairable and different techniques have been described. However, in some cases, either after failed TFCC repair or irreparable TFCC ligament, with an intact DRUJ cartilage, the reconstruction needs to be considered (Class 4 according to the Atzei-EWAS classification).

TFCC reconstruction, using a free tendon graft, was first described by Mansat in 1983, and then modified and popularized by Adams and Berger in 2002. The aim of this procedure is to reconstruct the ligament and restore function, thereby providing multidirectional stability. This procedure uses a tendon graft, preferably Palmaris Longus (PL), which is woven through transosseous tunnels in the distal radius, converging at the fovea through a distal ulnar transosseous tunnel. This procedure can be performed as an open surgery or as a minimally invasive arthroscopy-assisted surgery.

Operative technique

1. Patient preparation

The procedure comprises two steps: (1) harvesting the tendon graft, and (2) reconstruction of the TFCC. The first step will be performed with the hand flat on the table arm. The second stage of the procedure is performed with a 5 to 7 kg axial traction applied to the hand using Chinese finger traps. A pneumatic tourniquet is applied, and the arm is fixed to the table. The entire procedure is performed under regional anesthesia.

2. Harvesting the tendon graft

The tendon graft must be strong and long enough to stabilize the DRUJ, and thin enough to pass through the bone tunnels. Usually, a PL tendon graft suffices. However, in case the PL is absent, a hemi flexor carpi radialis or a plantaris tendon graft may be harvested. The PL tendon graft is harvested through a small incision at the distal flexion crease of the wrist joint at the base of the carpal tunnel. A tendon stripper is used to harvest the graft **(Figure 1)**. A grasping suture is applied to the two ends of the tendon graft using 4/0 Ethilon or a similar non-braided suture material. The suture is passed several times (Krackow suture), about 1.5cm on both ends of the tendon graft to create a strong grasping suture construct, and the ends of the suture are left long for retrieval while passing the tendon graft through the transosseous tunnels.

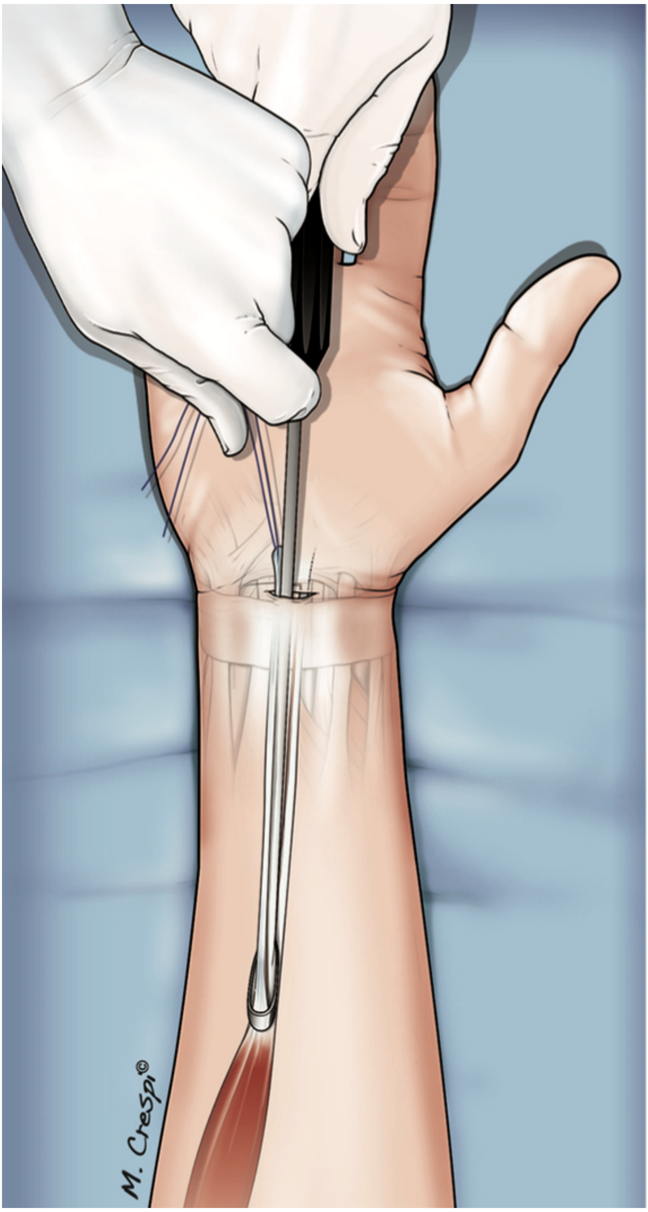


Figure 1.

Drawing showing the harvest of a PL tendon graft: the severed distal end of the tendon is secured by means of a suture passed through the eyelet of the tendon stripper. When tension is maintained on the tendon, the tendon stripper is pushed down subcutaneously to the musculotendinous junction to harvest a full-length graft without requiring another incision.

3. Making the Radial Tunnel and Passing the tendon graft

In this step, axial traction is applied to the wrist. The incision used for harvesting the tendon graft is extended proximally on the volar aspect to expose the ulnar corner of the distal radius, and retractors are positioned to improve the exposure. A second incision is made at the same level on the dorso-ulnar aspect of the wrist to expose the ulnar and distal edge of the dorsal surface of the radius. A guide wire is inserted from a dorsal to a palmar position using a protective sleeve. Care is taken to protect the soft tissues, and particularly the median nerve. The guide wire is inserted several millimeters proximally to the lunate fossa and radially to the articular surface of the sigmoid notch. The wire is inserted parallel to the articular surfaces of the distal radius and the sigmoid notch. To respect the distal radius sagittal slope and the sigmoid notch, we can introduce a needle into the radiocarpal and radioulnar joint to mimick the inclination of the radial bone tunnel.

Fluoroscopic views confirm appropriate guide wire position, and the tunnel is made with a cannulated drill, exiting through the palmar incision. A 2.5mm cannulated drill usually suffices. Care must be taken to properly clean the bone tunnel to facilitate the passage of the tendon graft. The tendon graft is then introduced from the dorsal side and retrieved through the volar side **(Figure 2)**.

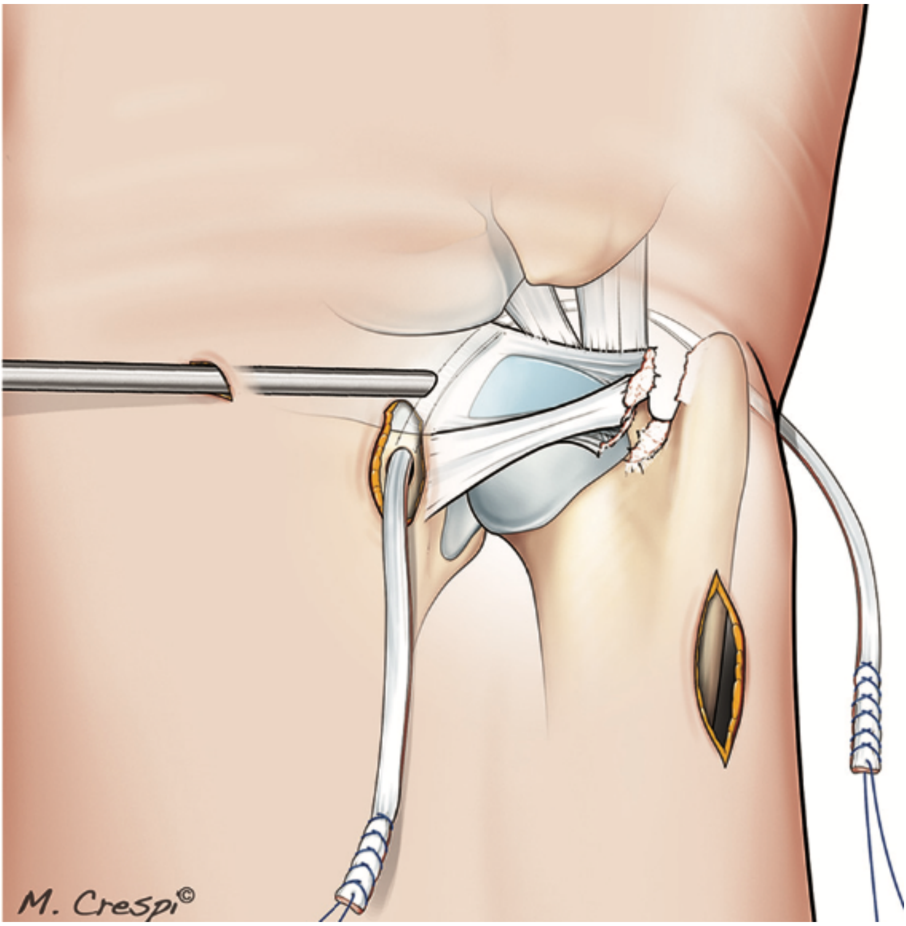


Figure 2.

Drawing of the tendon passing through a tunnel in the distal radius.

4. Preparation of the graft area in the TFCC

In this step, the TFCC is visualized arthroscopically. Debridement is performed using a “shaver” and a basket punch forceps, to clearly visualize the fovea and the ulnocarpal articulation.

The scope is introduced through the 3–4 radiocarpal portal, and the 6R is used for the shaver. Once the fovea is cleared of scar tissue and is properly visualized, the forearm is supinated and a small incision is made slightly proximal to the 6U portal. A 1 to 1.5cm incision is required to identify and protect the dorsal sensory branch of the ulnar nerve. A periosteum elevator is used to clear the soft tissue on the medial aspect of the ulna through the incision.

5. Creating the ulnar tunnel

To evaluate the position of the ulnar bone tunnel, needles can be introduced volarly and dorsally, and we can then control the position of the tip of the needle through the former foveal insertion of the TFCC arthroscopically.

A guide wire is inserted 1cm proximally to the ulnar styloid, then obliquely and distally toward the fovea. It is most often performed in a proximal to distal direction. A targeting device facilitates this step. A cannulated 3.2mm drill is used from proximal to distal to create the tunnel. The size of the tunnel is critical, and care must be taken not to fracture the ulna. Arthroscopic control helps to verify the correct entry and exit of the guide wire at the fovea.

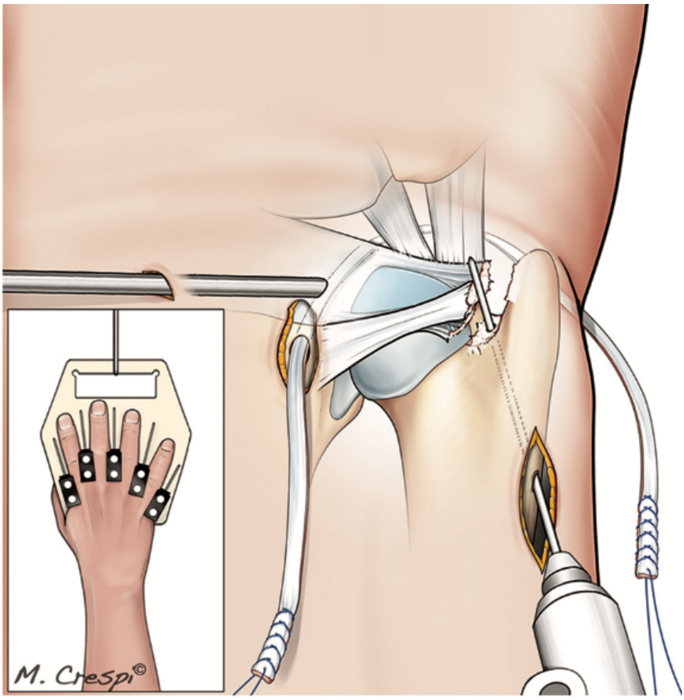


Figure 3.

Drawing showing the positioning of the guide wire in the center of the fovea.

6. Passing the graft through the ulnar tunnel

Once the bone tunnel has been drilled under arthroscopic control, joint lavage is performed. A fine straight mosquito forceps is inserted through the tunnel from proximally to distally. The two ends of the PL graft are introduced into the joint. The volar end of the tendon graft is passed through a small hole created in the capsule, ulnar, and distal to the radial tunnel at the radial insertion of the TFCC. The space is slightly distal to the edge of the radius, and the suture ends are introduced into the joint. Atzei and Luchetti [1] advised to pass the extremity of the palmar limb of the graft through the interval between the palmar ulnocarpal ligaments. As a result, this position replaces tension on the ulnocarpal ligaments stabilizing the ulnocarpal joint. The suture is retrieved with a fine mosquito forceps and passed through the ulnar bone tunnel. The tendon end is then pulled into the joint. It is crucial to first pass the volar end of the tendon graft before passing the dorsal end, otherwise the dorsal stump might block the arthroscopic visualization **(Figure 4)**. Next, a window is created: a small hole is made in the dorsal capsule, distal, and ulnar to the radial bone tunnel, and the dorsal end of the tendon graft is introduced into the joint while grasping the suture ends with a fine mosquito forceps. The suture is then passed into the bone tunnel through the distal ulna in the same manner.

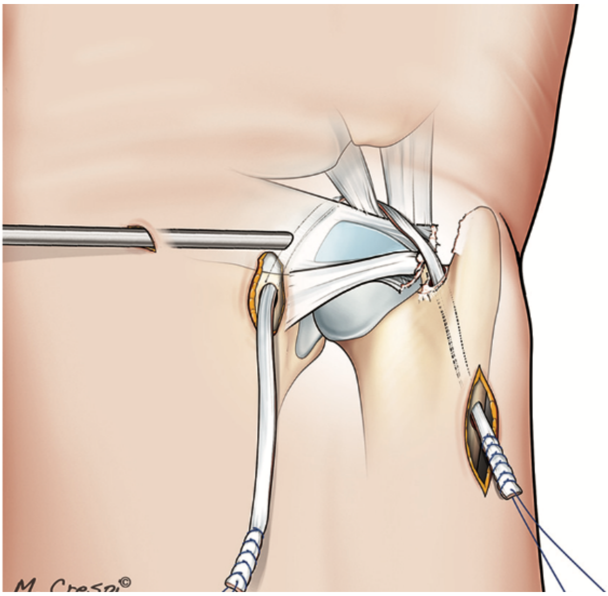


Figure 4.

Drawing showing the volar end of the tendon graft passed through the ulnar tunnel at the fovea.

7. Passage and fixation of the graft

Both ends of the tendon are inserted into the joint and the suture ends are pulled one by one through the ulnar bone tunnel. The passage of both suture ends can be challenging. It can be facilitated by cleaning the tunnel with a curette or a burr. When suturing the ends of the graft, it can then be managed to make the tendon ends as thin as possible to facilitate their passage through the bone tunnels **(Figure 5)**.

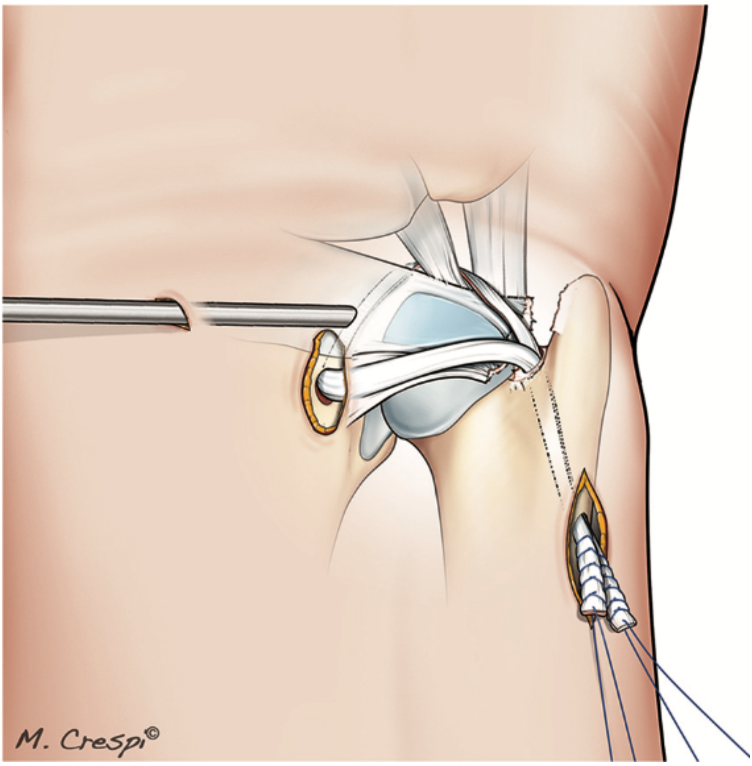


Figure 5.

Drawing showing the two ends of the tendon passing through the ulnar bone tunnel. The two bands of the tendon graft then reconstruct the palmar and dorsal portions of the TFCC, and the entry into the bone tunnel recreates the foveal insertion.

Manual tightening of both limbs of the graft should stabilize the DRUJ upon ballottement.

The graft fixation can be performed in several fashions. Mak and colleagues described fixation by performing a transverse bone tunnel made 1cm proximal to the oblique tunnel at the distal ulna using a 2.5mm drill. One of the graft limbs is inserted through the transverse tunnel. The graft is then tied to the other limb in a shoelace fashion, maximally tightened with the forearm in a neutral rotation. A non-absorbable suture is used to secure the tendon knot as to anchor the graft to the surrounding facial structures.

Atzei and Luchetti described another way of fixation. They fixed both limbs of the graft inside the ulnar tunnel with a 4mm interference screw.

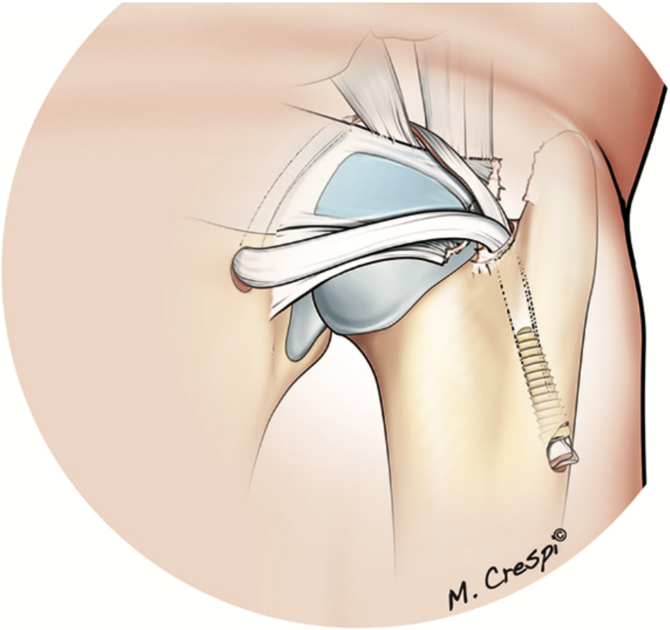


Figure 6.

Drawing showing fixation of the tendon ends using an interference screw.

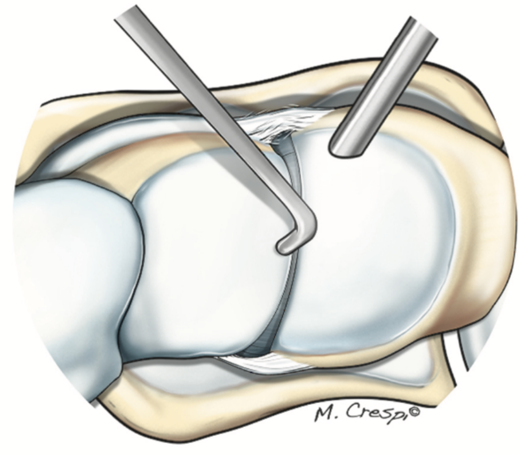


Figure 5.

Drawing of stage I scapholunate instability, viewed from above. The probe cannot be inserted between the scaphoid and lunate.

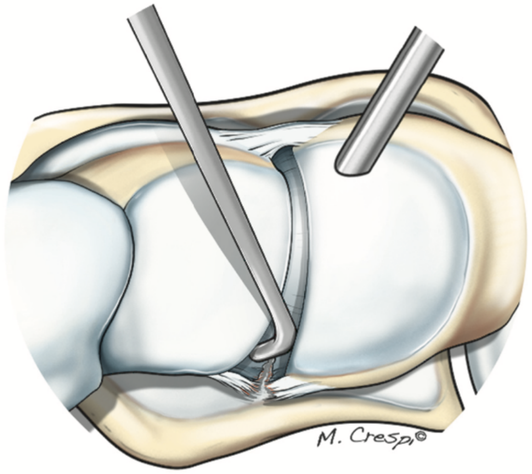


Figure 6.

Drawing of stage IIIa scapholunate instability, viewed from above. The probe can be inserted between the scaphoid and lunate, but only on the volar side; this is evidence of an isolated tear of the volar portion of the scapholunate ligament.

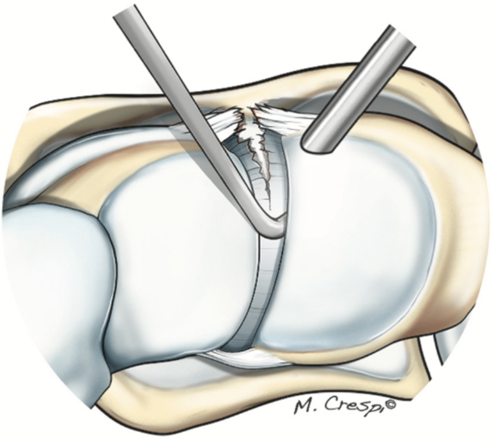


Figure 7.

Drawing of stage IIIb scapholunate instability, viewed from above. The probe can be inserted between the scaphoid and lunate on the dorsal side; this is the evidence of an isolated tear of the dorsal portion of the scapholunate ligament.

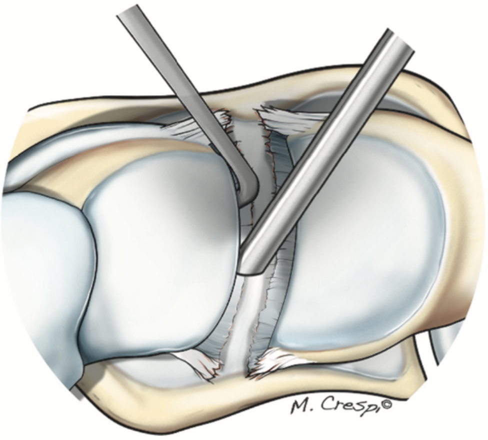


Figure 8.

Drawing of stage IV scapholunate instability, viewed from above. There is enough space between the scaphoid and lunate for the scope to pass easily between the two bones.

Tips & tricks

- To prevent bone fracture while creating bone tunnels, a K-wire must be placed properly and controlled under fluoroscopy. Cannulated drills are then recommended to maintain the proper direction of bone tunnels;
- Bone tunnels must be cleaned from any residual bone fragments to help in tendon graft passage;
- Dorsal sensory ulnar nerve branches have to be carefully dissected and protected as they represent the main complication of arthroscopy-assisted TFCC reconstruction.

Video 13: TFCC Arthroscopic reconstruction
https://vimeo.com/917907518

Rehabilitation

The wrist is immobilized in a neutral position during 3 weeks. A tong splint is then used for 3 more weeks. Subsequently, gradual recovery of wrist pronation and supination is obtained during physical therapy. Progressive resisted wrist and hand-strengthening exercises are started after 8 postoperative weeks. A complete use of the wrist is delayed until 3 months and heavy loading is avoided for 6 months.

16.
ANATOMY OF THE SCAPHOLUNATE COMPLEX

CHRISTOPHE MATHOULIN
JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

Scapholunate joint stability is ensured not only by the scapholunate interosseous ligament (SLIL), but also by a group of intrinsic and extrinsic elements called the scapholunate complex. A good understanding of this complex, based on technical advances and recent anatomical studies, is essential to provide timely specialized care when it is injured and to give it the best chance of healing. However, to accomplish this, we must have pertinent information about the various structures involved.

The objective of this chapter is to precisely describe the topographic and arthroscopic anatomy of the scapholunate complex and the use of a hook probe to test the integrity of its various structures.

Applied anatomy and biomechanics of the carpal ligaments

The proximal and distal interosseous ligaments, together with the volar and dorsal extrinsic ligaments, are directly involved in scapholunate stability.

During wrist flexion or extension, both rows of carpal bones flex or extend collectively, but to differing degrees. The primary flexion and extension lines (where the joint is most mobile) cross at the scapholunate ligament. Distal carpal compression is the greatest at the capitate. As the pressure is transmitted to the proximal row, it tends to separate the scaphoid from the lunate.

1. Intrinsic Ligament: Scapholunate Interosseous Ligament (SLIL)

The SLIL joins the scaphoid and lunate together (**Figure 1**). Its fibers are asymmetrical. The ligament consists of 3 separate macroscopically continuous parts, at least before age-related degeneration sets in:

- Dorsal: acts as a dorsal ligament between the posterior horn of the lunate and the scaphoid,
- Volar: thinner, but still strong,
- Proximal (intermediate): little to no vascularity, and consequently cannot be repaired (similar to central part of the triangular fibrocartilage complex [TFCC]); fibrocartilage between the articular surfaces of the scaphoid and lunate.

The dorsal portion is the strongest one due to its thick fibrous nature. It is considered to be the main scapholunate joint stabilizer.

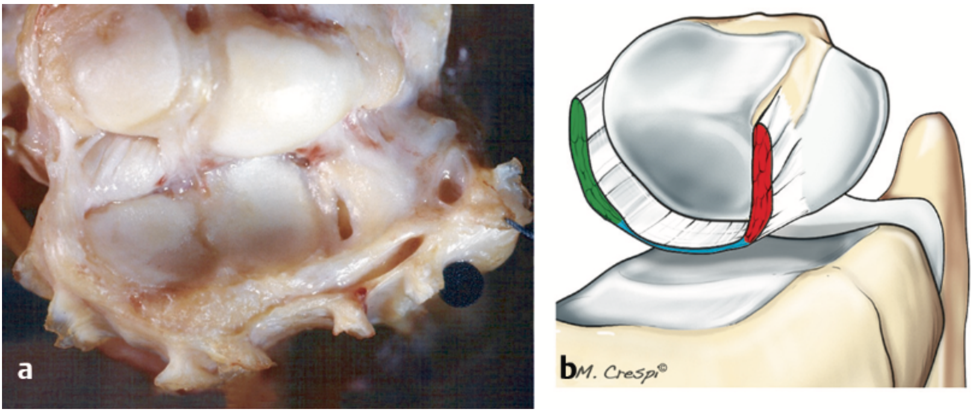


Figure 1.

a) Anatomical study in a fresh cadaver showing the first row flexed at 90 degrees toward the radius after having removed all dorsal extrinsic ligaments (Pagliei). The intrinsic SLIL is located between the proximal pole of the cartilage-covered scaphoid (upper left) and the lunate.
(b) Drawing of the 3 portions of the SLIL, in which red is the thick dorsal portion, blue is the thin non-vascularized proximal (intermediate) portion, and green is the volar portion.

2. Extrinsic Ligaments

Some of the extrinsic wrist ligaments provide additional stabilization to the scapholunate joint:

- The dorsal intercarpal (DIC) ligament seems to be the second most important stabilizer. The proximal portion of the DIC is also called the dorsal scaphotriquetral ligament. Spanning the distal scaphoid and the triquetrum, it combines with the dorsal radiocarpal (DRC) ligament to form the “dorsal V” described by Senwald and Segmüller. It is unique in that it has multiple insertions onto the lunate and the scaphoid (**Figure 2**). This ligament complex, which restricts intracarpal supination and ulnar translation of the carpus, has a particularly high number of nerve endings. Together, this "dorsal V" and the dorsal portion of the SLIL form a genuine crossroads of dorsal ligament attachments. Although its resulting length varies, it is always under tension, whether the wrist is in flexion or in extension.

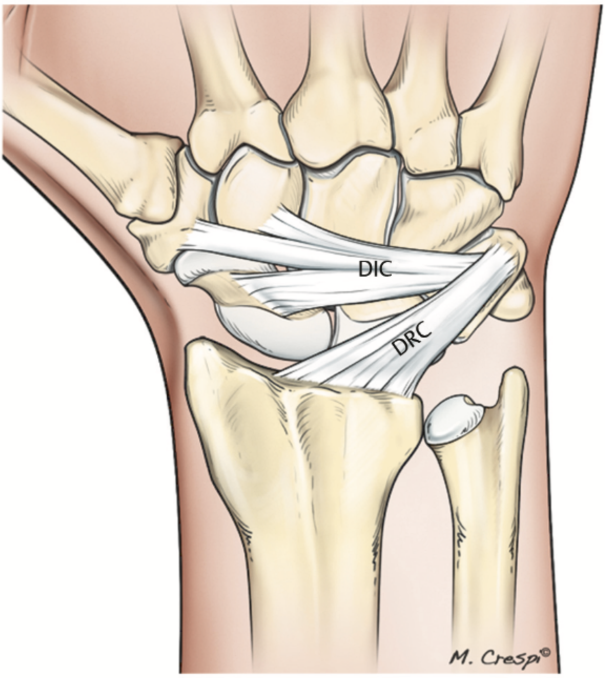


Figure 2.

Drawing of the two dorsal extrinsic ligaments: DIC ligament and DRC ligament. DIC, dorsal intercarpal; DRC, dorsal radiocarpal.

- In a recent cadaver study, the authors showed that this scapholunate confluence plays a major stabilizing role; we called this structure "dorsal capsuloscapholunate septum" (DCSS). It consists of a thickening of the capsule itself that connects the dorsal capsule with the dorsal portion of the scapholunate ligament (**Figure 3**).

- The volar radioscaphocapitate (RSC) ligament spans the radius and the capitate (**Figure 4**). It inserts deeply on the anterior side of the scaphoid's waist (isthmus). It restricts intracarpal pronation and stops dorsal translation of the proximal pole. It makes up the radial branch of the "distal palmar V."
- The scaphotrapezial (ST) ligament stabilizes the radiovolar side of the ST joint. It is extremely strong and rarely tears.

Stability of the scapholunate joint is ensured by a combination of structures that comprise an actual ligament complex. The peripheral ends of the flexor and the extensor carpi radialis and ulnaris tendons provide the additional stabilization of this complex by surrounding the carpus.

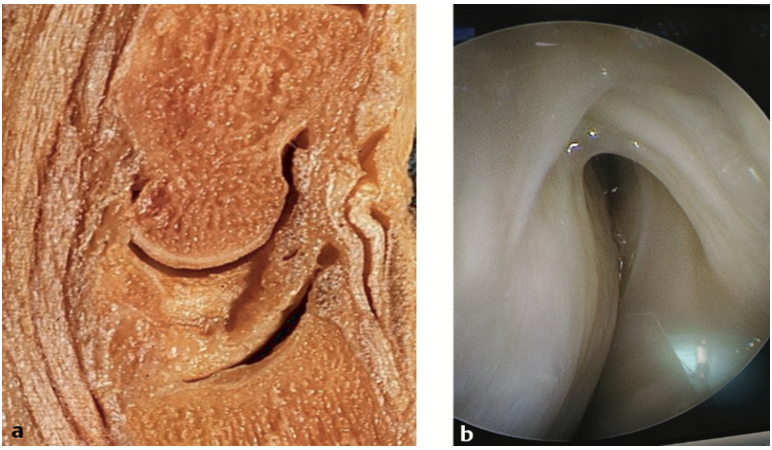


Figure 3.

Section of a cadaver wrist passing through the scapholunate ligament near the scaphoid. On the dorsal side, the DCSS is clearly visible between the dorsal capsule and the dorsal portion of the scapholunate ligament. (b) Arthroscopic view of an intact DCSS located between the capsule and the dorsal portion of the scapholunate ligament.

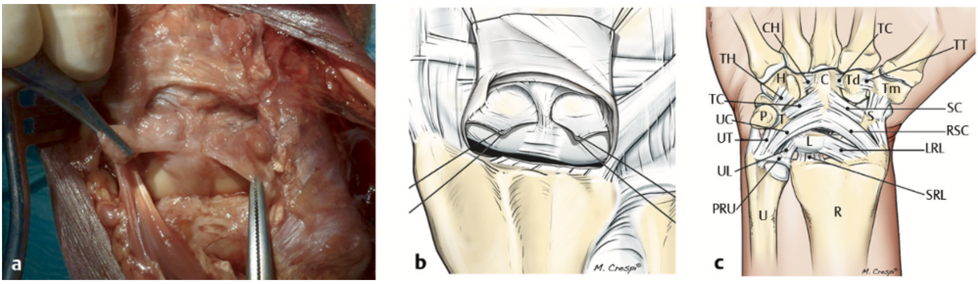


Figure 4.

__(a)__ Cadaveric dissection showing the DCSS. __(b)__ Drawing showing the DCSS ligament structure composed of 3 arches uniting the dorsal capsule to the dorsal scapholunate ligament. __(c)__ Drawing of all the extrinsic volar ligaments. H, hamate; C, capitate; Td, trapezoid; Tm, trapezium; P, pisiform; T, triquetrum; L, lunate; S, scaphoid; U, ulna; R, radius. RSC, radioscaphocapitate ligament; LRL, long radiolunate ligament; SRL, short radiolunate ligament; UL, ulnolunate ligament; UT, ulnotriquetral ligament; UC, ulnocapitate ligament; TC, trapezocapitate ligament; SC, scaphocapitate ligament; PRU, volar part of the TFCC.

Arthroscopic testing of scapholunate stability—new classification system

1. Arthroscopic testing of predynamic instability

Predynamic or occult instability provides evidence of an incomplete tear that can be detected arthroscopically. The procedure is performed on an outpatient basis under regional anesthesia. The patient lies supine. An upward traction (of 5–7 kg or 11–15.5 lbs) is applied to the arm and a support pad is placed against the upper arm. A 30-degree scope is used for radial or midcarpal arthroscopy. A blunt trocar is essential to prevent damage to the cartilage. It is inserted into portals once they have been located with needles. The standard radiocarpal (RC) (3–4 and 6R portals) and ulnar (MCU) or radial midcarpal (MCR) portals are typically sufficient to assess proximal row stability. A hook probe is a critical tool for testing.

Geissler and Dautel separately proposed classification systems for arthroscopic predynamic scapholunate instability based on midcarpal testing with a probe. This method was modified and improved by a European Wrist Arthroscopy Society (EWAS) group led by Messina. The basic concept rests on determining if the scapholunate joint opens spontaneously or can be opened with a probe.

2. EWAS Classification for scapholunate instability

Stage I corresponds to a stable scapholunate joint; the probe cannot be inserted into the scapholunate joint space (**Figure 5**). Stage II corresponds to a joint space which opens just enough to insert the probe, but does not rotate it. Stage III corresponds to a larger opening of the joint space, which can be further widened by turning the probe, either on the volar side of the joint (IIIa) (**Figure 6**), its dorsal side (IIIb) (**Figure 7**), or in its entirety (IIIc). In stage IV, the joint opens spontaneously, which allows the scope to be moved from the midcarpal to the radiocarpal joint (**Figure 8**). Stage V corresponds to major diastasis, visible on X-rays, with the scaphoid becoming horizontal. Any opening of the scapholunate joint indicates an injury to the SLIL and that the extrinsic ligaments are acting as secondary scapholunate joint stabilizers. An isolated SLIL tear does not result in scapholunate instability unless an extrinsic ligament is also torn.

Arthroscopic testing of extrinsic ligaments–injury classification

1. Classification for extrinsic ligament injury

Testing of extrinsic ligaments is performed under the same conditions as the testing for scapholunate stability in the midcarpal joint described earlier. Injuries are uncovered by visually inspecting the integrity of the structures and using the probe to determine how tight they are. In some cases, the synovial membrane will have to be reflected or resected.

Four injury stages have been described: in stage 0, the ligament is perfectly taut with all fibers continuous; in stage 1, the ligament is stretched and palpably lax, with more than 50% of fiber continuity; in stage 2, the ligament is stretched and lax with partial degeneration and less than 50% of fiber continuity; in stage 3, the ligament is completely torn or no longer present.

2. Method for arthroscopic testing of extrinsic ligaments

The testing sequence has been standardized and applies to all dorsal and volar ligaments which can be accessed in radiocarpal and midcarpal joints. Most of the time, testing requires the 4 standard portals (3–4, 4–5, MCR, and MCU) due to the scope's angle and triangulation. In rare cases, other portals may need to be used: scaphotrapeziotrapezoid (STT) to visually confirm the DIC testing, or 6U to visually confirm the DRC testing. The surgeon must be especially careful while using these portals due to the presence of the radial artery and of the sensory branch of the ulnar nerve.

3. Extrinsic ligaments visible in the radiocarpal joint

The following ligaments are palpated sequentially in the radiocarpal joint with the scope in the 3–4 portal and the probe in the 6R portal: RSC, long radiolunate (LRL), short radiolunate (SRL), ulnolunate (UL), ulnotriquetral (UT), and DRC (**Figure 5**).

The RSC and LRL ligaments are easily palpated through the space between ligaments. The SRL can be palpated on the ulnar side of the ligament of Testut or radioscapholunate (RSL) ligament, but it is often hidden by the synovium. The RSL has no mechanical role. The UL ligament is palpated immediately in front of the TFCC's radial insertion. The UT ligament is palpated immediately in front of the distal ulnar and palmar insertions of the TFCC. The DRC is palpated by sliding the probe onto the proximal surface of the triquetrum and hooking the ligament's dorsal insertion on the triquetral bone.

The DCSS is assessed by placing the scope in the 6R portal and the probe in the 3–4 portal (**Figure 9**). With the scope, the dorsal capsule is followed over the SLIL until the DCSS is located; it is the ligamentous structure between the dorsal capsule and the dorsal portion of the SLIL. If the DCSS is intact, the probe will stop and remain in the radiocarpal joint (negative push test) (**Figure 10**). If the DCSS is torn, the probe will breach the space between the dorsal capsule and the dorsal portion of the scapholunate ligament, and end up in the dorsal part of the midcarpal joint.

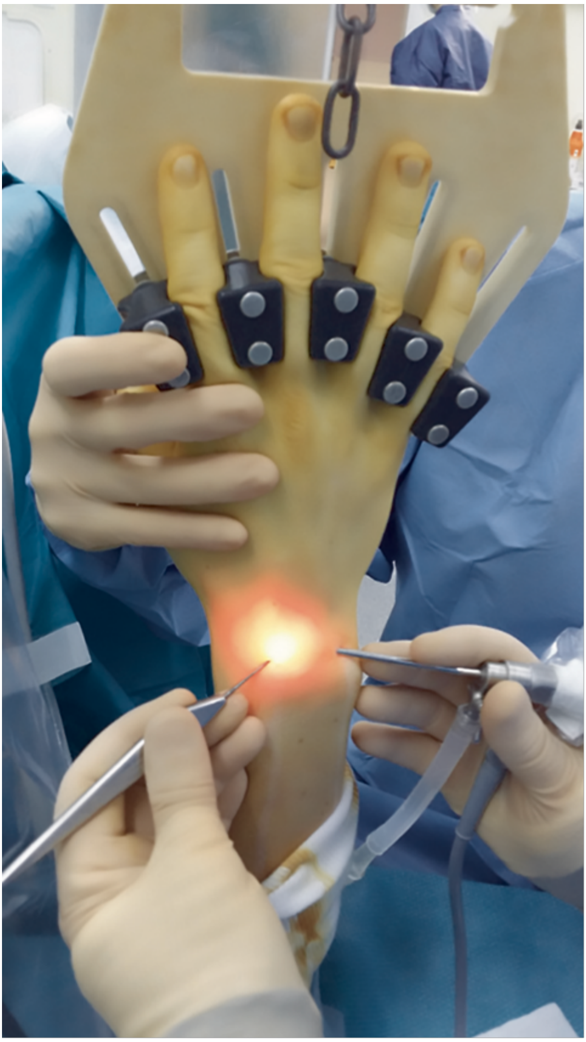


Figure 9.

Intraoperative view of instrument positioning used for the DCSS testing. The scope is in the 6R portal and the probe in the 3–4 portal.

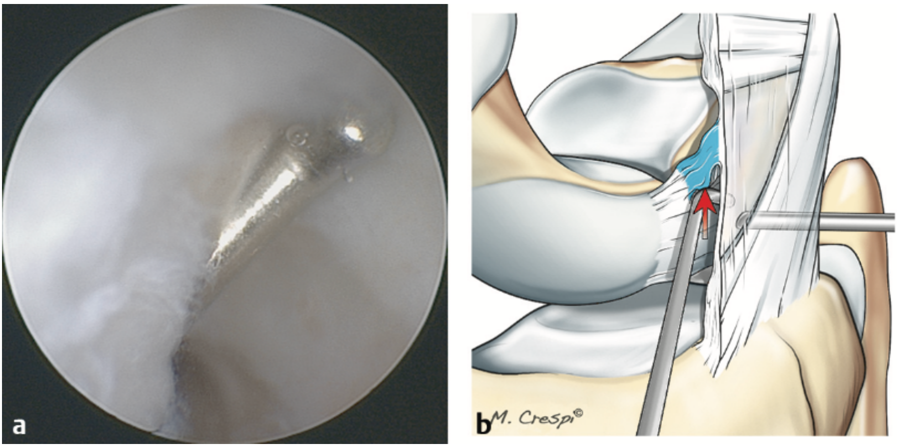


Figure 10.

a) Arthroscopic view during testing of an intact DCSS. The probe cannot go beyond the DCSS. (b) Drawing of the DCSS testing with a probe. The red arrow stimulates the pressure from proximal to distal on the DCSS with the probe.

4. Extrinsic ligaments visible in the midcarpal joint

With the scope in the MCU portal and the probe in the MCR portal, the scapholunate and triquetrolunate joints are evaluated within the midcarpal joint. The scope is then introduced into the MCR portal and the probe in the MCU to sequentially test the ST ligament, midcarpal portion of the RSC, triquetrocapitate (TC) ligament, and then the DIC ligament.

The ST is palpated by placing the scope in the MCR portal and the probe in the MCR or STT portals. The probe crosses and passes over the scope inside the joint. It slides along the distal surface of the scaphoid and it is pushed deep into the radial side of the STT joint. By following alongside the scaphoid, the scope can be advanced far enough to provide a direct view of the ligament in most cases.

The midcarpal portion of the RSC is located in front of the scapholunate joint and often covered by the synovium. The UC is the largest ligament in the anterior plane of the midcarpal joint. It is located in front of the triquetrolunate joint. To palpate the DIC, the probe is slid from volar to dorsal on the distal surface of the proximal third of the scaphoid. By pulling the scope almost out of the joint, the dorsal edge of the scaphoid can be viewed directly. The probe can hook the DIC at this location and test both its scaphoid and lunate attachments. However, this latter ligament is the hardest one to test through the standard midcarpal portals and may require the use of the STT portal.

Conclusion

Scapholunate stability is effectively ensured by a complex combining the dorsal and volar portions of the SLIL, the DIC ligament, the DRC ligament, the RSC ligament, the ST ligament, and the DCSS. The integrity of these various stabilizers is taken into account while determining the arthroscopic classification of "predynamic" scapholunate instability.

Arthroscopic testing of extrinsic ligaments supplements the diagnosis of scapholunate instability, while specifying the timeframe of the injury through well-defined criteria. From that stage onward, the choice of repair methods can be qualified. Given the information presented, it seems necessary to diagnose each injury and treat as many stabilizing structures as possible when caring for patients with non-arthritic scapholunate instability.

17.
DORSAL CAPSULOLIGAMENTOUS REPAIR OF THE SCAPHOLUNATE LIGAMENT TEAR

CHRISTOPHE MATHOULIN

JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

Scapholunate interosseous ligament (SLIL) tears are one of the most serious injuries associated with wrist trauma. Although open surgical repair can be performed, it is not indicated in the initial stages because of the resulting joint stiffness.

Wrist arthroscopy has completely changed the way these injuries are diagnosed and treated. The injury can be evaluated in its initial stage, before the ligament is completely torn and the scaphoid becomes horizontal. The dorsal portion of the scapholunate (SL) ligament and its attachment to the dorsal capsule through a dorsal capsuloscapholunate septum (DCSS) are the keys to SL stability. This dorsal complex can be repaired arthroscopically using capsule-to-ligament suturing, thereby preventing the stiffness typically observed with open procedures.

Operative technique

The procedure is performed on an outpatient basis under regional anesthesia. The patient is placed supine, with the arm resting on an arm board with an attached tourniquet. An upward traction of 5 to 7 kg (11–15.5 lbs) is applied to the hand. The arthroscope and sheath are inserted through the 3–4 radiocarpal portal to visualize the SLIL. However, the dorsal portion of the SLIL can be seen only with the scope in the 6R portal.

A shaver is introduced into the 6R portal to clean out the joint and perform a synovectomy. The shaver and arthroscope are reversed to finish the synovectomy, particularly at the dorsal recess. A probe is used to assess the nature of the SL ligament injury. The scope can be used to follow the volar portion of the SLIL to its dorsal insertion. Usually, the SLIL is avulsed from the scaphoid. The ligament stump that is attached to the lunate can easily be lifted with the probe.

The dorsal portion of the SLIL and the DCSS are then evaluated at the dorsal recess. More often than not, the ligament is torn, with ligament stumps remaining attached to the scaphoid and lunate (**Figure 1**). This technique can only be performed under such circumstances. A push test is performed to assess the DCSS, which is an anatomical structure located between the dorsal intercarpal (DIC) ligament and the dorsal portion of the SL ligament. The probe is placed in the dorsal recess under scope guidance, using the angulation and triangulation effects. If the DCSS is intact, it will be completely visible, and the probe will not be able to go any further. If it is not, the probe can subsequently move into the midcarpal joint without being hindered by the DCSS (positive push test).

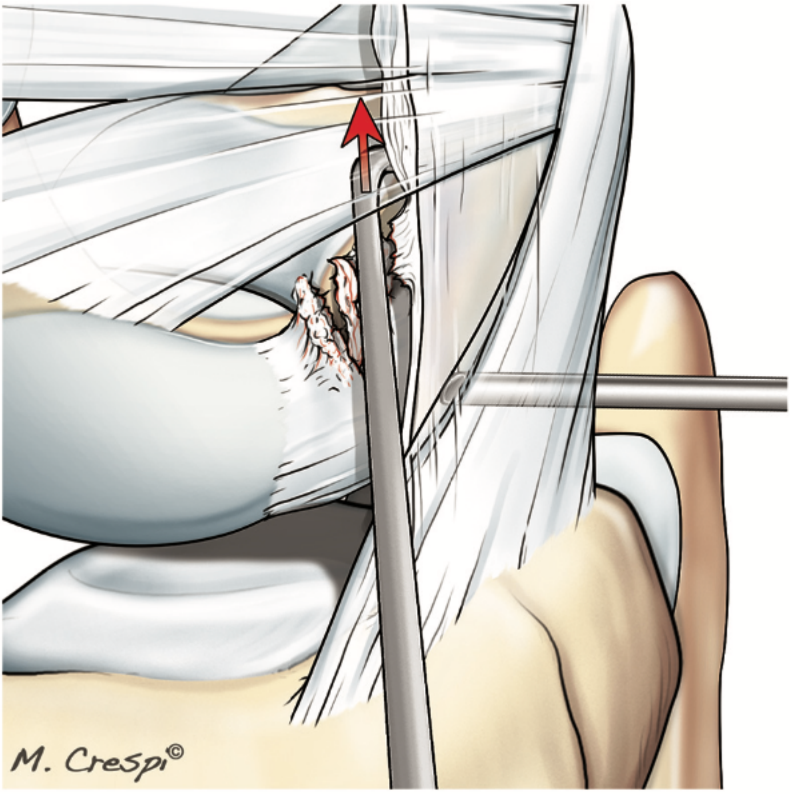


Figure 1.

Drawing of a torn scapholunate ligament. The probe indicates a positive push test with the torn DCSS. The repair can be performed only if the SLIL remnants are attached to the lunate and scaphoid.

1. Exploration of the Midcarpal Joint

The arthroscope and the sheath are introduced through the midcarpal ulnar (MCU) portal. The shaver is introduced through the midcarpal radial (MCR) portal to perform a synovectomy. In cases of dorsal intercalated segment instability, there will be a step-off between the scaphoid and the lunate. The probe is inserted between the scaphoid and the lunate to determine the dissociation stage.

2. Performing the Dorsal Capsuloligamentous Suture

The scope is introduced into the 6R portal to explore the gap between the lunate and the dorsal capsule. An absorbable monofilament suture (3/0 or 4/0 depending on the patient's size) is passed through a needle. This needle is inserted through the skin via the 3–4 portal, and then shifted slightly distally so as to cross the joint capsule (**Figure 2**). The needle is located inside the joint through the scope and then pushed through the SLIL stump on the scaphoid side. The needle is orientated dorsal to volar and angled proximally to distally, making it possible to enter the midcarpal joint (**Figure 3**).

If the 3–4 portal is not exactly overlying the SLIL, the assistant may pull on the skin on the medial side of the wrist to shift the 3–4 portal and avoid having to make a larger opening (**Figure 4**). A second needle and a suture are then inserted parallel to the first one into the SLIL stump attached to the lunate (**Figure 5**).

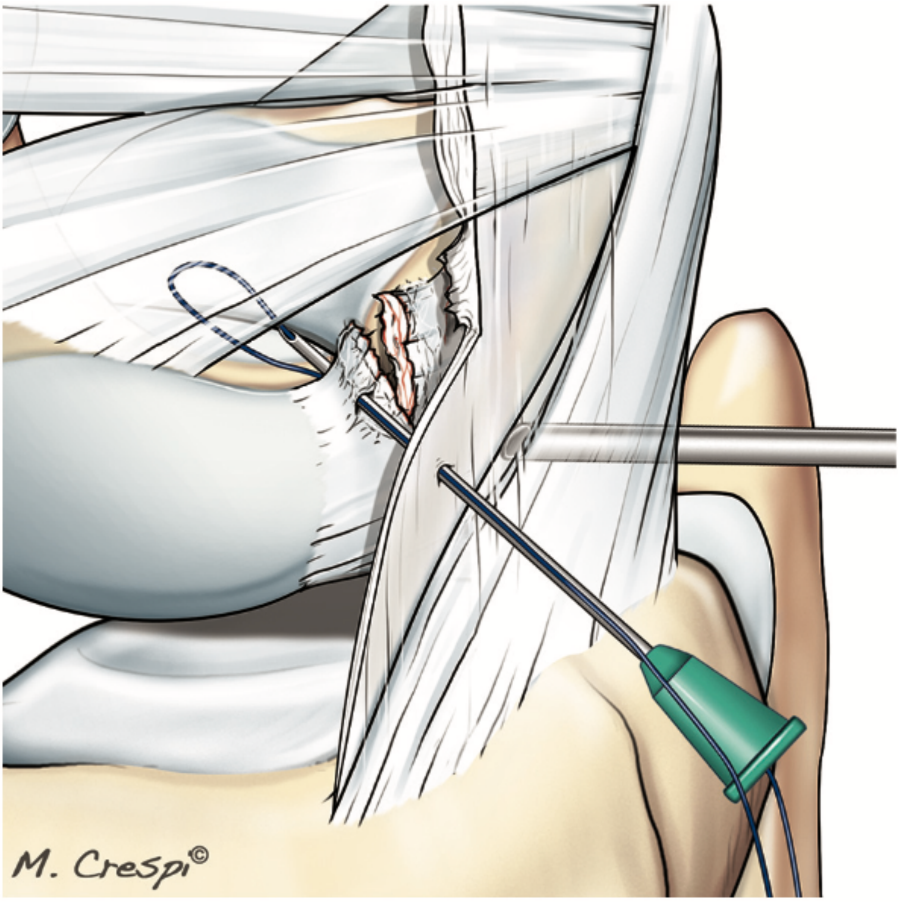


Figure 2.

Drawing of SL ligament suture repair to the dorsal capsule. A suture is passed through a needle. The needle is inserted through the capsule and then through the dorsal portion of the scapholunate ligament that remains attached to the scaphoid.

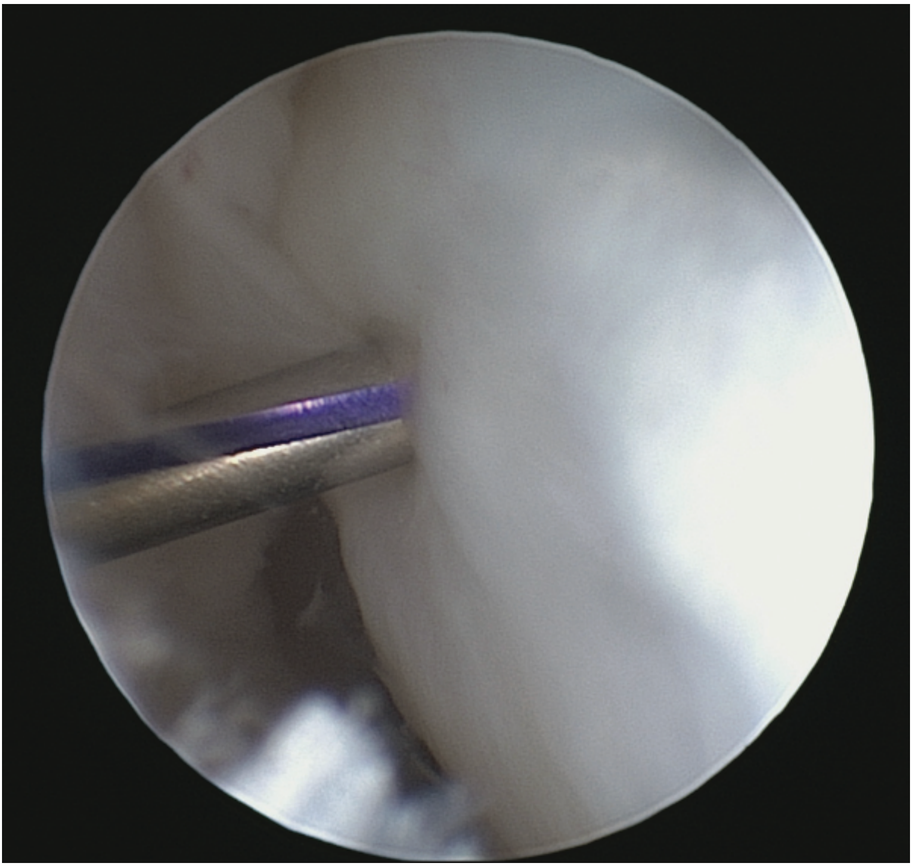


Figure 3.

Arthroscopic view of the needle passing through the capsule and dorsal portion of the SLIL. The needle is angled dorsal to volar and proximally to distally so that it can enter the midcarpal joint.

Figure 4.

Intraoperative view of a technical trick: by pulling on the skin on the medial side of the wrist, the 3–4 portal is shifted medially so that it lies overtop of the SLIL.

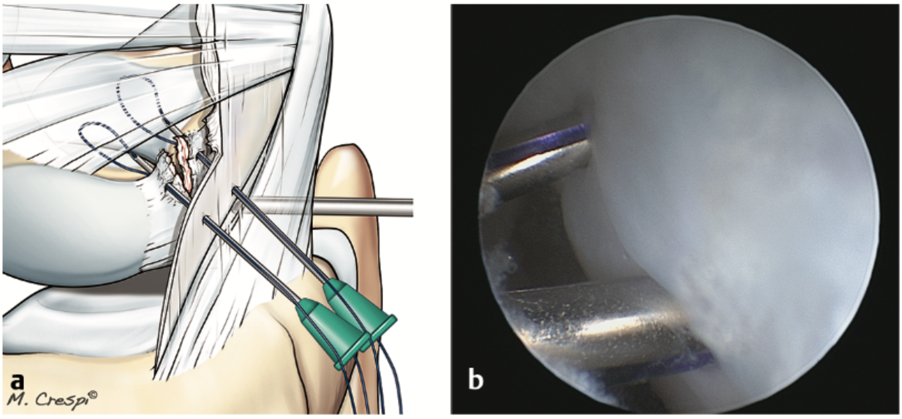


Figure 5.

(a) Drawing showing the position of the two needles passing through the dorsal capsule into the two stumps of the dorsal portion of the SLIL. (b) Arthroscopic view of the position of the needles inside the joint.

3. Tying the First Knot

The scope is returned to the MCU portal. The two needles are located inside the midcarpal joint, after they have passed between the scaphoid and lunate. A hemostat is introduced through the MCR portal to retrieve the two sutures (**Figure 6**). The needles are removed, and the hemostat is used to externalize both sutures. A knot is tied between the two sutures. Traction is applied to both sutures through the 3–4 portal to pull the first knot into the midcarpal joint and seat it between the scaphoid and the lunate (**Figure 7**). The knot is positioned volar to the remaining dorsal portions of the SLIL. The degree of reduction in the SL gap is determined by maintaining tension on the sutures and by slightly releasing wrist traction. If reduction is satisfactory, the ligament is sutured to the dorsal capsule.

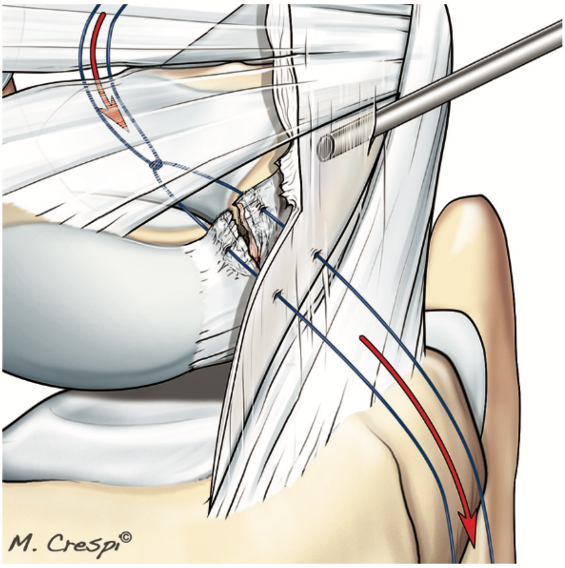


Figure 6.

Drawing showing suture retrieval using a hemostat introduced through the MCR portal.

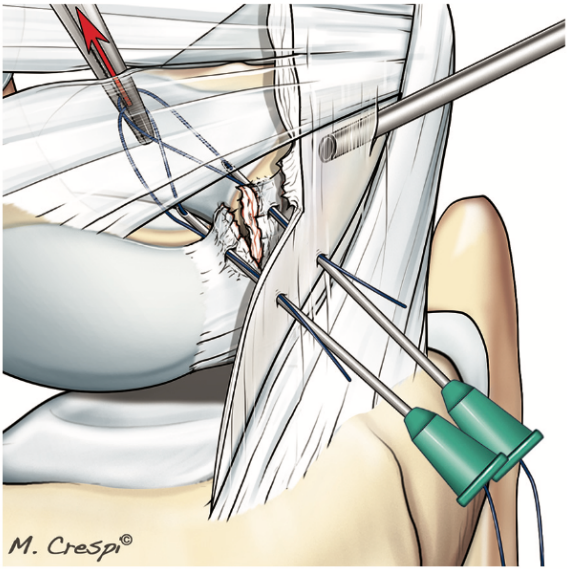


Figure 7.

Drawing showing traction placed on the proximal suture ends to bring the knot back into the joint.

4. Tying the Second (Last) Knot

The scope is returned to the 6R portal before the last knot is tied (**Figure 8**). To make sure that the dorsal capsule-to-ligament suture is properly positioned, the dorsal capsule is pressed with the thumb while keeping the sutures taut –this will roughly duplicate the action of the final knot. Closing the gap recreates the DCSS. A probe introduced through the 3–4 portal cannot go any further distally. After the hand has been released and the wrist has been extended, the last knot is tied subcutaneously.

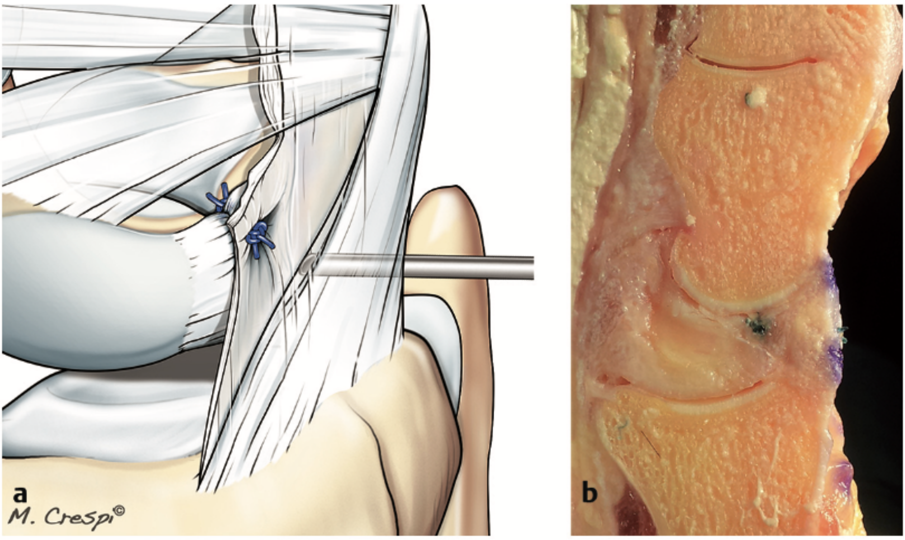


Figure 8.

(a) Drawing showing the suturing between the SL and the dorsal capsule with one intra-articular knot located in front of the dorsal portion of the SLIL and one extra-articular subcutaneous dorsal knot located behind the dorsal capsule. (b) Section through a cadaver wrist showing the thickness of the repair after the ligament and the dorsal capsule have been sutured.

5. Large SL Ligament Tear with Instability (EWAS 4)

In some cases, the instability is significant (EWAS 4) and simple dorsal capsuloligamentous suturing is not sufficient. In this case, we use a special trick: we catch a large part of the dorsal capsule, proximally and dorsally, to constrict the capsule and reduce the SL space. Proximally, the two needles pass through two different points on the capsule approximately 1cm apart. It is sometimes necessary to extend the 3–4 radiocarpal portal to protect the extensor tendons. Distally, the radiocarpal and midcarpal portals are also extended. Two different openings 1cm apart will be needed to pass the mosquito forceps (**Figure 9**). The distal knot stays outside of the dorsal capsule. With the final knot, constriction of the dorsal capsule avoids the need for K-wires (**Figure 10**).

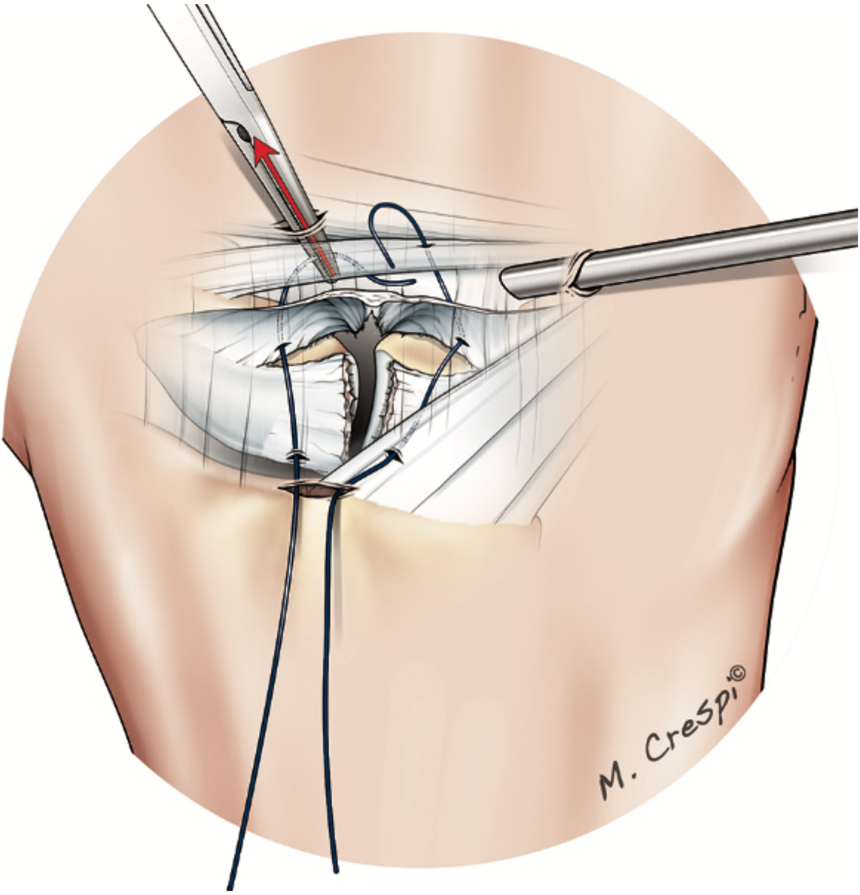


Figure 9.

Drawing showing the special trick in case of large scapholunate dissociation, catching a large part of the dorsal capsule, proximally and distally.

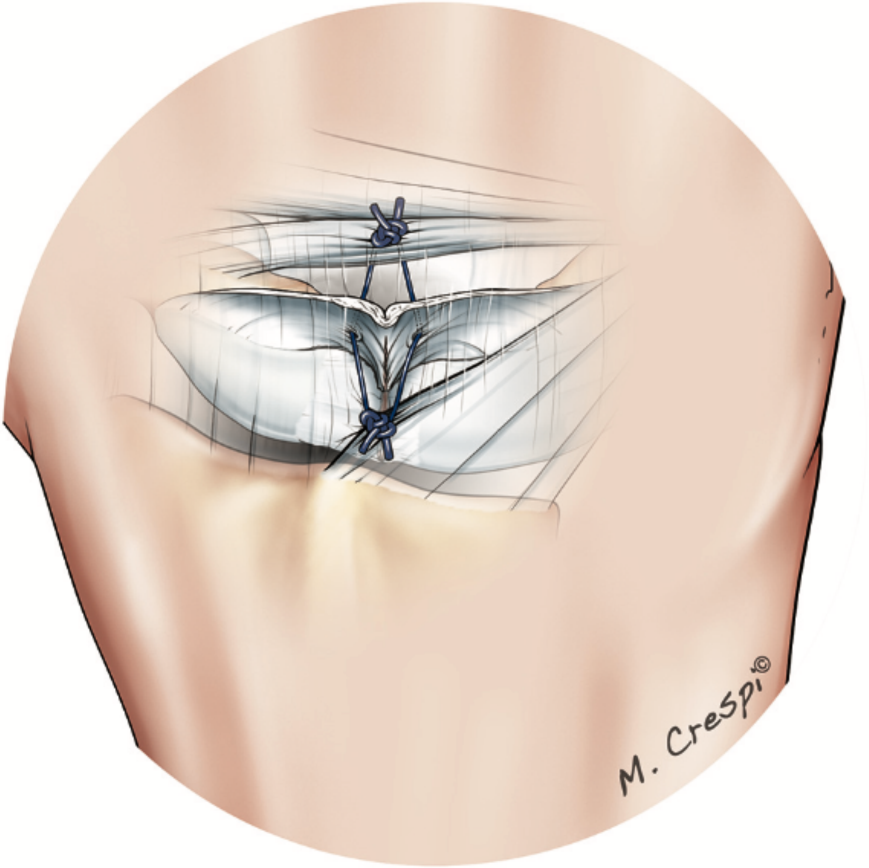


Figure 10.

Drawing showing the final knot with a constriction of dorsal capsule helping to reduce scapholunate dissociation.

6. Large SL Ligament Detachment without Ligament Stump on the Scaphoid

In other cases, the SL ligament detachment is very severe, with no SL ligament stump left on the dorsal proximal pole of the scaphoid. In these cases, an anchor is inserted into the dorsal distal part of the proximal pole (**Figures 11 and 12**). The suture in the anchor is used as the first suture for dorsal capsuloligamentous repair. Another suture is added, as in the conventional technique, and used to catch a large part of the dorsal capsule to achieve reduction, as described above (**Figures 13 and 14**).

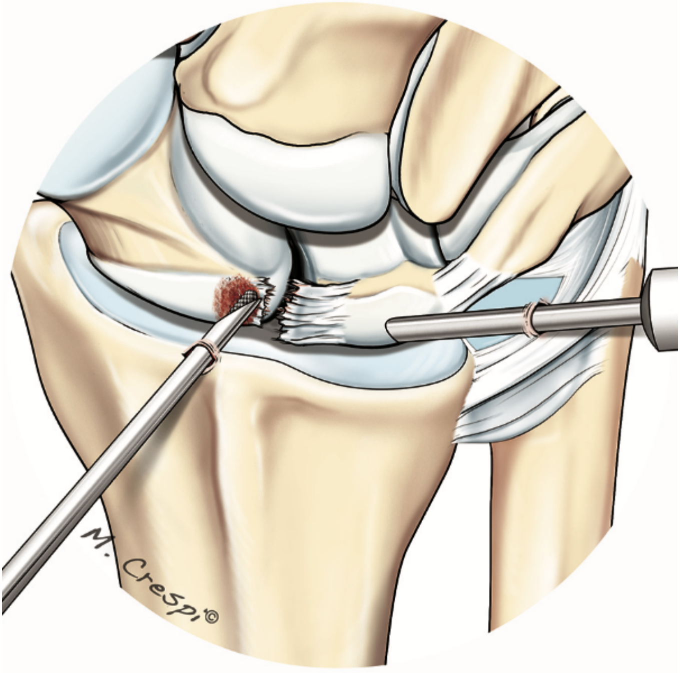


Figure 11.

Drawing showing the cleaning of the avulsion area of the dorsal scapholunate ligament attachment on the dorsal proximal pole of the scaphoid.

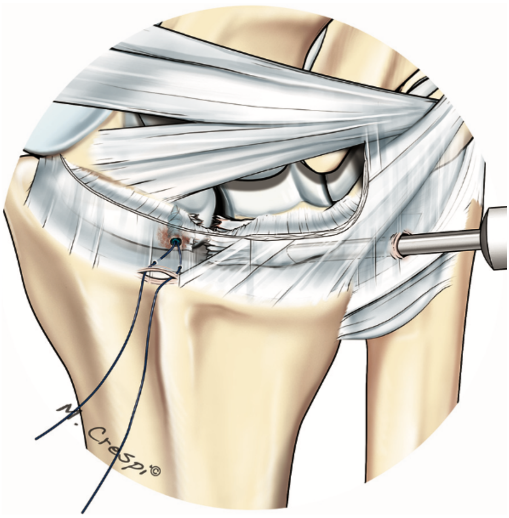


Figure 12.

Drawing showing the insertion of an anchor into the dorsal distal part of the proximal pole of the scaphoid.

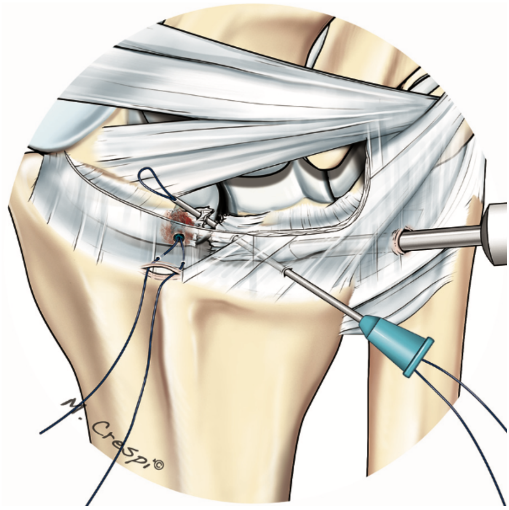


Figure 13.

Drawing showing the passage of second suture used to catch a large part of the dorsal capsule.

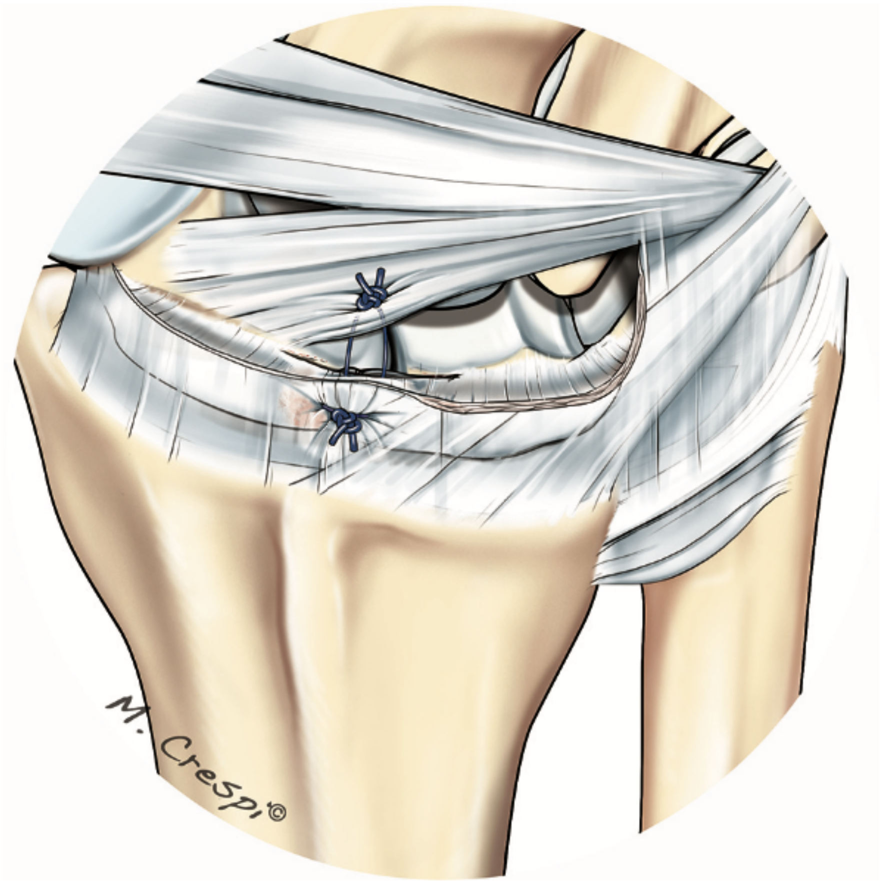


Figure 14.

Drawing showing the final knot between the suture from the anchor into the scaphoid, and the second suture through the remnant part of the scapholunate ligament attached to the lunate.

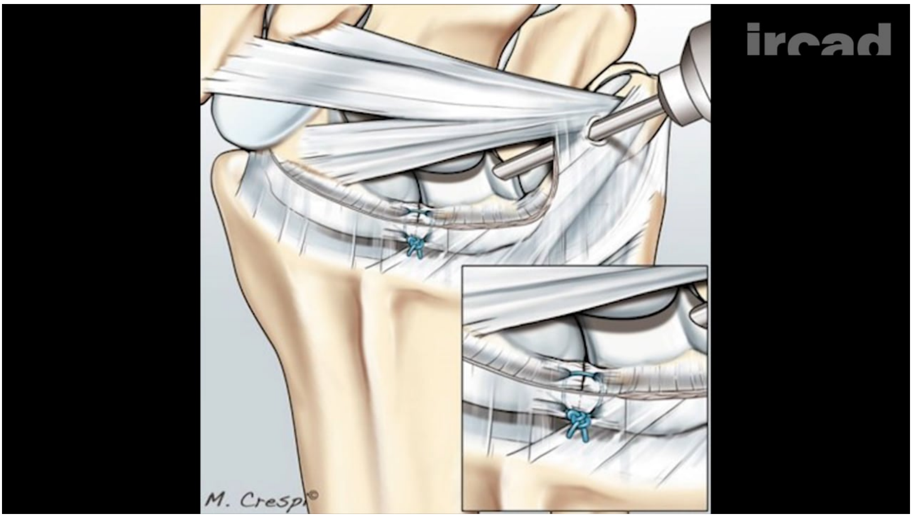
7. Postoperative care

The portal incisions are not closed. The wrist is immobilized in extension (45–60 degrees) with an anterior splint for 6 weeks in cases of suture repair only, and for 8 weeks in cases of associated K-wire fixation. The K-wires are removed after 8 weeks. Rehabilitation starts immediately after the immobilization period ends.

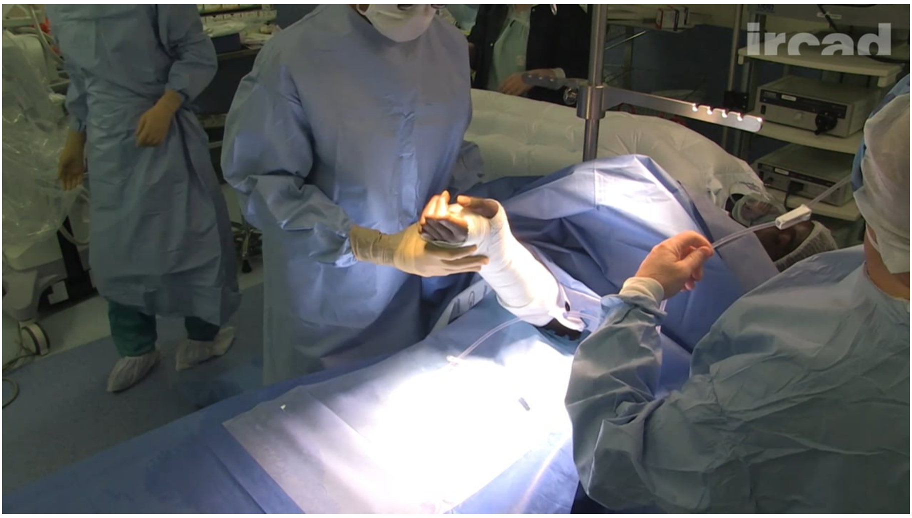
Conclusion

Arthroscopic repair of the SLIL has drastically changed the way SL injuries are treated. The resulting repairs are excellent. This method avoids the stiffness typically associated with open procedures. Athletes are able to return to pre-injury performance levels. Nevertheless, its use is limited to cases where the stump of the dorsal portion of the SLIL is still attached to the scaphoid. Arthroscopy and comprehensive clinical assessments can provide early diagnosis of SL tears, leading to early treatment.

Video 14: Arthroscopic dorsal capsuloligamentous repair and arthroscopic TFCC suture
https://vimeo.com/209952203



Video 15: Arthroscopic large dorsal capsuloligamentous suture for scapholunate dissociation EWAS stage 4
https://vimeo.com/270049074



Video 16: Arthroscopic capsuloligamentous suture with anchor for scapholunate dissociation EWAS stage 4
https://vimeo.com/270050837

18.
DORSAL INTERCARPAL LIGAMENT (DIC) DETACHMENT REPAIR

LORENZO MERLINI
CHRISTOPHE MATHOULIN

Introduction

The DIC ligament (or scaphotriquetral ligament, STL) runs from the dorsal aspect of the scaphoid to the dorsal aspect of the triquetrum, giving on its way fibers to the lunate. Its main role is stability of the proximal row of the carpus, especially regarding scapholunate (SL) stability. Specific isolated detachment of the DIC from the scaphoid has been described and needs direct repair, which is currently possible through an arthroscopic anchor-based technique.

Operative techniques

1. Radiocarpal Exploration

Using a conventional wrist arthroscopy set-up, the procedure starts with radiocarpal exploration with the scope in the 3-4 portal and then rapidly switching to the 6R portal, leaving the 3-4 portal for instrumentation of the repair. Radiocarpal assessment can confirm the diagnosis of detachment of the DIC ligament from the scaphoid, which will present a bald area instead of the normal attachment of the dorsal capsule on its dorsal and distal aspects **(Figures 1 A and B)**.

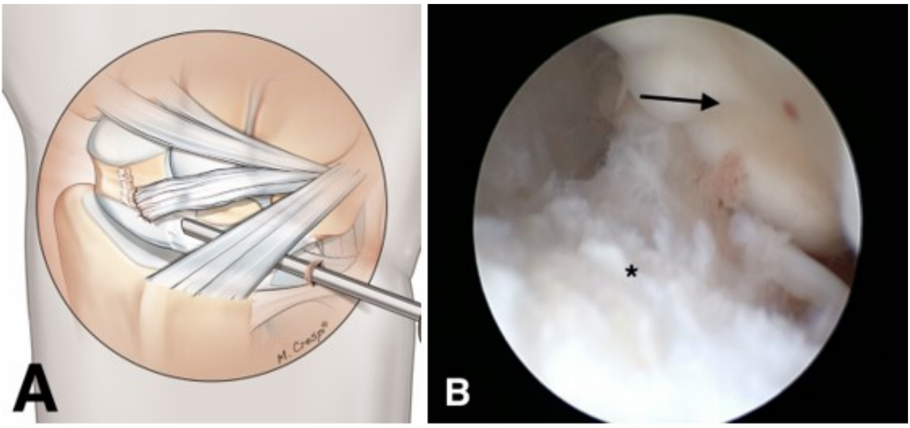


Figure 1.

2. Creating the "3-4 distal" portal (DIC specific portal)

To repair the DIC, a specific portal must be created directly facing the site of repair. The standard 3-4 portal is too ulnar, and the 1-2 portal too radial. The ideal position lies between these two portals, and a little more distally.

Correct position will be confirmed by means of needle try-out. It can be a risky portal for the EPL tendon, so caution must be the rule and mosquito blunt dissection is necessary.

3. Repair of the DIC ligament

The detached extremity of the DIC ligament and the scaphoid site of avulsion are then debrided with the shaver. Repair is possible through anchoring of the DIC ligament on its scaphoid footprint. The scaphoid is drilled through the DIC specific portal, and the anchor is positioned at the site of DIC avulsion **(Figure 2)**.

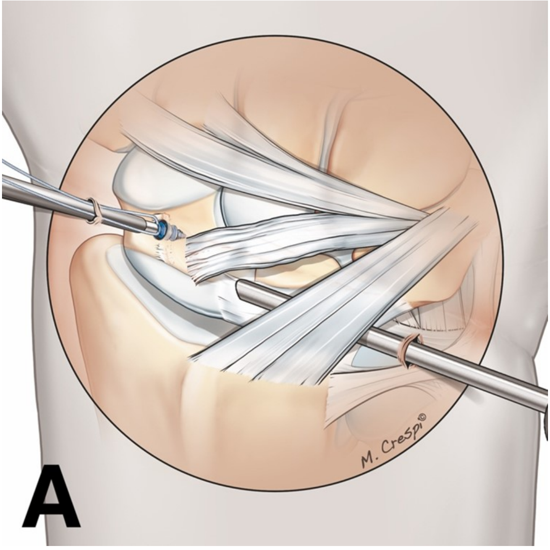


Figure 2.

The sutures of the anchor are passed through the DIC ligament and the dorsal capsule using a needle through the DIC specific portal (with the scope remaining in the 6R portal), aiming for the midcarpal joint **(Figure 3)**.

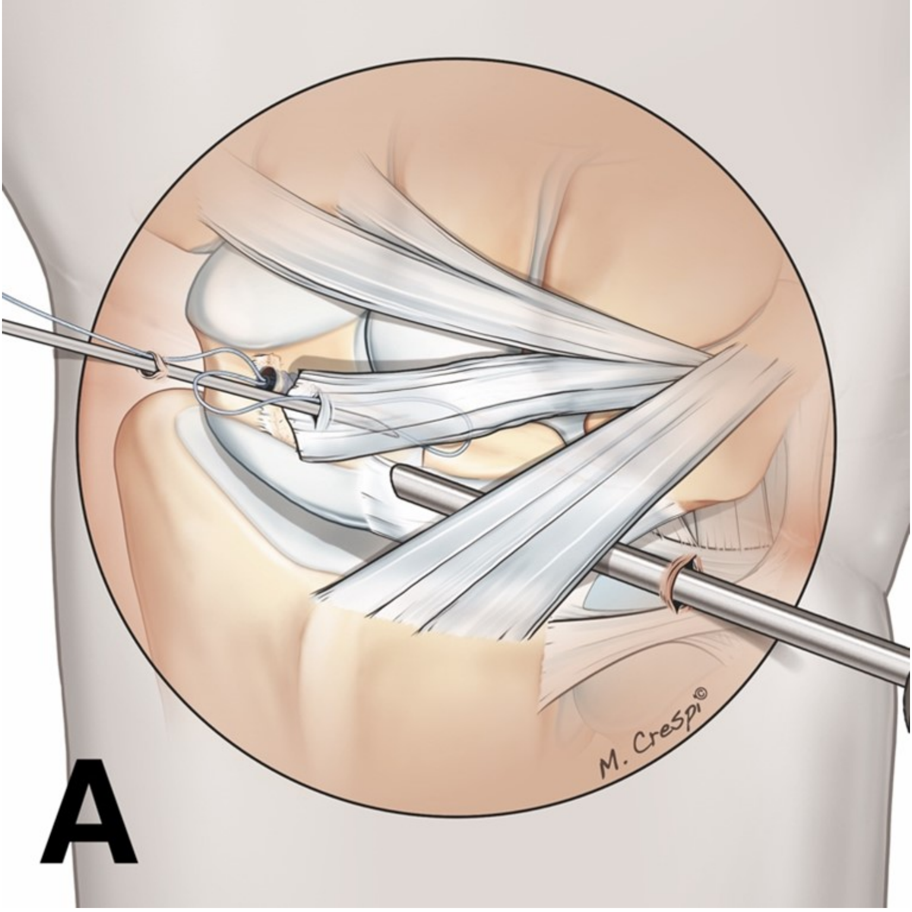


Figure 3.

MCU and MCR portals are created, and the scope placed into the MCU portal. The sutures are retrieved via the MCR portal. A mosquito forceps is then placed through the DIC specific portal, without entering the joint and it will be passed under the extensor tendons, in order to retrieve the sutures from the MCR portal. By doing so, the sutures will be back in the DIC specific portal and ready to be tightened.

The knot is finally tightened through the DIC specific portal, and arthroscopic control will show the application of the dorsal capsular wall along with the DIC ligament onto the scaphoid **(Figure 4)**.

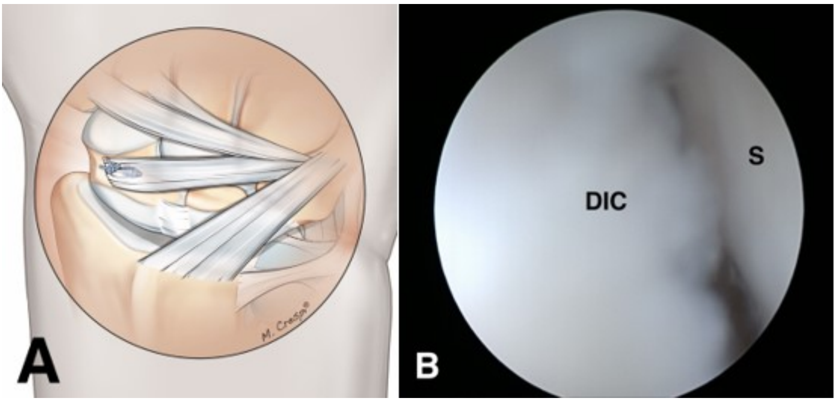


Figure 4.

4. Closure and postoperative care

In a standard fashion, skin incisions can be left to spontaneous healing and a 6-week immobilization is recommended with a custom-made splint, followed by rehabilitation.

Tips & tricks

- As it is an anchor-based repair, the suture is non-absorbable and it may create a small induration regarding the DIC specific portal, of which the patient should be warned. It is possible to avoid it by replacing the suture of the anchor using an absorbable suture such as Vicryl or PDS, if the type of anchor used allows it.
- Getting the sutures back in the DIC specific portal after having retrieved them via the MCR is at risk for

extensor tendons entrapment. A first "blank" dissection passage with the mosquito forceps from the DIC specific portal to the MCR portal, between the extensor tendons and the capsule, is the best option to create the pathway and ensure a free passage for the sutures.

Conclusion

DIC detachment is not an easy diagnosis and should be considered for dorsoradial pain with SL dorsal complex integrity. After MRI confirmation, an adequate bony anchor repair of the DIC is possible. The keystone is the use of the DIC specific portal, strategically positioned with caution for the extensor tendons, and especially for the EPL tendon.

Video 17: Dorsal Intercarpal Ligament (DIC) Detachment Repair
https://vimeo.com/917905042

19.
SCAPHOLUNATE RECONSTRUCTION

GUSTAVO GOMEZ RODRIGUEZ

Introduction

When all the primary (SLIOL) and secondary (DIC, DRC, RSC, and LRL) stabilizers are injured, a scapholunate dissociation is generated with a static deformity in DISI (EWAS V) with pronation and excessive flexion of the scaphoid while there is supination and excessive extension of the lunate. To restore the stability of this joint, an internal brace can be used with a 360-degree configuration passing inside the proximal pole of the scaphoid and the lunate **(Figure 1a)**. If there is additional instability of the scaphoid (dorsal subluxation), a tunnel through the scaphoid into its tubercle can be added with a distal fixation at the base of the second metacarpal **(Figure 1b)**. If there is additional instability of the lunate (ulnar translocation), a proximal fixation at the radial styloid can be added **(Figure 1c).**

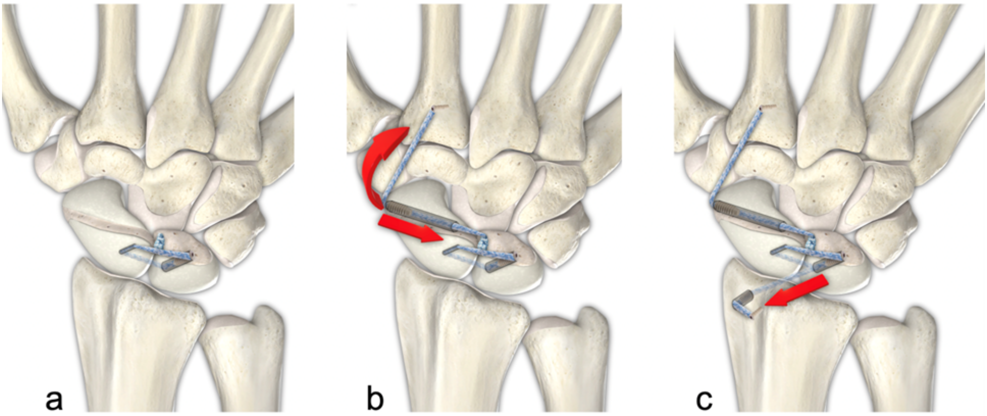


Figure 1.

360-degree configuration ***(a)****, with additional tunnel at the scaphoid and distal fixation at the base of the second metacarpal* ***(b)****, and additional proximal fixation at the radial styloid* ***(c)****. The red arrows show vectors of mechanical tension for scaphoid extension, scaphoid supination, and radial translocation of the carpus.*

Operative technique

1. Arthroscopic exploration & debridement

An arthroscopic exploration is performed through the classic portals (i.e., 3-4, 6R, midcarpal ulnar (MCU), and midcarpal radial (MCR)) in order to confirm and stage the degree of scapholunate instability, the reducibility of the bones, and the involvement of the volar radiocarpal ligaments (RSC & LRL) and of the dorsal ligaments (DIC & DRC). It is also essential to confirm the integrity of the lunotriquetral ligament. Accessory portals and incisions are made to perform the tunnels and to allow the passage of the internal brace **(Figure 2)**.

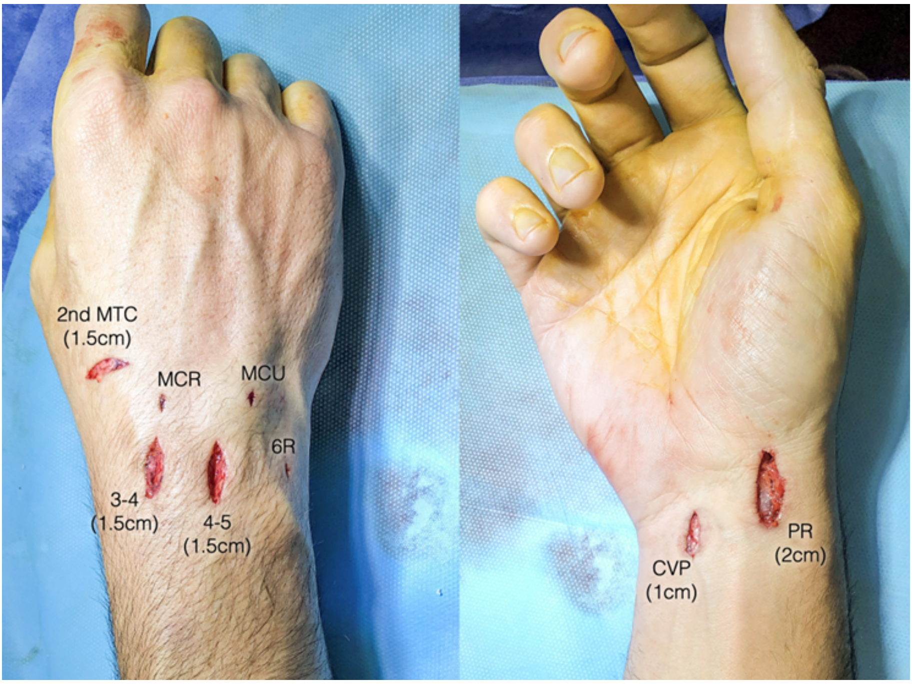


Figure 2.

Portals and accessory incisions. 2nd MTC: second metacarpal incision; CVP: central volar portal; PR: palmar radial incision.

The procedure starts with debridement of the fibrous tissue interposed between the lunate and the scaphoid. In the same way, the scar tissue generated at the dorsal and palmar capsule, behind and in front of the scapholunate joint is removed until the correct bleeding of the tissues can be visualized. Dorsal capsule debridement is performed from the radiocarpal joint by placing the scope in the 6R portal and the shaver in the 3-4 portal. Then, placing the scope in the MCU portal and the shaver in the MCR portal, debridement of the dorsal capsule, the scapholunate space, and the palmar capsule is performed.

2. 360-degree configuration of the scapholunate joint

Under an image intensifier or using arthroscopic guidance, depending on the surgeon's preference, two parallel horizontal tunnels are made. The 4-5 portal is used to perform the lunate tunnel, extending it to 1.5cm to retract the extensor tendons **(Figure 3a)**. The wrist is flexed to reduce excessive extension of the lunate and a 2.5mm cannulated drill is passed, after placing the K-wire, through the lunate from dorsal to palmar, parallel to the midcarpal joint **(Figure 3b)**. The K-wire can be placed using a 14-Gauge abbocath needle. The surgeon should remember that the lunate is supinated so the 14-Gauge abbocath needle must enter with ulnar inclination **(Figure 3c)**. The central volar portal is then made (1cm), and an internal brace is passed from dorsal to palmar through the lunate tunnel. A 2cm palmar radial skin incision is made over the scaphoid. The internal brace is then passed from the central volar portal to the radial palmar incision below the carpal tunnel contents, yet superficial to the palmar capsule.

At that time, the wrist is extended to reduce excessive scaphoid flexion, and a horizontal tunnel is fashioned on the proximal pole of the scaphoid from volar to dorsal **(Figure 4)**. This tunnel can be created with a 1.5mm K-wire with a wire loop at the tip so the internal brace can be captured and passed through the scaphoid tunnel from the palmar radial incision to the 3-4 portal.

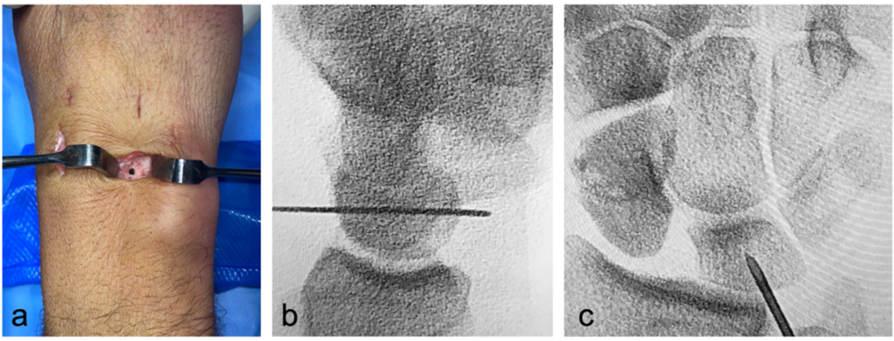


Figure 3.

*Entrance of the lunate tunnel through the extended 4-5 portal **(a)**, K-wire parallel to the midcarpal joint **(b)**, and 14-Gauge abbocath needle entering the lunate with ulnar inclination **(c)**.*

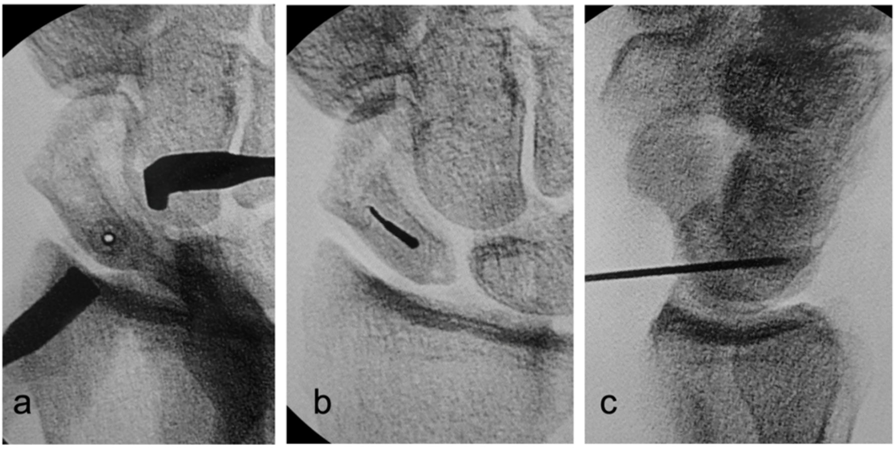


Figure 4.

14-Gauge abbocath needle over the proximal pole of the scaphoid (a), 1.5mm K-wire with a wire loop at the tip of the proximal pole of the scaphoid on the anteroposterior view (b), and lateral view (c).

The end of the internal brace, which enters the dorsal aspect of the lunate tunnel is then passed below the extensor tendons, but superficial to the dorsal capsule, from portal 4-5 to portal 3-4. We can extend the 3-4 portal to 1.5cm to be more comfortable if necessary. Both ends of the internal brace that come out through the 3-4 portal are tightened and a 3 by 8mm biotenodesis screw is placed in the lunate tunnel to fix the internal brace.

Finally, a knot is tied with both ends of the internal brace to create a 360-degree configuration around the scapholunate joint. The internal brace passes through the lunate, squeezes the palmar capsule, then passes through the scaphoid, and ends with a knot squeezing the dorsal capsule against the dorsal portion of the scapholunate joint **(Figure 5)**.

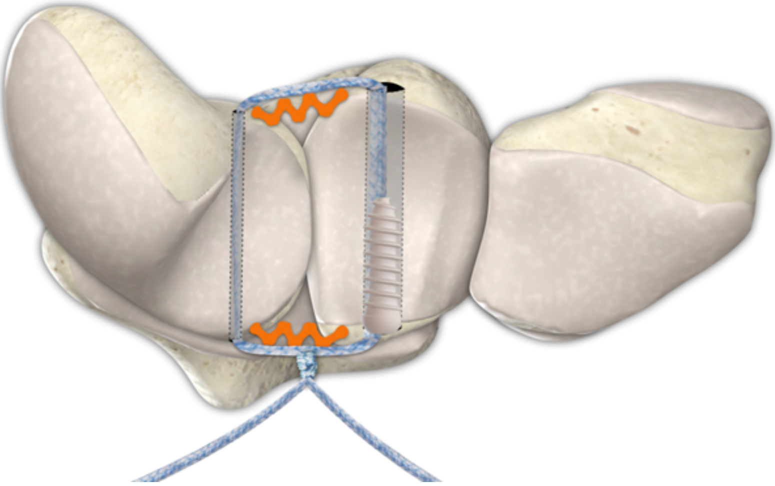


Figure 5.

Drawing showing the 360-degree configuration of the internal brace with the knot squeezing the volar and dorsal capsule (orange curly lines) against the scapholunate joint.

3. Modification for scaphoid instability

If the scaphoid is mounted on the dorsal rim of the scaphoid facet of the radius, a distal fixation of the internal brace can be added to extend and supinate the scaphoid **(Figure 6)**. To do so, a tunnel is created in the scaphoid from the dorsal ridge, proximally to the apex (close to the insertion of the DIC and to the dorsal portion of the scapholunate ligament), to the scaphoid tubercle. This tunnel is created with a 2.5mm cannulated drill. One of the ends of the internal brace coming from the knot is passed through this tunnel from dorsal to palmar toward the radial palmar incision. It is then passed from palmar to dorsal inside the STT joint to a new 1.5cm incision at the base of the second metacarpal. The internal brace is tightened and a 3 by 8mm biotenodesis screw is placed in the scaphoid tunnel. Finally, the internal brace is fixed at the base of the second metacarpal with a knotless anchor.

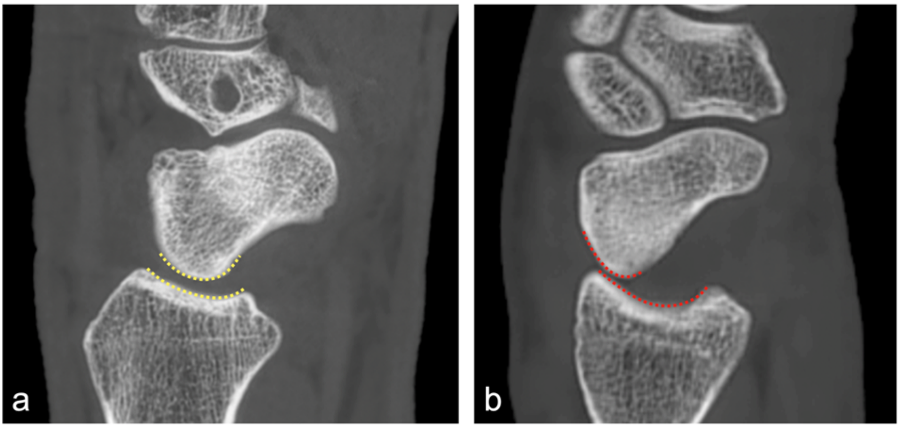


Figure 6.

Stable scaphoid (a), and unstable scaphoid mounted on the dorsal rim of the scaphoid facet of the radius (b).

4. Modification for lunate instability

If there is an ulnar translocation of the lunate, a proximal fixation of the internal brace can be added to reduce the position of the lunate above the lunate facet of the radius **(Figure 7)**. To do so, a tunnel is created at the volar aspect of the radial styloid from palmar to dorsal, at the watershed line (close to the insertion of the LRL), to the floor of the second compartment. A 2.5mm cannulated drill is used. One of the ends of the internal brace coming from the knot is passed through this tunnel from palmar to dorsal toward the extended 3-4 portal. The internal brace is tightened and a 3 by 8mm biotenodesis screw is placed in the radial tunnel. Finally, the internal brace can be cut or fixed at the floor of the second compartment with a knotless anchor.

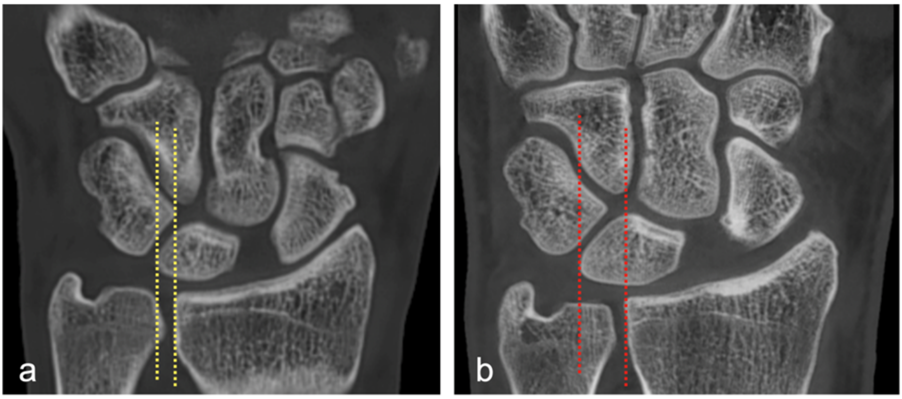


Figure 7.

Stable lunate (a), and unstable lunate with ulnar translocation (b).

5. Postoperative care

A period of immobilization of 4 weeks after surgery is recommended. Next, limited dart throwing motion exercises from neutral position to extension and radial deviation are allowed. Flexion and ulnar deviation are not recommended at that time. At 5 weeks, flexo-extension exercises begin. At 6 weeks, proprioceptive and progressive strengthening exercises are allowed. At 8 weeks, progressive axial loading exercises are started. Avoiding contact sports until 5 months is recommended.

Tips & tricks

If the surgeon does not have any advanced experience in wrist arthroscopy, this technique allows the tunnels to be created under an image intensifier and the internal brace to be passed percutaneously through the mentioned incisions.

If necessary, the longitudinal tunnel of the scaphoid can be made in the same way as the drill is passed when a scaphoid fracture is operated on using a retrograde approach, entering through the tubercle but trying to exit more dorsally **(Figure 8)**.

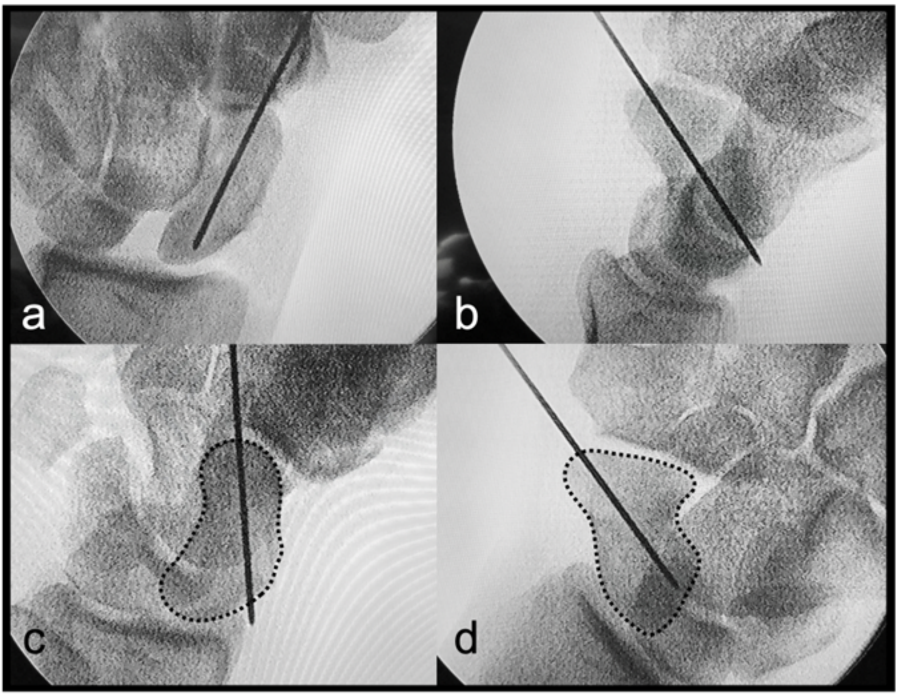


Figure 8.

*K-wire entering the scaphoid using a retrograde approach in anteroposterior view **(a)**, lateral view **(b)**, and both oblique views **(c) (d)**.*

To create the central volar portal, a slim arthroscopy forceps can be passed through the lunate tunnel from dorsal to palmar to perform a blunt dissection in the carpal tunnel until the forceps protrudes into the skin palm of the wrist.

Conclusion

This technique is based on the principles described in the techniques developed by Christophe Mathoulin, Marc García-Elias, PC Ho, and Fernando Corella in the past. This procedure allows to restore the multiplanar stability of the carpus by reconstructing the forces of the vectors of mechanical tension of all ligaments (primary and secondary stabilizers) that form the scapholunate complex **(Figure 9 and Figure 10)**. Long-term results with this implant are promising.

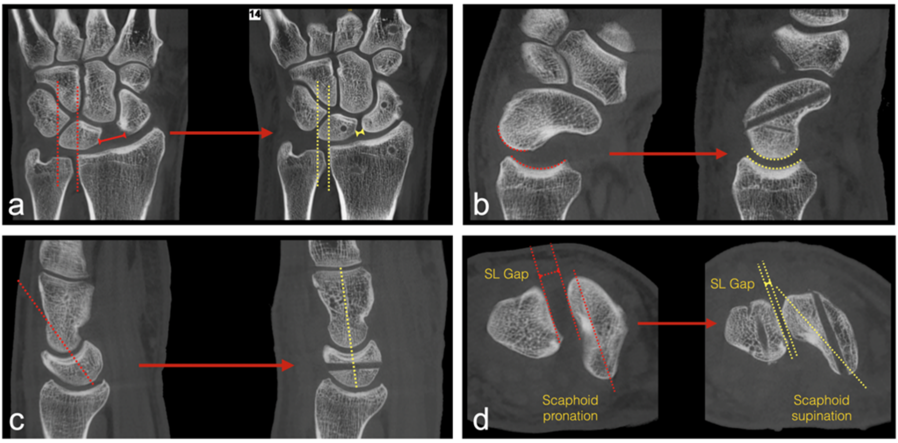


Figure 9.

*Reduction of ulnar translocation of the carpus and closure of the gap in coronal view of a CT-scan **(a)**, scaphoid reduction **(b)**, DISI deformity reduction **(c)**, and restoration of scaphoid supination in axial view **(d)**.*

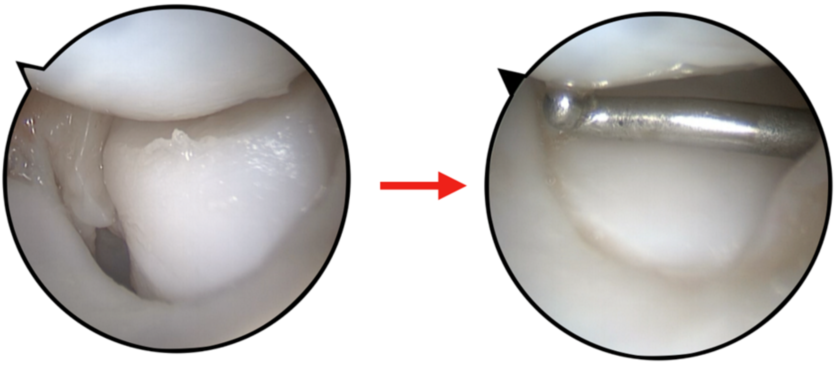


Figure 10.

Midcarpal view from MCU portal showing the difference in the scapholunate joint before (left), and after the procedure (right).

20.
ARTHROSCOPY-ASSISTED BOX RECONSTRUCTION OF SCAPHOLUNATE LIGAMENT WITH TENDON GRAFT

PAK CHEONG HO
MARION BURNIER

Introduction

Scapholunate (SL) dissociation is the most common carpal instability. Numerous surgical techniques have been described to restore or improve the stability of the SL joint and retard and prevent the progression to arthritis. Most methods provide only dorsal and uniplanar reconstructions. Recurrent or persistent gapping, tendon loosening, technical difficulty, limited motion and grip strength, and fracturing of or through drill holes have been reported.

Many studies have emphasized the importance of volar ligaments. But Yi *et al.* used a palmaris longus (PL) tendon to pass through drill holes in the anteroposterior plane of the scaphoid and the lunate. SL diastasis was effectively reduced to normal, and the scaphoid and lunate contact pressure on the radius and the scaphoid-to-lunate contact ratio were significantly improved after reconstruction. Zdero used bovine tendons passing through double bone tunnels of the scaphoid and lunate in 19 cadaveric wrists and found no difference in the mechanical property from normal wrists. It is logical and more ideal to restore both dorsal and volar components of the SL ligament.

Dobyns used a portion of tendon to pass through anteroposterior bone tunnels in the proximal pole of the scaphoid and lunate to reconstruct the SL linkage. Stability was obtained by tightly looping the tendon graft across the scaphoid and the lunate. However, creating drill holes across poorly vascularized areas of bone in an open fashion severely compromised their blood supply and resulted in fractures and avascular necrosis. Marcuzzi *et al.* reconstruct both the palmar and dorsal parts of the SL interosseous ligament through a combined palmar and dorsal approach in 6 patients produced very good clinical outcomes.

In 2002, authors developed an arthroscopy-assisted technique to reconstruct both the dorsal and the volar SL ligament simultaneously using a free tendon graft in a box-like structure without violating the major blood supply to the scaphoid and soft tissue envelope (**Figure 1**).

The indication is subacute and chronic SL dissociation of 6 weeks or beyond with reducible SL diastasis and dorsal intercalated segmental instability (DISI) deformity confirmed arthroscopically and radiologically.

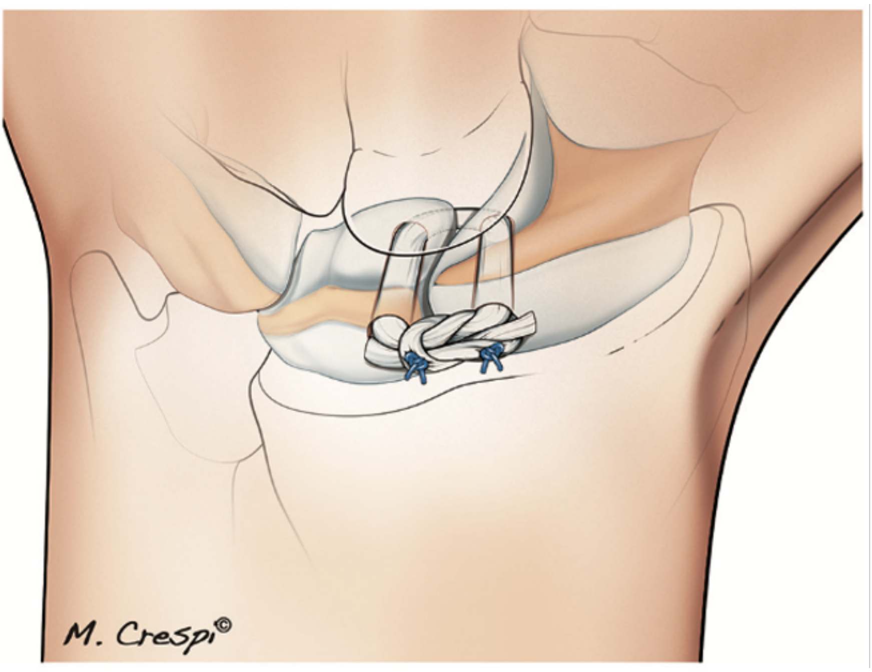


Figure 1.

Simultaneous reconstruction of the dorsal and palmar SL ligaments anatomically with the use of tendon graft in a box-like structure.

Operative techniques

The surgery is performed under general anesthesia or regional block with the patient in a supine position and the operated arm in a 90-degree shoulder abduction resting on hand table. The elbow joint is flexed to 90 degrees and the affected hand is subjected to 10 to 13 lbs of digital traction through the plastic finger traps by using a sterilizable Wrist Traction Tower (ConMed Linvatec Corp., Goleta, CA).

The tourniquet was not initially inflated. The 2% lignocaine with 1:200,000 adrenaline was injected into the portal sites to reduce bleeding. Continuous saline irrigation of the joint was achieved with a bag of 3L of normal saline instilled under gravity.

1. Exploration of radiocarpal joint and midcarpal joint

A 1.9mm or 2.7mm arthroscope is used. Radiocarpal joint arthroscopy is performed initially through the 3–4 and 4–5 portals with 6U as outflow portal, followed by midcarpal joint (MCJ) arthroscopy through the midcarpal radial (MCR) and midcarpal ulnar (MCU) portals. Synovectomy and radial styloidectomy are performed simultaneously if necessary, using a 2mm shaver and a 2.9mm burr. Intra-articular fibrosis is resected with a shaver to improve wrist motion and facilitate subsequent reduction of the SL malalignment and of the DISI deformity.

2. Preparation of dorsal and volar tunnel wound

The tourniquet is then inflated. A 2cm transverse incision is extended from slightly radial to the 3–4 portal toward the 4–5 portal (**Figure 2**). The extensor retinaculum is split along its oblique fibers. The extensor digitorum communis (EDC), extensor carpi radialis brevis (ECRB), and the extensor carpi radialis longus (ECRL) are identified. The lunate can be exposed by retracting the EDC or going through the EDC tendon interval ulnarly, whereas the ideal scaphoid tunnel position can be spotted between the ECRB and the ECRL.

Volarly, a transverse incision is made along the proximal wrist crease from the ulnar border of the PL to the ulnar border of the flexor carpi radialis (FCR) tendon (**Figure 3**). A PL free graft is harvested with a tendon stripper. The anterior forearm fascia was incised. The palmar cutaneous branch of the median nerve needs to be dissected, isolated, and safeguarded. The interval between the FCR tendon, the finger flexor tendons, and the median nerve is entered to reach the volar wrist joint capsule. Both volar and dorsal wrist joint capsules are preserved without violation.

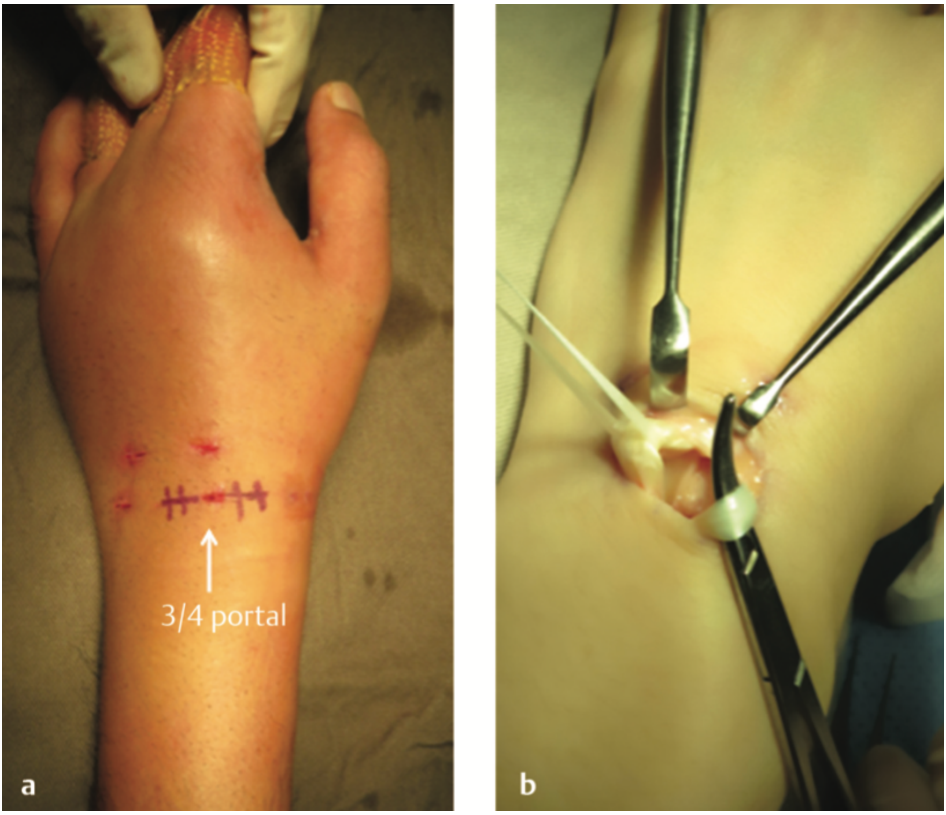


Figure 2.

(a) Through a dorsal incision, (b) the extensor tendons are retracted, exposing the dorsal wrist capsule.

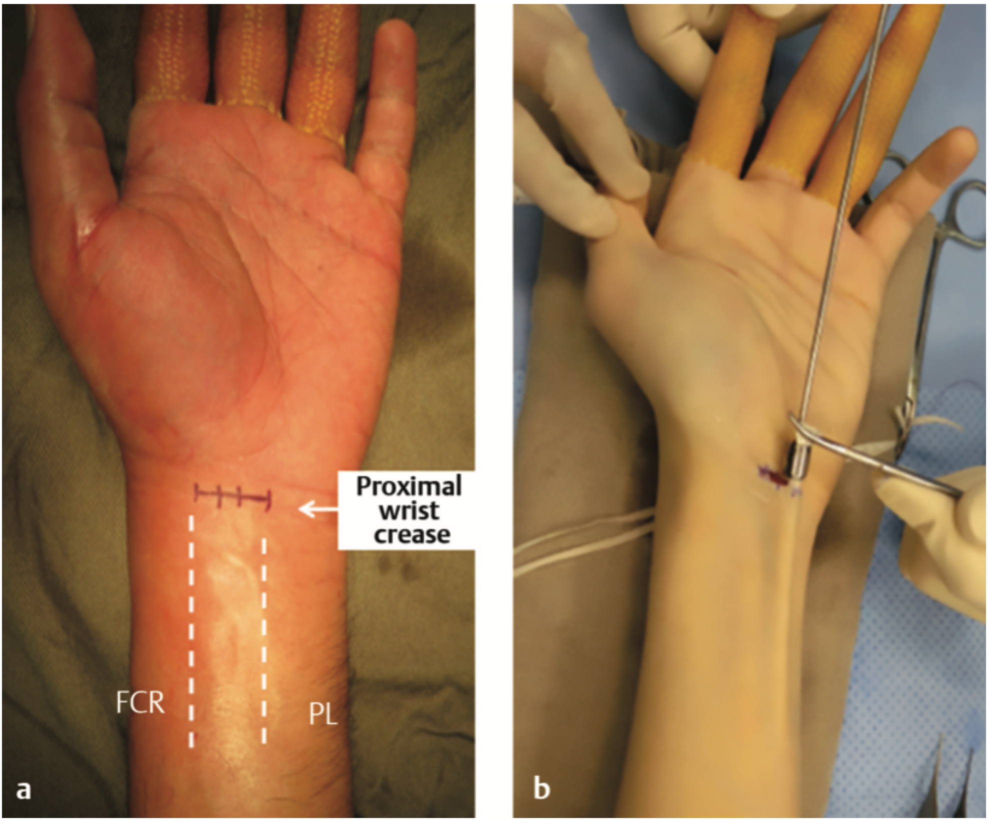


Figure 3.

(a) Through a volar incision, (b) the PL graft can be harvested with the use of a tendon stripper. FCR, flexor carpi radialis; PL, palmaris longus.

3. Correction of DISI deformity and stabilization of scaphoid and lunate positions

The DISI deformity needs to be corrected before drilling the bone tunnel.

The hand is examined under the fluoroscope. The extended lunate can be corrected by means of wrist flexion and the lunate position can be maintained by transfixing the radiolunate (RL) joint with a 1.6mm Kirschner wire (K- wire), that is inserted percutaneously through the dorsum of the distal radius. The RL pin should be aimed at the ulnar half of the lunate to prevent conflict with the lunate bone tunnel (**Figure 4**). Flexion deformity of the scaphoid and restoration of a normal SL angle are then achieved by means of passive wrist extension. The wrist is now ready for bone tunnel preparation. With the flexor tendons and the median nerve, including the palmar cutaneous branch, carefully retracted ulnarly, the lunate tunnel guide pin perforates the volar cortex of the lunate and exit through the volar wound (**Figure 5**).

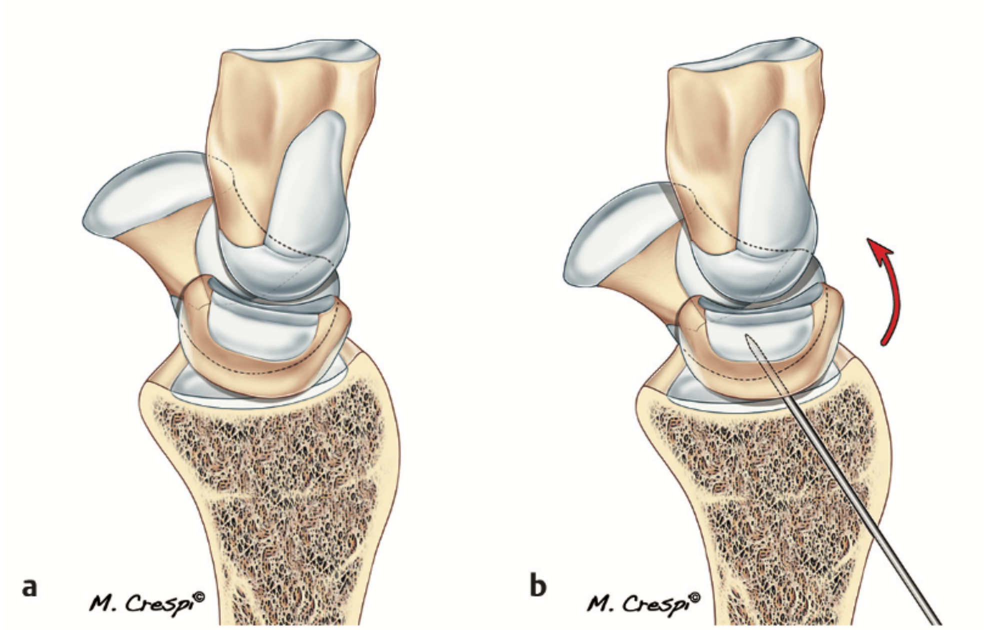


Figure 4.

*(**a**) Drawing showing the DISI deformity of the lunate. (**b**) Drawing showing the lunate reduction by the Linscheid maneuver. The radiolunate joint is transfixed with a 1.6mm K-wire with the lunate in a neutral position.*

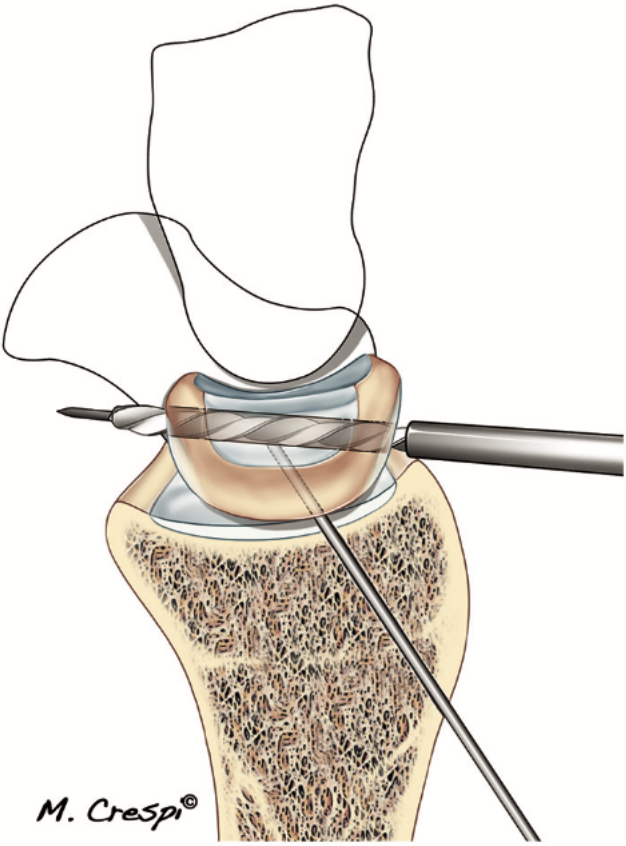


Figure 5.

Drawing showing another K-wire positioned to prepare the lunate tunnel with a cannulated drill from a dorsal to volar direction.

4. Preparation of scaphoid bone tunnel

Another guide pin was inserted through the dorsal tunnel wound onto the scaphoid in the interval between the ECRB and the ECRL tendons. It provides counter-rotational force on the scaphoid to correct flexion deformity when the guide pin trajectory is slightly directed proximally and volarly (**Figure 6**). With the FCR tendon retracted radially, the scaphoid guide pin exited through the volar tunnel wound. Caution should be taken to keep the scaphoid tunnel at least 2-3mm from all articular margins of the proximal scaphoid. Both the lunate and the scaphoid bone tunnel are subsequently enlarged and bored using 2.0 and 2.4mm cannulated drills. It must be borne in mind that the bone tunnel should not be too large as there is a risk of iatrogenic fracture or avascular necrosis or not too small, which would cause jamming of tendon graft inside the tunnel causing graft avulsion when forcefully pulling the tendon graft through the tunnel.

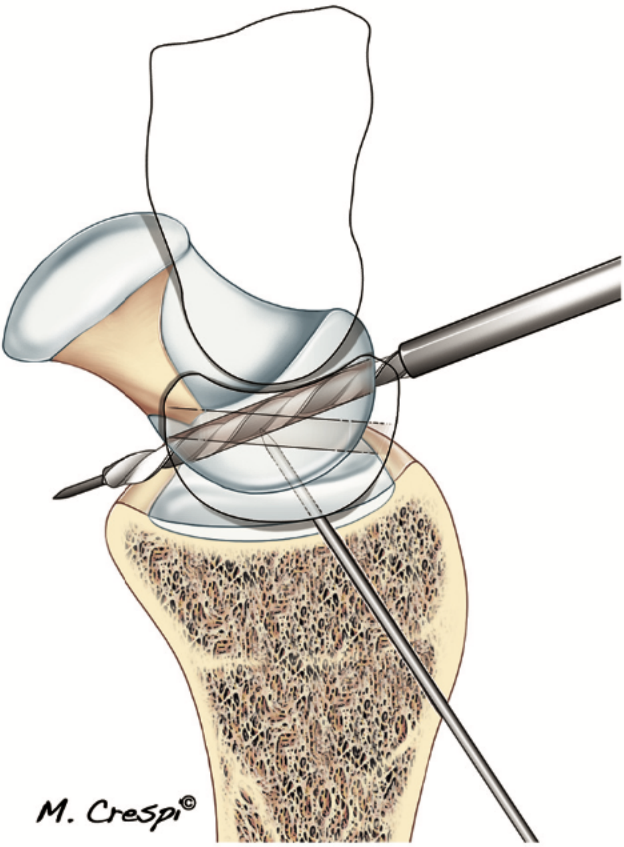


Figure 6.

Drawing showing the preparation of the scaphoid tunnel with a cannulated drill and a K-wire inserted through the dorsal capsule from a dorso-distal to a volar-proximal direction.

5. Passing the PL tendon graft through the scaphoid and lunate bone tunnel

The free PL tendon graft is delivered through the bone tunnels with a 2mm arthroscopic grasper. With the grasper passed from the dorsal side to volar aspects of the scaphoid and the lunate, the two ends of tendon graft are grasped and passed from the volar side of the scaphoid and lunate to dorsally (**Figure 7**). The tendon graft is passed outside the capsule to cross the SL interval so that the reconstruction also helps to tighten the capsule and the extrinsic ligaments, which confer added stability to the SL joint (**Figure 8**).

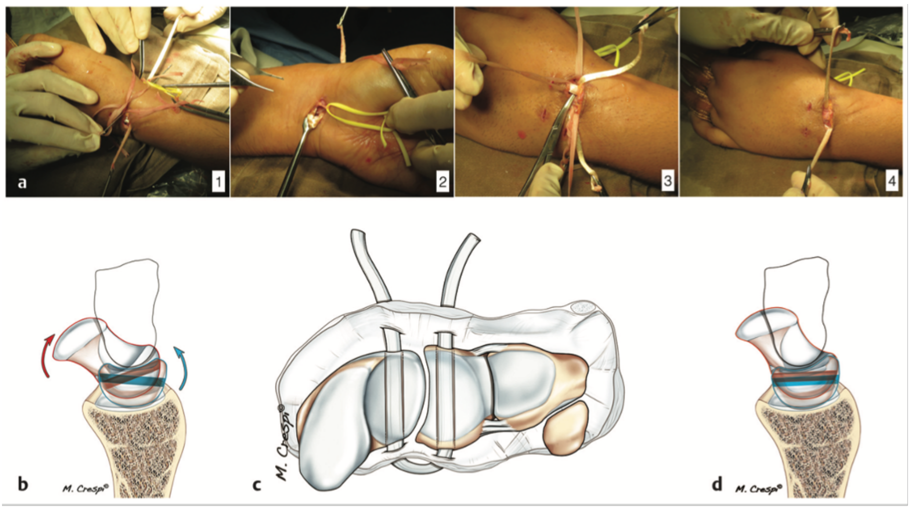


Figure 7.

(a) Operating view of the PL tendon graft delivered through the wrist capsule and the bone tunnels to reduce the two bones in a box-like fashion. (b) Drawing showing the position of tunnels before the passage of the tendon graft and before reduction. (c) Drawing showing the passage of the tendon graft from the scaphoid, volarly to the volar capsule and through the lunate before the final suture. (d) Drawing showing the reduction of both tunnels after tensioning placed on the PL graft.

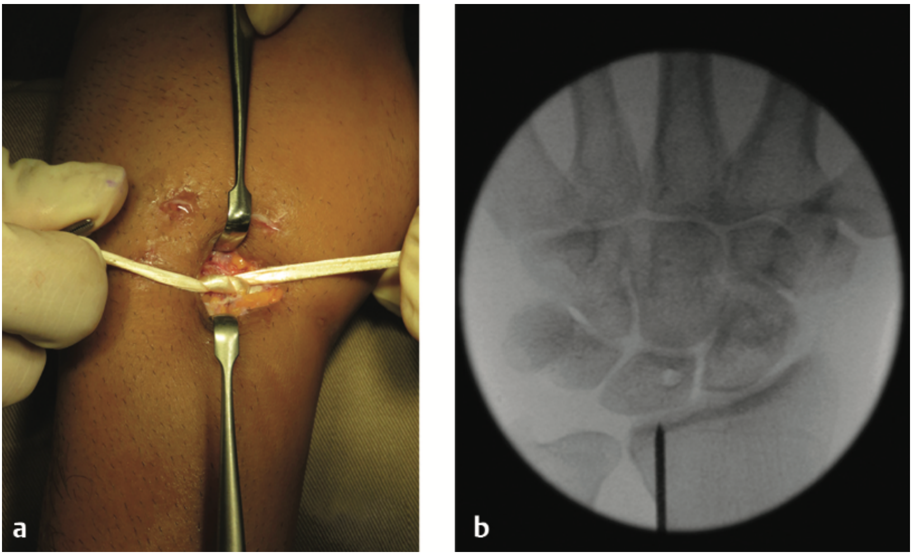


Figure 8.

__(a)__ The tendon graft is knotted and sutured under maximal tension on the dorsal surface of the SL joint extracapsularly in a shoelace manner. __(b)__ Note the reduction of the SL interval on X-ray.

6. Assessment through midcarpal joint arthroscopy and scapholunate interval reduction with PL tendon graft

The MCJ was then inspected through either the MCR or MCU portal. Any interposed tissue in the SL interval that blocks reduction is excised arthroscopically. The RL pin is then withdrawn from the lunate so that the lunate becomes mobile. With manual traction of the two ends of the tendon graft, any SL gapping or step-off is corrected. The reduction is facilitated by using a large bone reduction clamp between the scaphoid and the triquetrum. The tendon graft is maximally tensioned and tied in a shoelace manner over the dorsal capsule and secured with 2/0 non-absorbable braided sutures (**Figure 8**). SL stability is confirmed arthroscopically and fluoroscopically. The tendon graft is then tied once more and sutured. Two K-wires, which are cut short and buried underneath the skin, are inserted through a small incision in the anatomical snuffbox region to transfix the scaphocapitate (SC) joint to protect the reconstructed ligament during the healing process. Additional suture anchors can be placed at the dorsal bone tunnels for the scaphoid and the lunate for additional graft fixation. The RL pin is then advanced to maintain lunate reduction if necessary. The tendon knot is then sutured to the adjacent dorsal joint capsule and the extensor retinaculum is repaired (**Figure 9**).

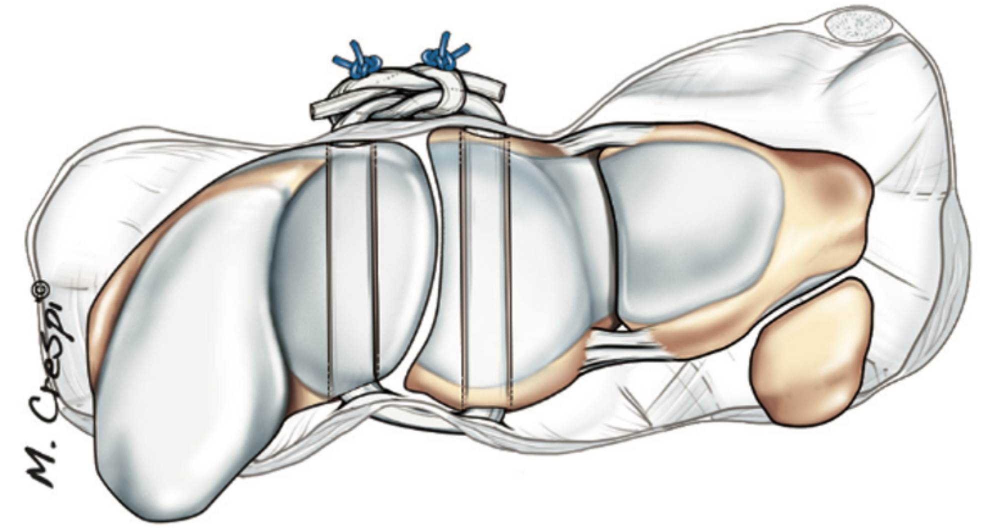


Figure 9.

Drawing showing the final dorsal suture dorsally to the dorsal capsule.

7. Closure and postoperative care

The wound is closed with absorbable sutures. Bulky dressing and a scaphoid plaster slab are applied with the wrist in a neutral position and the thumb in a neutral palmar abduction. The wrist is immobilized in a short arm thumb spica cast for 6 weeks. The RL pin is removed at the beginning of the third week. The cast is then changed to a thumb spica splint for an additional 2 weeks, at which time gentle wrist mobilization is allowed out of the splint. The SC pins are removed at the beginning of the ninth week. The splint is worn at nighttime for another 4 to 6 weeks. Gradual wrist range-of-motion exercises, under physiotherapy supervision, are started after pin removal. Gradual strengthening exercises are started at the beginning of the 13th week after surgery.

Conclusion

In our series of 17 patients with chronic SL instability, there were three Geissler grade 3 and 14 grade 4 instability cases. The average preoperative SL interval was 4.9mm (range: 3–9mm). The DISI deformity was present in 13 patients. Six patients had stage I SLAC wrist change, radiologically demonstrated. Concomitant procedures were performed in 4 patients.

The average follow-up was 48.3 months (range: 11–132 months). Thirteen patients returned to their pre-injury jobs. Eleven patients had no wrist pain, and 6 had some pain on either maximum exertion or at the extreme of motion. The average extension range improved for 13%, flexion range 16%, radial deviation 13%, and ulnar deviation 27%. Mean grip strength was 32.8 kg (120% of the preoperative status, 84% of the contralateral side). The average SL interval after reconstruction was 2.9mm (range: 1.6–5.5mm). Recurrence of a DISI deformity was noted in 4 patients, but remained asymptomatic. An ischemic change of proximal scaphoid was noted in one case without symptoms or progression. There were no major complications. All patients were satisfied with the procedure and outcomes.

21. VOLAR CAPSULOLIGAMENTOUS SUTURE AS TREATMENT OF VOLAR MIDCARPAL INSTABILITY

CHRISTOPHE MATHOULIN
JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

Midcarpal instability, as described by Lichtman in 1981, is a rare condition that occurs mainly in young people after a sport-related accident. Testing of the midcarpal joint provokes significant painful clicking due to a midcarpal pivot shift. In most patients, the pathophysiology of volar midcarpal instability is secondary to volar capsule-ligament injury due to stretching or avulsion of the arcuate ligament (the triquetrohamatocapitate [THC] and radioscaphocapitate [RSC] ligaments) and of the long radioulnar (LRL) ligament **(Figure 1)**. Imaging reveals dorsal intercalated segment instability (DISI) tilting of the second row of carpal bones along with volar intercalated segmental instability (VISI) tilting of the first row **(Figure 2)**.

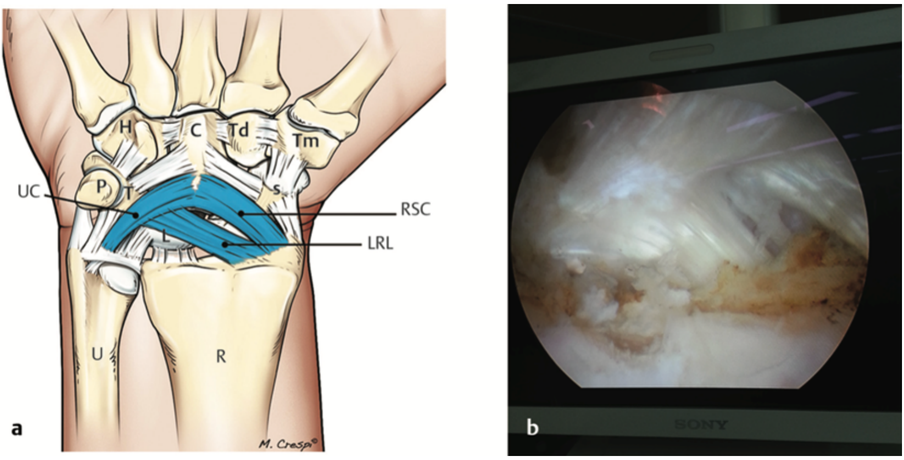


Figure 1.

(a) *Drawing showing the extrinsic volar ligament complex in a right wrist. The tears result in volar midcarpal instability. UC, ulnocapitate or ulnotriquetrocapitate ligament; LRL, long radiolunate ligament; RCS, radioscaphocapitate ligament.* ***(b)*** *Arthroscopic view of the midcarpal area of a left wrist showing an intact extrinsic ligament complex after synovectomy; UC ligament is on the left, RCS on the right, and distal end of LRL in the lower middle part.*

Treatment of volar midcarpal instability still remains challenging, as no method has proven to be effective yet. Conservative procedures, such as open ligament reconstruction or capsulodesis, not only stabilize the joint, but also cause significant stiffness. Palliative procedures have severe functional consequences, even though they are typically used as a last resort for these injuries. Arthroscopic thermal volar capsulorrhaphy has been described. However, its use is limited to partial tears.

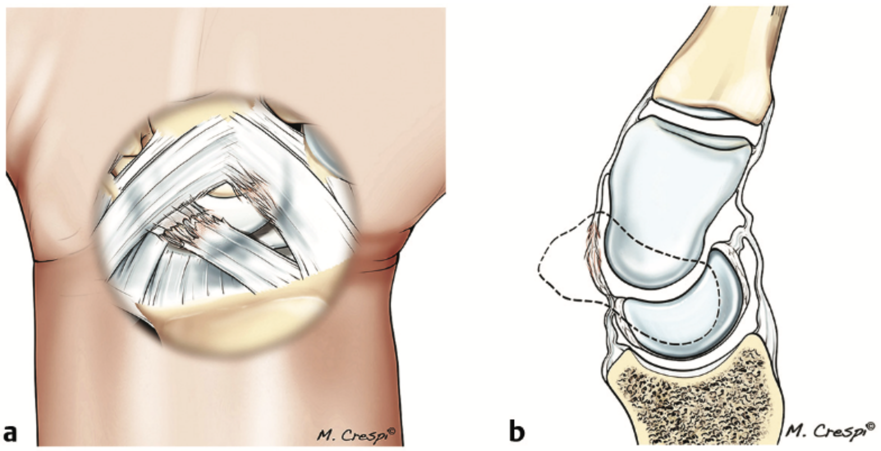


Figure 2.

Drawings showing frontal (a) and lateral (b) views of torn and stretched volar extrinsic ligaments at the volar midcarpal joint, leading to volar midcarpal instability.

Operative technique

1. Patient Preparation and Positioning

Surgery is generally performed on an outpatient basis under regional anesthesia. The patient is placed supine, with the arm resting on an arm board with an attached tourniquet. A standard traction tower (5–7 kg or 11–15.5 lbs) is used during arthroscopic procedures.

2. First Phase: Arthroscopic Exploration

Using a dorsal approach with the scope in the 6R portal and the hook probe in the 3–4 portal, arthroscopic radiocarpal joint exploration reveals a loosening of the extrinsic volar ligament complex, especially of the RSC and long radioulnar (LRL) ligaments. Probe testing of such structures reveals a significant loss of tension.

The midcarpal radial (MCR) and the midcarpal ulnar (MCU) portals are then used. The volar aspect is often hidden under a thick synovial membrane, which must be removed to inspect the volar ligaments. The volar arcuate ligament complex, which consists of the THC (ulnar limb of arcuate ligament) and RSC (radial limb) ligaments, will often be avulsed or stretched **(Figure 3)**. All ligaments are identified and their insertions abraded with a shaver.

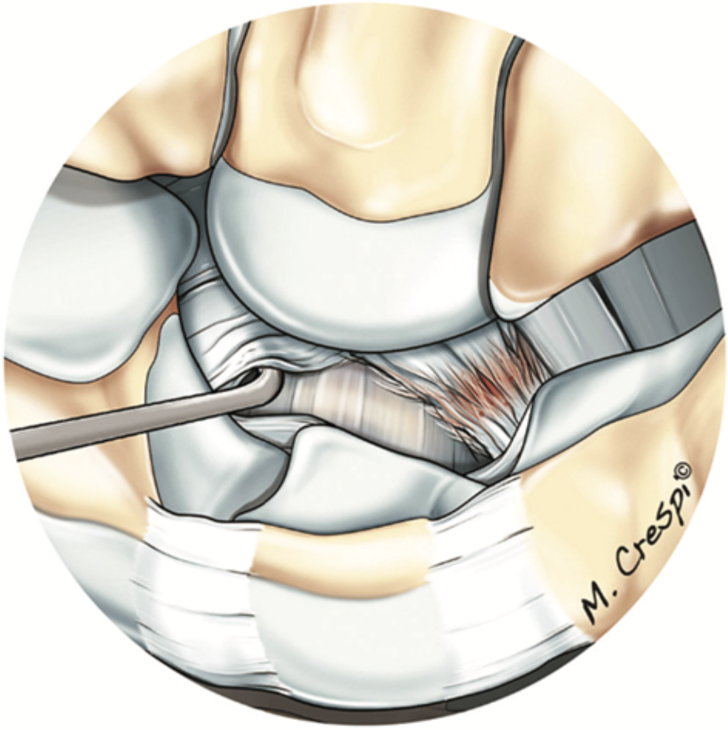


Figure 3.

Drawing of a stretched volar ligament complex (UC, RSC, and LRL) when tested with a hook probe.

3. Second Phase: Volar Ulnar Approach

The volar ulnar (VU) approach is performed through a 2cm longitudinal incision along the ulnar side of the flexor digitorum tendons over the proximal wrist crease **(Figure 4)**. The flexor tendons are reflected to the radial side. A needle is inserted into the midcarpal joint at the level of the arcuate ligament under visual guidance with the scope placed in the MCR portal. This step can be facilitated by using an inside-out VU approach **(Figure 5)**.

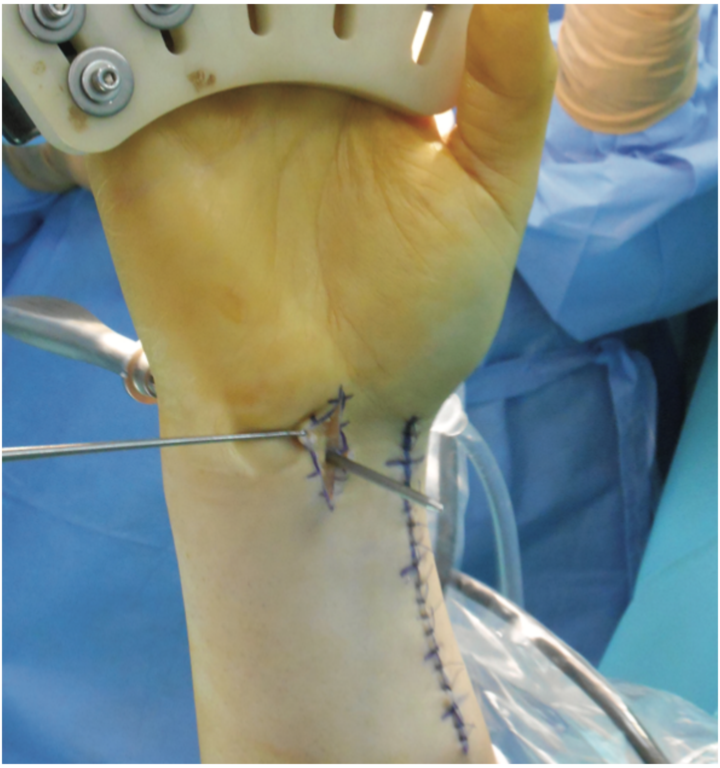


Figure 4.

Intraoperative view of the volar midline incision used to reflect flexor tendons and median nerve and access the volar side of the articular capsule; in this particular patient, an Henry anterior approach was also performed to remove a radius plate.

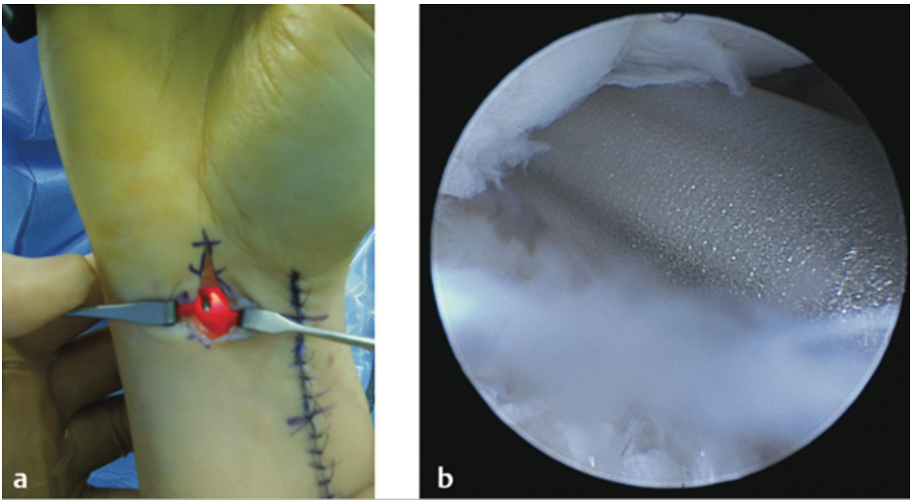


Figure 5.

(a) Intraoperative view of a blunt-tipped trocar inserted through the MCR portal and pushed forward at the volar capsule- ligament injury site to help localize the volar midline incision. (b) Arthroscopic view of a blunt trocar guide passing through the midcarpal joint.

4. Third Phase: Volar Capsule-Ligament Suturing

The scope is placed in the MCR portal. Using the VU incision, a 3/0 PDS (polydioxanone) suture is inserted through a needle into the ulnar limb of the arcuate ligament (THC ligament) **(Figure 6)**. A second 3/0 PDS suture and needle are then introduced into the distal limb of the arcuate ligament (RSC ligament) through the same incision. A third PDS suture is then inserted into the proximal part of the midcarpal joint where the LRL inserts. The three sutures are retrieved with a forceps through the MCU portal **(Figure 7)**.

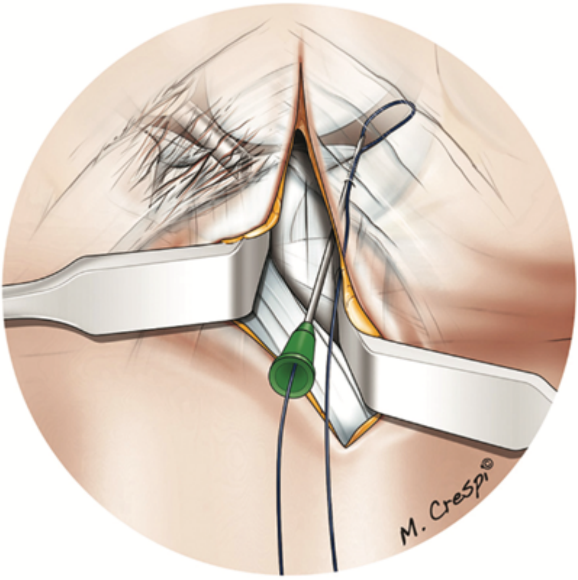


Figure 6.

Drawing showing the first outside-in suture passing through one of the torn ligament components.

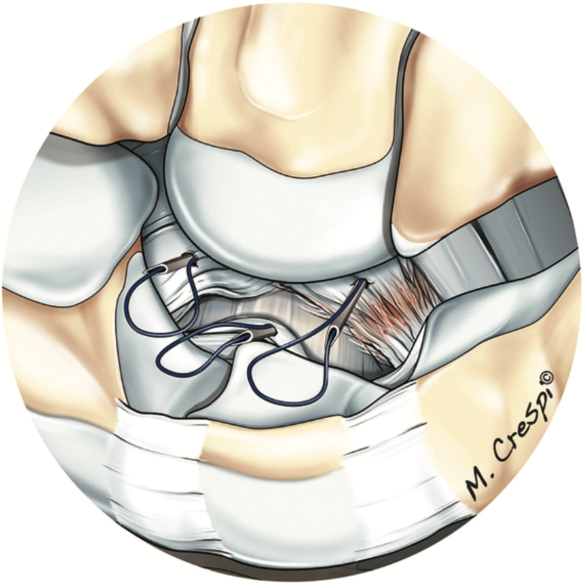


Figure 7.

Drawing showing three outside-in sutures passing through the volar aspect and capturing the three ligaments (UC, RSC, and LRL).

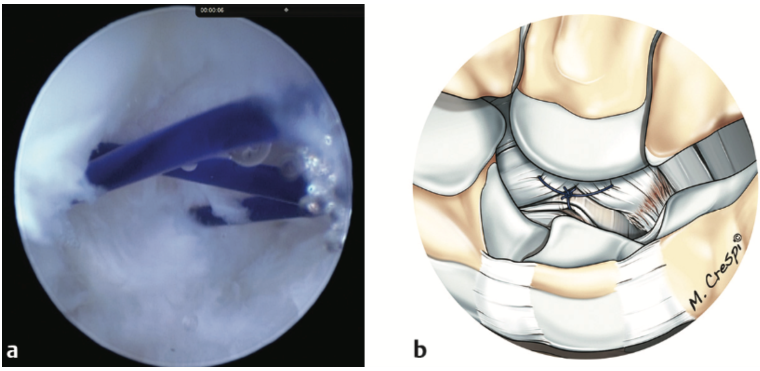


Figure 8.

(a) Arthroscopic view of the three sutures tied together outside the joint before volar traction is applied. (b) Drawing of the volar knot flattened against the intra-articular surface of the three ligaments.

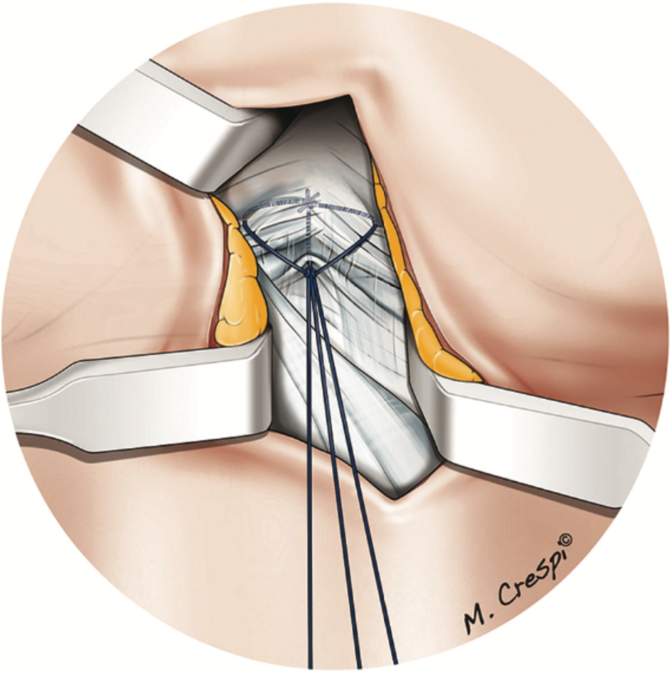


Figure 9.

Drawing showing the last volar knot tied; this knot will close the gap between the three torn ligaments.

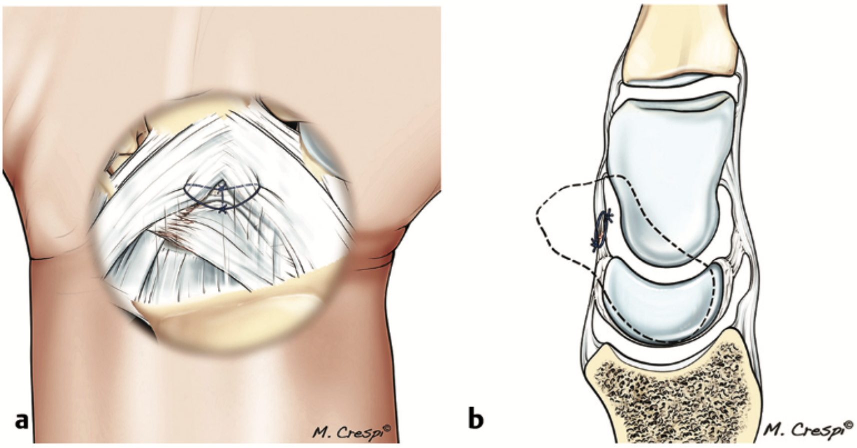


Figure 10.

(a, b) Drawings showing final suture placement between the three ligaments on the frontal and lateral views with VISI deformity reduced.

5. Postoperative care

The wrist is immobilized in a neutral position after surgery with a removable volar splint used for 6 weeks. Hand-intensive activities can be reinitiated 2 months after surgery.

Conclusion

The treatment of volar midcarpal instability is challenging. The surgeon must sometimes use extensive palliative methods. With wrist arthroscopy, the extent of the injuries can be accurately assessed and volar capsule and ligament suturing performed similarly as with scapholunate dissociation (Chapter 15). The initial results are encouraging, but a longer follow-up, with a greater number of patients, is required to validate this promising surgical technique.

Video 18: Palmar midcarpal instability: Arthroscopic volar repair
https://vimeo.com/917905348

22. ARTHROSCOPY-ASSISTED SCAPHOID FRACTURE FIXATION

JEAN-MICHEL COGNET

Introduction

Scaphoid fractures account for 70% of carpal fractures.

There is a fundamental difference between displaced fractures, which are more prone to nonunion and osteonecrosis, and non-displaced fractures. The latter, treated orthopedically, usually consolidate (85 to 95%) at the cost of a prolonged immobilization of at least 12 weeks. The disadvantages of this treatment include the period of immobilization, the consequent stiffness, the decrease in clamping force, and the delayed resumption of work or sports activities. One might subsequently intuitively think that surgical treatment would accelerate functional recovery. All authors agree that there was a rapid improvement in strength and amplitude between 8 and 16 weeks, but this difference disappeared at subsequent controls. Return to work was significantly faster only in manual workers. Early surgery also allows for a discrete, but significant increase in the consolidation rate to 95%.

Consequently, surgery for non-displaced scaphoid fractures remains controversial. While its benefits must be discussed with the patient, it is imperative that this surgery be performed with minimal iatrogenic lesions.

Surgical technique

1. Percutaneous approach

Scaphoid surgery must allow bone fixation while preserving the vascularity and ligaments of the carpus.

Analysis of the results of nonunion cure using the Matti Russe Technique showed a moderate improvement in clamping force and a secondary progression of carpal collapse despite the consolidation of nonunion.

This destabilization of the carpus was due to the extensive surgical approach, which partially or totally severed the palmar bundle of the radioscaphocapitate and radiolunotriquetral ligaments.

Since Streli's description of the first percutaneous technique for scaphoid fixation, many other studies have established the absence of ligament injury and the vascular preservation of this minimally invasive approach.

The percutaneous approach also allows for proper positioning of the osteosynthesis screw.

2. Palmar or dorsal approach?

Anatomical studies describing the vascularization of the scaphoid have historically guided the choice of the approach (dorsal or palmar). The predominant dorsal vascular network long substantiated the choice of the palmar approach until Slade popularized the dorsal approach, which allows better targeting of the central axis of the scaphoid (which is a major criterion to obtain consolidation).

We have summarized the benefits of each approach. This choice is more the one of an operator's habit, since no study has established a difference in the criteria of consolidation, duration of consolidation or functional evolution.

Recent studies have not found any difference in the preservation of the vascularity of the different approaches; the central position of the screw is the one that most spares the intraosseous vascularity.

PALMAR PATHWAY

- **Benefits**
  - Easier access,
  - Less technically difficult,
  - Easier to maintain the reduction with the wrist in extension,
  - No risk of bending the pin in the joint at the time of the CT-scan,
  - No risk for the extensors.
- **Disadvantages**
  - Difficult to avoid positioning the pin too palmar due to the conflict with the trapezium,
  - No compression of the proximal pole.

DORSAL PATHWAY

- **Benefits**
  - Targets the exact axis of the scaphoid (more precise screw placement),
  - No ligament damage,
  - Better rigidity for proximal pole fractures.

- **Disadvantages**
  - Painful scar due to its proximity to the sensitive branch of the radial nerve.

3. Arthroscopic control

Although percutaneous approaches have become popular, these incisions limit the surgeon's ability to grasp the anatomy of the fracture to allow for its anatomical reduction.

Arthroscopy, through its direct visualization, has provided added value to the management of such fractures. The radiocarpal and midcarpal approaches allow for the visualization of the most common scaphoid fractures.

Arthroscopy allows for the direct control of reduction during percutaneous screw fixation. This visualization helps to provide additional information that fluoroscopy cannot provide: it will avoid the protrusion of the material in the radiocarpal space, the quality of reduction, and it will check the compression of bone fragments.

In addition, arthroscopy allows for an assessment of potential associated ligament injuries and their management during the same surgical procedure.

Although arthroscopy is the ideal indication for non-displaced fractures, its indication can be extended to displaced fractures.

Reduction (aided by a "joystick pin" and the probe) can be guided under arthroscopic control. Several teams report conclusive experience in terms of reduction, consolidation, and functional recovery.

4. Our technique for osteosynthesis of a non-displaced scaphoid fracture of type II to IV of the Schernberg classification

For osteosynthesis of a non-displaced scaphoid fracture of type II to IV of the Schernberg classification, patients are operated on under locoregional anesthesia, in a supine position. A tourniquet is placed under the support to hold the arm during traction.

1st time : arthroscopic exploration and lesion assessment

We start with the radiocarpal joint (routes 3-4 and 4-5). The fracture line is hardly visible through this portal (unless the fracture is proximal).

The exploration allows for the visualization of the intrinsic and extrinsic ligaments and to look for degenerative damage existing before the fracture.

The midcarpal exploration (MCU and MCR) will allow testing of the scapholunate and lunotriquetral ligaments.

2nd time: osteosynthesis

We routinely use a percutaneous palmar approach: wrist detached from the traction tower in hyper-extension on a log, forearm in supination, fluoroscopy in place facing the operator.

A 1mm diameter wire mounted on a motor is pushed into the scaphotrapezium in the axis of the scaphoid. Once the wire has been ideally positioned in the central axis of the scaphoid perpendicularly to the axis of the fracture line (fluoroscopic control), the screw is inserted with or without prior drilling, depending on the type of material used.

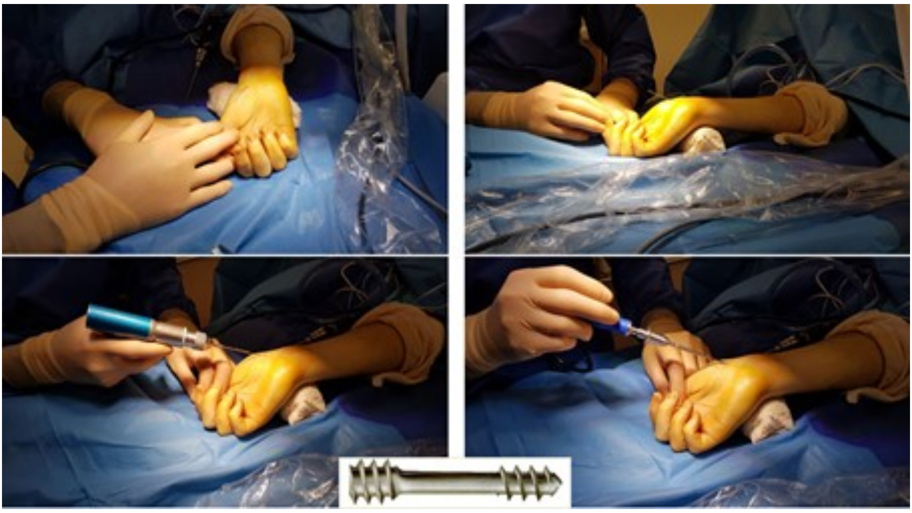


Figure 1.

The wrist is placed in extension. A wire is placed in the axis of the scaphoid under control of the image intensifier. The pin is then replaced by a cannulated screw with a double pitch.

If the fracture is displaced, the pin is pushed under fluoroscopic control from the base of the scaphoid to the fracture line. The wrist is put back in traction, and under arthroscopic control, reduction is performed with the help of the probe hook and/or the pin, used like a joystick. A 1.2mm pin can be inserted into the scaphoid tubercle to assist mobilization and finalization of the reduction.

For Schernberg type I fractures: Proximal screw fixation is recommended (sometimes requiring a reduced proximal pole approach). In case of a very proximal fragment, such fractures can be treated with scapholunate and scaphocapitate pinning (in the same way as a scapholunate ligament injury).

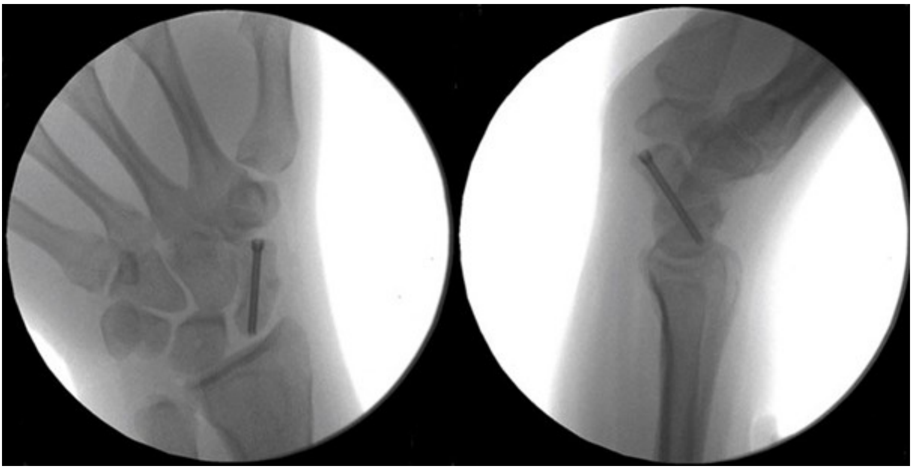


Figure 2.

Intraoperative appearance of the screw, which must respect the axis of the scaphoid from the front and from the side, without protruding proximally or distally.

3rd operating time: arthroscopic control

The radiocarpal exploration controls the absence of invasion of the screw.

In the midcarpal region, care is taken to ensure that the fracture site is properly compressed and that there is no rotational disorder.

Associated lesions are treated according to their nature, namely scapholunate lesion, free osteochondral fragments.

Associated ligament injuries

10% of scaphoid fractures are associated with ligament injuries, even when the scaphoid fracture is not displaced.

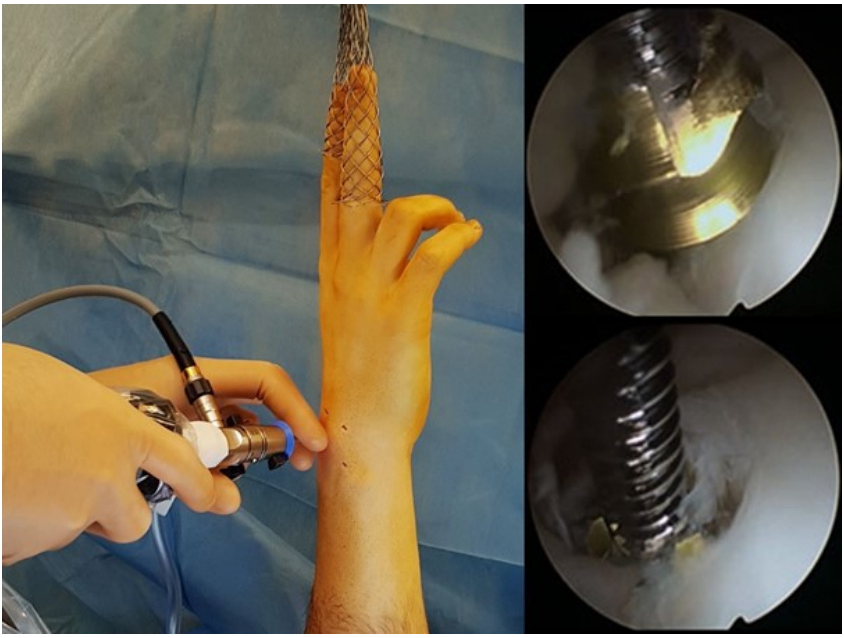


Figure 3.

Arthroscopic radiocarpal approach looking for a proximal screw breakthrough; if this is the case, the screw is retracted with the guide pin still in place.

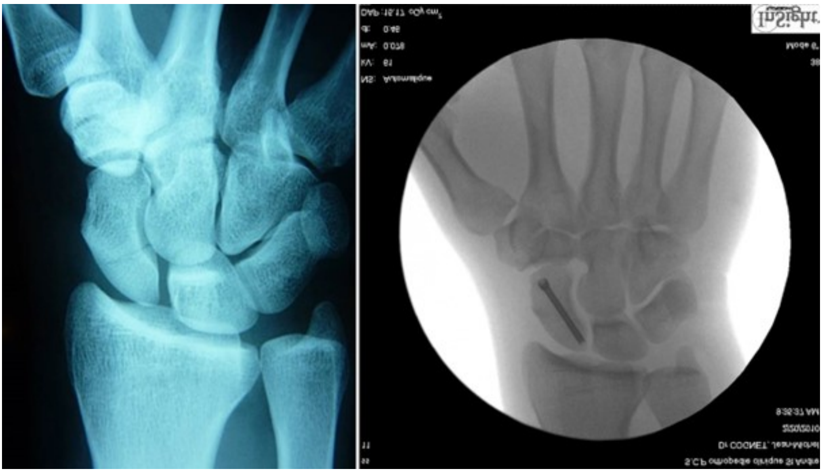


Figure 4.

Example of a non-displaced type II fracture of the Schernberg classification. A double-step screw is inserted under image intensifier control. The screw is centered and in good position. The procedure could be stopped at this stage.

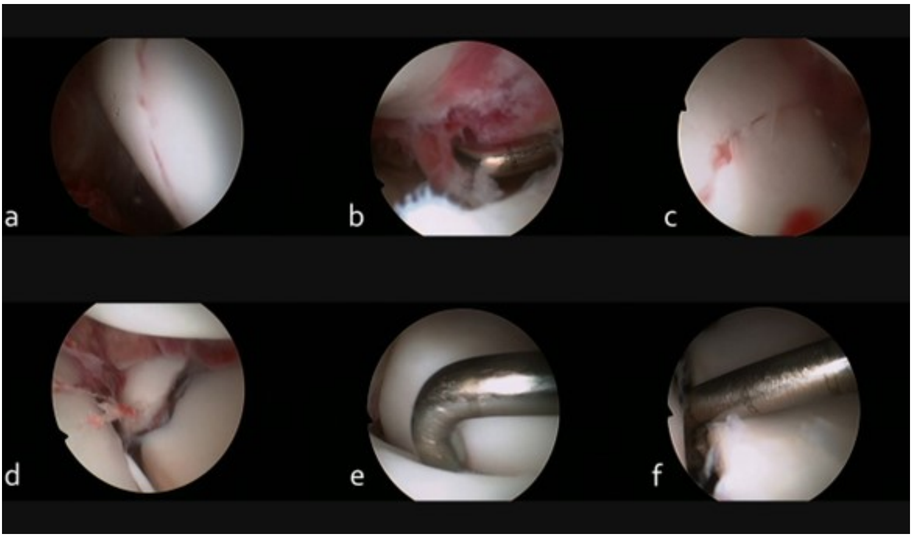


Figure 5.

Intraoperative arthroscopic monitoring yields the following findings:

- *Fracture line visible in radiocarpal, not displaced (a),*
- *fresh and total rupture of the scapholunate ligament (b),*
- *visible fracture line in the midcarpal region, not displaced (c),*
- *fracture of the anterior horn of the lunate (d) not visible on X-rays,*
- *lunotriquetral space that cannot be crossed by the feeler hook (e),*
- *scapholunate space that can be crossed by the palpating hook which can be turned over (f) (Geissler stage III), corresponding to the lesion of the scapholunate ligament visualized in the radiocarpal.*

Tips & tricks

- When screwing from distal to proximal, the pin should be driven into the scaphotrapezial joint and then tilted to create leverage and avoid having too anterior an entry point for the pin.
- It is also possible to pass through the trapezium to have a better axis of penetration in the scaphoid.

- In the case of a displaced fracture or if the fracture site is comminuted, a second pin should be placed in the axis of the scaphoid to prevent rotational disturbance during screwing.
- Once the screw is in place, the fracture site should be tested through the midcarpal approach with the probe to ensure that there is no residual mobility.

Conclusion

The arthroscopic treatment of scaphoid fractures does not present any technical difficulty. It allows us to guarantee the quality of the reduction, to check the length of the screw, and to detect and treat associated lesions if necessary. Arthroscopic monitoring in the management of scaphoid fractures now seems to be essential to obtain a good clinical result.

Video 19: Arthroscopic management of scaphoid fracture
https://vimeo.com/917907746

23. ARTHROSCOPIC MANAGEMENT OF SCAPHOID NONUNION: TECHNIQUES AND PROXIMAL POLE NONUNION SPECIFICITY

JEAN-MICHEL COGNET

Introduction

When a scaphoid fracture evolves into nonunion, the carpus gradually becomes misaligned, with the onset of radial and then midcarpal arthropathy. This evolution is clinically reflected by a stiffening of the wrist with pain and a decrease in strength. The surgical treatment of open carpal scaphoid nonunion involves the use of vascularized or non-vascularized grafts, usually combined with osteosynthesis. This treatment results in a consolidation rate varying from 80 to 91%, depending on the technique used. In recent years, the use of arthroscopy has been proposed for the management of such nonunions.

Surgical technique

1. Installation

The patient is placed in a supine position, with the arm abducted at 90 degrees and resting on an arm table. A pneumatic tourniquet is placed at the root of the operated upper limb. A counter-holding device necessary for traction is fixed to the table, placed on the tourniquet.

The arthroscopy unit is placed on the side of the non-operated limb, with the operator on the side of the limb to be operated on, at the patient's head. An image intensifier is required and is placed on the side of the operated limb, at the patient's feet. The traction tower is installed on the arm table if it is a sterile tower or on the contralateral side fixed to the table if it is a non-sterile tower.

As a result, for the left scaphoid, the operator is located at the patient's head, on the left side, the image intensifier is also located on the left side, in front of the operator, and the arthroscopy unit is located on the patient's right side, at the level of the pelvis or feet. The counter-holding device is placed on the tourniquet allowing traction and must be accessible under the drapes so that it can be loosened at the end of the procedure to facilitate the supination of the wrist, that is essential for osteosynthesis.

A bridge table passed over the patient is used to place the arthroscopic equipment (camera, shaver), as well as the motor that will be used for debridement of nonunion and to perform the fixation. The lens used has a diameter of 2.7mm. An arthropump is not mandatory, as the pressure required for wrist arthroscopy is usually less than 30mmHg.

The portals used are 3/4 and 4/5 in the radiocarpal, and MCR and MCU in the midcarpal. The radiocarpal approaches are not used for the treatment of scaphoid nonunion (as a general rule), but they do allow a complete assessment of the wrist. In the midcarpal region, it may be necessary to perform an accessory approach that we will call MCRS (MidCarpal Radial Scaphoid) **(Figure 1)**. This approach allows direct access to the site of nonunion to facilitate debridement and grafting.

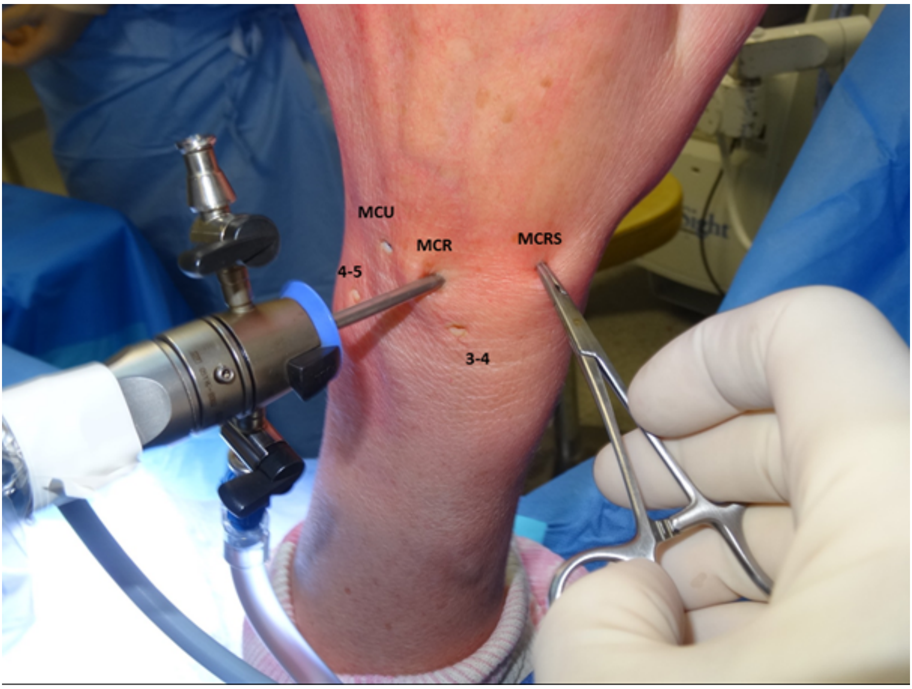


Figure 1.

Optics introduced through the MCR pathway, an accessory MCRS pathway is used for avulsion and grafting of the pseudoarthrosis.

The trephine used for the harvesting and placement of the graft is an essential instrument for the success of the procedure. We use an ARGON® brand trephine, which is usually used for the collection of osteomedullary biopsies. This trephine is composed of 4 parts **(Figure 2)**, i.e., a hollow cylinder used to harvest the graft, a solid cylinder, the pointed end of which is used to perforate the cortical bone, a hollow cylinder ending in 2 metal legs, and a solid cylinder, the end of which is flat.

The procedure to take the graft is the following one: a 10 to 20mm incision is made on the dorsal aspect of the Lister, slightly anterior to the tubercle. The extensor pollicis longus of the thumb is located and reclined ulnarly. The bone of the dorsal aspect of the radius is exposed. The trephine is used with the hollow cylinder containing the solid cylinder at the pointed end. The dorsal surface of the radius is perforated with the trephine.

As soon as the trephine has passed through the cortex, the solid cylinder is removed and the hollow cylinder is pushed by pronosupination movements until contact is felt with the opposite cortex. The cylinder ending with 2 legs is then pushed into the trephine. The 2 legs will position themselves on either side of the removed bone core and prevent it from remaining in the radius.

The trephine is removed from the distal radius. The cylinder ending in 2 legs is removed from the trephine and should contain the bone core **(Figure 2)**. If this is not the case, the full cylinder must be used to expel the bone core that has become trapped in the trephine. All bone grafts must be harvested in sequence. To do so, the trephine must be orientated at a different angle for each harvest. If possible, ten or so bone cores should be harvested, which are the bricks needed to rebuild the scaphoid.

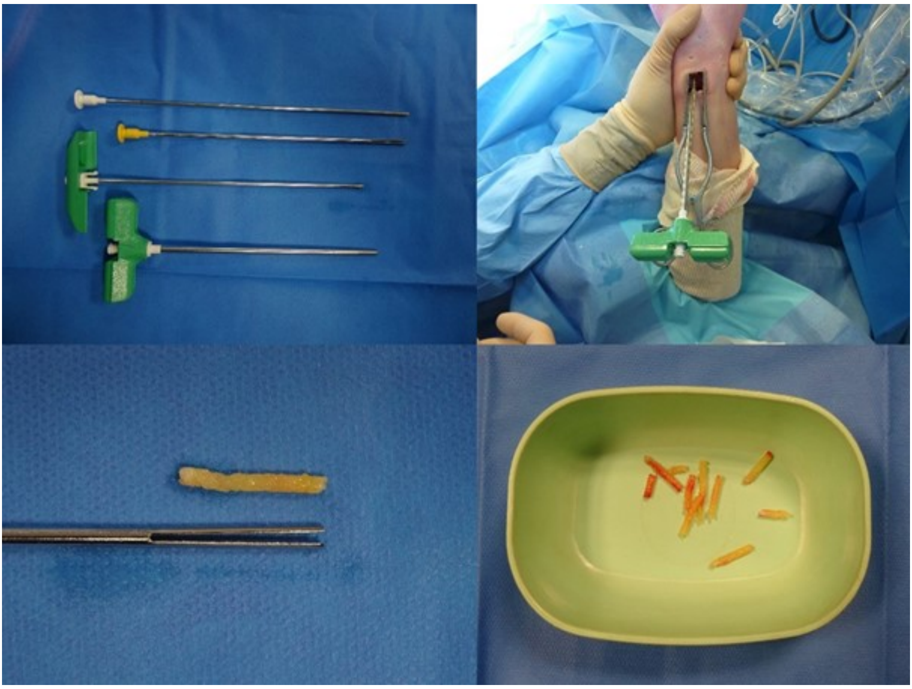


Figure 2.

A specific trephine is used to harvest the graft from the dorsal surface of the distal radius and to place the bone graft in the nonunion site.

2. Arthroscopic time

The wrist is put in traction with a vertical traction like a shoulder turn or a specific traction turn (Whipple or Geissler). A counter-holding device is placed on the tourniquet, with the elbow flexed to 90 degrees. The dorsal arthroscopic approaches are marked on the skin. Exploration is started at the radiocarpal joint using 3/4 and 4/5 portals. The purpose of this exploration is to look for associated lesions: cartilage damage, condition of the triangular ligament, lunotriquetral ligament, scapholunate ligament.

Nonunion can be visualized, but in a much more difficult way than in the midcarpal region: even for a type I or II in the Schernberg classification, the line is always located close to the scapholunate space in the midcarpal region and at a distance from the scapholunate space in the radiocarpal. It is crucial to begin with an exploration of the radiocarpal joint to avoid having to do so at the end of the procedure if scaphoid reconstruction takes longer than expected. It is also essential to ensure that there is no radioscaphoid osteoarthritis, which would be a contraindication to scaphoid reconstruction.

Exploration of the midcarpal joint begins with the search for the area of nonunion. The location of the nonunion is usually not a problem. The mobility of the nonunion should then be tested with the palpating hook. If the probe hook cannot mobilize the nonunion site, it is either a healing fracture or a tight nonunion. In this case, a graft is not necessary and a simple percutaneous screw fixation is sufficient. If the nonunion site can be mobilized with the probe, the indication for grafting is maintained. Further exploration of the midcarpal joint is then necessary to perform a complete assessment of the injury.

Debridement of the nonunion site is a major surgical step. The tools required are a small curette (2 to 4mm), an arthroscopic knife with a diameter of 3.5mm, and a motor-mounted ball bur with a diameter of 2 to 4mm. During exploration of the midcarpal joint, the focus of nonunion is visualized as a line, with an intact cartilage surface. A cavity corresponding to the radiographic or CT-scan image is never found. The cartilage must be attacked on both sides of the nonunion line, starting with a curette **(Figure 3)**.

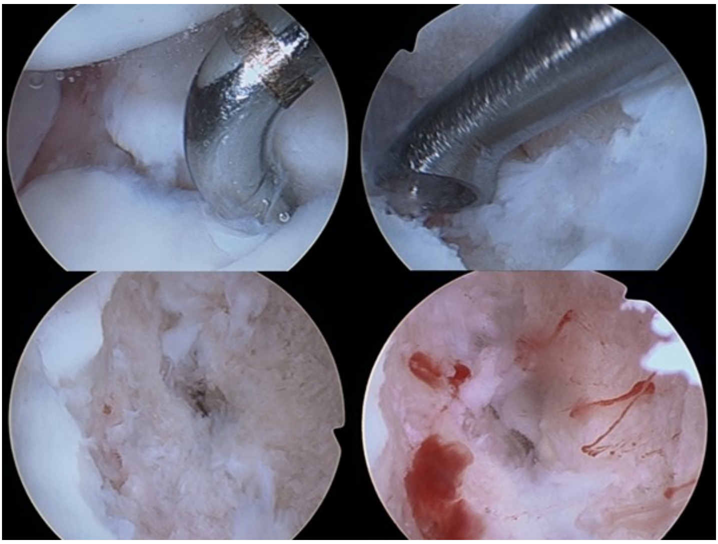


Figure 3.

Preparation of nonunion : assess the mobility of the nonunion site with the probe hook, aviva with a curette to obtain a cavity without residual necrotic bone and release of the tourniquet to assess the bleeding on both sides of the nonunion site.

This instrument creates a pocket into which the shaver can be introduced. Debridement is then continued with the use of a motor-mounted ball bur. This drill is much more aggressive than the shaver knife and much more effective, as the shaver tends to be quickly obturated by the bone fragments from the debridement. The result should be a bone trench corresponding to the debridement zone of the nonunion.

How to ensure that the debridement performed is sufficient? Three elements are essential to bear in mind:

- Absence of residual necrotic bone,
- Visualization of the opposite cortex showing that the debridement was performed on the entire section of the nonunion area,
- Bleeding from the proximal and distal walls of the scaphoid.

If these 3 elements are not obtained at the end of debridement, there is a risk of failure or patchy consolidation in areas not sufficiently debrided. Once debridement is complete and considered correct, the bone grafts can be introduced. It should be noted that the absence of bleeding from the proximal pole of the scaphoid reduces the consolidation rate to 85%.

The trephine used for harvesting is used to place cancellous bone grafts **(Figure 4)**.

This trephine is used through the same approach as debridement (i.e. either the MCR or the MCRS approach). The trephine is pushed to the bottom of the span created by the debridement.

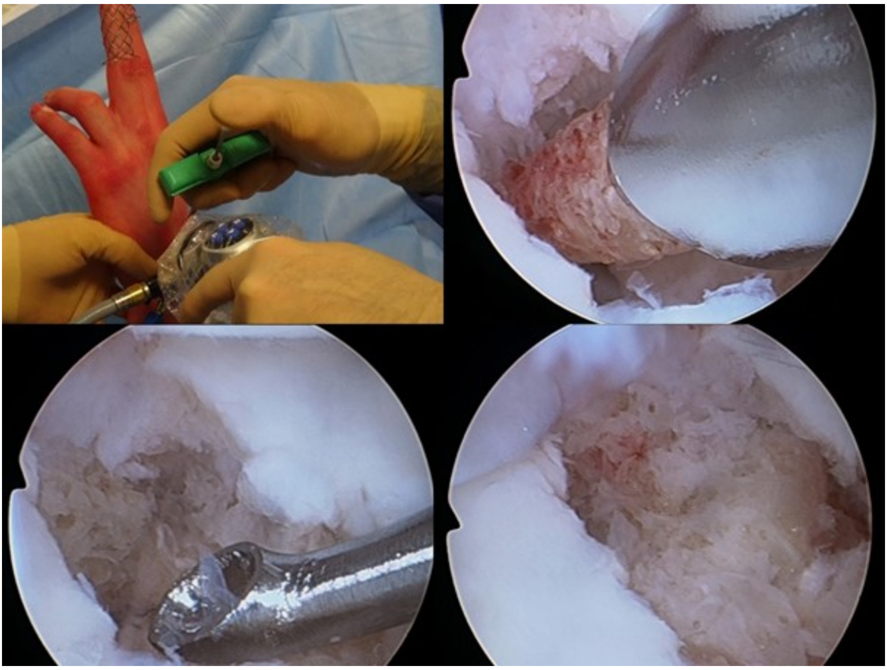


Figure 4.

Grafting of the nonunion site using the same trephine as for the harvesting.

The bone cores are then pushed into the trephine under arthroscopic control. Only one bone core should be inserted at a time. If several cores are inserted into the trephine, they may settle and become blocked. Each core is pushed into the trephine successively using the flat-tipped metal tube.

Each bone graft is then packed at the bottom of the debridement area using the flat tip or a curette. Because of the harvesting method (trephine), each cancellous bone graft behaves like a brick of compacted bone that has primary stability. Each brick joins the previous one to fill the bone trench created by the debridement. Once this filling has been achieved, the wrist can be detached from the traction tower to perform osteosynthesis.

3. Osteosynthesis

Fixation is performed percutaneously, with the wrist positioned in hyperextension and the forearm in supination. The type of osteosynthesis depends on the location of the nonunion. We refer to the Schernberg classification, which is the only descriptive classification according to lesion level. For Schernberg type 3 lesions, we recommend the use of a double-threaded screw.

For type 2 lesions, a pinning procedure is performed using two Kirschner wires (1mm in diameter). For type 1 lesions, we usually perform a scapholunate pinning with two wires and a scaphocapitate pinning with one wire. For types 2 and 3 lesions, a final arthroscopic control is performed to make sure that there is no intra-articular material exiting and that the graft remains in place.

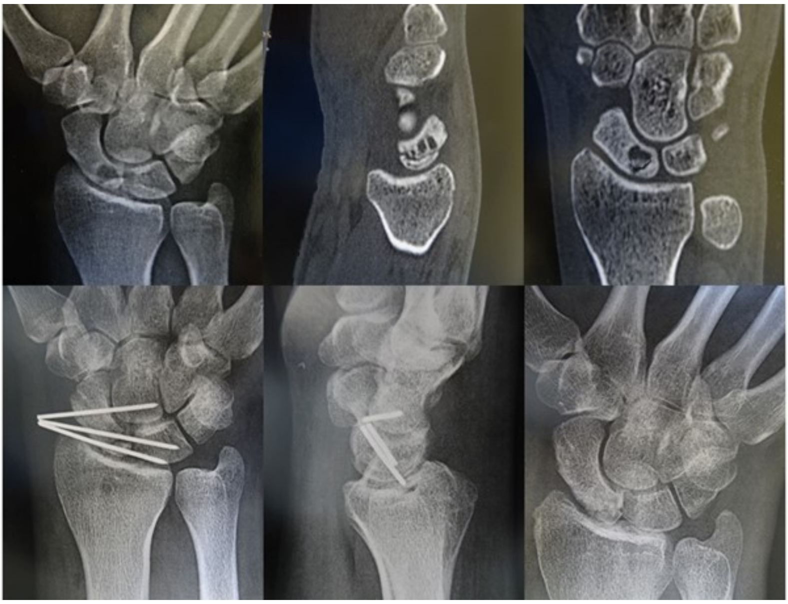


Figure 5.

Example of nonunion of the proximal pole of the scaphoid treated using an arthroscopic technique.

Tips & tricks

- In very proximal pseudarthroses, the line visualized in the midcarpal region is very close to the scapholunate space and may give the impression that there is no proximal pole. This is a false impression since the fracture line is never parallel to the scapholunate space.
- The midcarpal joint is sometimes tight: resection should be started with a curette and then with a motorized knife in order to create a working space before using a motorized burr that has a larger diameter and which could create iatrogenic lesions.
- The curette can be bent at the end to be more effective.

Conclusion

The use of arthroscopy for the treatment of scaphoid pseudarthroses facilitates the management of proximal pseudarthroses, which are usually more difficult to treat openly. This minimally invasive technique preserves the vascularity of the scaphoid and improves the rate of consolidation.

24. ARTHROSCOPIC BONE GRAFTING FOR SCAPHOID NONUNION: MY PERSONAL TECHNIQUE

CHRISTOPHE MATHOULIN

Introduction

Scaphoid fractures are often initially missed and then diagnosed only once nonunion manifests. As the natural history of such fractures results in radiocarpal arthritis and ultimately midcarpal arthritis, they must be surgically treated. However, there is still a controversy regarding the best treatment strategy. The various techniques range from less invasive ones, such as percutaneous fixation, to more invasive ones, such as autologous bone grafting from the iliac crest or vascularized bone grafts.

The surgical treatment of nonunions can be performed in a minimally invasive fashion with arthroscopy. It simplifies postoperative recovery, reduces complications, and preserves the wrist's capsule-ligament complex, and, as a result, the scaphoid's precarious vascularization.

Surgical technique

1. Patient Preparation and Positioning

The procedure is performed under regional anesthesia using a tourniquet. The patient's arm is secured to an arm board. Finger traps are used to apply 5 to 7 kg (11–15.5 lbs) of traction along the arm's axis.

2. Radiocarpal and Midcarpal Exploration

The scope is introduced into the 6R portal and the shaver into the 3–4 portal. The integrity of the scapholunate ligament can be controlled using this approach. The quality of the cartilage at the proximal pole of the scaphoid and radial styloid process is also verified. If need be, radial styloidectomy can be performed arthroscopically at that stage, in the procedure (Chapter 7).

The arthroscopic treatment of nonunion is performed via the midcarpal joint. The scope is introduced into the midcarpal ulnar (MCU) portal and instruments into the midcarpal radial (MCR) portal. The first phase of the arthroscopic procedure consists of complete synovectomy with a shaver.

3. Nonunion Site Preparation

The nonunion site will be visible or will appear as a bone fissure filled with fibrotic tissue **(Figure 1)**. This fissure can be located with a hook probe. The nonunion site is abraded with a curved curette, shaver, and/or burr successively **(Figure 2)**. The goal is to expose bleeding cancellous bone on both sides, visible arthroscopically. **(Figure 3)**.

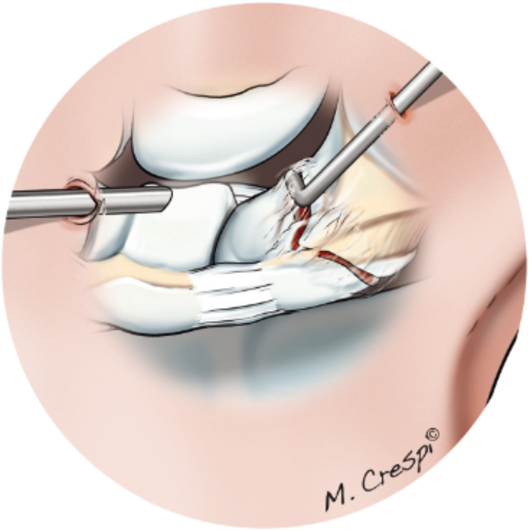


Figure 1.

Drawing of the nonunion site palpated with a probe.

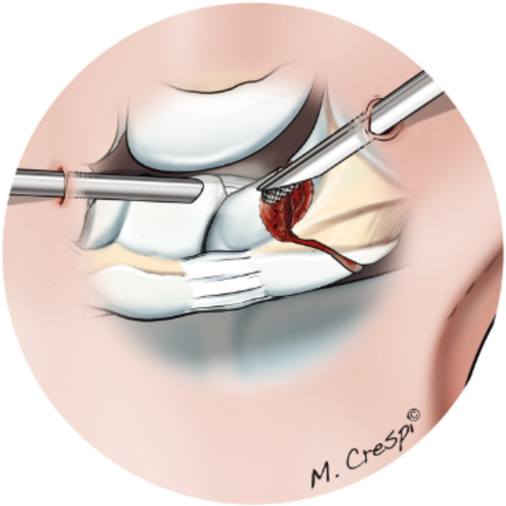


Figure 2.

Drawing of the nonunion site debrided with a burr inserted through the radial midcarpal portal (MCR) with the scope in the ulnar midcarpal portal (MCU).

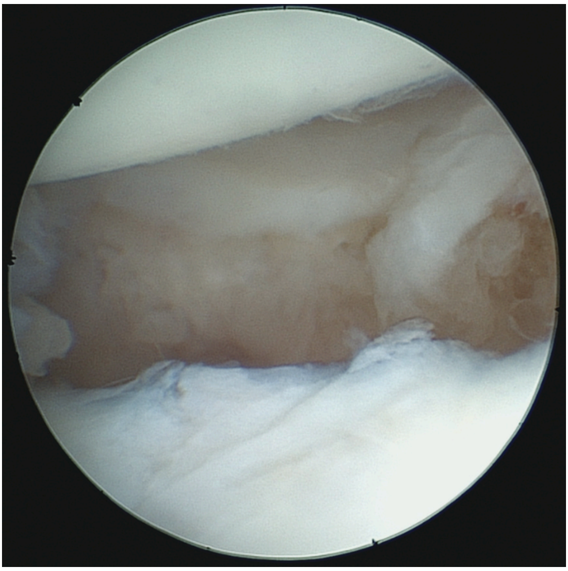


Figure 3.

Arthroscopic view of the abraded nonunion site after debridement.

4. Bone Graft Harvesting

The bone graft is harvested from the ipsilateral wrist. An incision is made on the lateral side of the wrist between the first and the second extensor compartments. The sensory branches of the radial nerve are identified and protected. The periosteum under the extensor tendons in the first and the second compartments are roughened with a bone rasp to free up the graft collection area. A three-sided osteotomy is performed while leaving a "bone cap" attached to the radius **(Figure 4)**. The bone graft is harvested with a curette; the graft's volume must be larger than the defect being filled **(Figure 5)**. After the graft has been collected, the cap is placed back onto the harvest site. The periosteum will spontaneously move back into place **(Figure 6)**. The skin is closed with interrupted sutures.

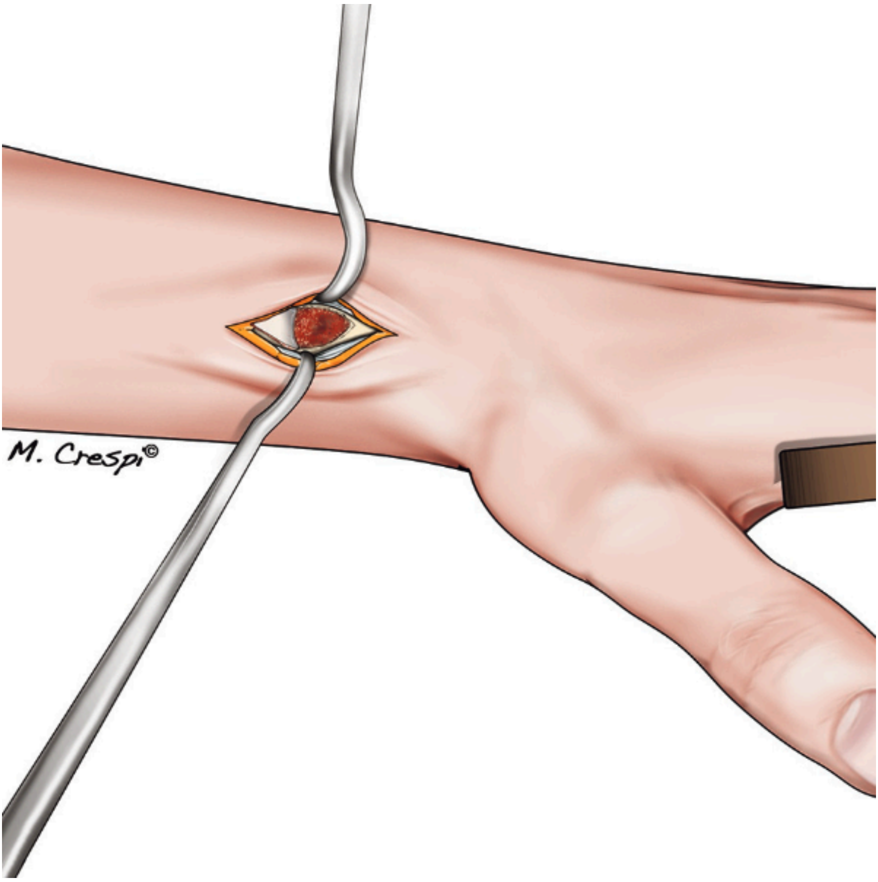


Figure 4.

Drawing of the bone graft harvesting site. Once the extensor tendons in the first and the second compartments have been reflected below the periosteum, a cortical bone cap, still attached on its proximal side, is lifted, allowing access to the cancellous bone in the distal radius.

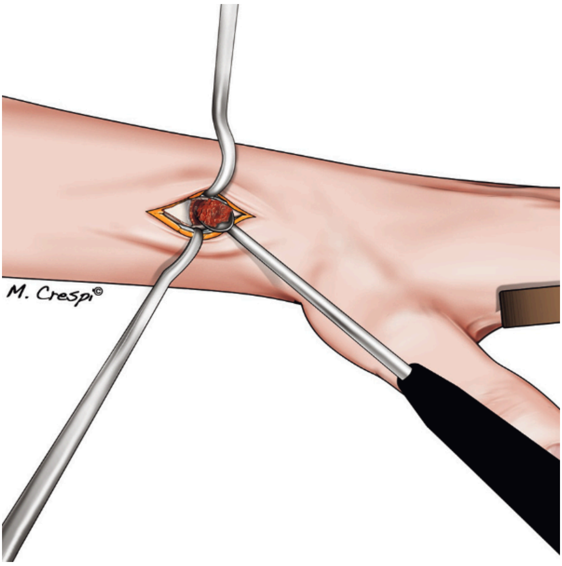


Figure 5.

Drawing of the graft collected with a curette.

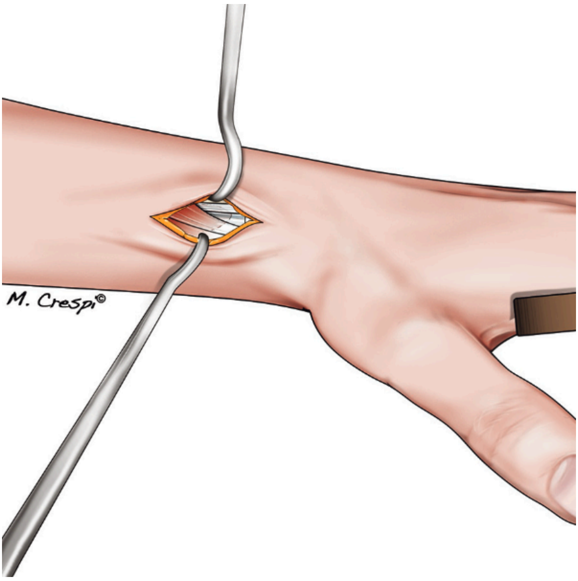


Figure 6.

Drawing of the two extensor compartments repositioned once the cortical bone cap has been replaced after graft collection.

5. Temporary Fixation of the Nonunion

The abraded nonunion site is reduced and temporarily held in place with one or more K-wires (1.0mm). This step can be performed with traction on the hand, or by setting the hand flat on the arm board if necessary. Reduction and K-wire positioning are controlled via arthroscopy and fluoroscopy **(Figure 7)**.

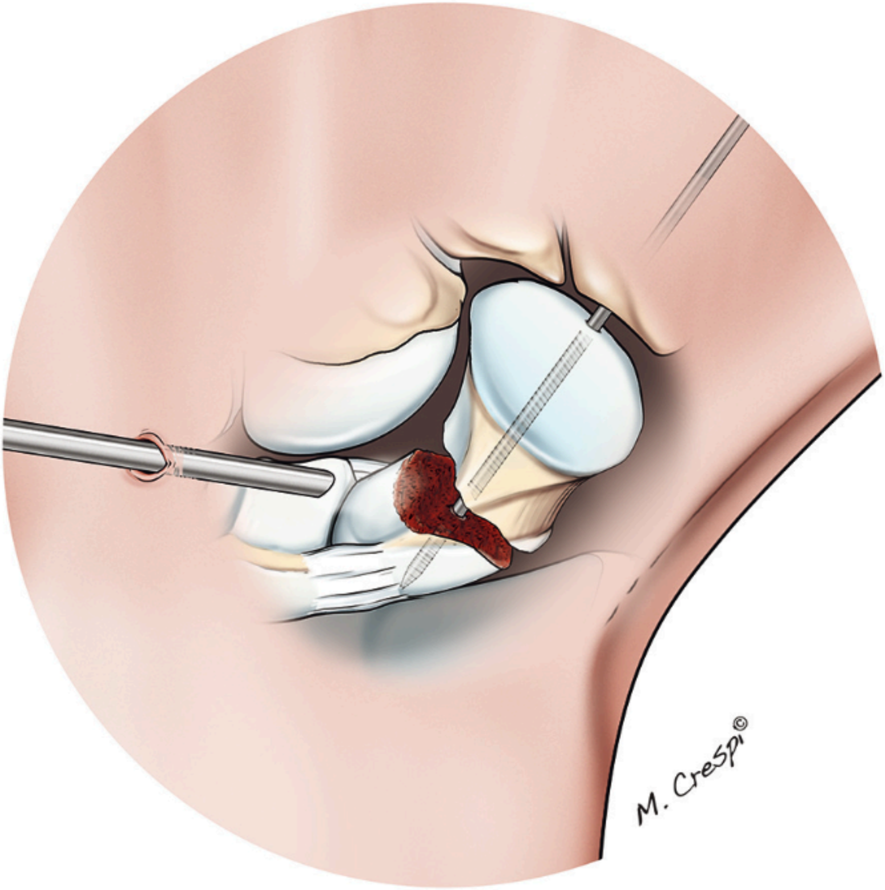


Figure 7.

Drawing of the graft collected with a curette.

6. Graft Implantation and Fixation

The next step is performed in a dry environment. If the initial part of the procedure was performed in a wet environment, the entire fluid must be aspirated. The bone graft is inserted into a trocar and the end of the trocar is then placed at the nonunion site. The graft is pushed into the trocar with a blunt guide wire **(Figure 8)** until the nonunion site is filled. The bone graft is tamped down with a spatula **(Figure 9)**. At that stage in the procedure, biological glue can be used to stabilize the grafts. However, once the scaphoid has been fixed and the traction released, the capitate's native anatomical position will provide sufficient graft stabilization.

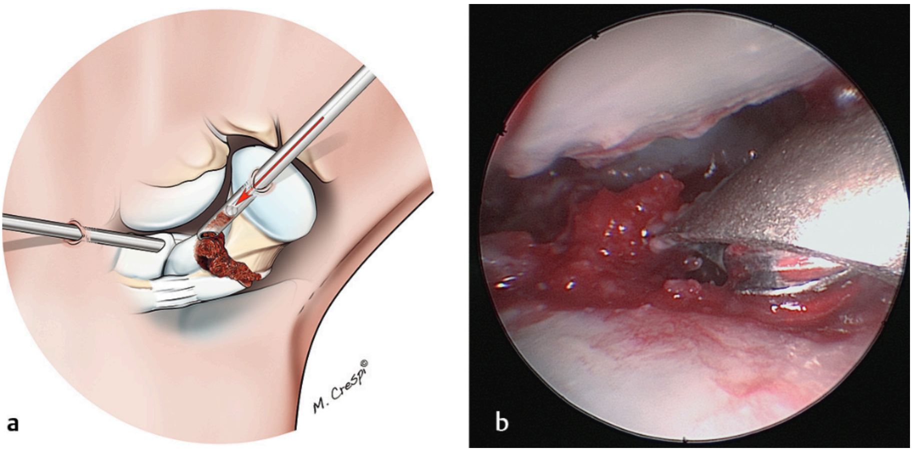


Figure 8.

(a) *Drawing showing the graft placed through a trocar inserted into the MCR portal, with the distal tip placed at the nonunion site.*
(b) *Arthroscopic view of the graft seated in the nonunion site, with the trocar in the MCR portal and the scope in the MCU portal.*

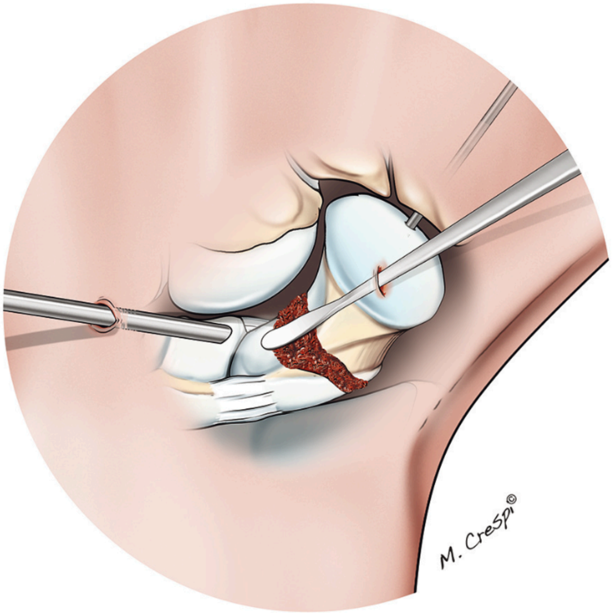


Figure 9.

Drawing showing the graft tamped down with a spatula introduced through the radial midcarpal portal (MCR).

Once the bone graft is in place, scaphoid fixation can be performed. If the nonunion is located in the scaphoid's body, the fragments are secured with a compression screw, preferably a self-tapping cannulated one, which is inserted through a small distal percutaneous incision. If the nonunion is at the proximal pole, stabilization can be improved by means of transcutaneous scapholunate pinning through a lateral incision. Two or three K-wires (1.0 or 1.2mm) are inserted so that their trajectories fix both the nonunion site and the scapholunate gap. The K-wires are buried under the skin **(Figure 10)**.

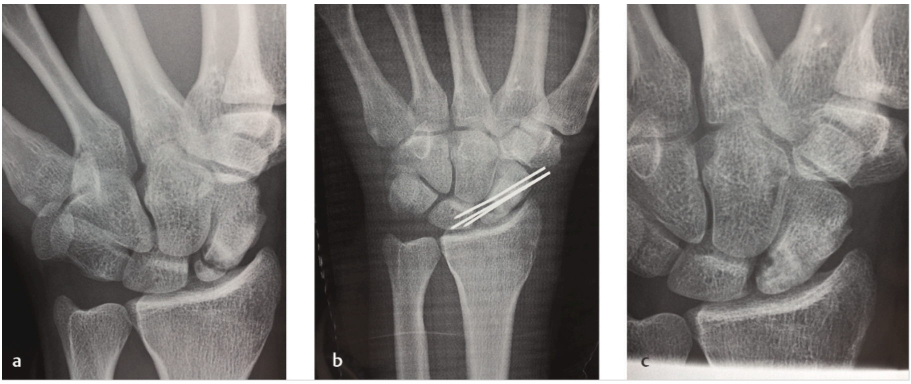


Figure 10.

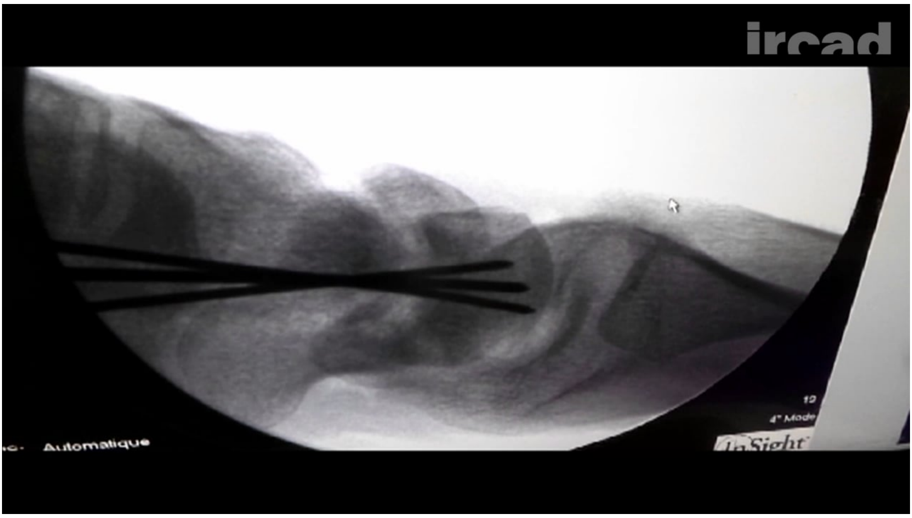
(a) *X-ray of nonunion at the proximal pole of the scaphoid.* **(b)** *Postoperative X-ray of the fixation construct consisting of triple scapholunate pinning that spans the scaphoid body, grafted nonunion site, proximal pole, and lunate.* **(c)** *X-ray showing bone union 60 days after K-wires were removed.*

7. Closure and Postoperative care

The wrist is immobilized until union has been achieved. Rehabilitation is initiated once the splint and/or K-wires have been removed.

Conclusion

Scaphoid nonunion is a common disorder since the initial fracture can go undetected and the bone is poorly vascularized. It can eventually progress to scaphoid nonunion advanced collapse and must be treated surgically before osteoarthritis sets in. Arthroscopic bone grafting is a simple reliable technique, which preserves vascularization, especially in cases of proximal pole nonunion.



Video 20: Arthroscopic Bone Grafting for Scaphoid Nonunion
https://vimeo.com/189163982

25.
ARTHROSCOPY-ASSISTED FIXATION OF TRANS-SCAPHOID PERILUNATE DISLOCATION

MARION BURNIER

Introduction

Trans-scaphoid perilunate dislocation (TSPD) is a high-energy trauma, which usually occurs in young patients. The characteristic features of the TSPD include scaphoid fracture, dislocation of the capitate from the lunate, and lunotriquetral ligament injuries **(Figure 1)**.

After emergency closed reduction and preoperative CT-scan to evaluate bony lesions, open surgery remained the gold standard to treat (fracture) perilunate dislocation.

However, aggressive surgical interventions, that involve inevitable soft tissue dissection, can adversely affect the carpus. In addition, arthroscopy allows for the evaluation and treatment of associated injuries such as TFCC tear and cartilage defect of the capitate as a prognostic factor of the wrist. This chapter introduces arthroscopic techniques to perform a less invasive treatment of arthroscopy-assisted trans-scaphoid perilunate fixation.

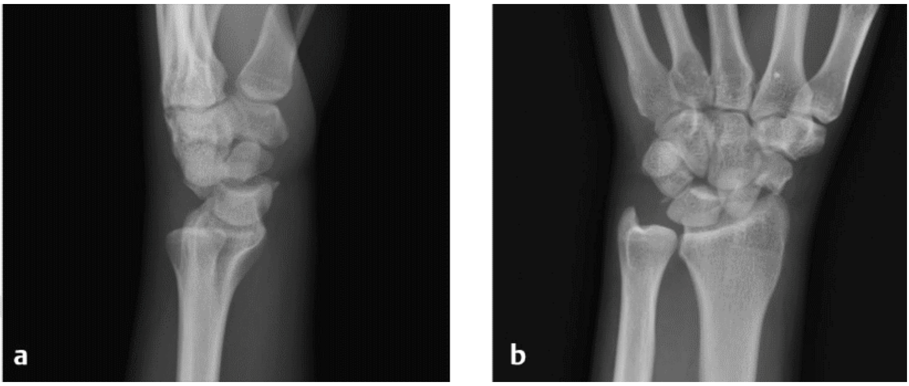


Figure 1.

(a) Lateral view of trans-scaphoid perilunate dislocation (TSPD). (b) Frontal view of the TSPD.

Operative technique

1. Patient Selection

First, it is critical to identify perilunate injuries dedicated to an arthroscopic treatment since not all of those injuries can be properly and safely treated under an assisted or all-arthroscopic procedure. We can recommend to use arthroscopic assistance for the following injuries:

pure ligamentous lesions such as PeriLunate Injury Non Dislocated (PLIND), dorsal stage 1 and stage 2A PLD according to the Herzberg classification.

2. Patient Preparation and Positioning

The arthroscopic procedure is usually performed after an emergency closed reduction and CT-scan work-up. In some cases when closed reduction is not successful and the arthroscopic technique using the probe and dry arthroscopy has been described by Bo Liu and colleagues. Brachial plexus regional anesthesia is performed with the patient in a supine position. The arm is abducted to 90 degrees, with the elbow flexed to 90 degrees, and resting on a hand table. A tourniquet is used at the proximal part of the arm. After a traction tower has been applied with finger traps, closed reduction is attempted, but quite often, fluoroscopy shows that closed reduction failed **(Figure 2)**. Palpation shows that the lunate is absent among the scaphoid, capitate, and triquetrum **(Figure 3)**.

Bo Liu *et al.* reported that failure of the closed reduction of the capitolunate dislocation was due to the volarly tilted lunate which got stuck by the capitate or interposed torn palmar capsular ligaments. The authors found that the 4-5 portal was convenient to apply this maneuver because the instrument was directly facing the subluxated lunate.

Dry arthroscopy with automatic wash-out would be particularly appropriate in such indications since this technique can be associated with a mini-open dorsal approach to help the reduction of the scaphoid fracture or to reinforce the repair of the scapholunate ligament.

Figure 2.

Fluoroscopy shows that closed reduction failed.

Figure 3.

Palpation shows that the lunate was absent among the scaphoid, capitate, and triquetrum.

3. Radiocarpal Arthroscopy and Synovectomy

Radiocarpal arthroscopy is initiated through the 3–4 portal, and lots of red synovium are found in the radial scaphoid space. The 6R portal is used to pass instruments like a shaver. Automatic wash-outs are performed first to evacuate hematoma. After debridement of the synovium, the distal part of the scaphoid is found shifting dorsally to the proximal part **(Figure 4)**. Some bone or cartilage loose fragments can be removed. In the meantime, cartilage defects, particularly defects of the head of the capitate, are evaluated and reported as prognostic factors.

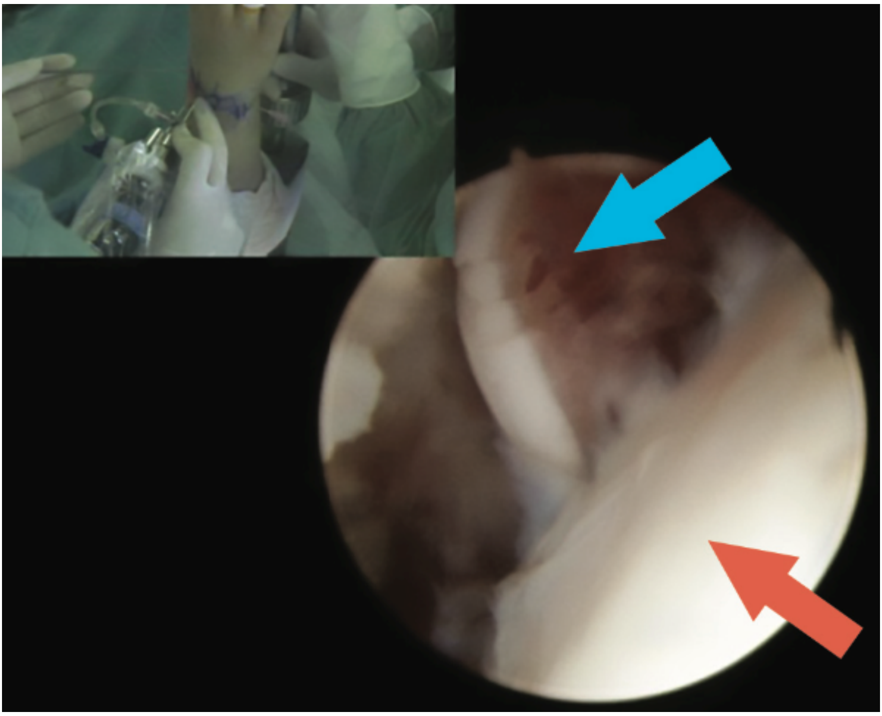


Figure 4.

Arthroscopic view from the 3/4 portal. The distal part of the scaphoid (blue arrow) was found shifting dorsally to the proximal part (red arrow).

4. Midcarpal Arthroscopy and Exploration

Radiocarpal arthroscopy is initiated through the midcarpal radial (MCR) and the midcarpal ulnar (MCU) portals. The lunate could not be found among the scaphoid, capitate, and triquetrum, which would be filled with synovium **(Figure 5)**. Synovectomy of the midcarpal joint is performed with a shaver. Volar capsule rupture could be found after debridement whereas the arc ligament might be still intact **(Figure 6)**. However, the radioscaphocapitate (RSC) ligament could be stuck in the scaphoid fracture site, which would be blocking reduction **(Figure 7)**.

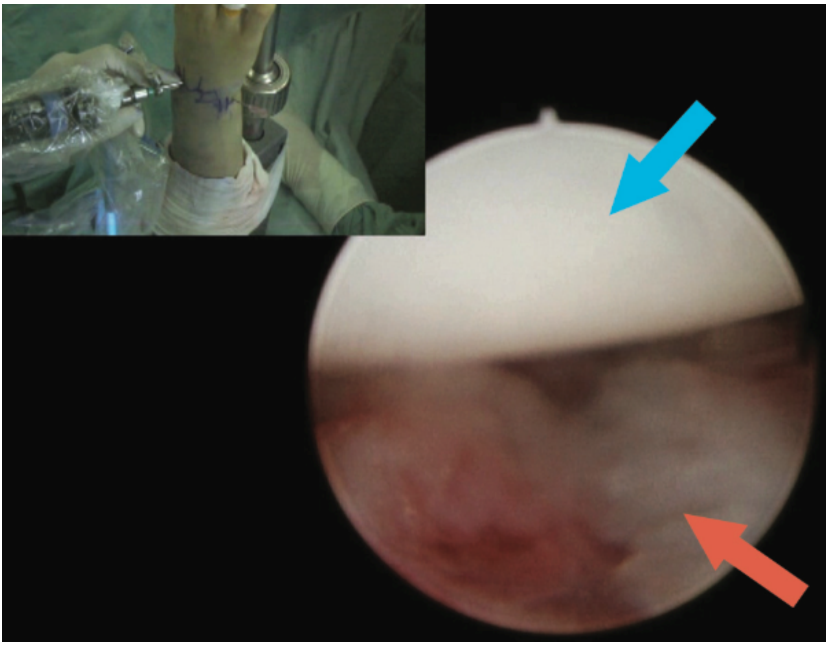


Figure 5.

View from the MCR portal. The lunate could not be found among the scaphoid, capitate (blue arrow), and triquetrum, which was filled with synovium (red arrow).

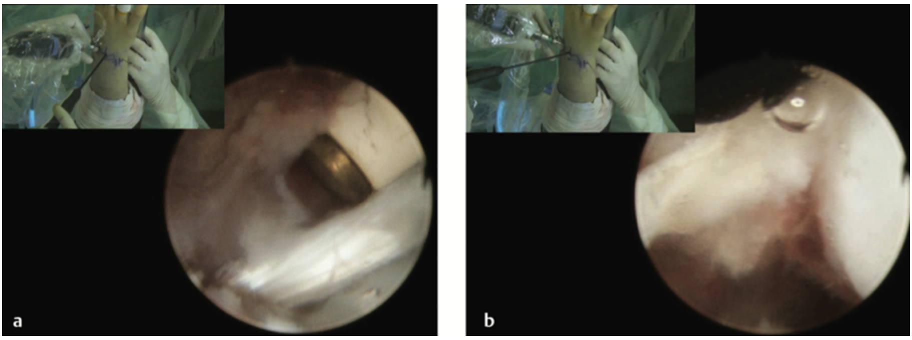


Figure 6.

(a) *Arthroscopic view from the MCR portal showing the scaphoid insertion of the arc ligament.* ***(b)*** *Arthroscopic view from the MCR portal showing the triquetrum insertion of the arc ligament.*

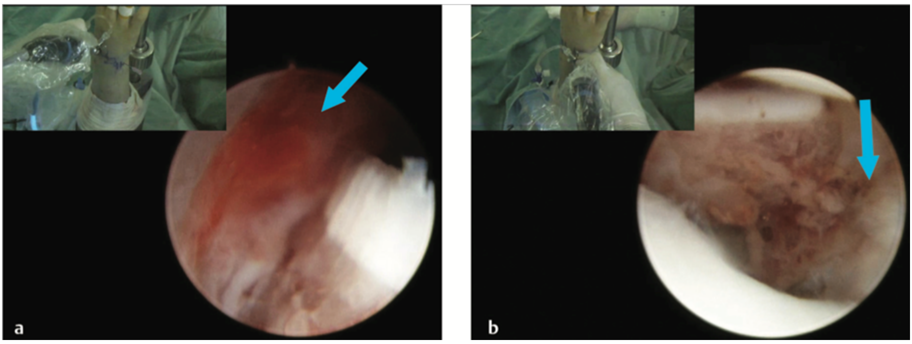


Figure 7.

(a) *Arthroscopic view from the MCR portal showing that the radioscaphocapitate ligament (blue arrow) could be stuck in the scaphoid fracture site.* ***(b)*** *Arthroscopic view from the midcarpal ulnar portal (MCU) showing that the radioscaphocapitate ligament (blue arrow) could be stuck in the scaphoid fracture site.*

5. Dissection of the volar capsule

After synovectomy of the midcarpal joint, with the scope in the MCU portal, a probe is inserted into the MCR portal to dissect the volar capsule of the scaphoid and the lunate and push out the RSC ligament **(Figure 8)**. During dissection, the carpal bones reduce gradually. The scaphoid could then reduce without the blocking of the RSC ligament **(Figure 9)**.

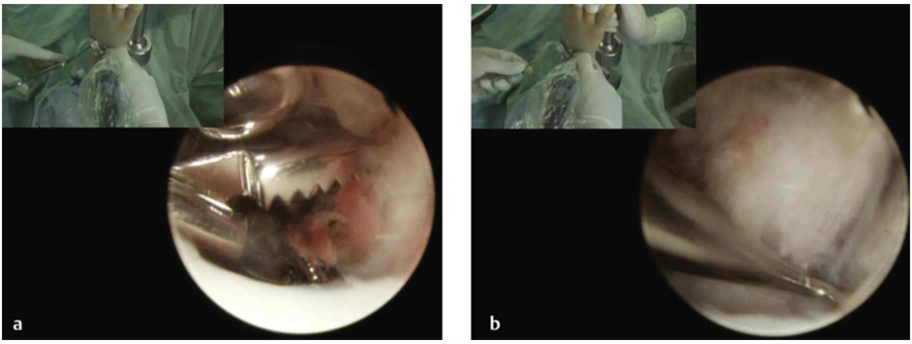


Figure 8.

(a) *Arthroscopic view showing dissection of the volar capsule (view from the MCU portal) and the debridement of the scaphoid fracture site.* ***(b)*** *Arthroscopic view showing the dissection of the volar capsule (view from the MCU portal) pushing out the RSC ligament from the scaphoid fracture site.*

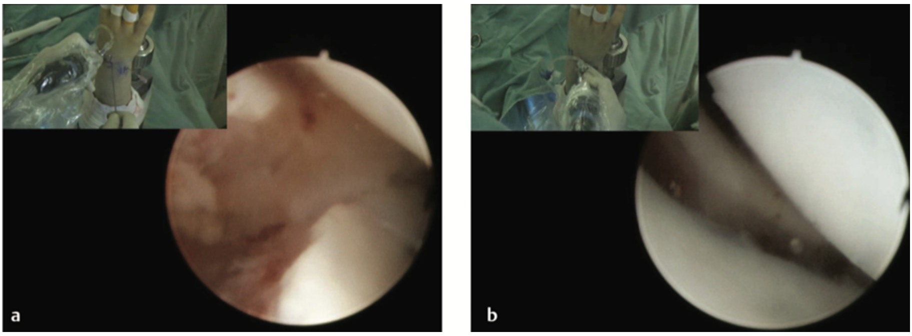


Figure 9.

*(**a**) Arthroscopic view from the MCR portal showing the dislocation of the scaphoid fracture reduced after debridement. (**b**) Arthroscopic view from the MCU portal showing the dislocation of the scaphoid fracture reduced after debridement.*

6. Assessment of intercarpal ligament instability

With the scope in the MCR portal, a probe is inserted into the MCU portal to assess the stability of scapholunate and lunotriquetral ligaments. During the assessment, the traction should be temporally reduced. Naturally, in such injuries, the probe could be easily inserted into, which indicates a complete rupture of lunotriquetral ligaments **(Figures 10 and 11)**. In rare cases of trans-scaphoid PLD, an arthroscopic evaluation may report an associated torn scapholunate ligament.

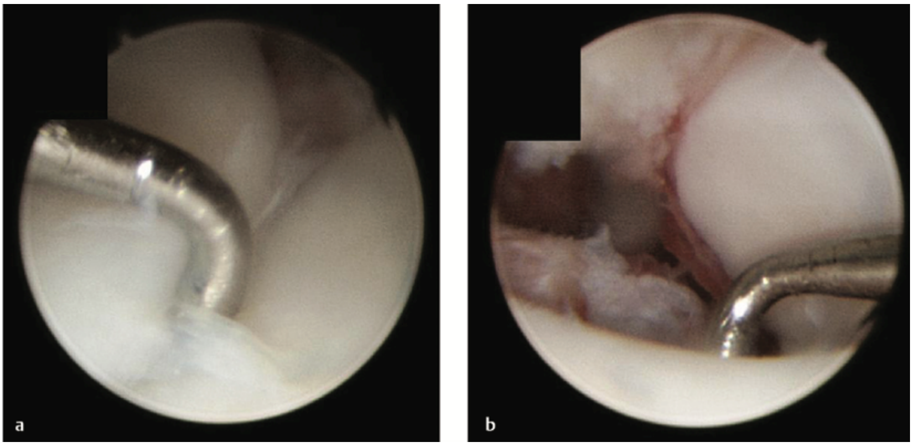


Figure 10.

(a) *Arthroscopic view from the MCU portal, showing the assessment of intercarpal ligaments stability, the probe could not be inserted between the scaphoid and the lunate.* ***(b)*** *Arthroscopic view from the MCR portal, showing the assessment of lunotriquetral stability, indicating a complete rupture.*

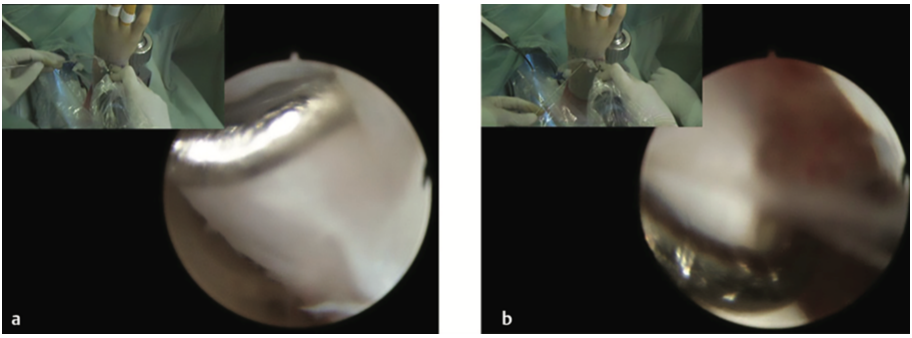


Figure 11.

(a) Arthroscopic view from the 3–4 radiocarpal portal showing the assessment of scapholunate stability and the intact scapholunate ligament. (b) Arthroscopic view from the 6R radiocarpal portal showing the assessment of lunotriquetral stability with a complete rupture.

7. K-wires preparation under fluoroscopic guidance

Traction can be removed and the K-wire can be introduced under fluoroscopic control.

Two K-wires are inserted from the distal volar tubercle of the scaphoid to the proximal pole. As the fracture can usually not be reduced using external maneuvers, the K-wires are introduced only into the scaphoid fracture. To prevent ulnar carpal translation, a radiolunate K-wire is usually kept in place during 6 weeks. Two K-wires are introduced through the triquetrum until the lunotriquetral interval to prepare the lunotriquetral stabilization.

8. K-Wire fixation under arthroscopic control

The wrist is then placed under traction and the scope introduced through the MCR portal, but just at the entrance of the midcarpal joint not to block the lunotriquetral reduction. After reduction of the lunotriquetral step-off and gap, the two K-wires are pushed through the lunate **(Figure 12)**.

After reduction of the scaphoid fracture by using one of the K-wires as a joystick, the two K-wires are pushed through the proximal fragment and a compression cannulated screw is then introduced under arthroscopic control.

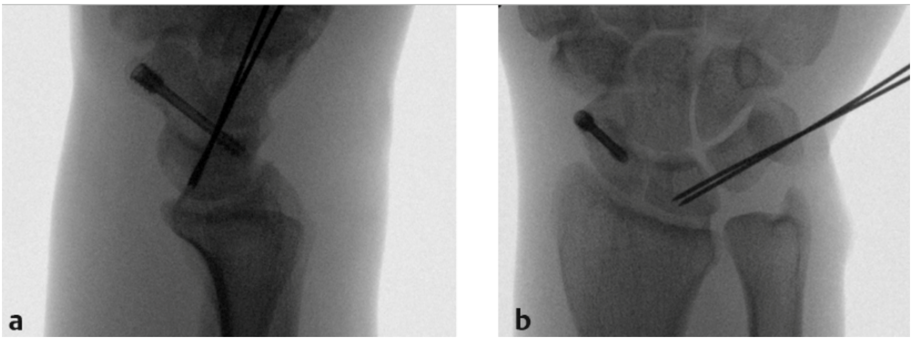


Figure 12.

(a) Radiograph showing the lateral view after fixation. (b) Radiograph showing the frontal view after fixation.

9. Assessment of stability after fixation

After the reduction and fixation of the carpal bones, the assessment of stability was performed again. The scope was inserted into the MCU portal, and a probe was inserted into the MCR portal to check the scaphoid and the lunotriquetral space. The scaphoid fracture showed an excellent stability **(figure 13)**, so did the lunotriquetral ligament **(Figure 14)**.

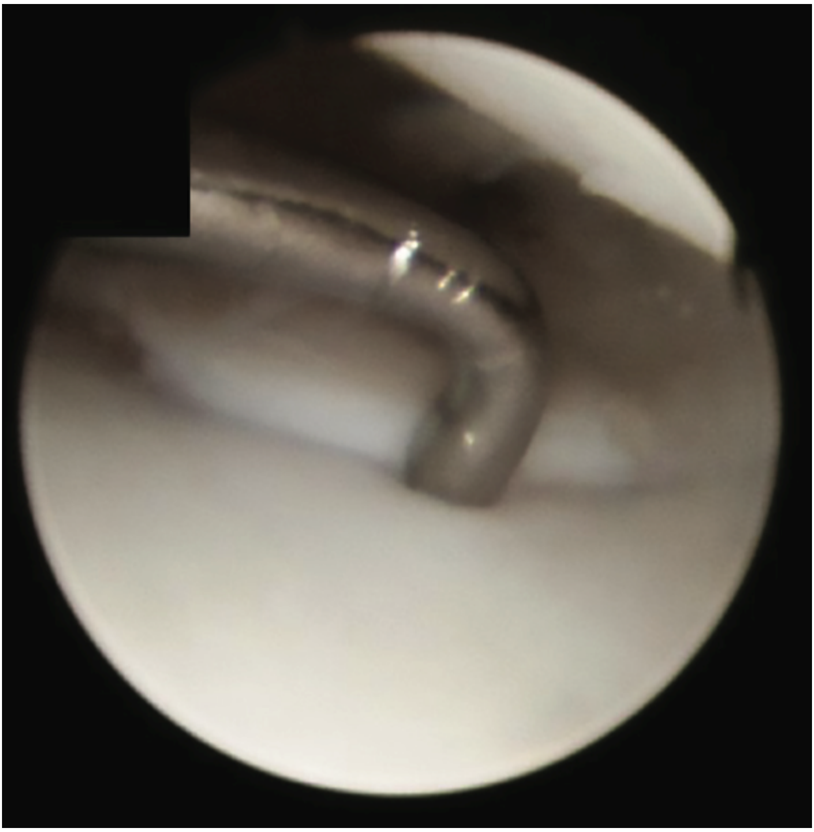


Figure 13.

Arthroscopic view from the MCU portal showing the scapholunate stability after the reduction and fixation of the scaphoid.

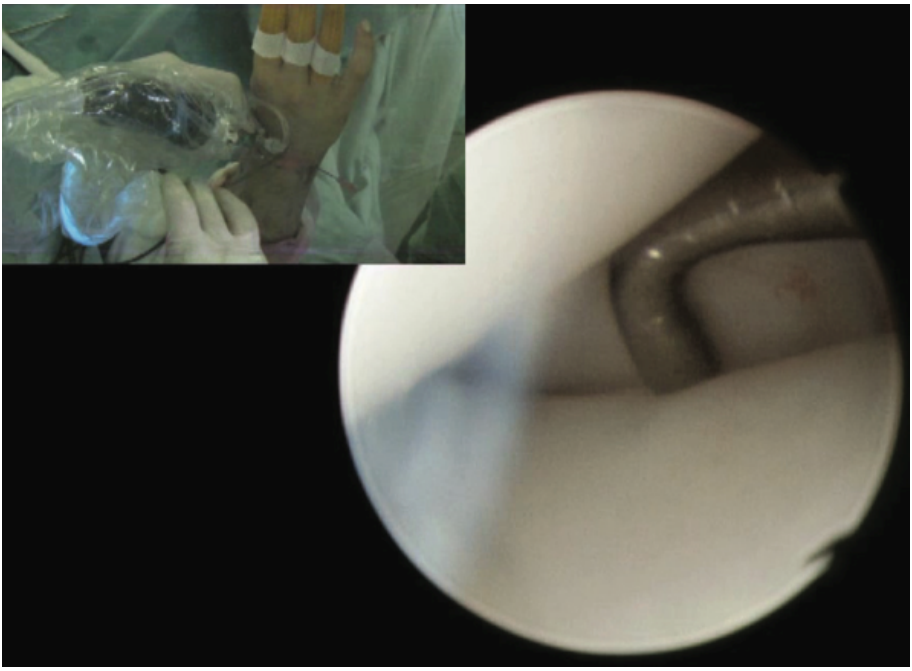


Figure 14.

Arthroscopic view from the MCR portal showing the lunotriquetral stability after the reduction and fixation of the lunotriquetral space.

- When operating under arthroscopic assistance, select the appropriate stage of PLD;
- Use dry arthroscopy with automatic wash-outs to make it more comfortable for the open part of the technique;
- Do not hesitate to associate a mini-open dorsal approach with arthroscopy-assisted reduction and fixation of PLD.

26. ARTHROSCOPIC REPLACEMENT OF THE PROXIMAL POLE OF THE SCAPHOID WITH A PYROCARBON IMPLANT

CHRISTOPHE MATHOULIN

MATHILDE GRAS

Introduction

Avascular necrosis of the proximal pole of the scaphoid is challenging to treat. Vascularized bone grafts do not always provide the expected results. In some cases, the necrotic proximal pole is fragmented and attempts to repair it are unrealistic. In 2000, a mobile pyrocarbon implant was first implanted through a standard open approach. Inserting this implant arthroscopically is a logical next step since all extrinsic ligaments remain intact, thereby preserving carpal bone stability. However, this technique is reserved for cases where reconstruction is impossible.

Operative technique

1. Arthroscopic exploration

The procedure is performed under regional anesthesia with the arm secured to an arm board and using an upward traction of 5 to 7 kg (11–15.5 lbs) applied to the hand, wrist, and forearm.

Three portals are generally used during this procedure:

- a standard 3–4 portal, extended to about 1cm to allow the implant to pass through it,
- 6R or 4–5 portals for the scope,
- a midcarpal ulnar (MCU) portal for midcarpal control,
- we can sometimes use the 1–2 radiocarpal portal to perform a styloidectomy.

The procedure starts with the 3–4 and 6R or 4–5 portals. The scope is inserted into the medial portal. A shaver is used to debride the joint (synovitis, bone, and/or cartilage debris). The proximal pole is located, and the degree of necrosis measured (e.g., one or multiple fragments). The arthroscope and the sheath are then introduced through the MCU portal to assess the proximal pole's position in relation to the remainder of the scaphoid and the lunate **(Figure 1)**.

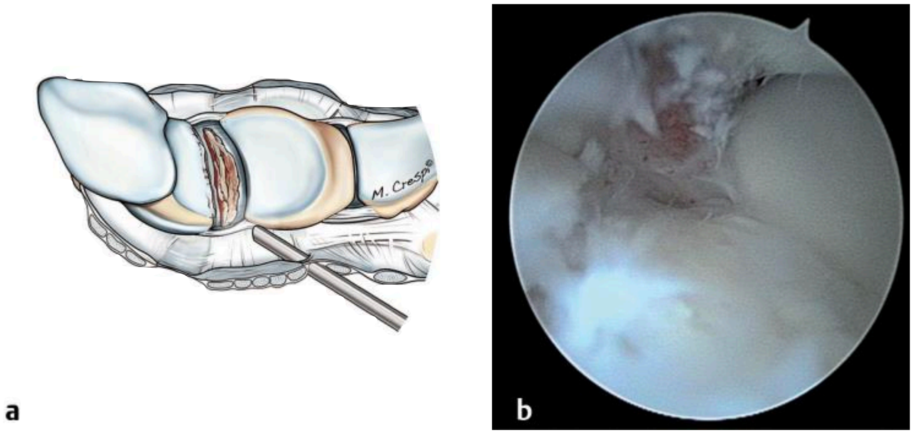


Figure 1.

*Drawing **(a)** and midcarpal arthroscopic view **(b)** of the scaphoid on the left, lunate on the right, and necrotic proximal pole of the scaphoid in the middle.*

2. Proximal pole excision

All of the proximal pole's fragments will be taken out through the 3–4 portal with the scope in the radiocarpal ulnar portal. But first, the scapholunate interosseous ligament must be cut if it is still intact. A small No. 11 scalpel is used **(Figure 2)**.

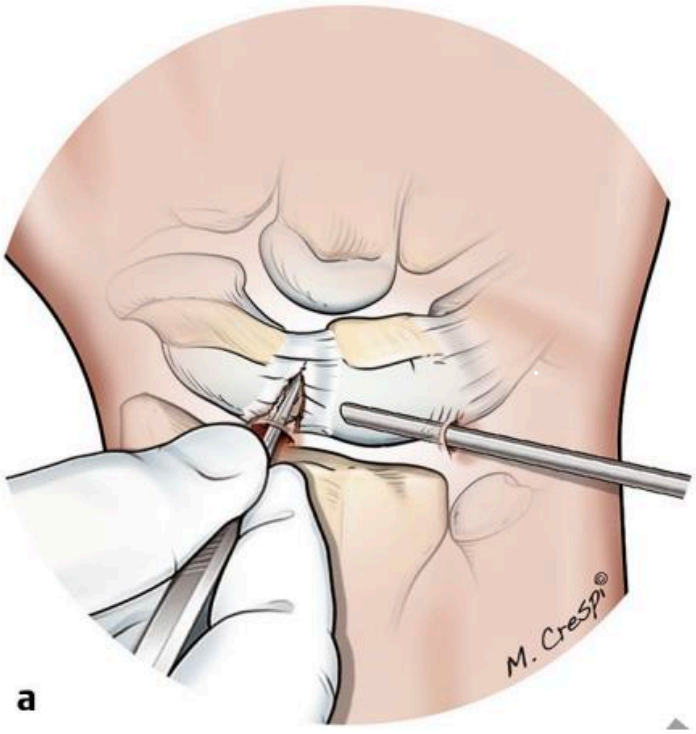


Figure 2.

Drawing showing a scalpel blade used to start cutting the scapholunate interosseous ligament.

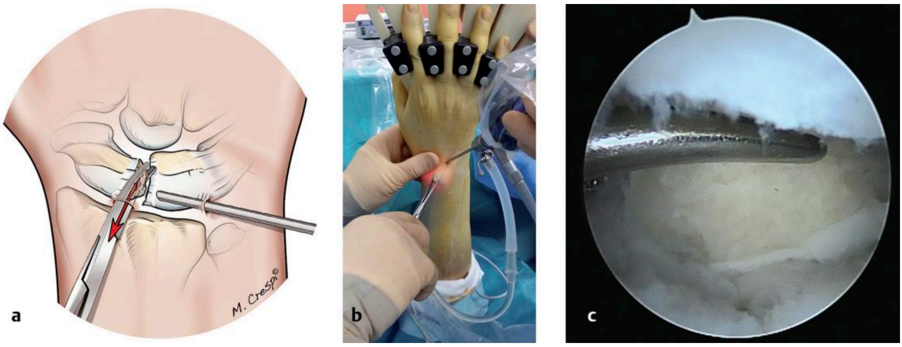


Figure 3.

Drawing (a), intraoperative (b), and arthroscopic views (c) of the excision of necrotic fragments from the proximal pole of the scaphoid.

Stevens's tenotomy scissors are then used to cut through the entire scapholunate ligament. The proximal pole or its various fragments are then removed using hemostats **(Figure 3)**.

If the dorsal and volar portions of the scapholunate ligament are difficult to cut, this can be accomplished with a shaver inserted into the 3–4 portal; the scope is placed into the radiocarpal ulnar portal for the dorsal portion and the MCU portal for the volar portion. If the scaphoid's proximal end has a convex shape, a burr is inserted through the 3–4 portal and used to reshape this end until it becomes concave and can match the implant's shape.

3. Selection of implant size

The first option to select the appropriate implant size is to reconstruct the proximal pole on the back table and then compare it with the trial implants. The selected implant is then pushed into the 3–4 portal with the fingers under radiocarpal and midcarpal arthroscopic control **(Figure 4)**. If the implant has the correct size, the midcarpal view will show that the space between the scaphoid and the lunate has been filled in completely. A hemostat is used to remove the trial implant under radiocarpal and/or midcarpal arthroscopic control.

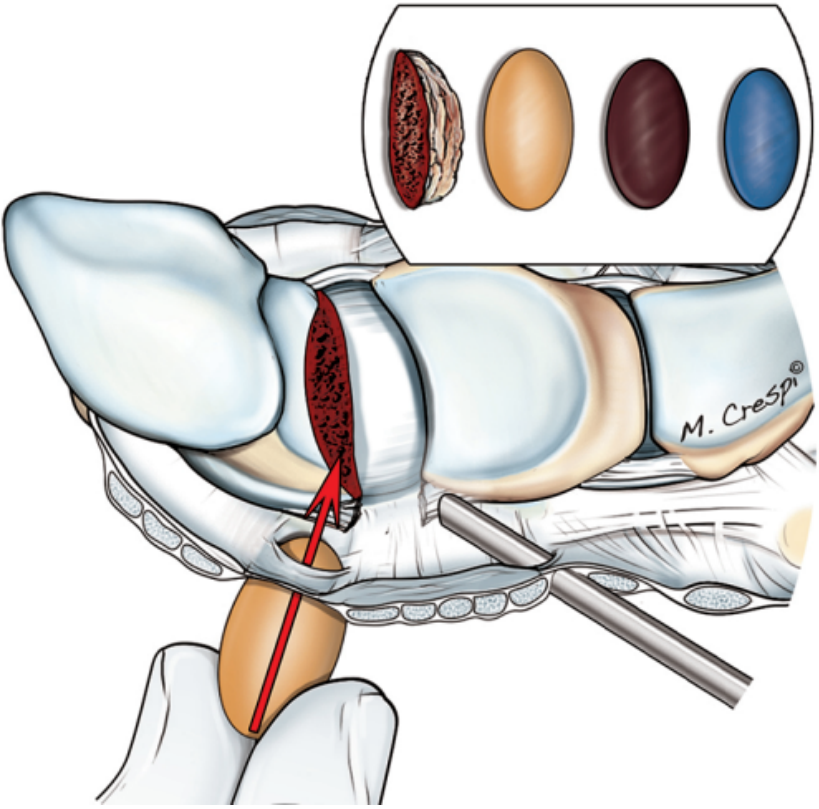


Figure 4.

Drawing showing the trial implant put into place.

4. Placement of the final implant

The final implant is inserted in the same manner under dual radiocarpal and midcarpal control **(Figure 5)**. The skin at the extended 3–4 portal incision is closed with simple interrupted sutures. These sutures can be removed when the first dressing is changed one week later.

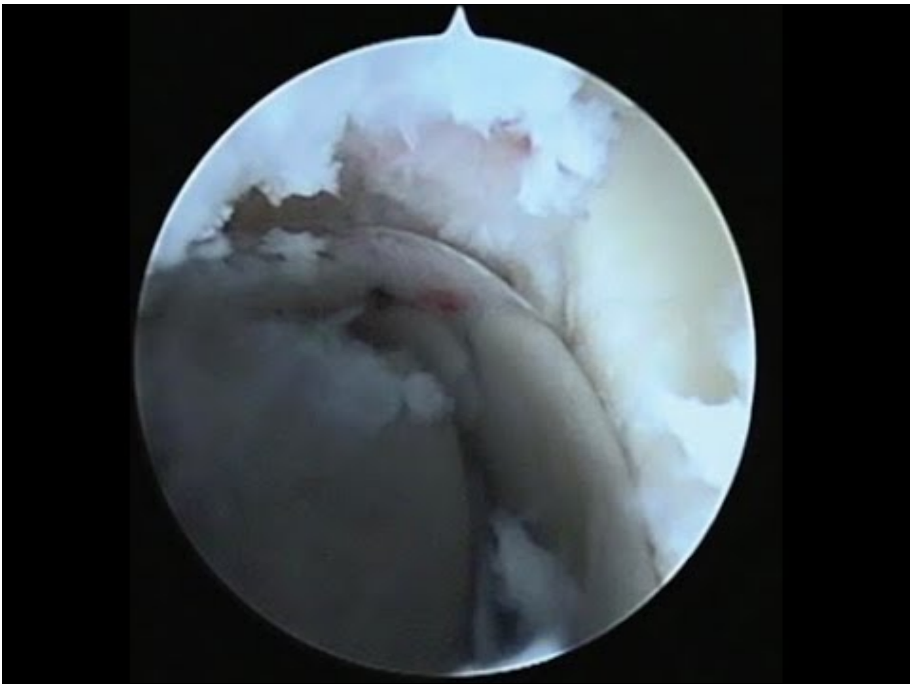


Figure 5.

Midcarpal arthroscopic view of the seated implant, which is perfectly positioned between the scaphoid and the lunate.

5. Postoperative care

The mobile implant allows for the immediate recovery of joint range of motion. However, a removable anterior splint is used to reduce pain while allowing patients to regain their range of motion. If needed, rehabilitation can be initiated after the third week.

Tips & tricks

The implant's ovoid shape can make it difficult to grasp. One trick is to place a small plastic tube (such as a surgical drain tubing) on the tips of the hemostat.

Removing the trial implant can be very uneasy. One trick is to slip it into a strong glove finger to allow for its easy removal.

In order to select the right implant size, it is recommended to remove the entire proximal pole in order to compare it with the different implant sizes available **(Figure 6)**.

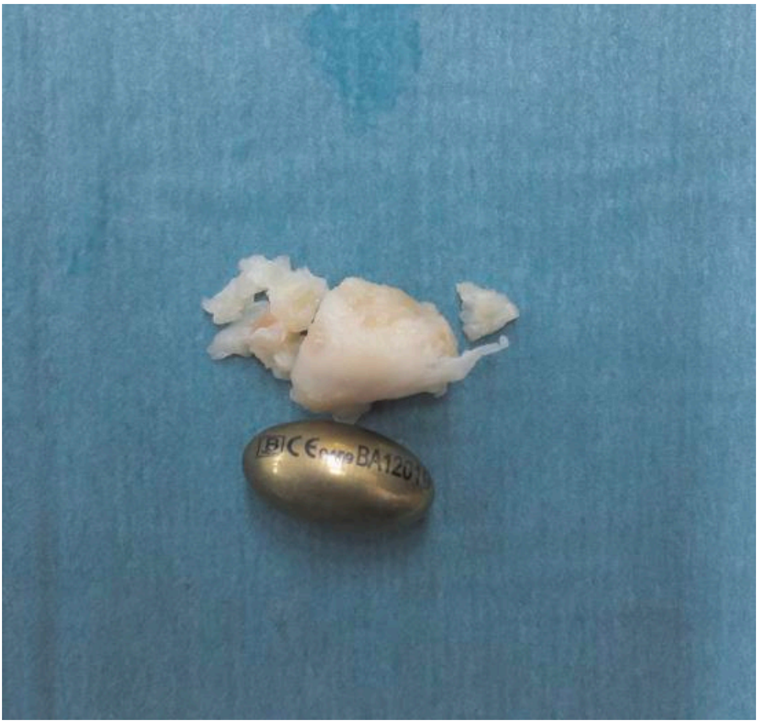


Figure 6.

Intraoperative view of the various fragments from the necrotic proximal pole reconstructed on the back table to compare the fragments with the size of the trial implants

Conclusion

Arthroscopic replacement of a necrotic proximal pole is a simple, reliable technique that does not burn any bridges. Long-term results with this implant are promising. This method avoids the use of more extensive palliative methods. However, it should be used only in cases where reconstruction is impossible.

Video 21: Proximal pole scaphoid pyrocarbon interposition
https://vimeo.com/917909346

27.
ARTHROSCOPIC BONE GRAFTING FOR LUNATE BONE GANGLION

LORENZO MERLINI
CHRISTOPHE MATHOULIN

Introduction

Lunate ganglions are relatively common, but usually painless. They are generally discovered by chance during an MRI or CT-scan examination. Pain may develop when the outer wall of the ganglion collapses, opening the cyst into the scapholunate (SL) joint space. The standard treatment consists of curettage of the ganglion and, typically, bone grafting. Open treatment is very challenging and requires a large volar incision. Arthroscopy makes it possible to perform a noninvasive treatment, which preserves the vascular and anatomical structures by passing through the proximal non-vascularized portion of the SL ligament.

Operative techniques

1. Radiocarpal exploration and localization of the ganglion

The usual set-up is to have the scope in the 1-2 portal (in order to directly face the lateral aspect of the lunate, which will be visible after intermediate SL debridement), and instrumentation in the 3-4 portal, in the axis of the SL space.

The intermediate portion of the SL ligament (biomechanically irrelevant) is located; its precise location can be confirmed with a needle. It is then debrided, and the lateral aspect of the lunate is exposed (**Figure 1**).

In most cases (depending on a reliable spotting with preoperative 3-D imaging), the opened bony ganglion will be visible due to its leakage into the SL space.

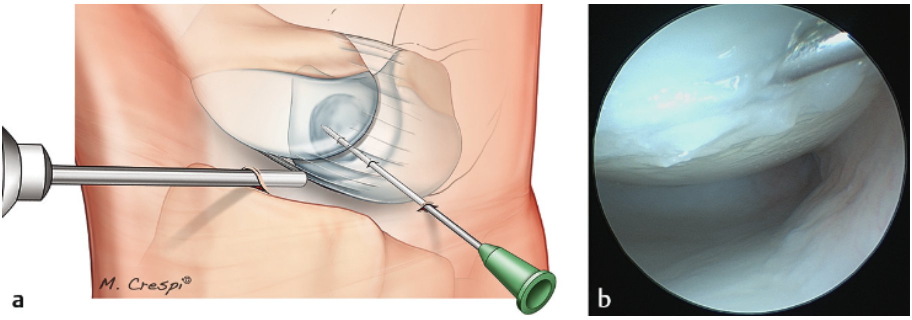


Figure 1.

2. Ganglion curettage

Using the curette and the shaver alternately, the ganglion is emptied until cancellous bone becomes visible in the whole cavity of the former ganglion **(Figures 2 and 3)**.

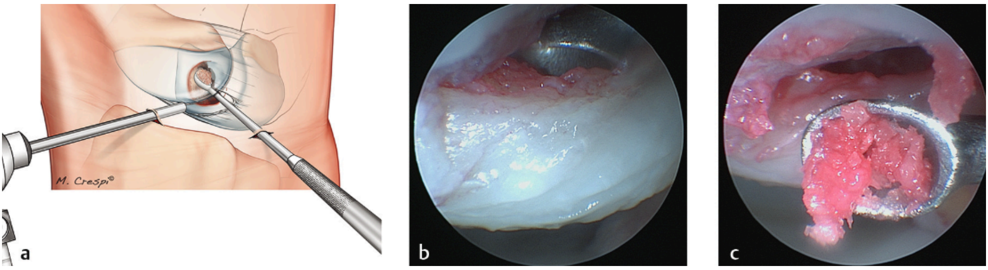


Figure 2.

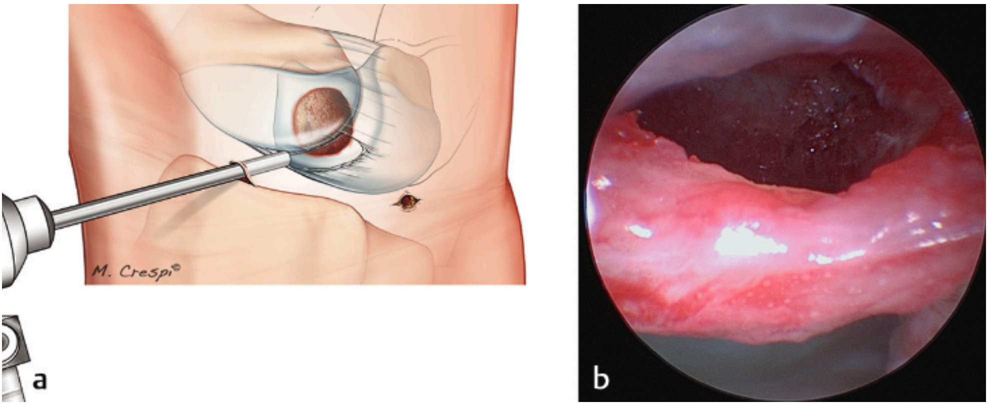


Figure 3.

3. Bone graft harvesting

For this step, the ideal instrument is a large bone marrow biopsy needle such as the Jamshidi trocar.

Once a small incision (2-3mm) has been performed regarding the Lister's tubercule, the Jamshidi trocar is directly inserted into the metaphyseal bone of the distal radius, and cancellous bone is subsequently harvested.

This method of harvesting allows to have an already strongly compacted bone graft, which can be directly inserted into the ganglion cavity by putting the Jamshidi trocar in the 3-4 portal and into the cavity. The graft is then pushed and packed inside. It can be precisely packed with the help of a spatula or a blunt trocar if needed **(Figure 4)**.

This step (harvesting and grafting) is repeated as many times as necessary until the cavity is completely filled.

It takes usually 3 to 4 trips between the harvesting site and the cavity to obtain a proper filling with strongly packed cancellous bone.

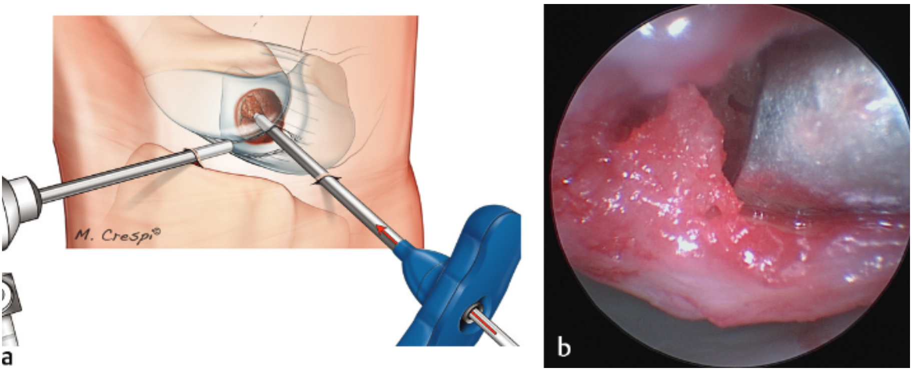


Figure 4.

4. Closing and postoperative care

No further step is required once the cavity has been successfully filled in. There is no need for intermediate SL repair, as it is non-vascularized tissue without biomechanical relevance.

The skin incisions can be simply closed using Steri-strip bandages.

A comfort splint can be put on for 3 to 6 weeks. However, in most cases, a properly well-packed graft will be stable and can allow for an early mobilization.

Tips & tricks

The main trick to facilitate this procedure is the use of the Jamshidi trocar. Going back and forth between the harvesting site and the lunate ganglion is not a loss of time, as the graft remains in the trocar and is actually self-prepared to be put inside the cavity.

The graft can sometimes be so strongly packed that it can have difficulties to be pushed outside the needle with the blunt pusher. In that case, the sharp cutting guide can be used to start the descent of the graft **(Figure 5)**.

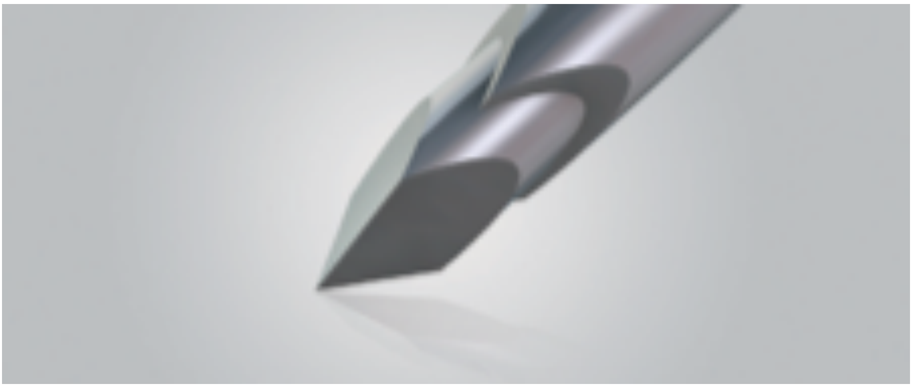


Figure 5.

Conclusion

Bone grafting of lunate ganglion is one the best examples of something extremely invasive and difficult when performed in open surgery can be quite simple, reliable and harmless when performed arthroscopically.

Video 22: Arthroscopic bone graft for intraosseous lunate bone ganglion
https://vimeo.com/917908028

28.
ARTHROSCOPY-ASSISTED FIXATION OF INTRA-ARTICULAR DISTAL RADIUS FRACTURES

JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

OLIVIER MARES

Introduction

Intra-articular fractures of the distal radius need to be anatomically reduced. However, it is often very difficult to achieve using standard open surgical techniques. Knirck and Jupiter showed the importance of complete reduction; any persistent step-off (of 2mm or more) will likely lead to the development of arthritis. Wrist arthroscopy has changed the way these fractures are treated. It can be used to make sure that the fracture is completely reduced and it gives the surgeon the ability to view and treat any associated injuries. In addition, new plates with distal locking screws have streamlined the fixation process.

Operative technique

The patient lies supine with the arm abducted at 90 degrees and resting on a hand table. The procedure is typically performed with regional anesthesia. The surgeon stands at the patient's head, and the assistant stands across from the surgeon. The fluoroscopy unit is placed at the patient's feet and the arthroscopy tower is located on the side of the non-operated arm (**Figure 1**). Traction must be applied and removed as many times as necessary during this procedure; As a result, the use of a sterile wrist traction tower or sterile finger traps is recommended. All of the standard arthroscopy portals may be used during arthroscopy-assisted distal radius fracture fixation. The anterior portals can be useful for some fractures located on the posterior margins.

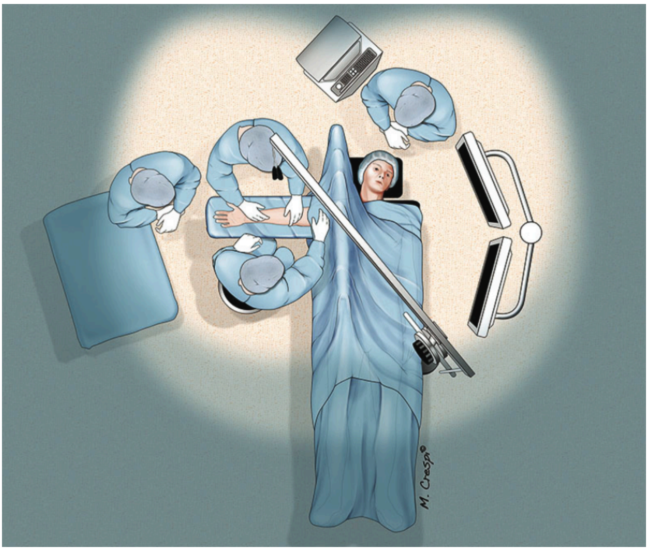


Figure 1.

Drawing showing the relative position of the surgical team: the surgeon stands at the patient's head, and the assistant stands across from the surgeon.

1. First Surgical Phase: Provisional Fixation

There is no specific instrumentation for arthroscopic-assisted fixation of intra-articular distal radius fractures. Surgeons are free to use their preferred instrumentation. Provisional fixation aims to achieve acceptable reduction–stabilization based on intraoperative fluoroscopy controls, while allowing the fixation to be subsequently altered based on arthroscopic findings. The use of locking plates simplifies fracture fixation and ensures good distal stability. Screw fixation is used only in cases of isolated lateral radial styloid fractures (**Figure 2**).

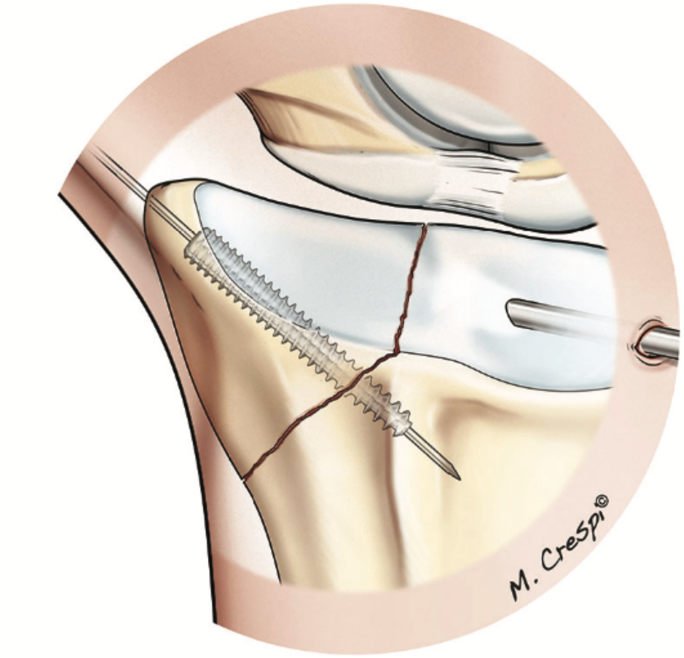


Figure 2.

Drawing showing the fixation of an isolated radial styloid fracture using a cannulated screw after reduction performed under arthroscopic control.

K-wires are used from time to time to hold the articular fragments or prop up the articular surface. We recommend that you start by securing only the styloid using two K-wires. Using joystick movements and the probe, you can reduce the fracture and push in your two pins to stabilize the fracture (**Figure 3**).

Figure 3.

Example of a radial styloid fracture (left) reduced and screwed arthroscopically (right). The use of arthroscopy for radial styloid fractures is an indication of choice: it is a straightforward procedure with landmarks that are only slightly altered, and it also enables the assessment of the scapholunate complex simultaneously, which is often altered by the fracture line.

The Henry anterior approach passes between the radial neurovascular bundle laterally and the flexor carpi radialis medially. After identifying the flexor pollicis longus (FPL), a Beckmann retractor is placed between the radial neurovascular bundle and the flexor digitorum superficialis, the flexor digitorum profondus, and flexor pollicis longus tendons. The pronator quadratus is detached from its radial insertion and abraded with a rasp. The extra-articular portion of the fracture site is exposed. The fracture can be initially reduced by pulling the distal radius along its main axis and, if need be, by using a thin bone rasp (3mm) to consolidate bone fragments. A volar locking plate is secured through its oval slot to the volar side of the radius with a non-locking screw (**Figure 4**).

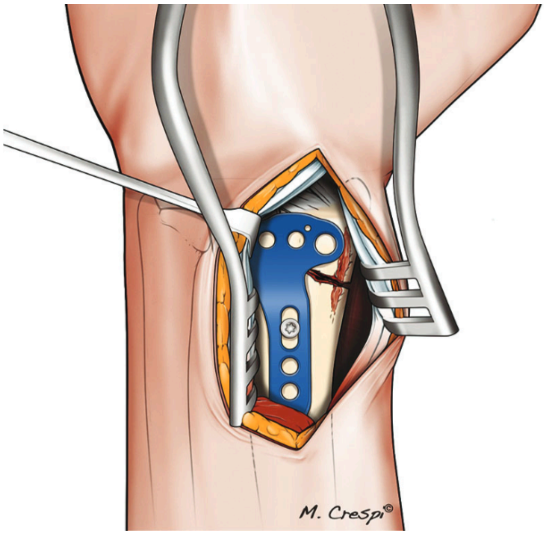


Figure 4.

Drawing showing the placement of a volar buttress plate secured with a single screw in the oval slot; it allows the position of the plate to be adjusted as needed later on in the procedure.

If the fragments are displaced posteriorly, one or two K-wire(s) are manually inserted into the dorsal side of the distal radius through the fracture line and pushed into the radial shaft. The quality of the reduction is controlled using fluoroscopy. One or two locking screw(s) are inserted into the epiphyseal portion of the plate over the areas that show the best reduction on fluoroscopy images. The posterior K-wires (if they were used during the reduction) are then removed so as not to interfere with the arthroscopy phase.

If volar plate fixation is used, not every epiphysis screw should be inserted right away. If any of these screws have to be changed after arthroscopic inspection, the profusion of bone tunnels will negatively affect the construct's stability.

2. Second Surgical Phase: Arthroscopic Evaluation

Traction is placed on the wrist with the forearm pointing upwards. The elbow is flexed to 90 degrees and 5 to 7 kg (11– 15.5 lbs) of traction are applied. The arthroscopy portals may be difficult to identify because of fracture-related edema. The scope is introduced into the 3–4 portal and the shaver into the 4–5 or 6R portal. The hemarthrosis associated with an intra-articular distal radius fracture will interfere with the view of the joint; a lavage step is performed before starting the exploration to remove the accumulated blood. The goal of arthroscopic exploration is to evaluate reduction quality, cartilage damage, as well as intrinsic and extrinsic ligament involvement.

3. Fracture reduction and fixation

Several scenarios may exist:

- Remove the motorized blade to facilitate the aspiration of osteocartilaginous debris.
- Use transillumination to perform the 2nd portal.
- Irrigate the joint during milling to prevent thermal burns of the subchondral bone.
- The fracture is completely reduced and the ligaments are not injured; fracture fixation must be finalized. Postoperative recovery will be similar to the one for extra-articular distal radius fracture.
- The fracture is not anatomically reduced and there is an articular step-off or subsidence; indeed, reduction maneuvers must be performed under arthroscopic control. Any large fragments can be reduced using a spatula or a hook probe (**Figures 5 and 6**). In cases of central subsidence (die-punch fracture), the fragment can usually be lifted up with a hook probe. Stabilization can then be achieved with small K-wires or locking screws that prop up the articular fragments. If the fracture is comminuted, the joystick method can be used to move the various fragments around and reduce them. A K-wire is drilled into one of the fragments that need to be reduced. The surgeon can use the proximal end of the K-wire to manipulate this fragment, reduce it, and then stabilize it by driving the K-wire further in. If need be, a K-wire or a small tendon rasp can also be inserted into the metaphysis through a small incision over the fragment that needs to be reduced. The scope may need to be moved, depending on which area has been impacted. If subsidence affects the dorsal part of the scaphoid

fossa, reduction will be impossible with the scope in the 3–4 portal – it must be moved to a volar portal or to the 6R portal. If subsidence affects the lunate fossa, the scope may be placed in the 1–2 or 6R portal.

- The fracture cannot be reduced since the central articular fragment is overly affected; indirect reduction can be attempted. A dorsal incision is made proximally to Lister's tubercle to perform a shortened corticotomy. A small diameter osteotome (5mm) is inserted through the corticotomy and tapped with a hammer to lift the central fragment. The extensor pollicis longus tendon requires special attention, as it is often ruptured in this type of fracture. If complete reduction is achieved with this method, a bone substitute is packed into the tract left by the bone tamp to stabilize the reduced articular fragment (**Figures 7 and 8**).
- The fracture is comminuted, with no possibility of arthroscopy-assisted intra-articular reduction. There are two options in this case: either add an incision on the dorsal side to attempt to improve the reduction or leave it as it is.

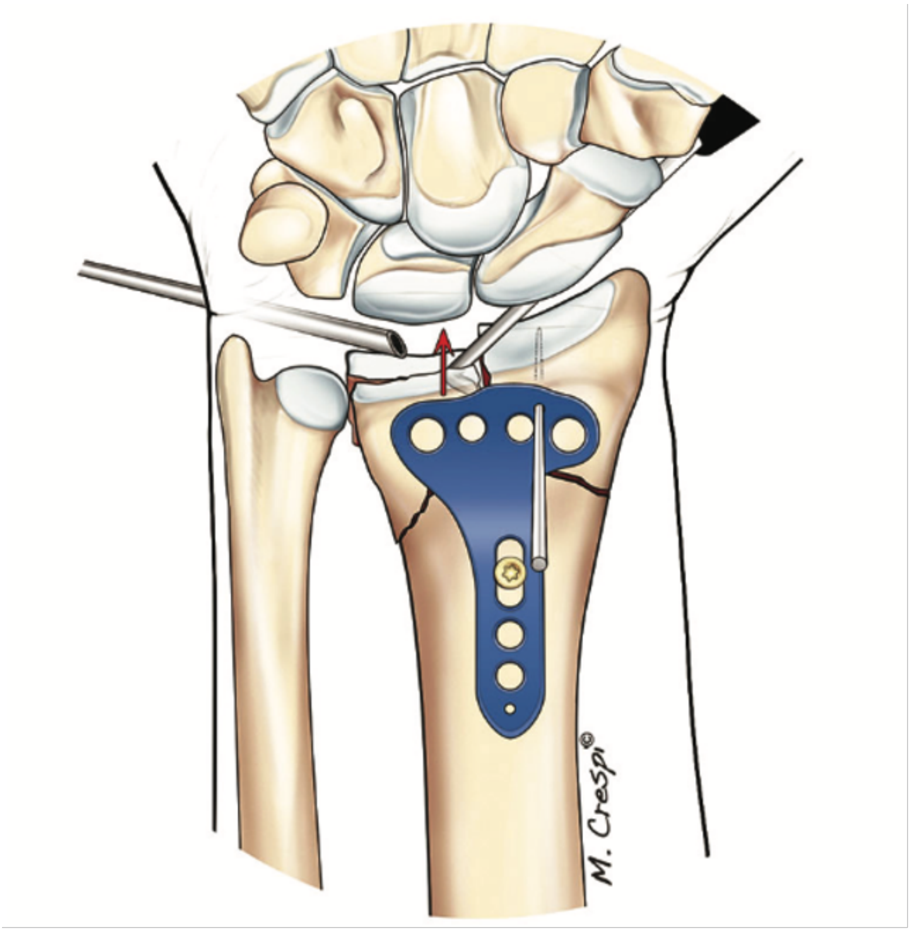


Figure 5.

Drawing showing intra-articular fragments reduced with a probe. The lateral fragment has been temporarily fixed with a dorsal K-wire.

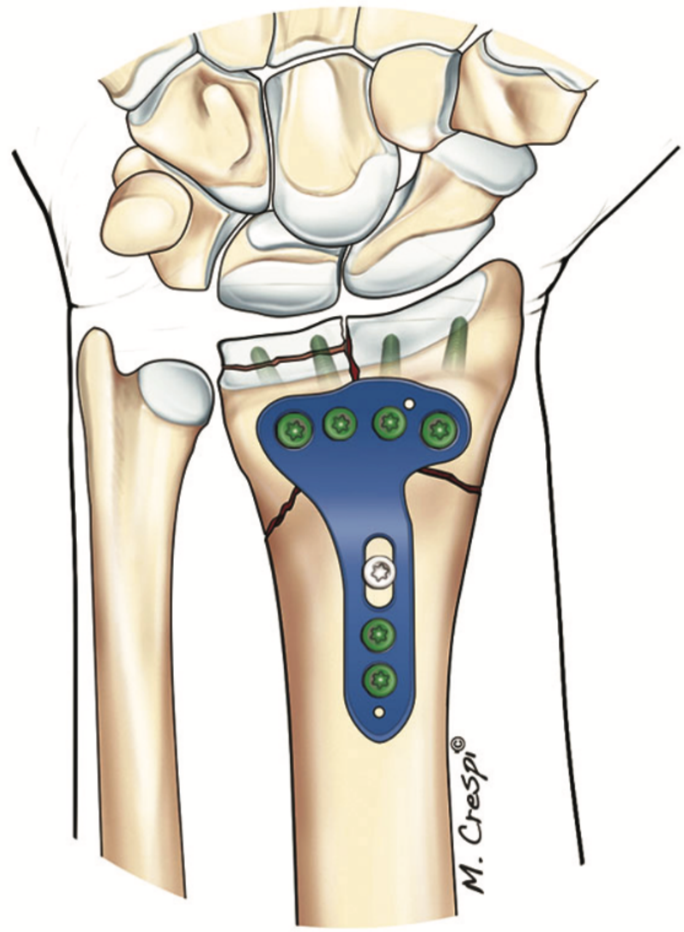


Figure 6.

Drawing showing the locking plate fixation of the reduced fragments once the temporary K-wire has been removed.

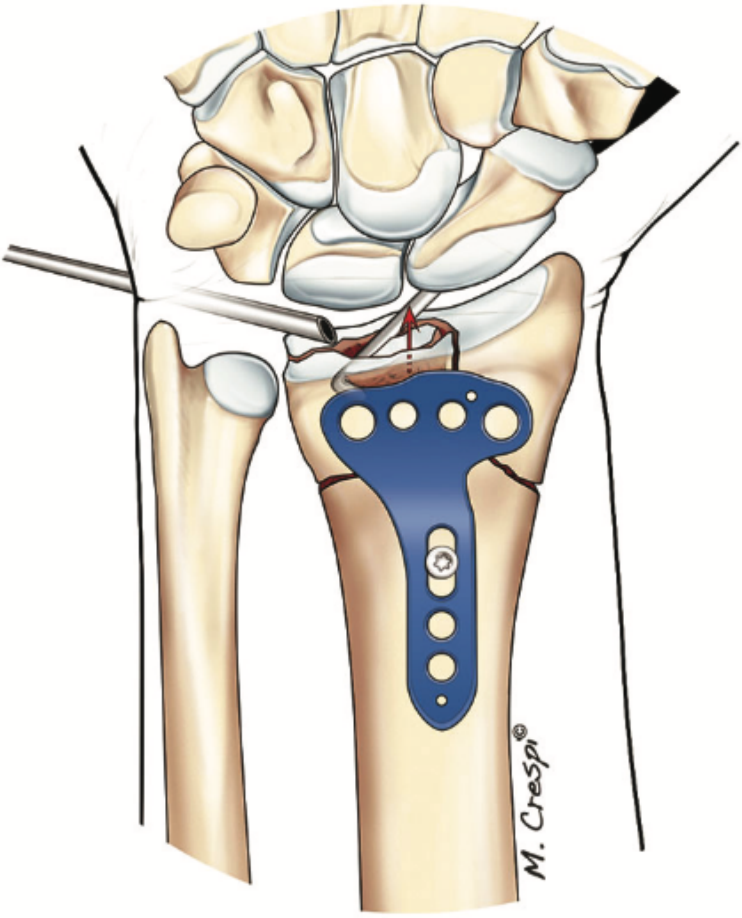


Figure 7.

Drawing showing a large impacted central fragment (die-punch fracture) reduced with a probe. This type of fragment is easier to reduce with arthroscopic assistance.

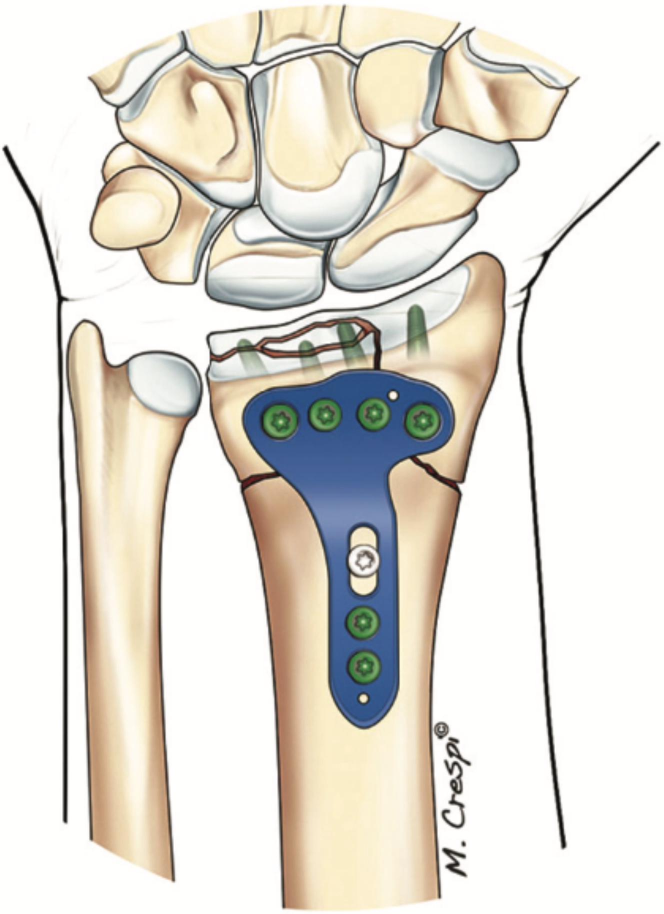


Figure 8.

Drawing showing the locking plate fixation once the central fragment has been reduced.

4. Detection of associated lesions

Associated lesions often determine the prognosis. The first priority is to evaluate the scapholunate ligament, as it is torn in 30% of cases, and a tear can lead to secondary osteoarthritis. The objective is to induce peripheral wound healing by abrading the posterior capsule and then performing either dorsal capsule-to-ligament suture repair or scapholunate and scaphocapitate pinning, with the K-wires left in place for 6 to 8 weeks.

The lunotriquetral ligament and the triangular fibrocartilage complex (TFCC) must also be evaluated. If the lunotriquetral ligament is torn, lunotriquetral pinning is performed and left in place for 6 to 8 weeks. If the TFCC is injured, the exact nature of the injury must be determined:

- Central perforation: often degenerative in nature and not related to trauma, and subsequently does not require treatment.
- Peripheral detachment: repair based on the surgeon's preferences, but requires 6 weeks of immobilization to achieve good healing.

Foveal detachment: leads to distal radioulnar joint (DRUJ) instability; if DRUJ instability is found after fracture fixation, the foveal portion of the TFCC must be reattached during the same procedure.

The radiocarpal and the midcarpal joints are also examined to control the integrity of the articular surfaces of the wrist bones. It is also essential to make sure that none of the carpal bones are damaged, especially the scaphoid.

5. Third Surgical Phase: Final Fixation

The fracture fixation is finalized. If the surgeon decided to use a locking plate, all of the epiphyseal screws will be placed as close as possible to the articular surface. If possible, these screws should be inserted under arthroscopic guidance to avoid losing the reduction when arm traction is released and to make sure that the screw tips do not protrude into the joint.

The entire surgical procedure (provisional fixation, arthroscopic evaluation, and final fixation) must not exceed 90 minutes; otherwise, there is a risk of postoperative edema.

6. Postoperative Care

Postoperative care varies depending on arthroscopic findings:

- If the fracture was anatomically reduced and no ligaments were torn, recovery is similar to the one for extra-articular distal radius fractures. If a locking plate was used, rehabilitation can be initiated immediately after surgery and a splint can be worn for 15 days to provide pain relief. If the fracture was pinned, a splint is worn for 6 weeks and rehabilitation started afterwards.
- If reduction was incomplete, the radial articular surface was comminuted, reduction of the articular surface required several small-diameter K-wires, or a scapholunate tear required scapholunate and scaphocapitate pinning, a removable brace is worn for 6 weeks. Rehabilitation is initiated once the K-wires have been removed.
- Postoperative recovery depends on the fixation method selected and the presence of additional lesions detected during arthroscopic examination.

Tips & tricks

- In radial styloid fractures, the use of joystick wires enables an easy mobilization of the fragment. These pins must be inserted after a 2cm incision and soft tissue dissection to prevent nerve damage.
- Always check scapholunate stability in radial styloid fractures.

- Preoperative planning and visualization of all fractured fragments are essential in the management of arthroscopic distal radius fractures. It is a deceptively easy procedure, and it requires a good experience in arthroscopy.
- Do not hesitate to "waste time" on joint debridement, and perform numerous wash-outs using a syringe with saline to obtain a perfect intra-articular view.
- Prefer dry-arthroscopy, as conversion to open surgery is very complicated after wet arthroscopy.
- Identify the limits of arthroscopic reduction and know when to convert to open surgery.
- You should never perform this surgery in more than 90 minutes and
- always respect the three periods of 30 minutes
  - First period of 30 minutes: osteosynthesis and partial reduction,
  - Second period of 30 minutes: arthroscopic control and articular reduction,
  - Third period of 30 minutes: last screws and treatment of associated lesions.

Conclusion

Arthroscopy is a very useful approach for the diagnosis and treatment of intra-articular distal radius fractures. It allows the surgeon to control the reduction and then to fine-tune it as need be. It also allows associated injuries to be diagnosed and treated; these typically go undetected and may cause the development of wrist osteoarthritis. It is a difficult technique that can become very time-consuming.

29.
ARTHROSCOPIC GUIDED OSTEOTOMY FOR DISTAL RADIUS MALUNION

FRANCISCO DEL PIÑAL

Introduction

"Arthroscopy is the 'missing link' to achieve a perfect result in distal radius fractures (DRF)" (Piñal in Green 2018).

Intra-articular malunion of the radius causes considerable interference with a patient's life: limited and painful range of motion is the norm (Figure 1). Most malunion cases occur because of inappropriate management of the original fracture, and more rarely due to secondary subsidence. The former is usually due to not using the arthroscope as the checking tool, at the time of fracture management, but the fluoroscope. Indeed, restoring joint anatomy is the main objective when dealing with a DRF. Imaging with a mini-fluoroscopy is the more common technique to assess fracture reduction in the operating room (OR). However, several articles in the literature have demonstrated limitations and the poor reliability of this imaging modality for such particular and similar applications in our field.

Excellent results have been reported regarding the "outside-in" technique in the treatment of intra-articular malunion. However, difficulties were found with visualization once a reduction was achieved and the procedure relied heavily on fluoroscopy rather than direct visualization, which, as stated, is not a very reliable instrument. We devised a technique with arthroscopy that, under good light and magnification, allowed us to precisely trace the cartilage line of the old fracture with the osteotome. In this way, the possibility of wrong-site fracture during the osteotomy does not exist, hence converting a malunion into an acute fracture.

Figure 1.

This 59-year-old patient sustained bilateral distal radius fractures, which were surgically treated elsewhere. Given the continued pain and loss of range of motion on the left wrist, the patient sought a second opinion at 8 weeks post-surgery. (Copyright © Dr. Piñal, 2018)

Indications & Contraindications

Diagnosis of a malunion is often evident from the plain X-rays **(Figure 2)**. However, a CT-scan with cuts in pure orthogonal planes is invaluable in the decision-making process and for the surgeon's orientation at the time of the arthroscopy **(Figure 3)**.

Classically, a 2mm or a greater step-off of the distal radius articular surface was considered to be an indication for the osteotomy. Each patient should be considered on an individual basis. In a young active patient, even a 1mm step-off in the lunate or scaphoid facet should be considered for repair. Alternatively, a low-demand patient with a similar step-off may benefit from a resection arthroplasty (i.e., from leveling the joint – the latter having a much more benign postoperative course).

An additional consideration is the status of the cartilage, which again requires experience to make the appropriate decision. In general, the longer time between the fracture and the visit, and the more the patient has attempted to move the joint, the less cartilage will remain. As a rule, no exact contraindications for the procedure can be given. The following factors: i.e., more than 6 months after the fracture; very committed patients in rehabilitation; and the presence of hardware in the joint, all cast a shadow over the possibility of joint restoration. By the same token, in order to prevent further damage, when a patient is seen in the office with a step-off, physical therapy must be called off immediately. Additionally, a splint should be applied while CT-scan studies are performed and surgery scheduled to minimize motion.

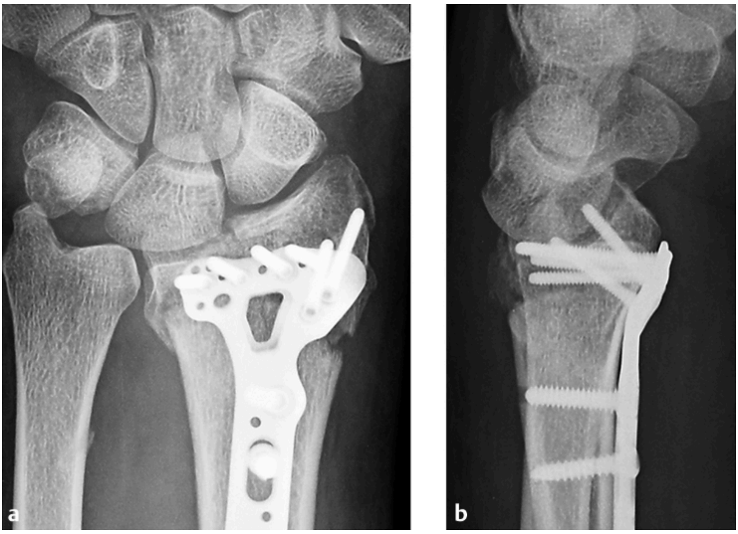


Figure 2.

PA and lateral radiographs demonstrated a distal radius malunion with articular incongruity, the apparent loss of radial height, and persistent dorsal angulation with secondary carpal adaptations. A CT-scan was performed to better delineate the malunion (Copyright-© Dr. Piñal, 2018).

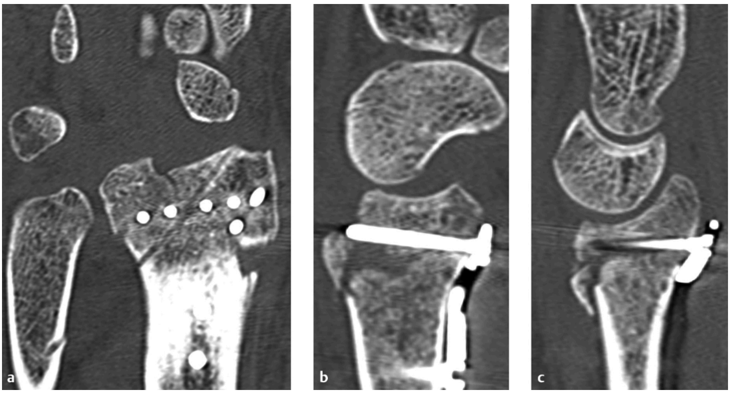


Figure 3.

CT-scan confirmed the degree of articular disruption and distal radius malunion. Given such findings, corrective extra- and intra-articular osteotomies were advised (Copyright © Dr. Piñal, 2018).

Operative Technique

All patients with an intra-articular malunion in the author's practice are managed similarly. First of all, an arthroscopic exploration is performed. Due to the large portals required to introduce the osteotomes, it is of paramount importance that the surgeon adheres to the dry technique, as otherwise constant loss of vision would occur due to lack of watertightness. The only special instruments that we use are the osteotomes and periosteal elevators borrowed- from the shoulder and knee trays. These are 4mm wide instruments and with different angulations to access the always tight wrist **(Figure 4)**.

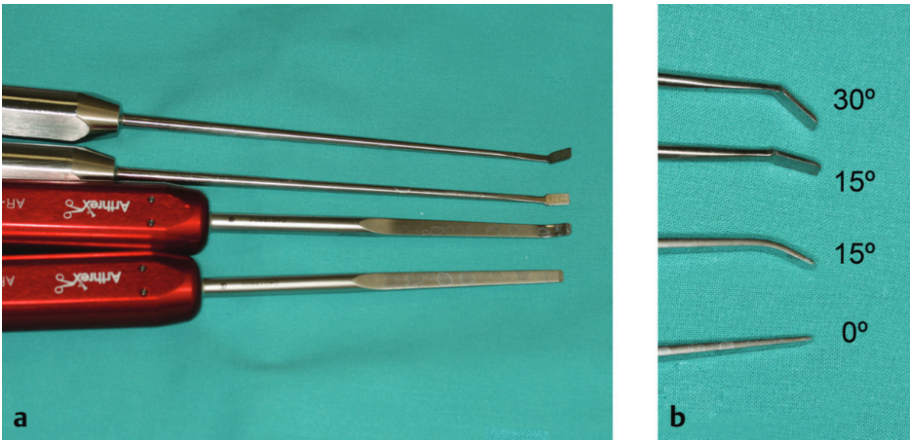


Figure 4.

Instruments used during the procedure. From above to below: shoulder periosteal elevator (of 15- and 30-degree angle) (Arthrex® AR-1342–30° and AR-1342–15°, Arthrex, Naples, FL, Unted States) and straight and curved osteotomes (Arthrex® AR-1770 and AR-1771). (In Ref. 15. Copyright © Dr. Piñal, 2018).

Under a tourniquet, the hand is set in traction from an overhead bow. Traction of 12 to 15 kg is evenly applied to all fingers. Establishing the portals is more difficult than in a standard arthroscopy as the space is collapsed by scar tissue. Once the scar tissue has been removed, the cartilage is carefully assessed and a decision is made as to whether the osteotomy is feasible. Basically, if the cartilage is mostly preserved, I will go ahead with the osteotomy. Contrarily, if the cartilage is worn, I prefer to perform some form of salvage operation: ideally, an arthroscopic arthroplasty or a transplant of vascularized cartilage. If the damage is diffuse, the option would be to consider an arthroscopic radioscapholunate fusion.

Typically, once the surgeon has opted for an arthroscopic guided osteotomy, the hand is set on the table and a standard volar-radial approach is performed exposing the radius. This is needed, above all, not only to remove the volar callus, but also since there is often hardware to be removed. Additionally, a volar plate will be used for fixation and has to be preset at that stage. Removing the extra-articular callus will weaken the fragment connection. However, no attempt to release the fragments is made at that stage, as they may break at the wrong spot intra-articularly. The hand is now set in traction, and depending on the type of malunion and the location of the step-off, the so-called straight or tear-line osteotomies are performed.

From a technical standpoint, straight cuts with the straight osteotome are the easiest ones but only possible when the fracture line is straight and in line with one of the portals **(Figure 5)**. For those malunions not amenable to this simple osteotomy (such as any coronal fracture line), multiple perforations are made with the osteotome creating a sort of "tear line" in the cartilage and subchondral bone for easy breakage when prying with the osteotome **(Figure 6)**. Given space limitations and the fact that malunions are quite commonly irregular, one must be prepared to use any portal, any osteotome, and combinations of linear and tear-line osteotomies in order to manage a given malunion.

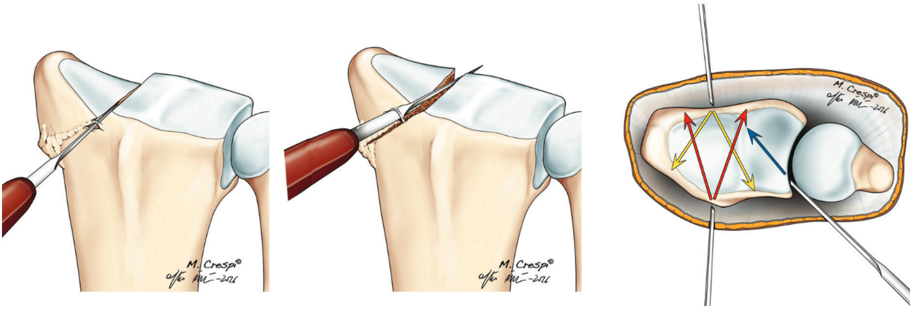


Figure 5.

Straight line osteotomy
(In Ref. 15. Copyright © Dr. Piñal, 2018).

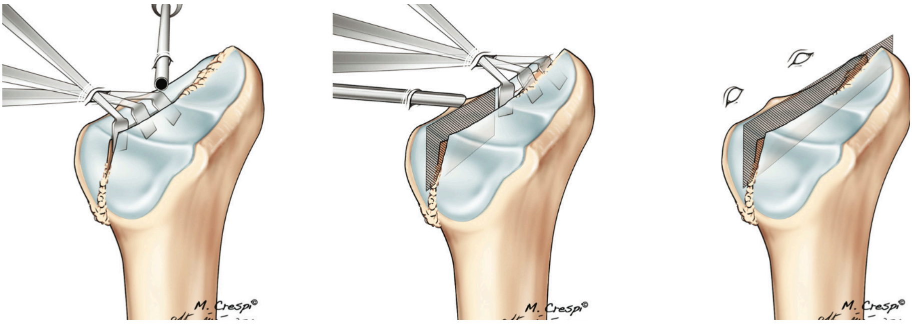


Figure 6.

Tear line osteotomy
(In Ref. 15. Copyright © Dr. Piñal, 2018).

Once the fragment has been mobilized, the redundant callus and fibrous tissue are removed from inside and outside the joint, until easily reducible. Hitherto, the case is managed as for an acute fracture. The highlights of the surgical management of the case introduced in **Figure 1**, **Figure 2**, **Figure 3,** are presented in **Figure 7**, **Figure 8**; **Figure 9**, **Figure 10**, **Figure 11**; **Figure 12**, **Figure 13**, **Figure 14**.

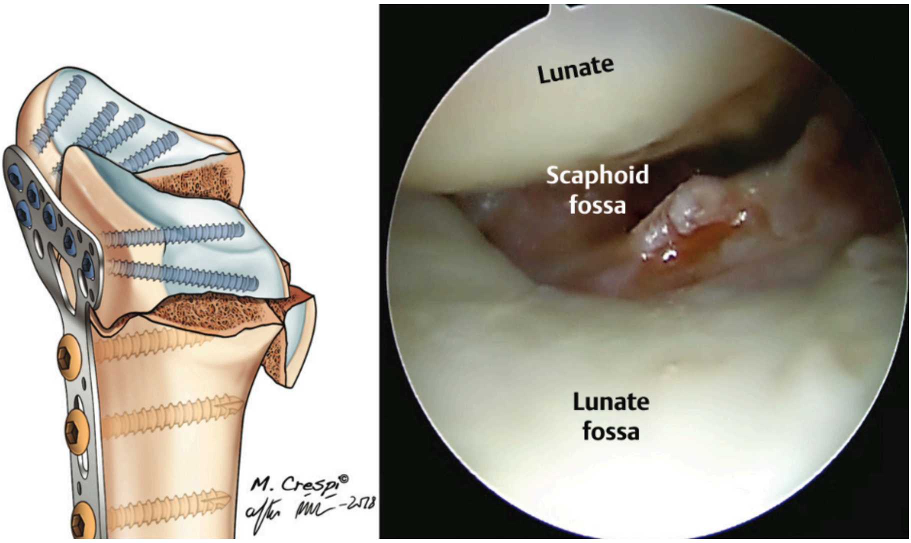


Figure 7.

Taking into account the preoperative images, I came up with this sketch. During arthroscopy, scar tissue within the radiocarpal joint is debrided, thereby delineating the magnitude of the articular incongruity (Copyright © Dr. Piñal, 2018).

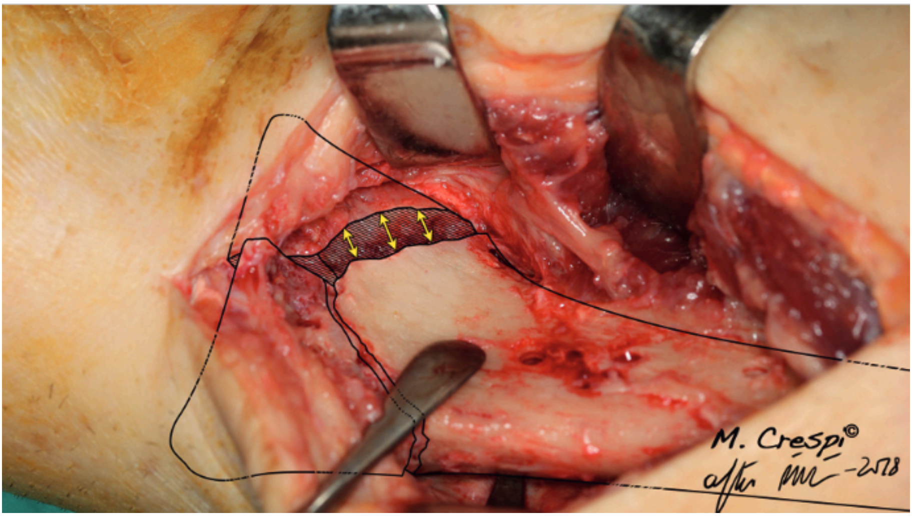


Figure 8.

The next step of the procedure comprised the removal of the volar plate and of the volar callus from the radial shaft. Note that the radial styloid fragment was relatively well-aligned to the shaft of the radius, whereas the volar ulnar fragment was malreduced. Any attempt to mobilize the fragments is delayed until the intra-articular osteotomies are performed as doing so may cause further fragmentation (Copyright © Dr. Piñal, 2018).

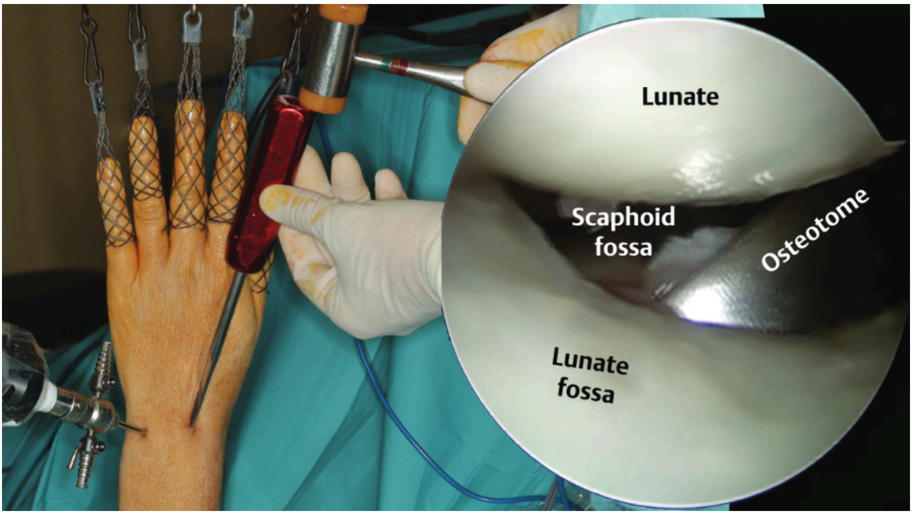


Figure 9.

With the scope placed within the 6R portal, a curved osteotome was introduced through the 3–4 portal to perform intra-articular osteotomies. Finally, the osteotome was "rocked" until the radial fragment was eventually freed (Copyright © Dr. Piñal, 2018).

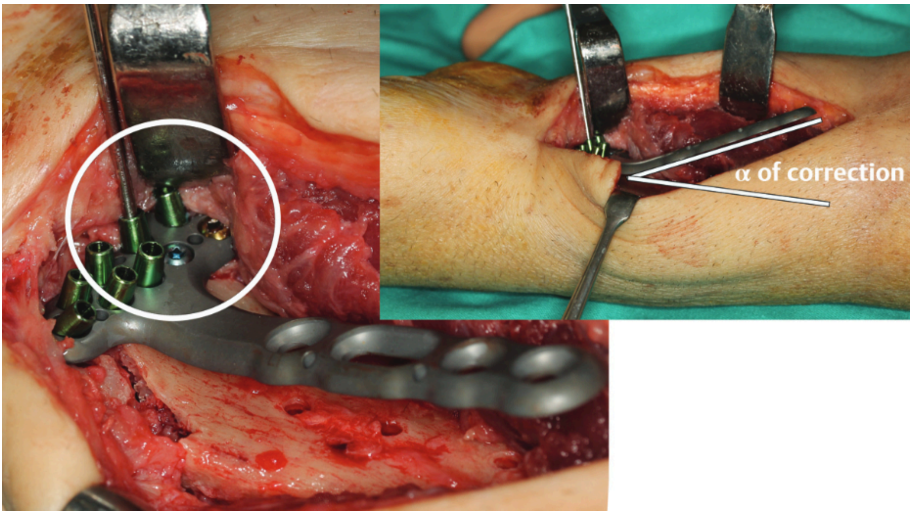


Figure 10.

The volar distal radius plate was applied and fixed to the distal ulnar fragment (circle) only (Copyright © Dr. Piñal, 2018).

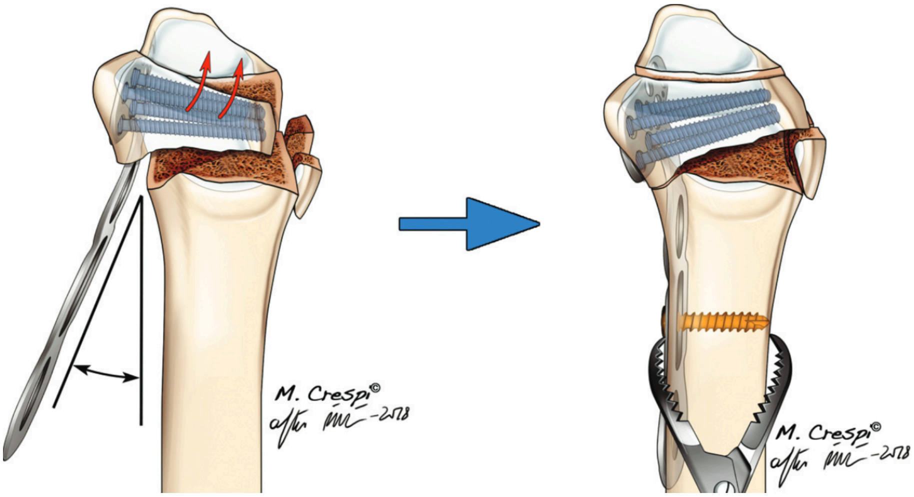


Figure 11.

By using the plate as a reduction tool, the malpositioned lunate facet fragment is anatomically reduced as described by Lanz's technique for pure extra-articular malunions (Copyright © Dr. Piñal, 2018).

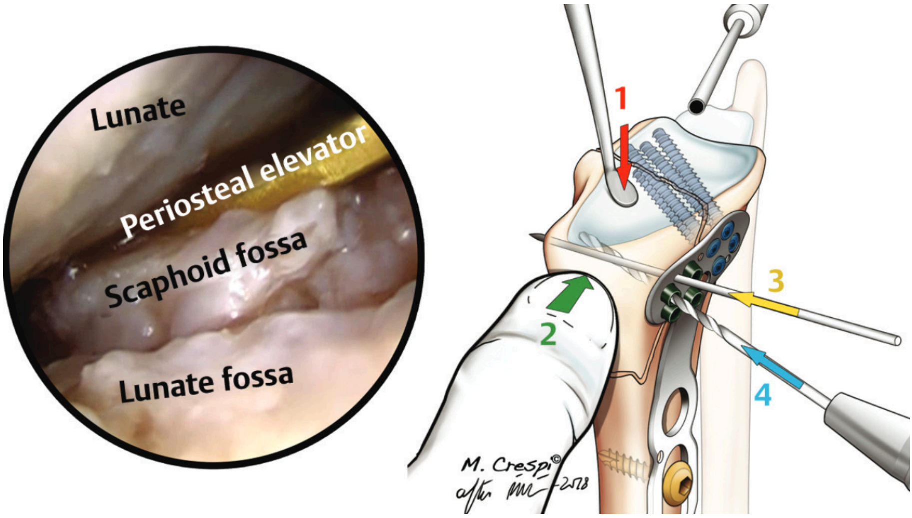


Figure 12.

After securing the lunate facet, attention is diverted to reduce the scaphoid fossa fragment. Note that it is slightly over-reduced, using the anatomical lunate facet as a guide, the fragment is depressed with a periosteal elevator ***(1)*** *and the radial fragment compressed with the thumb* ***(2)****. The assistant secures the scaphoid facet with a K-wire* ***(3)*** *followed by screw fixation into the plate* ***(4)*** *(Copyright © Dr. Piñal, 2018).*

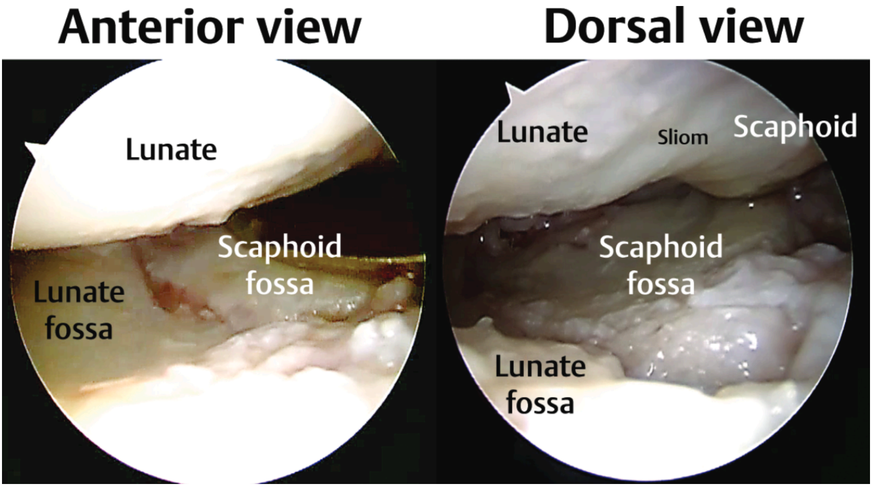


Figure 13.

Final arthroscopic view of the corrected intra-articular malunion (Copyright © Dr. Piñal, 2018).

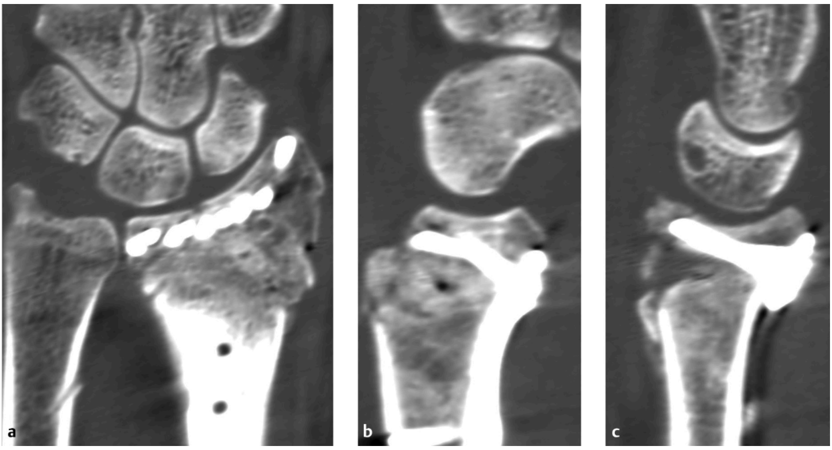


Figure 14.

Postoperative CT-scan confirming the correction of the distal radius articular surface with alignment of the carpus (Copyright © Dr. Piñal, 2018).

Conclusion

The arthroscopic guided osteotomy allows for the delineation of the original fracture line with minimal additional cartilage injury. The operation enables the surgeon to obtain an anatomical reduction while minimizing the possibility of wrong-site fracture. In the author's experience with intra-articular osteotomies, excellent results can be consistently achieved if one adheres to the described surgical steps. The reader should be warned that the operation ranks among the most difficult arthroscopic procedures a surgeon can be faced with in the wrist. In addition, substantial education in the conventional management of distal radius fractures is required. Otherwise, we risk to throw the patient into a catastrophic situation (**Figure 15**, **Figure 16**). The operation with a conventional arthroscopic technique (wet arthroscopy) is impracticable, and as a result, familiarity with the dry arthroscopy technique is of paramount importance.

Figure 15.

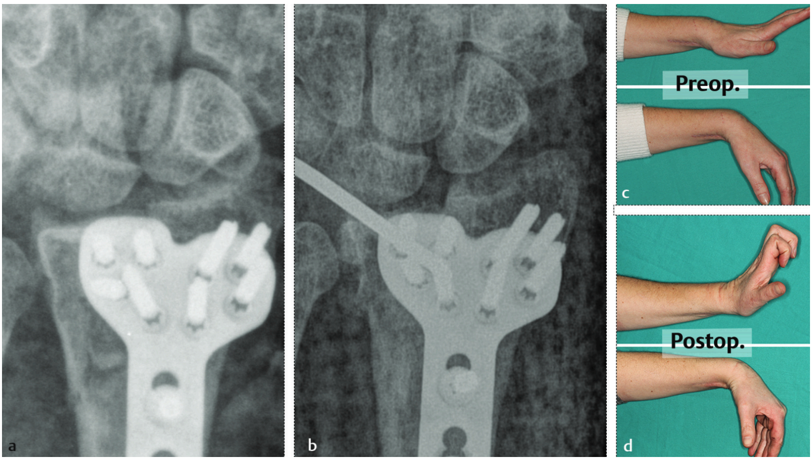


Figure 16.

(a) *This patient was operated on arthroscopically to correct an articular malunion by the same surgeon who had treated the original fracture 2 years earlier. The result of this first malunion correction* **(b)** *was a larger step-off than before and a disastrous functional result* **(c)**. *The case was redone by the author and after a second intra-articular osteotomy, a good functional outcome was achieved* **(d)**. *(Copyright © Dr. Piñal, 2018).*

30.
ARTHROSCOPIC STT INTERPOSITION ARTHROPLASTY

CHRISTOPHE MATHOULIN
JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

Isolated osteoarthritis of the scaphotrapeziotrapezoidal (STT) joint is rare, but very painful. As a general rule, conservative treatment is used. If this fails, the STT fusion is conventionally the next treatment option, but the repercussions on joint mobility are problematic. Isolated resection of the distal tubercle of the scaphoid is another option. However, secondary collapse may lead to pain recurrence. Interposition arthroplasty precludes this pitfall. Arthroscopic surgery gives the surgeon a better view of the STT joint, which makes it easier to resect the distal tubercle, and postoperative recovery is faster.

Operative technique

1. Patient Preparation and Positioning

The procedure is performed under regional anesthesia. The patient's arm is secured to the table. Upward traction can be placed on either the long fingers or the thumb alone. If traction is placed on the thumb, only 2 to 3 kg (4.5–6.5 lbs) of counterweight are necessary.

2. Midcarpal Joint Debridement

This procedure requires only a midcarpal joint approach. The midcarpal ulnar (MCU) portal is the most straightforward way to enter the joint. A shaver is introduced through the midcarpal radial (MCR) portal to debride the joint. The scope and the shaver positions are then reversed to complete the midcarpal joint debridement.

3. Scaphotrapeziotrapezoid Joint Exploration

The STT joint can be easily examined with the scope in the MCR portal. From the midcarpal joint, the medial and distal faces of the scaphoid are followed while passing between the scaphoid and the capitate. When the scope reaches the STT joint, the view may be hindered by widespread synovitis. The joint must first be cleaned out through the 1–2 or STT portal. A needle is inserted between the first and second compartments, about 1.5cm below the trapeziometacarpal joint. Since this joint is straight, the natural angulation of the carpal bones does not need to be taken into account as it does when determining the positions of other portals. The scope is held stationary and used to find the needle tip inside the joint **(Figure 1)**.

A small horizontal incision is made. Mosquito forceps are used to pass through the capsule, and the shaver is inserted into the joint. Synovectomy is performed until the entire joint is completely debrided; any small cartilage fragments are also removed.

Figure 1.

Intraoperative view of the needle in the 1–2 portal located with the scope's transillumination feature.

4. Distal Resection of the Scaphoid

A burr is introduced into the 1–2 portal. The tubercle on the distal pole is resected under visual control, starting at its dorsal section and gradually going toward its volar section **(Figure 2)**. The resection must be uniform. It is also critical to ensure that no bone lip remains, especially on the medial portion against the capitate **(Figure 3)**. When the resection is properly performed, the scope (2–3mm), which is still in the MCR portal, can easily be moved into the STT joint. However, it is easier to directly inspect the quality of the resection through the 1–2 portal.

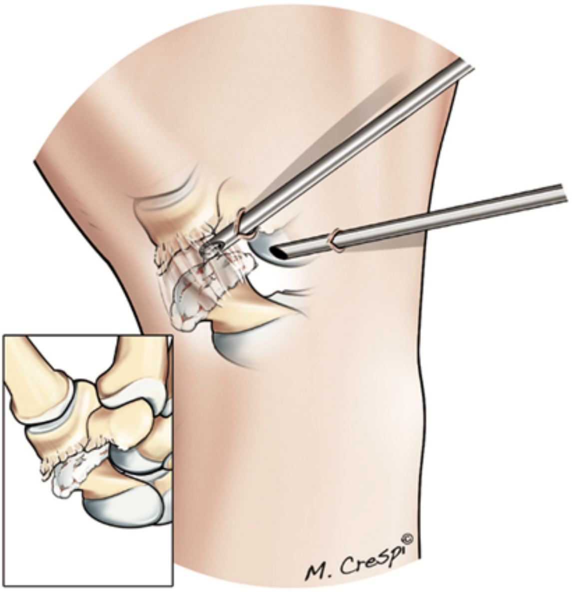


Figure 2.

Drawing of the initial burring of the scaphoid's distal facet.

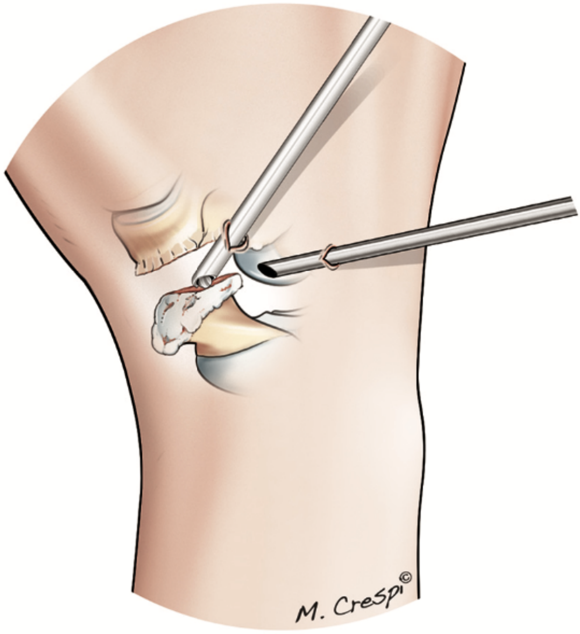


Figure 3.

Drawing of the scaphoid's distal facet resected with a shaver.

5. Implant Selection

The different types of implants are available. We prefer using a thin pyrocarbon implant with a dual concave shape. Various methods can be used to select the proper implant size. Although trial implants can be used, the implant's excellent primary stability makes it difficult to subsequently remove arthroscopically. A simpler method consists of using a graduated probe, inserted into the STT joint through the 1–2 portal. The probe's tip hooks onto the anterior part of the scaphoid. The scope is then used to count the number of markings and determine the implant size **(Figure 4)**.

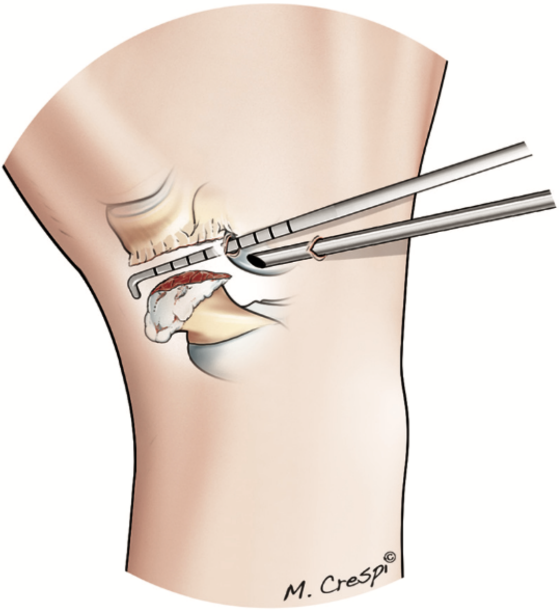


Figure 4.

Drawing of the implant size measured with a graduated probe.

6. Implant Placement

First, the 1–2 portal incision must be extended to about 1cm to insert the implant. The capsule also has to be opened further while making sure not to damage the superficial branch of the radial nerve. The capsule can be opened safely by introducing the mosquito forceps into the joint and spreading them.

The implant is either inserted directly with the fingers **(Figure 5)** or the forceps where the tips have been "dressed" so as not to damage the pyrocarbon.

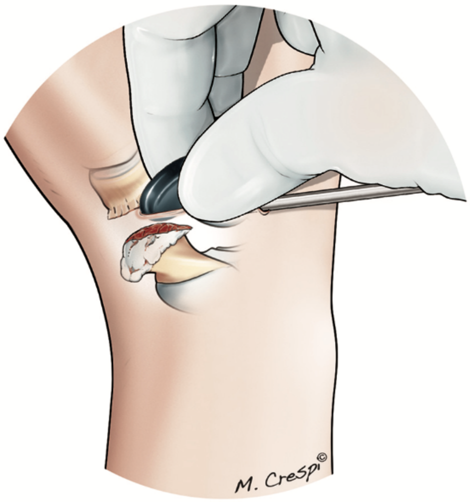


Figure 5.

Drawing of the implant directly inserted into the scaphotrapeziotrapezoidal (STT) joint through a slightly wider 1–2 portal incision.

A piece of surgical drain tubing can be placed on the forceps tips for this purpose. The implant must be positioned so that one of the implant's concave sides fits into the natural concavity of the trapezium and trapezoid. The implant will spontaneously settle into the correct position, and its primary stability is excellent **(Figure 6)**.

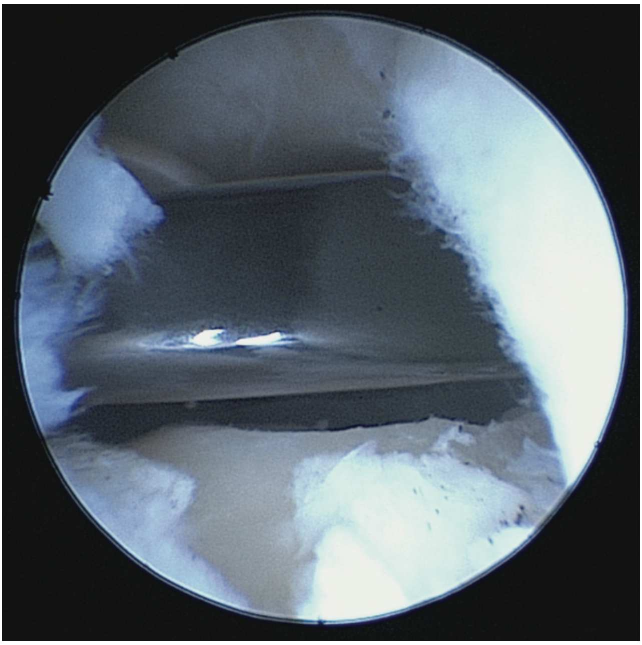


Figure 6.

Arthroscopic view of the implant in the proper position, with the scaphoid at the bottom, trapezoid at the top, and capitate on the right.

7. Closure and Postoperative Care

After releasing the hand traction, the capsule is closed with one cross-stitch of resorbable suture. The 1–2 portal incision can be closed with 1 or 2 skin sutures, which are removed at the first dressing change **(Figure 7)**. The joint is immobilized with a thumb abduction splint for 1 month **(Figure 8)**. Rehabilitation is typically performed by the patient. The patient must be informed that a fully functional pain-free wrist requires 3 months of recovery time.

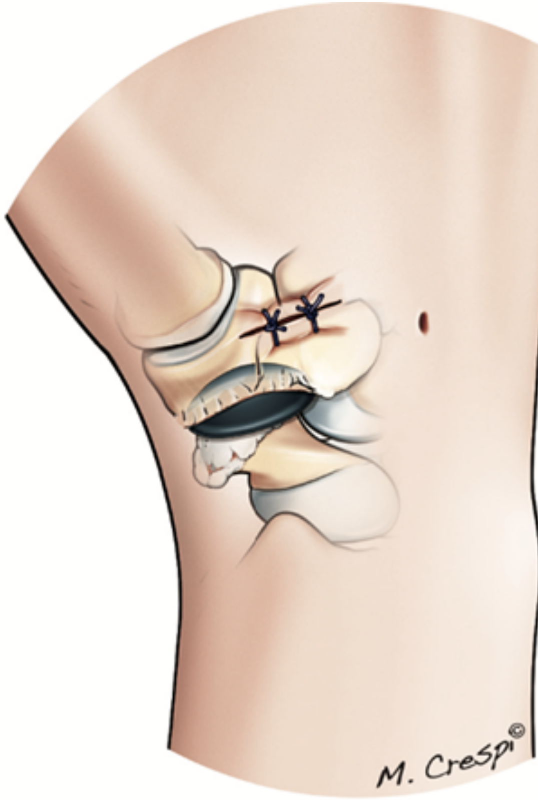


Figure 7.

Drawing of the implant in position and the wider portal skin incision closed.

Figure 8.

*X-rays of a clinical case of the isolated STT osteoarthritis, before **(a)** and after **(b)** interposition arthroplasty with a pyrocarbon implant.*

Tips & tricks

- It is possible to insert the trial implant into a glove finger before inserting it into the joint to allow for its easy removal.
- These implants are very slippery; it is possible to use plastic tips attached to the jaws of the mosquito forceps for a better hold.
- It is very easy to make a mistake between the STT and the trapeziometacarpal joint. It is possible to use a scopic check to avoid getting lost or to observe the distal pole of the scaphoid, which is convex, whereas the one of the trapezium is concave.
- To enter the STT area, the junction between the 2nd metacarpal and the long extensor tendon of the thumb is a good landmark.

Conclusion

The treatment of isolated STT osteoarthritis using arthroscopy is straightforward for patients and provides stable long-term results. Interposition arthroplasty preserves carpal height. It does not burn any bridges. Indeed, a secondary procedure can still be performed later if arthritis progresses to the trapeziometacarpal joint.

Video 23: Pyrocarbon trapezometacarpal interposition
https://vimeo.com/917911559

31.
TARGETED PARTIAL ARTHROSCOPIC TRAPEZIECTOMY AND DISTRACTION (TPATD)

MICHEL LEVADOUX
JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

First CMC arthritis is osteoarthritis between two bones, the trapezium, and the first metacarpal, forming the trapeziometacarpal (TM) joint. CMC joint arthritis affects women in 80% of cases, most often around the age of menopause. It is not usually seen before the age of 50. Its frequency ranges from 8 to 22% in women and 2 to 5% in men. Although there is no consensus on treatment, conventional treatments are mainly non-conservative and do not allow for backtracking toward other less invasive options. Trapeziectomy is the most accepted surgical option for disabling basal joint arthritis. However, complications with this technique are not uncommon and can be difficult to manage, often resulting in very unsatisfactory results, especially in young patients. Consequently, there is a real need to find less invasive therapeutic options for young patients suffering from basal joint arthritis.

In this article, we describe the technique of an arthroscopic partial trapeziectomy associated with temporary distraction.

Operative technique

The operation is performed under regional anesthesia with the patient in a supine position and an inflated tourniquet at the base of the limb. The thumb is equipped with a Chinese finger trap, and 3 kg of traction is applied to distract the TM joint. Distension of the joint is achieved via a percutaneous injection of physiological saline in the CMC joint. A pure skin incision over the CMC 1U portal (less than 3mm) is made to introduce the blunt trocar after careful dissection of the soft tissues using mosquito-type forceps **(Figure 1)**.

A traumatic insertion of a 2.4mm arthroscope is then made, and the joint structures inspected. In most cases, a wrist arthroscope can be used, with the 1.9mm arthroscope being much too fragile with a very short half-life **(Figure 2)**.

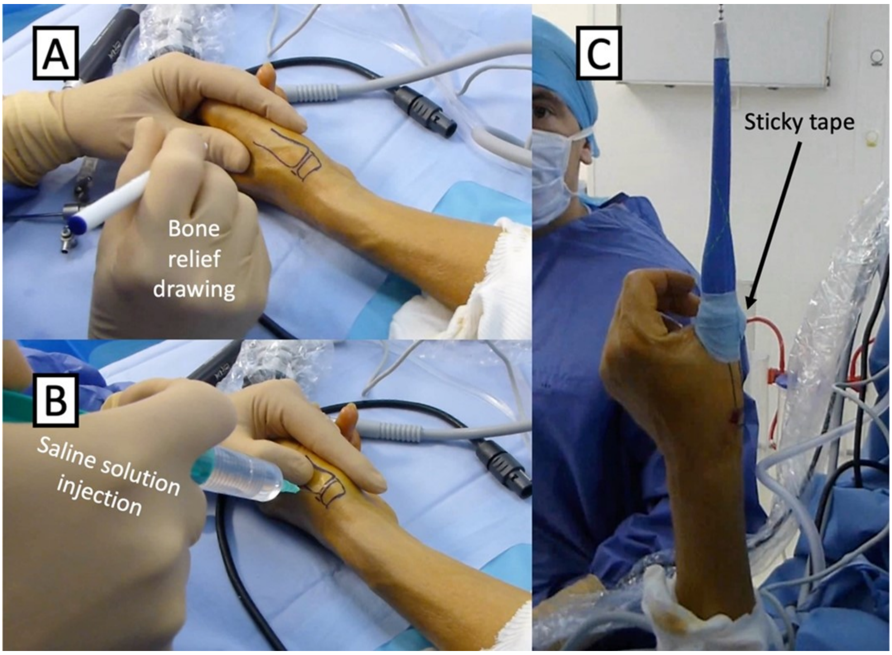


Figure 1.

Arthroscopy of the trapeziometacarpal joint is relatively difficult because of the narrow intra-articular space and difficulty in maintaining traction. Adequate installation is essential.
A/ *Drawing skin incisions and bone reliefs after careful palpation may be useful before applying traction.*
B/ *Introduction of a 25-Gauge needle of saline solution into the joint to distend it. This step can be performed before or after traction.*
C/ *Traction of the thumb with the placement of a sticky tape between the skin and the Chinese finger to prevent the thumb from slipping down.*

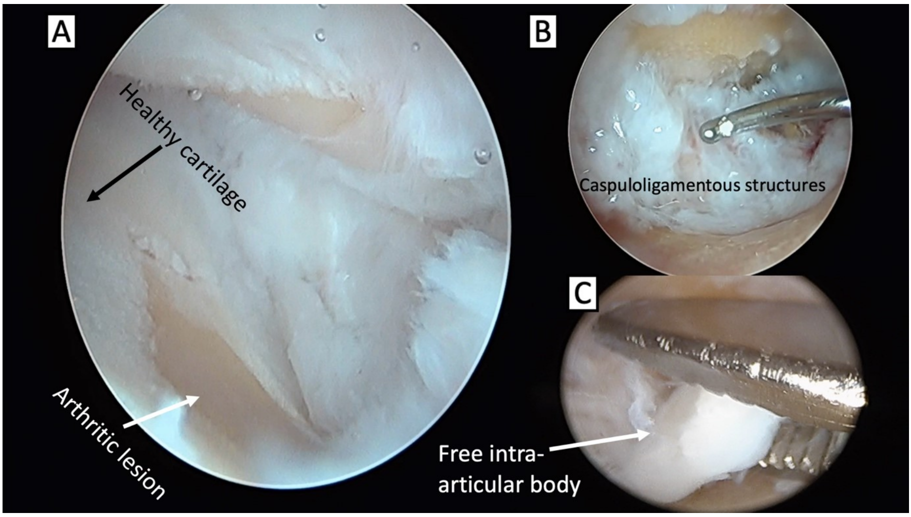


Figure 2.

Arthroscopic exploration (arthroscopic view with optics in 1U and instrumental route in 1R):
A/ *Loss of bipolar articular substance of the trapeziometacarpal joint. Conservation of healthy cartilage in adjacent areas. Above, it is the articular surface of the metacarpal. Below, the one of the trapezium. The portals can be alternated to better observe the entire joint.*

B/ *Ligament testing with the probe showing relaxation of capsuloligamentous structures. The probe should press on the capsuloligamentous structures to assess their strength.*

C/ *Removal of osteophytes and intra-articular foreign bodies that may interfere with visibility during the rest of the procedure. The largest osteophytes will be removed using Mosquito forceps.*

A second portal, first via the CMC 1R portal, is defined via transillumination and could serve as an instrumental portal. A probe can be used to check the integrity of the ligaments and to detect distension of the capsuloligamentous structures and the presence of free intra-articular osteophytes. Next, a synovectomy is performed with a shaver. It allows for a better analysis of the joint as a whole, as well as freeing it from specific adhesions. Once the reactive synovial hypertrophy has been resected and the joint is clear, resection of the bare subchondral bone using a 3mm motorized burr induced a “bloody dew” intended to promote regrowth of fibrocartilage **(Figure 3)**.

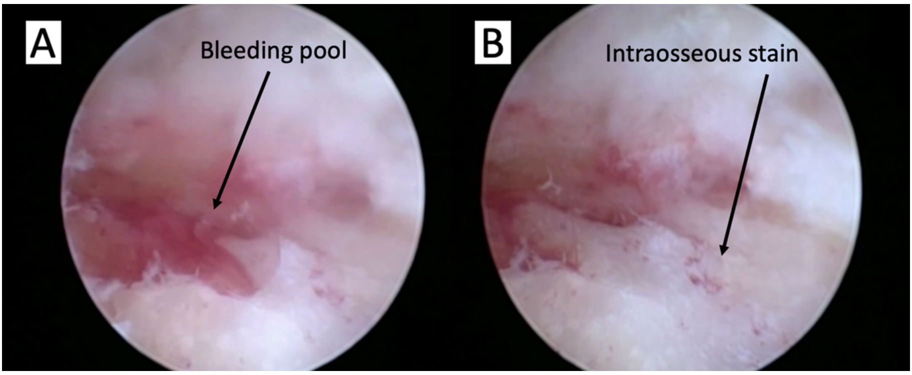


Figure 3.

Visualization of the “Bloody Dew” (arthroscopic view with optics in 1U)
The appearance of a “Bloody Dew” means that the depth of osteocartilage resection is sufficient. This “Bloody Dew” can appear as a bleeding pool ***(A)*** *or as an intraosseous stain* ***(B)****.*

The resection could be performed during either dry or wet arthroscopy depending on the surgeon's preference. We stop the subchondral bone resection once we get a satisfactory bloody dew. Intra-articular cartilaginous loose bodies were then removed.

Once resection is deemed satisfactory and a good joint lavage has been performed, the limb's traction is either released or maintained, and two divergent pins are placed under fluoroscopic control to maintain the joint space and promote the development of a postoperative hematoma assisting the development of a fibrocartilage. These K-wires are left in place for 6 weeks and are then removed. Two different distraction methods are possible.

- Inter Metacarpal Distraction (IMD) (the so-called Iselin technique): traction on the arm is released, and axial traction is applied to the thumb while inserting a proximal tricortical K-wire from the first metacarpal to the second metacarpal. A second distal tricortical K-wire is inserted in the reverse direction once distraction is satisfactory. This method has been abandoned due to a rate of complications (Complex Regional Pain Syndrome).
- TM transarticular distraction (TMTD) **(Figure 4)** (the so-called Wiggins technique, yet doubled): the arm is left in traction and, using a motorized driver, two K-wires are introduced from the base of the metacarpal to the body of the trapezium. Once the fluoroscopic appearance of the construct is deemed satisfactory, a dressing is made, without any suturing.

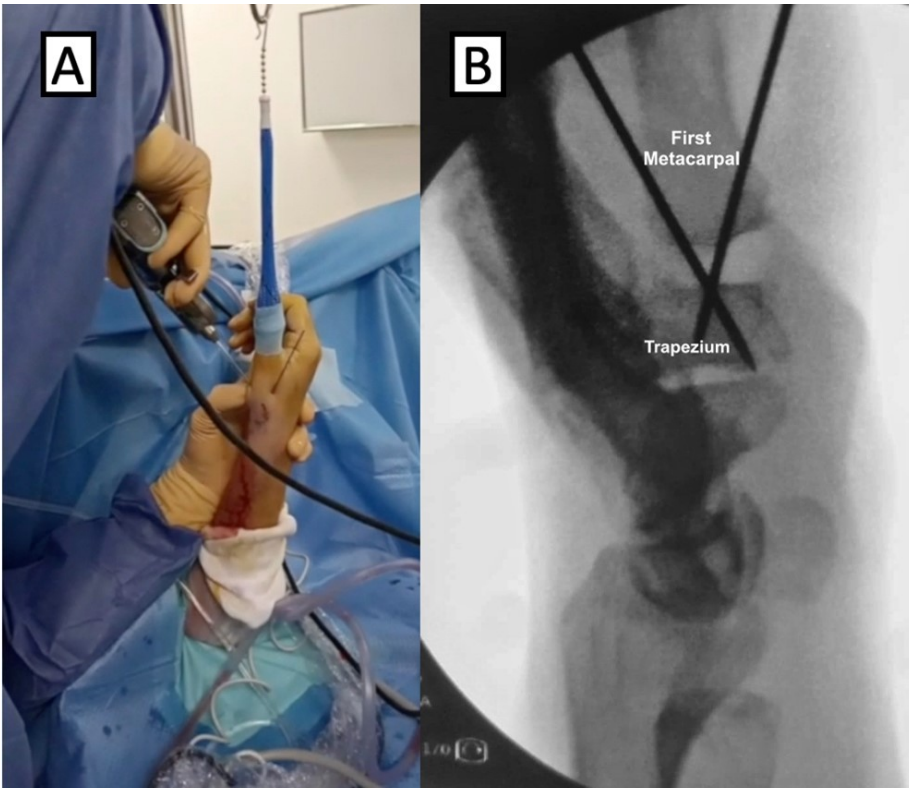


Figure 4.

Bone fixation method allowing for distraction of the trapeziometacarpal joint.
A/ *Intraoperative view of the placement of the 1mm wires without releasing traction. The wires are inserted from distal (metacarpal) to proximal (trapezium), with less risk of nerve damage. To avoid discomfort, they will not be buried under the skin.*

B/ *Intraoperative radiograph with the wires in place, but after removal of distraction. Note the intra-articular space maintained by the pins.*

Postoperative care

Immobilization consists of the patient wearing a semirigid orthosis of the thumb column for the first 6 weeks postoperatively in order to avoid the piercing of the skin. After K-wire removal under local anesthesia, physiotherapy is started immediately, including mobilization of the interphalangeal joint and of the wrist **(Figure 5)**.

Figure 5.

Case 1: Preoperative X-ray of radiological Dell 2 osteoarthritis (A). Postoperative X-ray at 11 months after arthroscopic partial trapeziectomy and TMTD distraction (B).

Tips & tricks

- Thumb distraction is achieved with a Japanese finger trap. In order to prevent any brutal failure of traction during the surgical procedure, the Japanese finger trap must be secured with a sticky tape on its proximal part.
- Subchondral bone resection can be achieved during either dry or wet arthroscopy depending on the surgeon's preference. In our hands, the best solution consists in a dry resection with frequent "wash-out" using saline.
- To facilitate the resection of the small pieces of bone, we use the cannula of the burr after removal of the drill.
- For the implantation of the K-wire, it is recommended to perform a 3mm longitudinal incision of the skin in order to spread out the underlying soft tissue (dorsal branches of the radial nerve).
- Make sure that you are in the trapeziometacarpal joint and not in the scaphotrapeziotrapezoid joint (using fluoroscopic control and a 20-Gauge hypodermic needle).
- Distend the joint using an intra-articular injection of saline solution.
- Remove the motorized blade to facilitate the aspiration of osteocartilaginous debris.
- Use transillumination to perform the 2nd portal.
- Irrigate the joint during milling to prevent thermal burns of the subchondral bone.
- Leave traction in place for pinning.
- Perform a careful dissection for the approaches.

- Instruments that are too large will interfere with the surgery, possibly resulting in iatrogenic injuries.

Conclusion

The CMC joint arthritis in young people is a challenging issue. Conventional treatments can be a little bit destructive. Arthroscopic partial trapeziectomy with K-wire distraction in young patients suffering from TM osteoarthritis is a simple technique, which requires minimal equipment and yields satisfactory outcomes. Conversion to another surgical treatment is still possible if this less invasive technique is unsuccessful and when CMC osteoarthritis keeps increasing.

32. ARTHROSCOPIC RESECTION ARTHROPLASTY OF THUMB CARPOMETACARPAL JOINT

TYSON COBB
JESSICA COBB

Introduction

Arthroscopic resection arthroplasty (ARA) of the thumb CMC joint is a simple procedure for patients that can be accomplished through two or three portals allowing for minimal soft tissue dissection and, as a result, for an early recovery and less postoperative scarring, pain, and stiffness. Our research has shown that mean postoperative return to full duty times are about half of the one needed for ligament reconstruction tendon interposition procedures. Tendon harvest, resection of trapezium, interposition, pins and sutures are not typically necessary. Stages III (isolated CMC arthritis) and IV (pantrapezial arthritis) can be treated with the ARA technique. When the CMC and the scaphotrapeziotrapezoid (STT) joints are arthritic and symptomatic, both are resected through separate portals.

Operative technique

1. Patient Preparation and Positioning

The patient is placed supine on the operating room table with the shoulder abducted. The brachium is taped tightly to an arm table. The tape should be as close to the flexor crease of the elbow as possible **(Figure 1a)**. Thumb traction (3–6 kg) is applied with a traction tower and Chinese finger trap after standard preparation and draping **(Figure1b)**.

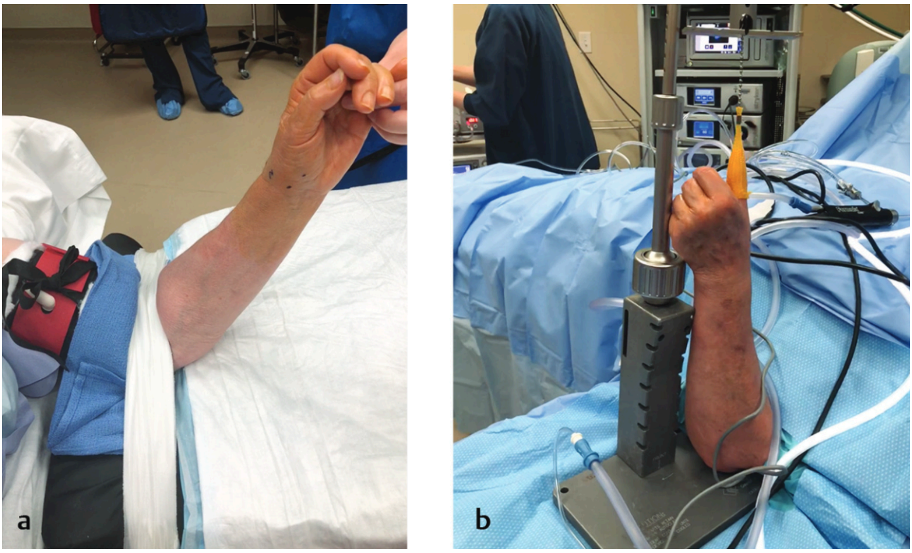


Figure 1.

(a) *Arm taped to the hand table.* **(b)** *Thumb hung in finger trap traction.*

The procedure can be performed using general, regional, or wide-awake local (WALANT) anesthesia, with or without a tourniquet. If WALANT anesthesia is used, the injection is administered 30 minutes prior to the start of surgery to allow sufficient time for vasoconstriction. If general anesthesia is used, a local anesthetic is injected after the patient is induced to provide hemostasis and pain relief postoperatively. Approximately, 8 to 10mL of 0.25% bupivacaine (or 1% lidocaine) with epinephrine is infiltrated under the skin and in the subcutaneous tissue at each portal site. The needle is passed across the joint and out of the back side of the joint where an additional 8–10mL of solution is administered **(Figure 2)**.

Figure 2.

Approximately 40mL of 0.25% marcaine with epinephrine is injected prior to beginning the case.

2. Portal Placement and Exploration of the Thumb CMC Joint

Dorsal and volar portals are localized on both sides of the first dorsal compartment with 18-gauge hypodermic needles under fluoroscopy. The needles are placed centrally and parallel to the joint **(Figure 3)**. These two portals should be at least 2 cm apart to allow better visualization of the radial side of the joint.

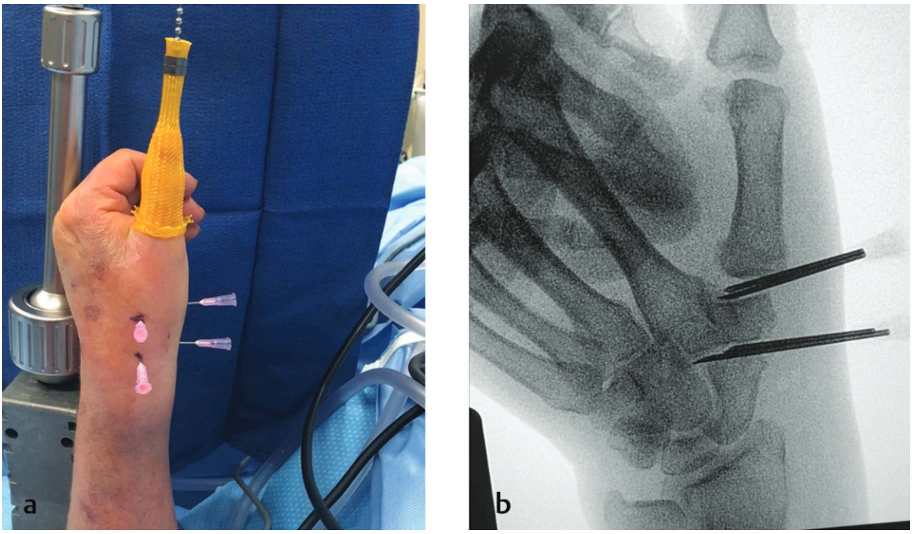


Figure 3.

(a) *Portal sites are localized with18-Gauge hypodermic needles and care is taken to make sure that the portals are placed far enough apart to allow for visualization of the radial side of the joint. Shown here is a patient undergoing ARA of the CMC and the STT (stage IV).* **(b)** *Fluoroscopic guidance is used to confirm that hypodermic needles are centrally located and parallel in the joint.*

An incision is made just through the skin with a No. 15 blade. Care should be taken not to injure superficial nerves. The radial artery, superficial branches of the radial nerve, and extensor tendons are all near. These structures are protected through adequate blunt dissection. Blunt dissection with a hemostat allows entry into the joint **(Figure 4)**. A blunt hemostat is used to dissect down to and through the capsule. It is crucial to avoid aggressive spreading in the subcutaneous tissue where subcutaneous nerves may be irritated. A second dorsal portal (i.e., the dorsal ulnar portal) can be used as necessary for better viewing the radial side of the joint by placing a trocar into the volar portal, across the CMC or the STT joint and out of the dorsum of the hand. The cannula is placed retrograde over the trocar into the joint **(Figure 5a)**. The dorsal ulnar portal improves the visualization of the radial side of the joint.

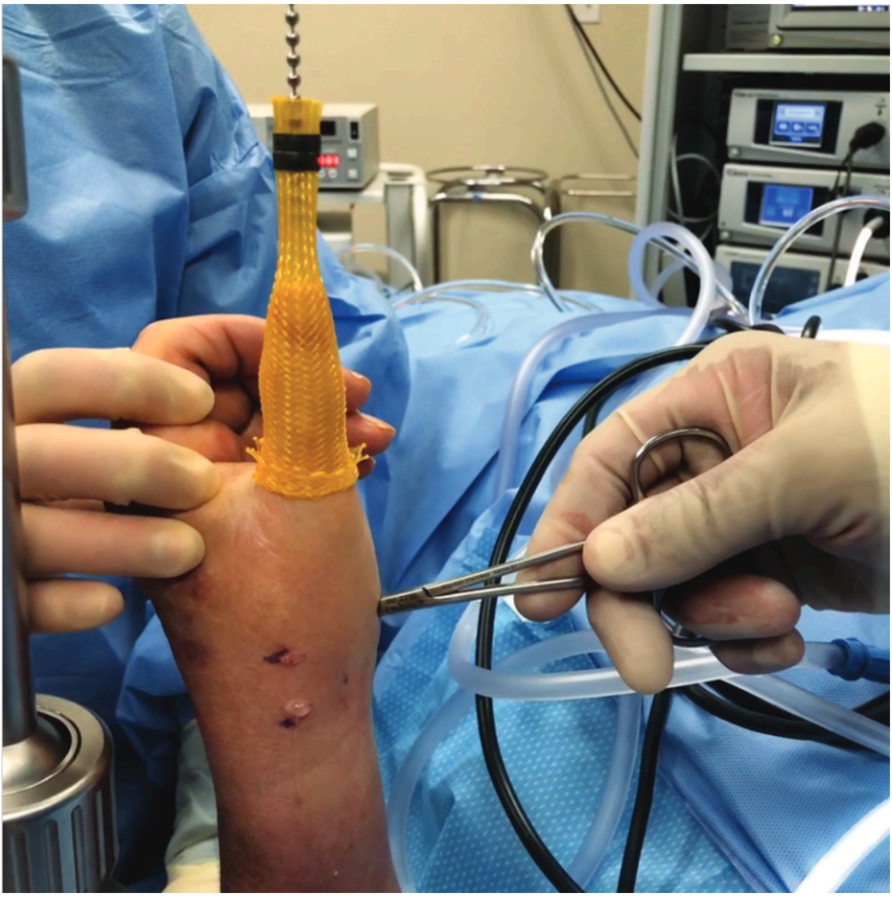


Figure 4.

Incision is made with a No.15 blade just through the skin and a hemostat is used to dissect down to and puncture the capsule and enter the joint.

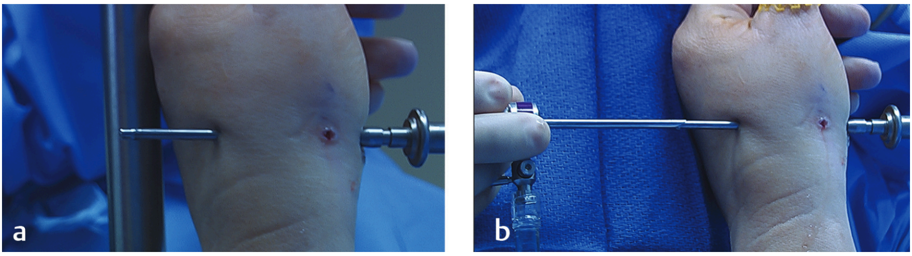


Figure 5.

"Inside-out" technique for establishing the ulnar dorsal portal for the CMC and/or STT. ***(a)*** *Second dorsal portal (which is often used to better visualize the radial side of the joint) is established by placing a blunt probe through the volar portal and across the CMC or the STT, exiting the dorsum of the hand.* ***(b)*** *A cannula is placed retrograde over the probe and inserted into the joint. The probe is removed, and the scope is placed in the newly established ulnar dorsal portal.*

3. Debridement and Denervation of the Thumb CMC Joint

A 30-degree, 2.7mm arthroscope is placed in the dorsal portal and a 3.5 full-radius shaver is used with suction in the volar portal. The shaver is used to perform synovectomy and clean the joint of any debris for better visualization **(Figure 6)**. A hemostat or a grasper is used to remove loose bodies as necessary **(Figure 7)**. A 1.9 or 2.3mm scope is used for stage I or II cases where joint salvage procedures are planned, or for smaller tighter joints. Arthroscopy of the STT joint is performed when symptomatic using volar and dorsal portals centered over the STT joint (approximately 1cm proximally to the volar and dorsal portals as described for the CMC ARA). As instruments are taken in and out of the joint, the portals will occasionally seem to become obstructed and not allow access. When this occurs, simply reverse the portal placement steps. If the instrument will not enter the joint, try the hemostat. If the hemostat will not enter, try the needle. If the needle does not enter, you are in the wrong plane and may need to use fluoroscopy. Radio frequency ablation with a 3.5mm SERFAS Energy RF Ablation System (Stryker, Santa Clara, CA, United States) is used to perform intra-articular joint denervation. Using a high setting, this ablation system is used to transect the articular sensory branches of the superficial radial sensory branch, median motor branch, ulnar motor branch, palmar cutaneous branch, and lateral antebrachial cutaneous nerves. These nerves are resected by removing the capsule proximally and distally with the SERFAS ablation system (Stryker, Santa Clara, CA, United States). High saline inflow and outflow prevent overheating.

Figure 6.

The scope is stabilized with the index finger to prevent pistoning in and out of the joint. A 3.5mm shaver is used to perform synovectomy and debridement to allow for a clear visualization of the joint.

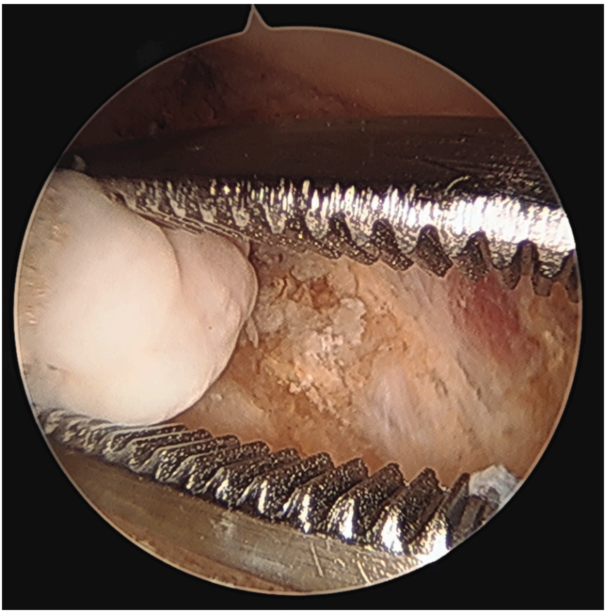


Figure 7.

Loose body removed with a hemostat.

4. Arthroscopic resection arthroplasty: CMC joint

A 4.0mm barrel bur (Stryker, Santa Clara, CA, United States) is placed into the volar portal and used to resect 2 to 3mm of bone from the distal aspect of the trapezium and from the proximal aspect of the first metacarpal. The burr is perched on the side of the trapezium as resection is started so a ridge of bone is not left behind. The burr is then advanced across the joint in a trough of resected bone using a dorsal-volar windshield wiper motion. Once the bone has been resected up to the scope, the portals are switched and the segment of bone near the dorsal portal is resected. Fluoroscopy is used to assess the amount of resection **(Figure 8)**. Care is taken to resect the opposite joint.

Figure 8.

Postoperative X-ray showing resected CMC and STT joints.

5. Arthroscopic resection arthroplasty: STT joint

For patients with symptomatic STT joints, repeat afore mentioned steps for STT resection. STT resection arthroplasty is also performed with the 4.0mm barrel burr. Approximately 2 to 3mm of bone are resected from the distal aspect of the scaphoid and from the proximal aspect of the trapezium and of the trapezoid **(Figure 9)**.

Figure 9.

Arthroscopic view of resected STT joint showing the resection of the proximal surface of the trapezium (right) and of the trapezoid (left). The remaining cartilage of the trapeziotrapezoid joint is shown separating the trapezium and the trapezoid.

6. Tourniquet removal, hemostasis, and pain control

If a tourniquet is used, it is deflated to confirm hemostasis. An additional 20 to 30mL of 0.25% bupivacaine with epinephrine (if not contraindicated) is injected directly into the resected joint to provide further hemostasis and facilitate postoperative pain control. The assistant holds his/her fingertips tightly over the portals to prevent fluid from leaking out while the surgeon is injecting the remaining bupivacaine into the resected joint space. The total amount of 0.25% bupivacaine used throughout the entire case is typically approximately 40 to 60mL. No interposition, pins, or sutures are used. In the rare case of post-resection instability, a tight rope or a palmaris tendon stabilization technique can be used to stabilize the joint.

7. Closure and postoperative care

Portals are closed with Steri-strips. A well-padded thumb spica splint with an elastic bandage (ACE) is applied. Whenever necessary, a second compressive ACE is applied for a short period of time during the immediate postoperative recovery period for hemostasis. Patients are instructed to keep their extremities elevated and apply ice. They begin with a gentle range of motion of the digits the day after surgery.

Patients are warned that their fingers may remain numb for 18 to 36 hours after surgery due to the long-acting effects of bupivacaine with epinephrine. Patients are scheduled to see a hand therapist on postoperative days 5–7 for the fabrication of a hand-based arthroplast orthosis and instruction for a home program of therapy to be started before their first postoperative follow-up with the surgeon.

The home therapy program should emphasize the gentle range of motion of the thumb and CMC joint in three planes: 1) Extension: lay hand flat on a table, palm up, and push tip of thumb to table; 2) Palmar abduction: hand flat on table, palm up, with thumb metacarpal pointed at the ceiling; 3) Opposition: thumb tip pulled to the base of the small finger. Initially, patients may need to start with opposition to the tip of the index finger and progress to tips of the middle, ring, and small fingers before they are able to achieve opposition to the base of the small finger. Patients should attempt to perform these exercises actively. However, patients should be instructed to use assistance from their contralateral hand until they can achieve such motions actively. This preoperative visit with therapy allows the patient to get over the initial anxiety that often occurs with the removal of postoperative dressing and it allows the surgeon to perform a more complete assessment at 7–10 days postoperatively, after patients have begun to work on their range of motion.

Postoperative blocks and continued therapy visits can be helpful to facilitate the early range of motion in patients who are having difficulties. It is essential to communicate to the therapist that moderate swelling and bruising are normal, especially as patients will have variable levels of commitment to ice and elevation. In addition, many therapists may be more familiar with more restrictive therapy and rehabilitation protocols typically used for open CMC procedures; as a result, it is critical to stress the importance of early motion, as it is the author's belief that an early range of motion provides better overall outcomes.

There is a wide range in time required for pain resolution following this procedure. Some patients will be doing very well within a few weeks of surgery, whereas others may require many months. The surgeon should resist the urge for early revision surgery in patients who are slow to respond and rather reassure the patient that pain will resolve over time.

Conclusion

The ARA as treatment for 1st CMC arthritis is a reliable, effective, and safe procedure for patients. The failure rate with this procedure is less than 5% if joints are completely resected. We have 14 years of follow-up on our earliest patients and recurrence has never occurred.

33. ARTHROSCOPIC THUMB CARPOMETACARPAL INTERPOSITION ARTHROPLASTY

CHRISTOPHE MATHOULIN

Introduction

Osteoarthritis in the thumb carpometacarpal (CMC) joint is a common condition, especially in women over 60 years of age. Various treatment approaches are currently used, including fusion, prosthesis, and trapeziectomy, with or without ligament reconstruction. Outcomes are generally good with such methods, but problems persist. In the early stages of moderate osteoarthritis and normal alignment, arthroscopic interposition arthroplasty makes sense. It is straightforward for the patient and does not burn any bridges if another procedure is required later on.

Operative Technique

1. Patient Preparation and Positioning

The procedure is performed under regional anesthesia. The patient's arm is secured to the arm board. Traction is placed on the thumb using a finger trap. Only 2 to 3 kg (4.5–6.5 lbs) of counterweight are required.

2. Exploration of the Thumb Carpometacarpal Joint

A needle is used to locate the 1st palmar (1P) portal, which is in front of the first compartment (abductor pollicis longus and extensor pollicis brevis). This portal is located at the palmar-dorsal skin junction of the hand, or even slightly in front on the volar side (**Figure 1**). The terminal branches of the radial nerve are not a concern at that level. This portal can be enlarged as required to accommodate the implant. The joint is identified with hemostats and the sheath and the arthroscope are then inserted. Direct entry is possible since this joint is not concave as the wrist joint is. A standard 2.4mm scope is used, although some prefer to use a smaller 1.9mm scope. Based on our experience, this smaller and more fragile scope is unnecessary. The second portal (1 dorsal, 1D) is located using a needle and the scope's transillumination feature; this portal is positioned behind the first compartment (**Figure 2**). The shaver is inserted through this portal.

Figure 1.

Intraoperative view of a needle used to locate the 1st palmar (1P) portal in front of the first compartment.

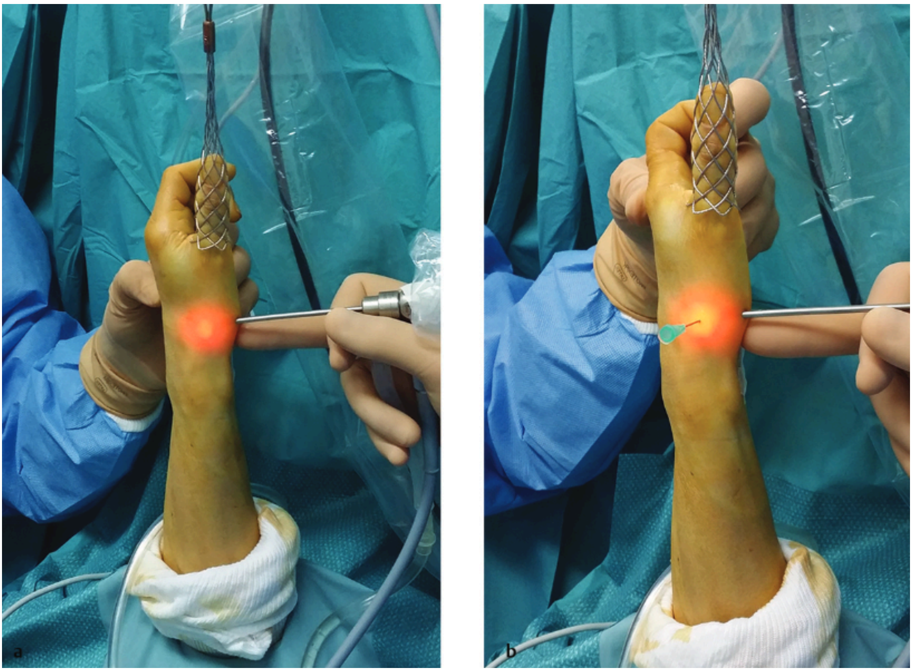


Figure 2.

(a, b) *Intraoperative views of the 1 dorsal (1D) portal located using the scope's transillumination feature.*

3. Debridement of the Thumb Carpometacarpal Joint

The thumb CMC joint is usually filled with inflamed synovial tissue. As a result, the first step consists of performing a synovectomy with the shaver. The shaver and scope positions can be reversed to complete the synovectomy. In some cases, the joint will contain foreign bodies that are free-floating or partially attached to the capsule. They must be removed completely.

4. Osteophyte Resection

No matter which type of implant is used, every single trapezium osteophyte must be resected. The medial osteophyte is removed first with the scope in 1D and the burr in 1P **(Figure 3**, **Figure 4)**. The burr and scope positions are reversed if a lateral osteophyte needs to be resected **(Figure 5)**. A pyrocarbon implant may require the resection of the volar and dorsal osteophytes at the base of the first metacarpal as well.

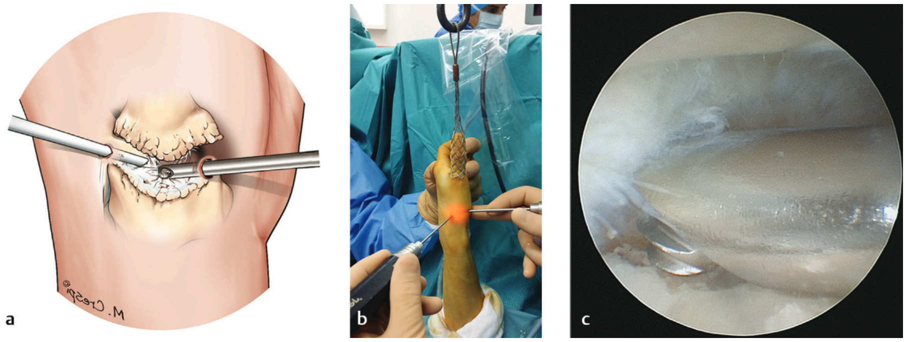


Figure 3.

Drawing **(a)**, intraoperative view **(b)**, and arthroscopic view **(c)** of the initial stages of the medial osteophyte resected with a burr.

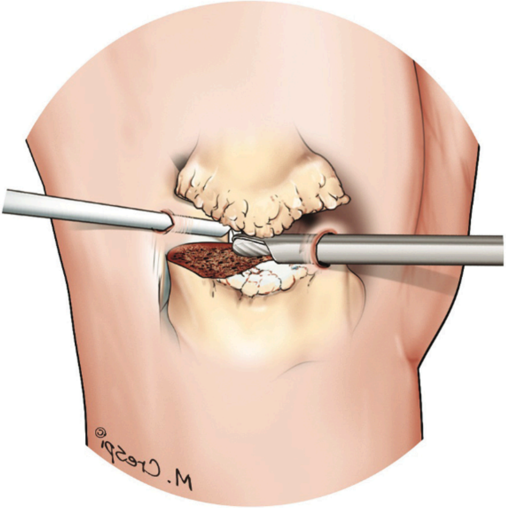


Figure 4.

Drawing of progressive resection of the medial osteophyte with a burr.

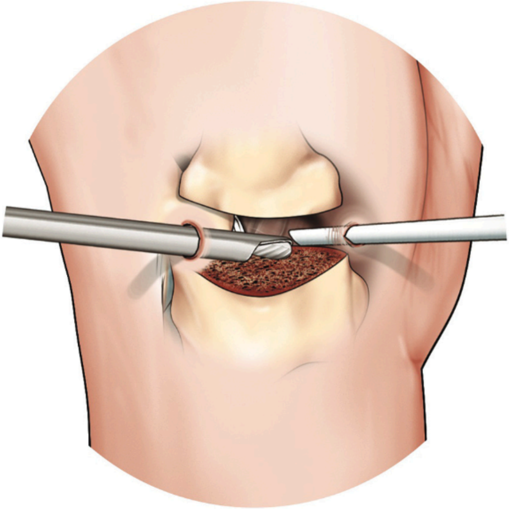


Figure 4.

Drawing of the distal end of the trapezium completely resected once the scope and burr positions have been reversed.

5. Placement of Implant

For both arthroscopic and open surgery, sufficient space must be created in the joint to accommodate the implant. The four osteophytes are resected first, as described in the previous step. A graduated probe is used to determine the size of the implant needed. The 1P portal will need to be enlarged to 1cm. The joint capsule is opened with hemostats, using the same technique. The chosen implant is then either pushed or pulled into the joint, and the scope is used to control its positioning **(Figure 6**, **Figure 7**, **Figure 8)**.

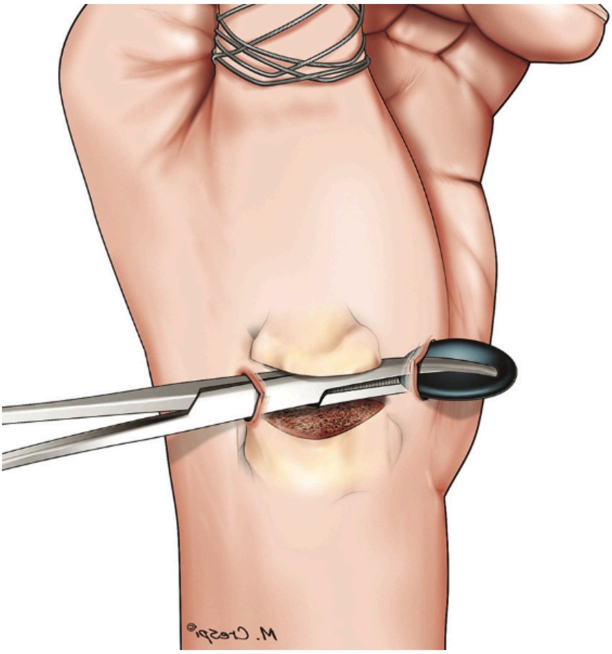


Figure 6.

Drawing of one of the methods used to insert the implant through a slightly enlarged 1P portal incision.

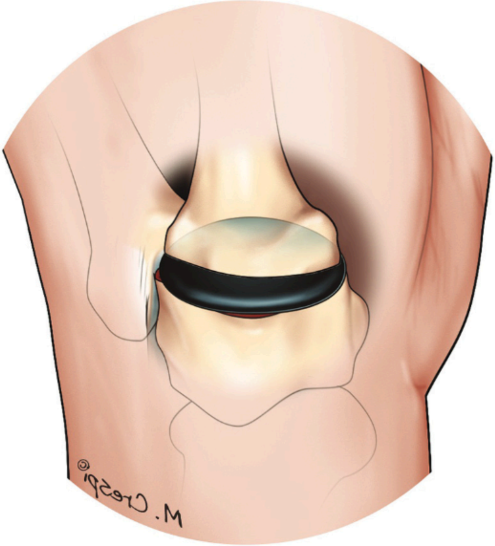


Figure 7.

Drawing of the seated implant

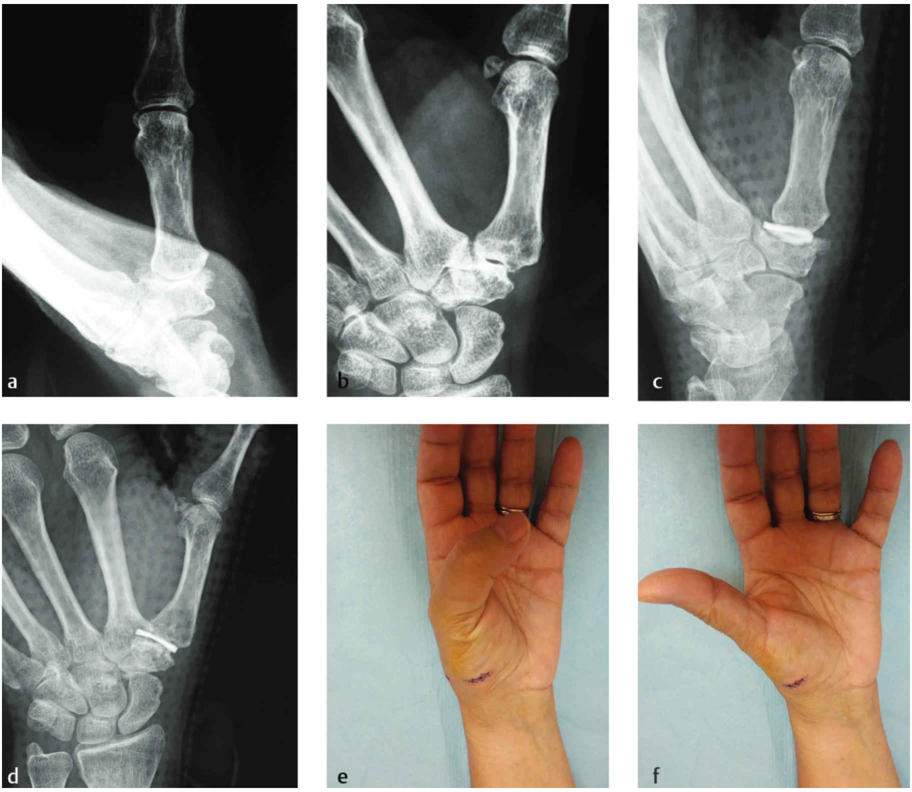


Figure 8.

Example of clinical case: anteroposterior (A/P) **(a)** and lateral **(b)** X-rays of isolated osteoarthritis in the thumb CMC joint with alignment maintained; A/P **(c)** and lateral **(d)** X-rays after interposition of a pyrocarbon spacer; photos of the thumb 7 days after surgery **(e, f)**; the enlarged 1P incision was closed with a few sutures.

6. Closure and Postoperative Care

The capsule is closed with one cross-stitch of resorbable suture and the 1P skin incision is also closed with a suture. A thumb abduction splint is used for about one month before starting rehabilitation.

Conclusion

As long as indications are followed, interposition arthroplasty for thumb CMC arthritis is a straightforward technique for patients; it provides satisfactory results without burning any bridges in case another type of surgery is later necessary.

34.
ARTHROSCOPIC HEMI-DORSAL RADIOCARPAL TENDINOUS INTERPOSTION

MICHEL LEVADOUX
JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

ScaphoLunate Advanced Collapse (SLAC Wrist) is a frequent complication of injury of the Scapholunate ligament. Many treatments have been proposed: partial arthrodesis, proximal row carpectomy, total wrist denervation, etc. However, these methods are invasive and cause significant functional impact and the management of failures has serious consequences on functional outcomes. For patients who want to conserve strength and mobility, we have imagined a new management under arthroscopy. The goal is to perform a styloidectomy and a tendinous radiocarpal interposition. In this article, we present the surgical technique of one-loop arthroscopic radiocarpal tendon interposition (1L-ARTI), a minimally invasive procedure using only dorsal arthroscopic approaches.

Operative technique

1. Arthroscopic exploration and debridement

For this procedure, arthroscopic equipment is necessary, including a 2.4mm arthroscope, a 2.5mm shaver, a 2.5 or 3mm burr, and mosquito-type forceps. A small diameter anchoring device is also required. The operation can be performed under locoregional anesthesia, with a tourniquet, and the patient in a supine position. A traction of 5–7 kg is applied by a hand of Finochietto or by a Chinese finger trap system. Basic instrumentation is required for harvesting a portion of the flexor carpi radialis (FCR) or palmaris longus (PL) tendon, although the presence of a tendon stripper may facilitate removal of the PL tendon. The first operative step consists of assessing the stage of arthritis in the Watson classification with a radiocarpal and midcarpal synovectomy and exploration. SLAC stage III is a contraindication to this technique.

2. Removal of a tendon graft

A PL tendon graft harvest, if present, is performed by two short 5mm incisions or using a stripper. In its absence, the radial half part of the FCR tendon is harvested through two to three incisions between the wrist and the forearm.

3. The "enlarged" styloidectomy

The arthroscope is positioned in 6R or 3-4 and orientated toward the radial styloid. This must be well-individualized by performing sufficient debridement to discern the styloid in the palmar and dorsal aspects. A 1-2 portal is performed and makes it possible to complete and perfect the synovectomy. Once the styloid has been individualized, the styloidectomy can be performed in a classically described manner. However, unlike a conventional styloidectomy, burring must be extended over the entire area devoid of cartilage by abrading with a burr until exposing the subchondral bone (approximately 1–2mm of resection) to obtain a “bloody dew”. This should theoretically induce a potential fibrocartilage regrowth, as well as better integration of the tendon into the bone.

There is no superiority in achieving this, whether in dry or wet conditions. We recommend using both techniques by performing dry abrasion with a wet wash-out.

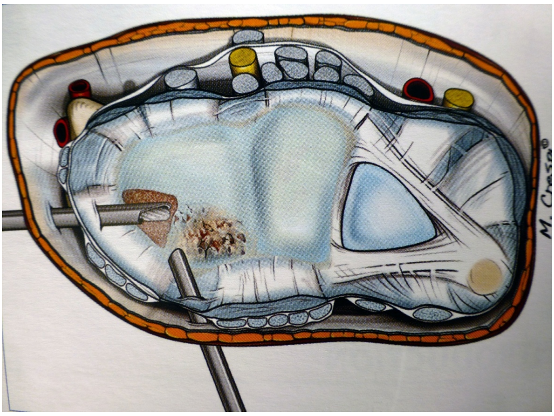


Figure 1.

The enlarged styloidectomy using 1-2 (burr) and 3-4 portals (view).

One of the tendon extremities is "secured" to the anchor using a strong suture, and traction on the other thread of the anchor brings the tendon end deep into contact with the bone intra-articularly. A new suture is made with the anchor suture to permanently immobilize the graft in this position.

At that time, the tendon is positioned within the joint. A closed Halsted forceps is introduced from the 3-4 portal to the 1-2 portal, making its tip protrude through the 1-2 portal. The free portion of the tendon is captured by the forceps and the tendon is gently pulled from 1-2 to 3-4 portals **(Figures 2 and 3)**.

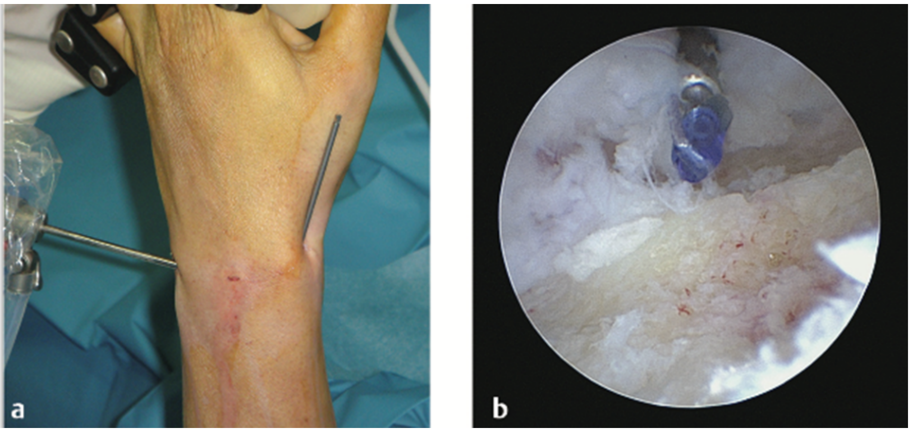


Figure 2.

(a) Intraoperative and (b) arthroscopic views of the suture anchor inserted into the tip of the radial styloid process through the 1–2 portal.

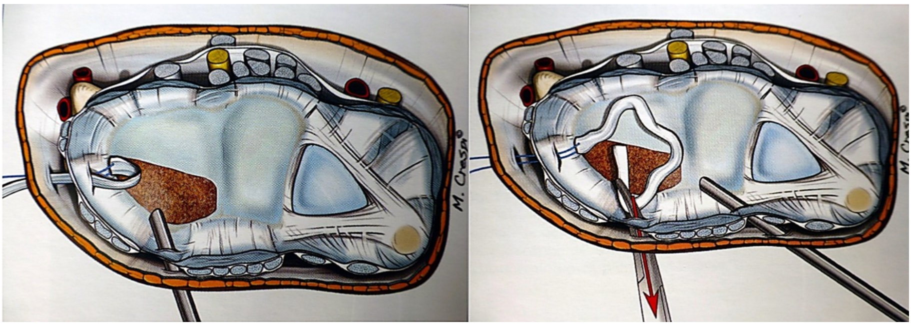


Figure 3.

Suturing one end of the tendon to the anchor (left) and passing the tendon graft from the 1-2 portal to the 3-4 portal (right).

The forceps are then introduced via the 6R portal. However, instead of being introduced inside the joint, it must be directed extracapsularly, between the posterior capsule and the anterior aspect of the extensor tendons, to reveal its tip in the 3-4 portal. The tendon free end is then recovered and then gently pulled toward the 6R portal, constituting the dorsal extracapsular part of the tendon loop **(Figure 4)**.

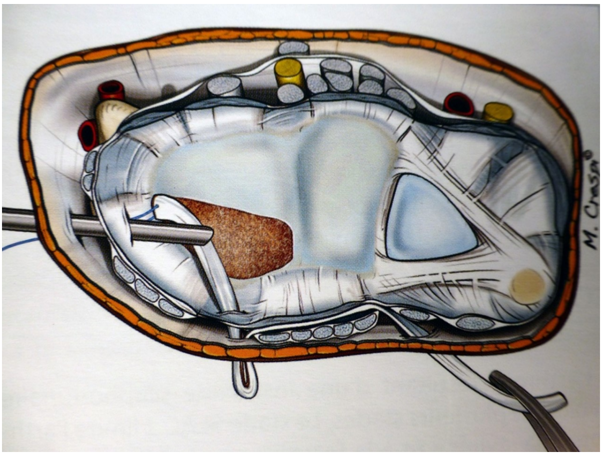


Figure 4.

Passage of the graft from the 3-4 to the 6R portal in between the dorsal capsule and the extensor tendons.

The same process is then performed to move the tendon from 6R to 1-2 **(Figure 5)**.

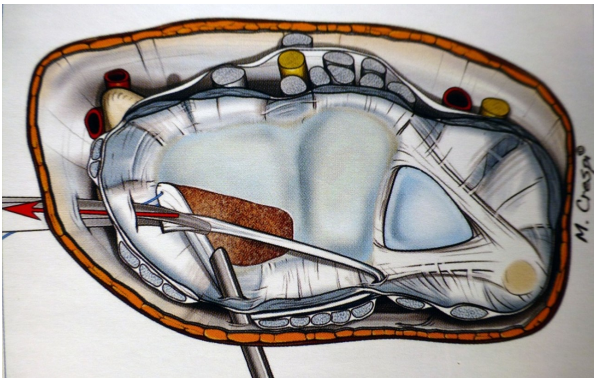


Figure 5.

Passage of the graft from the 6R to the 1-2 portal.

It is then necessary to remove traction and stretch the transplant as much as possible to promote a real dynamic interposition effect. The protruding part is then sutured to the anchor as deeply as possible to prevent any "relaxation" of the device **(Figures 6 and 7)**.

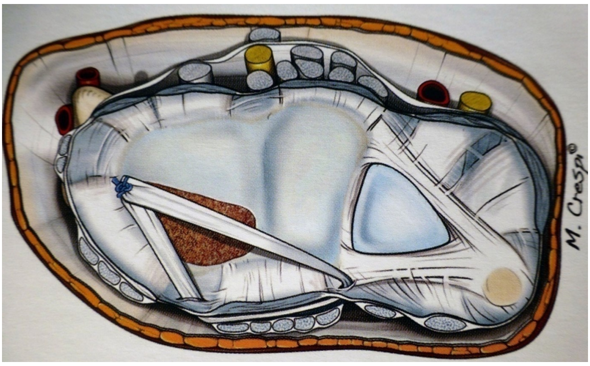


Figure 6.

Final assembly with the complete dorsal loop.

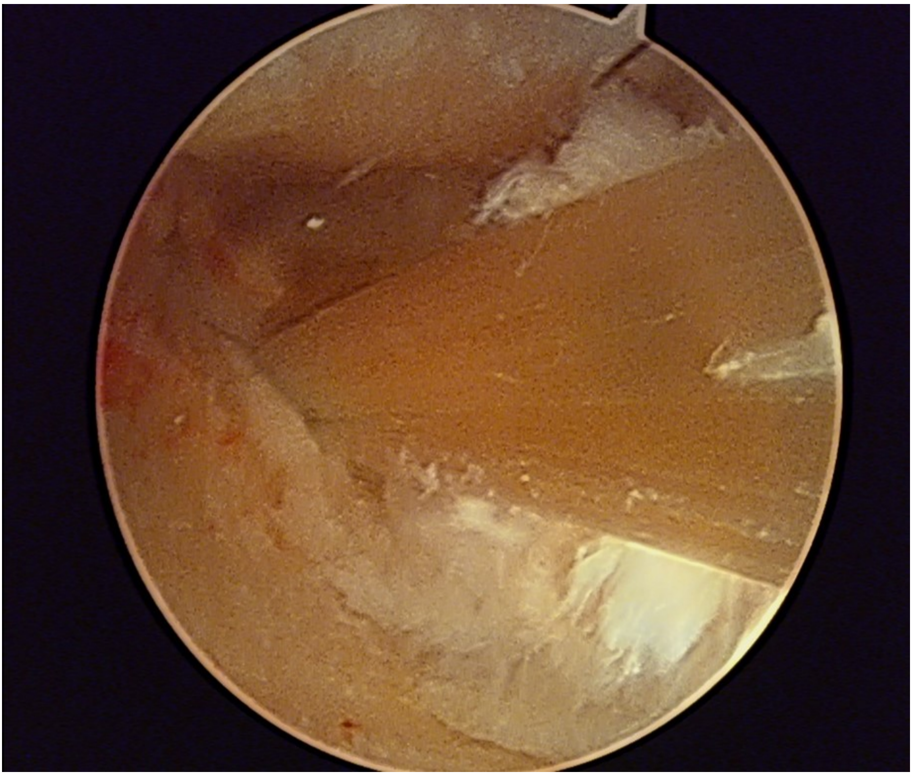


Figure 7.

Arthroscopic view of the radiocarpal tendon interposition.

The wrist is then immobilized for 10 days, after which immobilization is removed and patients are asked to move their wrist without restriction, except for pain. A postoperative X-ray is performed to ensure the increase in the radioscaphoid space and to also ensure the correct positioning of the anchor. A six-week follow-up is necessary to ensure good outcomes **(Figure 8)**.

Figure 8.

Personal case. Note not only the presence of osteoarthritis but also of an uncommon radiocarpal space in correspondence to this marked radiocarpal osteoarthritis.

Tips & tricks

- In case of lack of PL, the removal of the radial half of the FCR can be facilitated using a steel wire. A surgical loop must be passed underneath the entire FCR tendon to tension the tendon apparatus and facilitate traction on the thread which, like a butter-cutting thread, will divide the tendon into two equivalent strips. To stretch the tendon during the harvest, the wrist should be hyperextended.

- At the end of the styloidectomy, an increasingly marked and deep anterior footprint is made with a burr over 2mm to prevent slipping on the very oblique styloid rim and to allow a better grip of the anchor, which will be introduced via the 1-2 portal.

- To be sure not to "entrap" extensor tendon with the tendon graft and to ensure the correct passage of the tip, the scope is introduced in 1-2 and ensures extracapsular passage; the tip of the curved forceps is then orientated opposite of the tendons and the correct path of the forceps is followed arthroscopically.

Conclusion

Arthroscopic styloidectomy and interposition represent an efficient alternative method to treat SLAC stage I and SLAC stage II but also SCAC I and SCAC II. This method of treatment does not "burn the bridge" for a conventional treatment.

This surgery seems to have few complications for a real effect on pain without progression of stiffness.

The method can be probably improved with a double loop, one dorsal and one volar, to treat the distal intra-articular radius malunion when arthritis is not only limited to the dorsal rim of the radius.

Video 24: Arthroscopic radiocarpal tendinous interposition
https://vimeo.com/917909600

35. ARTHROSCOPIC INTERPOSITION ARTHROPLASTY IN STAGE II SCAPHOLUNATE ADVANCED COLLAPSE WRISTS

CHRISTOPHE MATHOULIN

Introduction

Arthritis secondary to scapholunate (SL) ligament rupture has been divided into four stages. In a stage II scapholunate advanced collapse (SLAC) wrist, only the scaphoid fossa of the radius is arthritic **(Figure 1)**. The gold standard treatment consists of proximal row carpectomy. However, it is a fairly aggressive and definitive treatment. To prevent or delay this inevitability, an arthroscopic technique can be used that combines styloidectomy, SL gap stabilization, and interposition arthroplasty between the first and second row of carpal bones.

Figure 1.

X-ray of a patient with stage II SLAC wrist secondary to SL dissociation; there is a visible gap between the scaphoid and the lunate, and osteoarthritis between the scaphoid and the scaphoid fossa of the radius; however, the midcarpal joint is intact.

Operative Technique

1. Patient Preparation and Positioning

The procedure is performed under regional anesthesia. The patient's arm is secured to the arm board. An atraumatic hand holder is used to apply 5 to 7 kg (11–15.5 lbs) of traction along the arm's axis.

2. Harvesting the Tendon Graft

The tendon graft must be strong and long enough to stabilize the distal radioulnar joint (DRUJ), and thin enough to pass through the bone tunnels. Usually, a palmaris longus (PL) tendon graft suffices. However, in case the PL is absent, a hemi flexor carpi radialis or a plantaris tendon graft may be harvested. The PL tendon graft is harvested through a small incision at the distal flexion crease of the wrist joint at the base of the carpal tunnel. A tendon stripper is used to harvest the graft. A grasping suture is applied to the two ends of the tendon graft using 4/0 Ethilon or similar non-braided suture material. The suture is passed several times (Krackow suture), about 1.5cm on both ends of the tendon graft in order to create a strong grasping suture construct, and the ends of the suture are left long for retrieval while passing the tendon graft through the transosseous tunnels.

3. Debridement and Exploration of Radiocarpal Joint

The radiocarpal joint is typically affected by significant synovitis, often with accompanying bone and cartilage fragments. The sheath and arthroscope are inserted through the 3–4 portal. The shaver is inserted in the 6R portal to start debriding the medial side of the radiocarpal joint. The synovectomy is completed once the positions of the scope and of the shaver are reversed. All cartilage fragments must be removed.

4. Styloidectomy

The scope can be placed either in the 3–4 or 6R portal; both portals can be used if need be. The joint assessment often reveals that the cartilage on the scaphoid fossa of the radius – and on the proximal pole of the scaphoid – is completely gone **(Figure 2)**. All other cartilage surfaces will be intact.

Figure 2.

Arthroscopic view of the radiocarpal joint showing the lack of cartilage on the proximal aspect of the proximal pole of the scaphoid and the scaphoid fossa of the radius.

After locating the 1–2 portal with a needle, the shaver is inserted to complete the synovectomy around the radial styloid process. A burr is used to perform the styloidectomy as in a typical arthroscopic styloidectomy procedure **(Figure 3)** (see Chapter 7). The styloid is resected at an angle while preserving the volar and dorsal attachments of the extrinsic ligaments (dorsal radiocarpal and radioscaphocapitate).

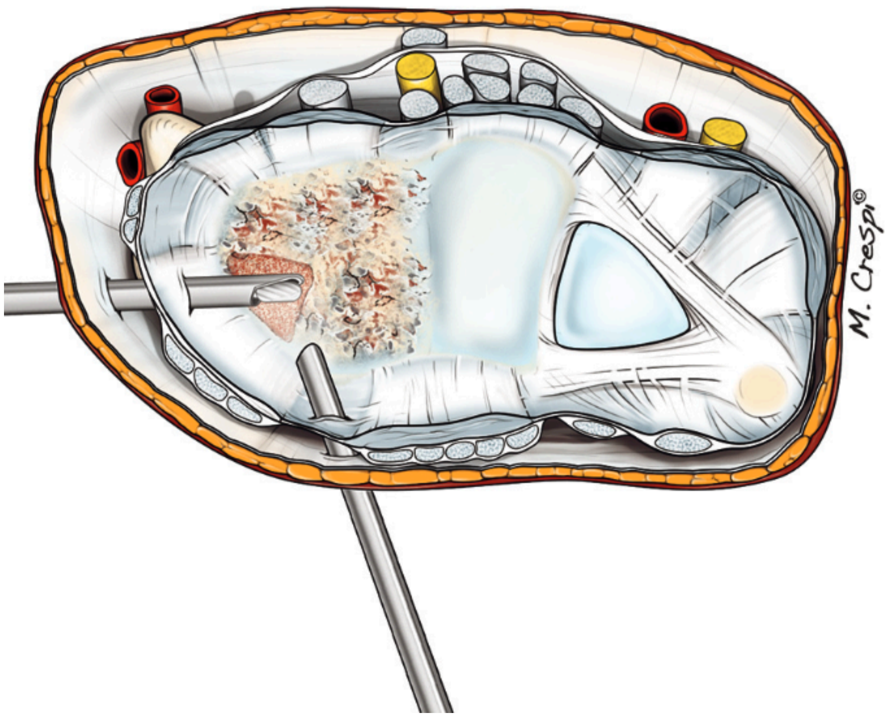


Figure 3.

Drawing of the PL graft attached to the anchor sutures.

After styloidectomy, a suture anchor is introduced via the 1–2 portal and inserted into the tip of the styloid process under arthroscopic control **(Figure 4)**. The anchor's sutures are externalized via the 1–2 portal and will be used to secure the tip of the V-shaped interposition implant.

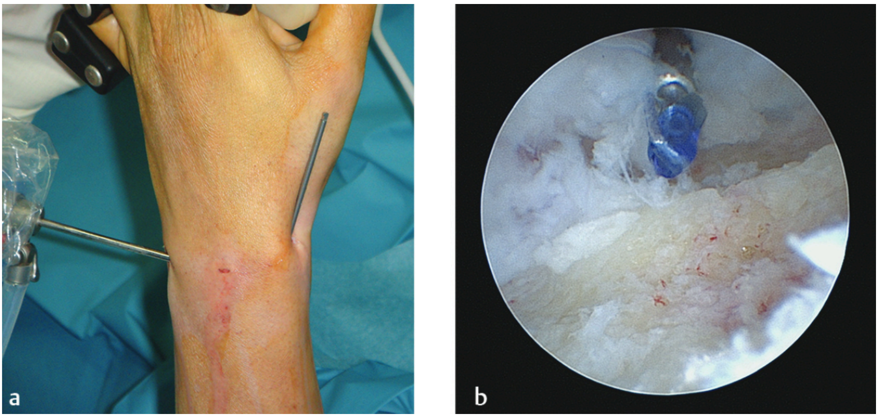


Figure 4.

(a) *Intraoperative and* **(b)** *arthroscopic views of the suture anchor inserted into the tip of the radial styloid process through the 1–2 portal.*

5. Stabilization of SL Joint Space

Repairing the SL ligament at that stage is unrealistic. However, dorsal capsule-to-ligament suture repair (see Chapter 17) can be used to stabilize the SL joint to prevent any further degradation. It is performed using the same technique as for SL ligament repair in less advanced SLAC cases. It is rare to find the dorsal SL ligament stump still attached to the scaphoid. The following technical tricks can be used instead: (1) We catch a large part of the dorsal capsule, proximally and dorsally, to constrict the capsule and reduce the SL space. Proximally, the two needles pass through two different points on the capsule approximately 1cm apart. It is sometimes necessary to extend the 3–4 radiocarpal portal to protect the extensor tendons. Distally, the radiomidcarpal portal is also extended. Two different openings, 1cm apart, will be necessary to pass the mosquito forceps (Chapter 17). The distal knot stays outside of the dorsal capsule. With the final knot, constriction of the dorsal capsule avoids the need for K-wires. An anchor is inserted into the dorsal distal part of the proximal pole (Chapter 17). The suture in the anchor is used as the first suture for dorsal capsuloligamentous repair. Another suture is added, as in the conventional technique, and used to catch a large part of the dorsal capsule to achieve reduction, as described in Chapter 17. The final phase of the dorsal capsule-to-ligament repair will be performed at the end of the procedure.

6. Preparation for Interposition Arthroplasty

A PL graft is typically used for this step, but other tendon grafts can also be used. The two ends of the graft are loaded with an absorbable suture, typically 3/0 Vicryl®. The sutures associated with the anchor in the radial styloid process will be attached to the tip of the V **(Figure 5)**.

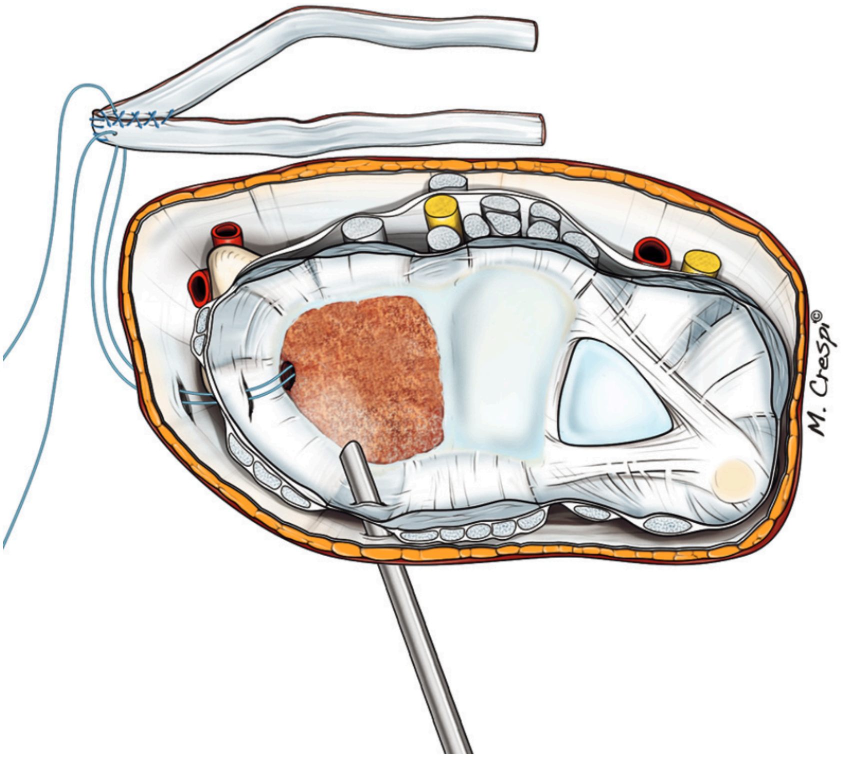


Figure 5.

Drawing showing the sutures associated with the anchor in the radial styloid process that will be attached to the tip of the graft.

7. Passage of the Implant's Dorsal Portion

The first suture at the dorsal end of the graft is passed intra-articularly using mosquito forceps from the 1–2 portal to the 3–4 portal **(Figure 6)**. The graft's marking suture is passed extra-articularly from the 3–4 portal to the 6R portal, volarly to the extensor tendons **(Figure 7)**. Lastly, the suture is loaded in the mosquito forceps, which is introduced inside the joint through the 6R portal and then externalized by the 1–2 portal **(Figure 8)**. The second end of the graft follows the same path.

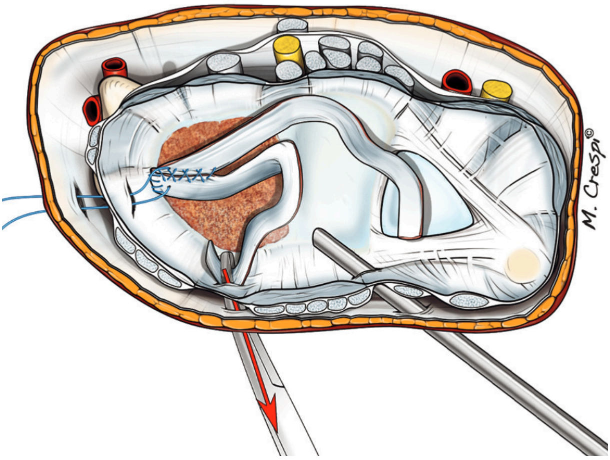


Figure 6.

Drawing showing the first step of the dorsal passage of the implant from the 1–2 portal to the 3–4 portal.

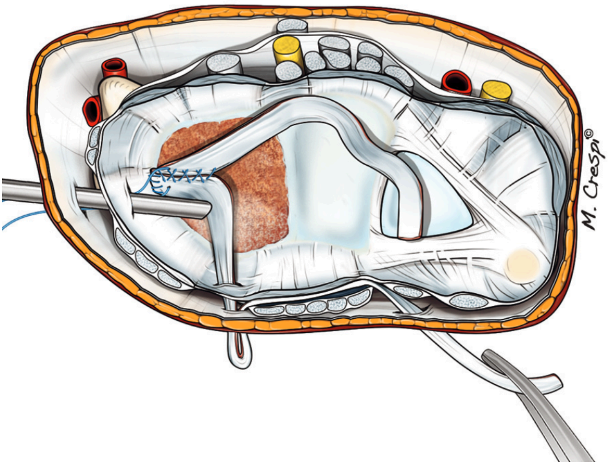


Figure 7.

Drawing showing the second step of he dtorsal passage of the implant from the 3–4 portal to the 6 R portal extra-articularly.

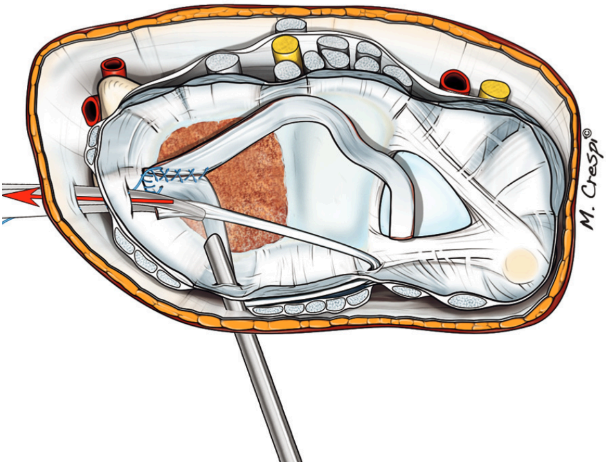


Figure 8.

Drawing showing the last step of the dorsal passage of the implant from the 6R portal to the 1–2 portal.

8. Passage of the Implant's Volar Portion

After making the 1–2 portal incision slightly wider (1–2cm), the radial pedicle and the flexor carpi radialis are reflected forward. Long mosquito forceps are loaded with one of the sutures at the end of the graft, and then passed through the 1–2 portal toward the volar aspect, while staying outside the capsule **(Figure 9)**. With the scope in 6R, the forceps enter the joint between the radioscaphocapitate ligament and the long radiolunate ligament, or even better, on the ulnar side of the long radiolunate ligament. This suture is retrieved through the 1–2 portal using mosquito forceps and externalized by the 1–2 portal **(Figure 10)**. Traction is applied to this suture until the graft is positioned correctly inside the joint.

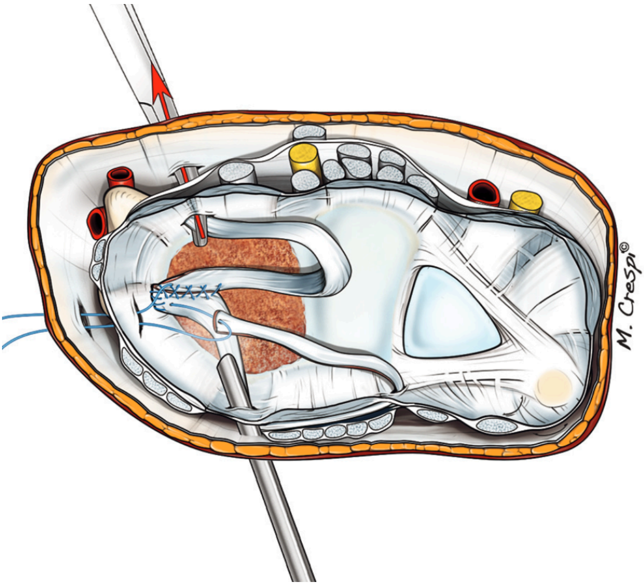


Figure 9.

Drawing showing the first step of the volar passage of the implant from the 1–2 portal to the volar radial portal.

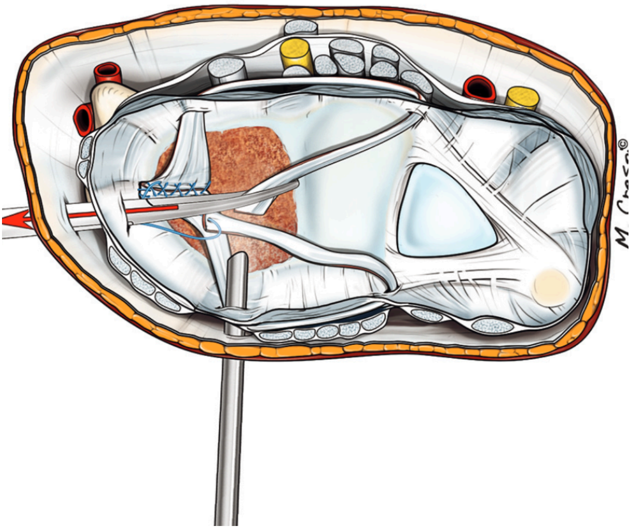


Figure 10.

Drawing showing the last step of the volar passage of the implant from the 1–2 portal to the volar radial portal.

9. Stabilization of Tendon Graft

The two ends of the graft are tied together and secured to the styloid process using the sutures from the anchor **(Figure 11)**.

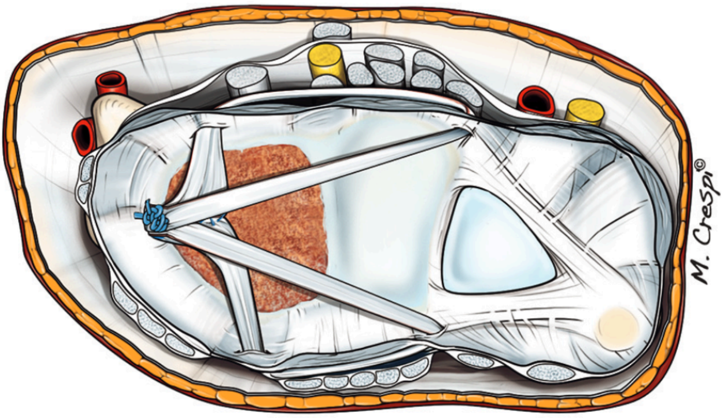


Figure 11.

Drawing showing the last step of the dorsal passage of the implant from the 6R portal to the 1–2 portal.

10.Closure and Postoperative Care

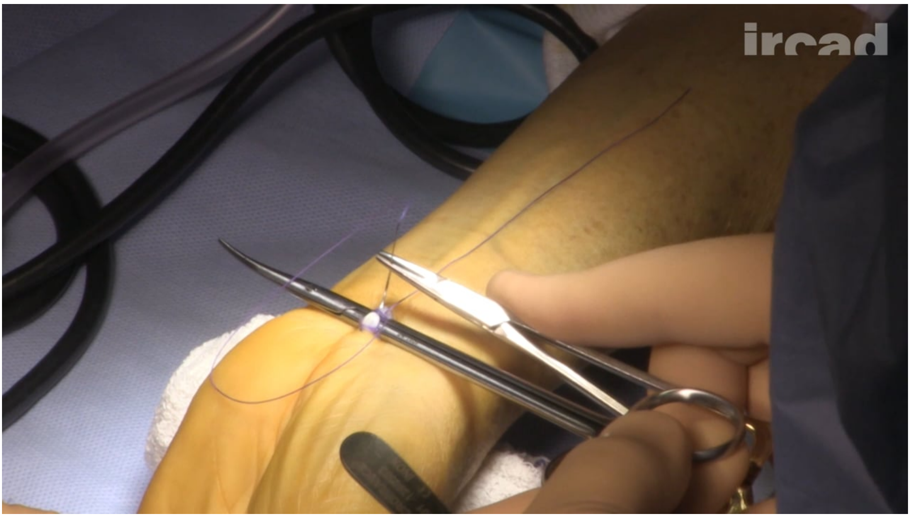
After releasing traction on the hand, suture stabilization of the SL ligament is performed with the wrist extended. The incisions are typically left to heal by first intention. If the 1–2 portal is extended to insert the implant, one or two sutures may be required to close it. A volar splint is worn in the resting position (between a 45 and a 60-degree extension) for 45 days.

Conclusion

Although arthroscopic interposition arthroplasty is a tricky technique, it is a straightforward solution for patients with stage II SLAC wrists. It does not burn any bridges with other palliative techniques and recreates the radiocarpal joint space in a way that provides the patient with pain-free function **(Figure 12)**.

Figure 12

X-rays before surgery **(a)** and at 5 years postoperatively **(b)** of a patient with a stage II SLAC wrist.



Video 25: Arthroscopic interposition in scapholunate advanced collapse wrist arthritis, stage II (SLAC II)
https://vimeo.com/270047978

36.
ARTHROSCOPIC ARTHROLYSIS OF THE WRIST

JANE MESSINA

JEAN-BAPTISTE DE VILLENEUVE DE BARGEMON

Introduction

Intra-articular wrist fractures (radius and scaphoid) and, occasionally, the repair of intrinsic ligaments (even arthroscopic ones) can lead to wrist stiffness due to intra-articular fibrosis, which is more severe in the radiocarpal than the midcarpal joint. Open surgical arthrolysis itself produces postoperative fibrosis, which limits its effectiveness. Arthroscopy precludes this pitfall by cleaning out the joint without affecting the joint capsule and by enabling immediate recovery of the patient's range of motion.

Operative technique

1. Debridement of the Medial Radiocarpal Joint

The procedure is performed under regional anesthesia. The range of flexion and extension is measured under regional anesthesia to control the true nature of the stiffness. The arm is then secured to an arm board and an upward traction of 5 to 7kg (11–15.5 lbs) is applied to the hand and forearm.

The 3–4 radiocarpal portal is used first. The sheath and the scope are placed at a slightly medial angle toward the triangular fibrocartilage complex (TFCC). In most cases, the view of the joint is impaired by significant fibrosis. A needle is introduced through the 4–5 portal and an attempt is made to find its distal tip at the end of the scope **(Figure 1)**. A shaver is inserted through the 4–5 portal and the position of the distal end is located without moving the scope. The view gradually improves as intra-articular fibrosis is removed **(Figure 2)**. This entire medial area is debrided to fully release the TFCC. In some cases, a secondary 6R portal may be required.

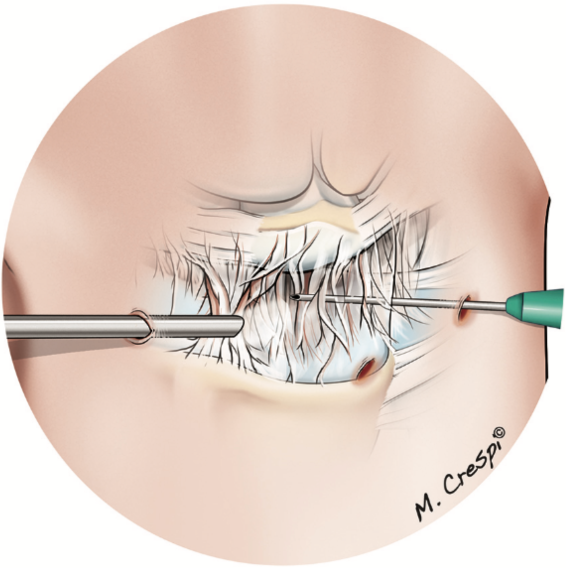


Figure 1.

Drawing showing the difficulties encountered when trying to locate the needle in the radiocarpal joint due to extensive fibrosis

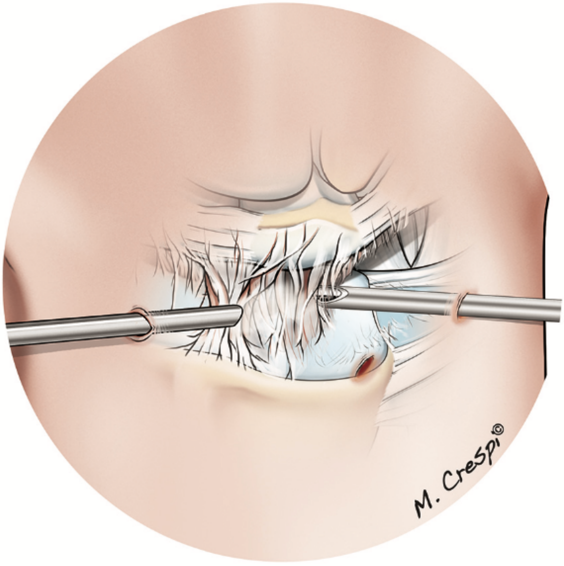


Figure 2.

Drawing showing fibrosis gradually resected with a shaver.

2. Resection of the Fibrous Radiocarpal Wall

Once the medial part of the joint has been completely cleaned out, the scope is inserted into the 6R portal. In many cases, there will be a fibrotic wall between the scapholunate ligament and the ridge separating the scaphoid and lunate facets of the radius. This wall can be very thick (**Figure 3**). The wall is completely cut away using Stevens tenotomy scissors from dorsal to volar (**Figure 4**).

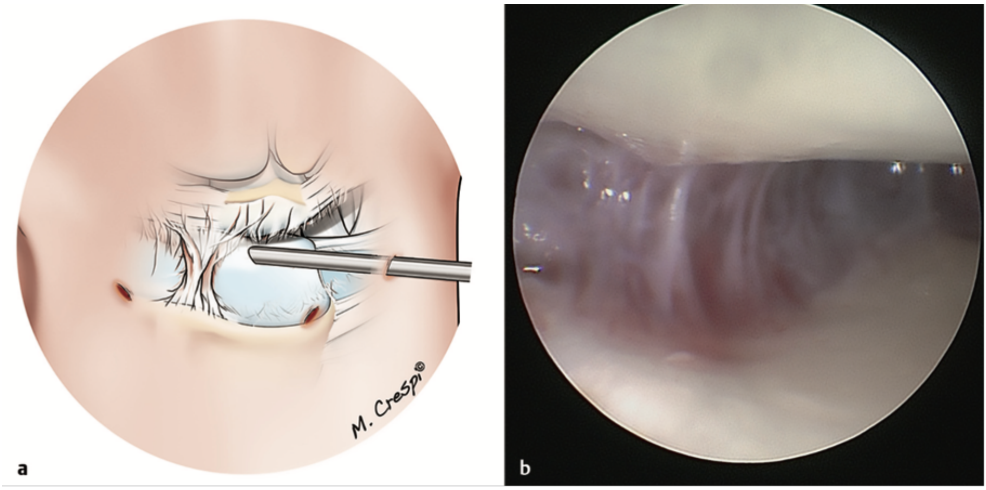


Figure 3.

Drawing (a) and arthroscopic view (b) of the fibrotic wall between the scapholunate interosseous ligament and the ridge between the lunate and scaphoid facets on the radius.

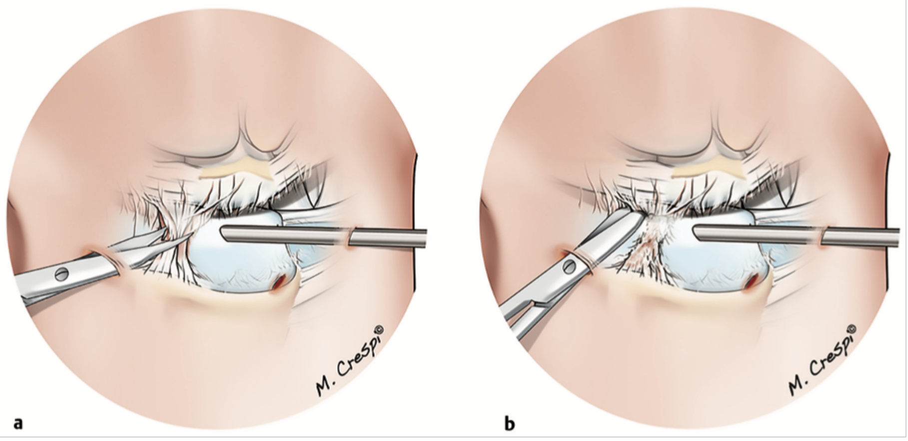


Figure 4.

a) Drawing showing fine tip scissors used to initially cut into the fibrotic wall. (b) Drawing showing the last part of the fibrotic wall cut with scissors.

3. Debridement of the Radiocarpal Dorsal Recess

After cleaning the rest of the joint, the final step of radiocarpal debridement consists of separating adhesions between the dorsal capsule and the first row of carpal bones (**Figure 5**). The scope remains in the 6R portal. The dorsal part of the joint capsule can be inspected through triangulation and the scope's angulation. The shaver is introduced into the 3–4 portal to release all adhesions between the proximal row and the capsule, starting at the lunate and moving toward the scaphoid, making sure that the entire dorsal recess of the joint has been freed. It is crucial not to cut the dorsal capsuloscapholunate septum (DCSS), which is located between the capsule and the dorsal portion of the scapholunate ligament. The DCSS is of utmost importance to stabilize the scapholunate joint.

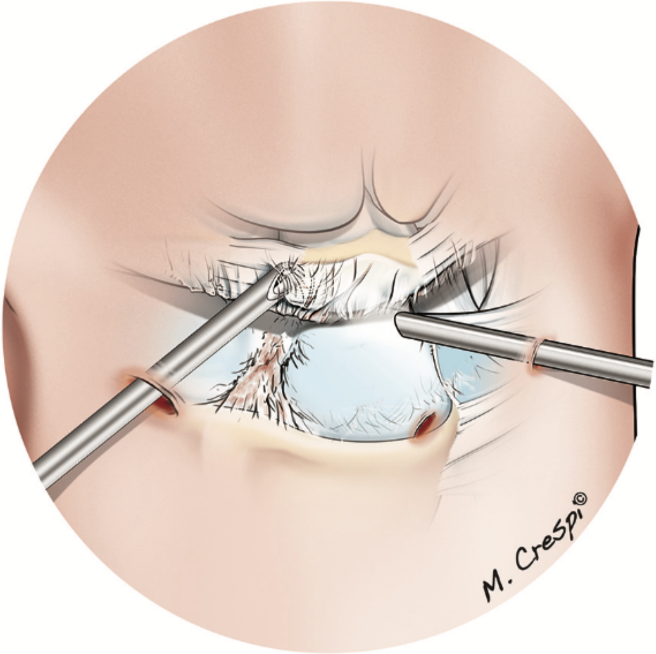


Figure 5.

Drawing showing a shaver used to resect the fibrosis located in the dorsal recess of the joint capsule.

4. Inspection of the Radiocarpal Joint

The scope is placed in the 6R and then in the 3–4 portal. The joint is inspected from the styloid recess of the TFCC to the radial styloid process to make sure that no adhesions remain. If the arthrolysis procedure is hemorrhagic, a suitable radiofrequency probe is used to achieve hemostasis in any areas of the capsule that are bleeding.

5. Debridment of the Midcarpal Joint

Wrist stiffness is much more rarely ascribable to the midcarpal joint, and any fibrosis in this joint is rarely significant. The scope is introduced through the midcarpal ulnar portal. The shaver is introduced through the radial midcarpal (MCR) portal and the joint is completely cleaned out. The position of the scope and of the shaver are then reversed to complete the debridement. The dorsal part of the joint capsule is completely released at the carpometacarpal joint. If need be, the instruments may remain in the same portals but shifted into the scaphotrapeziotrapezoidal (STT) joint to remove any adhesions between the scaphoid and the capitate. In this particular instance, the 1–2 STT portal can be used to complete the arthrolysis.

6. Postoperative Care

The hand traction is released, and the range of motion in flexion and extension is then measured to determine any improvement. A simple dressing is placed on the wrist and rehabilitation is started immediately.

Conclusion

The presence of intra-articular fibrosis, especially in the radiocarpal joint, is not unexpected during recovery from intracarpal trauma involving bones and ligaments. Arthroscopic arthrolysis is a challenging procedure from a technical standpoint. However, patients are extremely satisfied with the procedure since it is usually completely painless.

37.

PARTIAL WRIST FUSION – ARTHROSCOPIC ASSISTED

EVA-MARIA BAUR

JEAN-BAPTISTE DE VILLENEUVE BARGEMON

Introduction

There are different intercarpal fusions according to different indications. The technique is always more or less the same. The most common ones include midcarpal fusions with scaphoidectomy and two or three or four bone fusions (2CF, 3CF, 4CF). The indication is advanced carpal collapse due to chronic SL lesions or scaphoid nonunions or osteoarthritis following chondrocalcinosis. Isolated midcarpal osteoarthritis and/or severe instability could also be indications. Partial wrist fusion is a definitive palliative treatment used in cases of advanced wrist arthritis, which is most often secondary to scapholunate ligament injuries (SLAC wrist) and scaphoid nonunion (SNAC wrist). This procedure is recommended for stage III SLAC and SNAC cases. The exact nature of the fusion will depend on the quality of the remaining cartilage. The advent of cannulated self- tapping screws has greatly simplified such procedures. Scaphocapitate fusion is mainly indicated in advanced Kienbock's disease **(Figure 1)**.

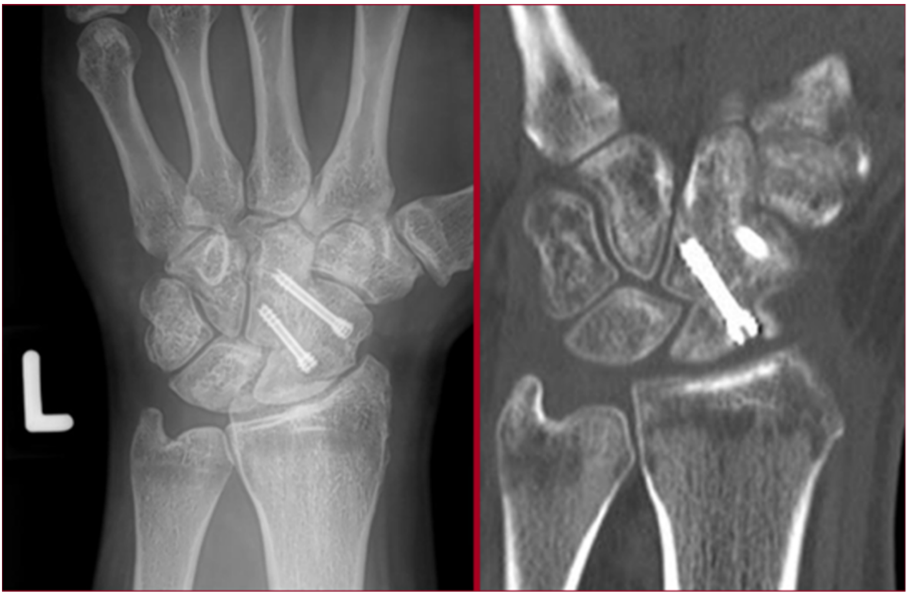


Figure 1.

CT-scan image of frontal sections of scaphocapitate arthrodesis performed arthroscopically with bone grafting from the iliac crest.

Operative technique

The procedure is performed in two phases: an open procedure to excise the scaphoid and then a fully arthroscopic procedure to perform arthrodesis. An open technique is used for scaphoidectomy since excision is faster than when performed arthroscopically, although the final result is similar. The second part of the procedure (i.e., the arthroscopy phase) is performed with the arm secured to an arm board and traction applied along the hand axis with an atraumatic hand holder.

1. Scaphoidectomy

Only a plain distal lateral volar incision over the scaphoid tubercle is necessary here. This incision can be either horizontal or longitudinal. The volar scaphotrapezial ligaments are always more difficult to cut if a dorsal approach is used. After cutting such ligaments, a bone rasp and a spatula can be used to excise all or part of the scaphoid bone.

In cases of SL ligament injury sequelae, the SL ligament is torn and the entire scaphoid fossa of the radius is arthritic. The scaphoid bone is removed as a single piece. In cases of scaphoid nonunion sequelae, only the radial styloid is arthritic; the segment of the scaphoid fossa of the radius across from the pole will be intact. The proximal pole remains attached to the lunate by the SL ligament. In such cases, only the distal part of the scaphoid is removed (**Figure 2**). The incision is reclosed layer by layer (**Figure 3**). Grafts can be harvested from the resected scaphoid bone. A corkscrew or drilled wire may be helpful for this procedure (**Figure 4**).

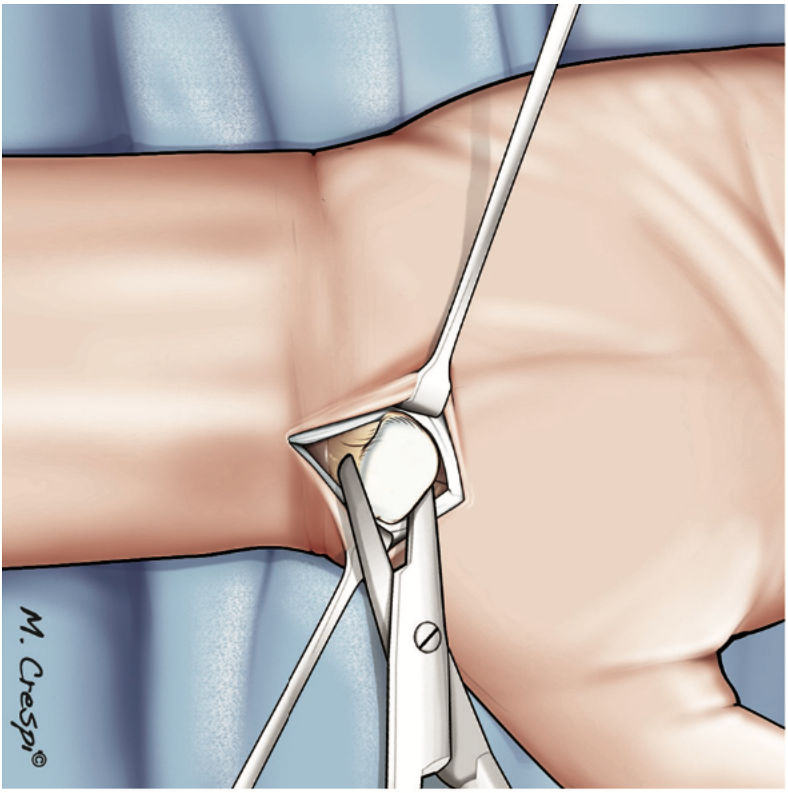


Figure 2.

Drawing showing the scaphoid excised in one piece; a distal fragment in a stage III SNAC wrist is shown here.

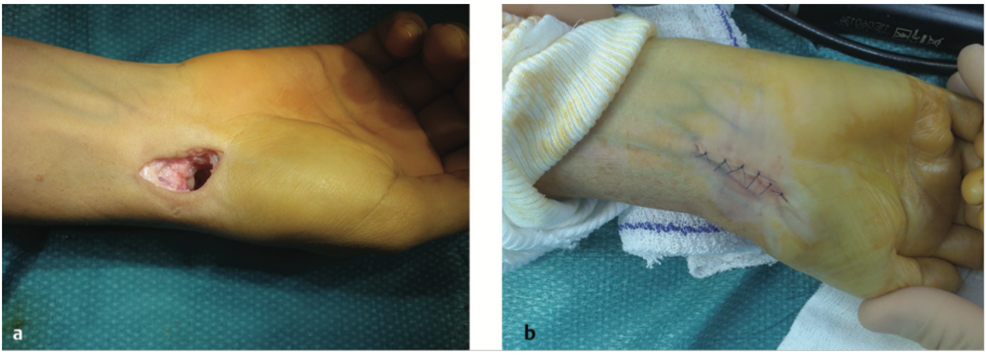


Figure 3.

Intraoperative view of the distal volar incision before the skin and capsule are closed (a) and after suturing is complete (b).

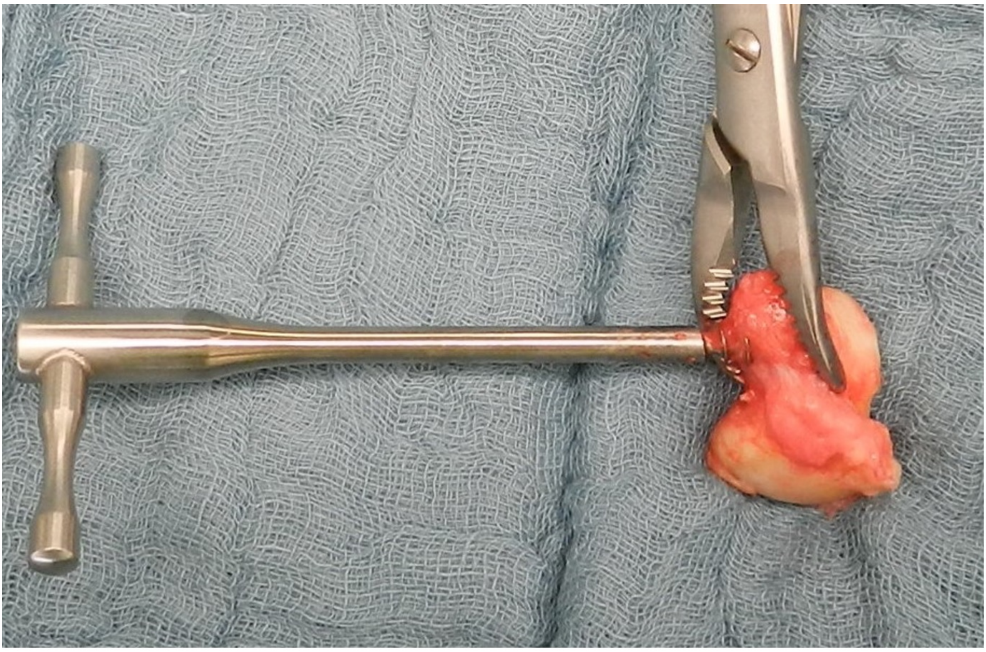


Figure 4.

Carpal stick (courtesy of KLS Martin).

2. Exploration of radiocarpal and midcarpal joint

Traction is placed on the wrist using an atraumatic hand holder and 5 to 7 kg (11–15.5 lbs) of counterweight. The 3–4 portal is used to explore the radiocarpal joint. The main purpose is to inspect the lunate fossa of the radius and to assess the quality of the lunate cartilage and the radiocarpal (especially radiolunate) joint.

In stage III SNAC wrists, the proximal pole of the scaphoid and the cartilage across from the scaphoid fossa of the radius must also be inspected. At that stage, a styloidectomy may be required. If so, a burr is introduced through the 1–2 portal to resect the radial styloid process without disturbing the volar and dorsal attachments of the extrinsic ligaments (dorsal radiocarpal and radioscaphocapitate). The arthroscope and the sheath are introduced through the midcarpal ulnar (MCU) portal. The shaver is introduced through the midcarpal radial (MCR) portal to debride the joint, which may show signs of extensive synovitis. The shaver and the scope are reversed to debride the remainder of the joint.

3. Preparation for Arthrodesis

The scope is returned to the MCU portal. A burr is introduced into the MCR portal to resect the surface of the capitate and of the lunate until bleeding subchondral bone is visible (**Figure 5**).

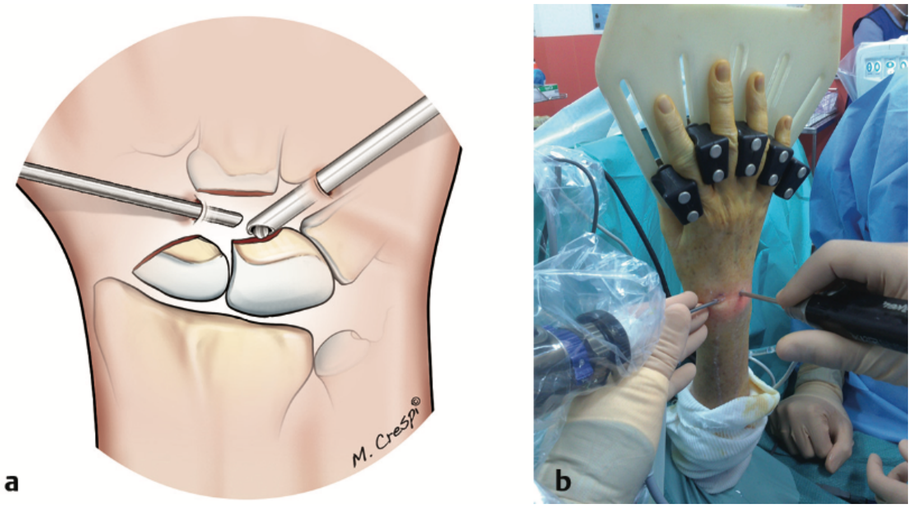


Figure 5.

Drawing (a) and intraoperative view (b) of cartilage and bone resected from the bones fused in the midcarpal joint so that bleeding subchondral bone is exposed.

It is key to then start resection of the midcarpal joint surfaces (capitolunate or capito-hamato-lunate or capitolunate and hamatotriquetrum). In cases of stage III SNAC wrists, the remaining distal segment of the proximal pole of the scaphoid must also be resected. A scapholunate-capitate fusion will eventually be performed. A four-corner fusion will be performed in cases of stage III SLAC wrists (**Figure 6**).

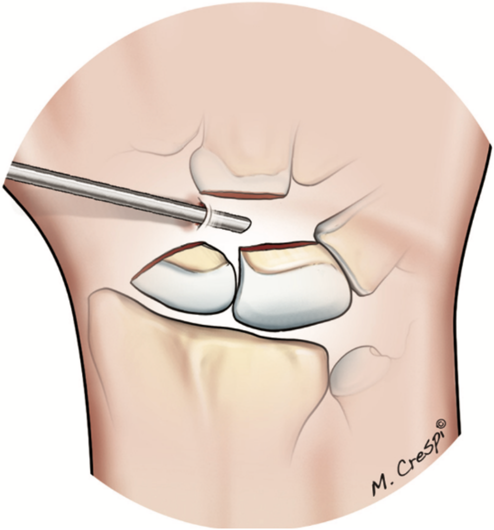


Figure 6.

Drawing showing the final arthroscopic control of scapholunate-capitate fusion in a stage III SNAC wrist.

The scope and burr positions are reversed to resect the head of the hamate and distal aspects of the triquetrum until the bleeding bone is exposed. We recommend not to resect the joint surfaces between the capitate and the hamate and between the lunate and the triquetrum – it means a 2 by 2 column fusion in case of 4CF. An oval or big round burr makes this step faster and more effective.

4. Hamate resection

If an isolated lunocapitate or scapholunate-capitate fusion will be performed, especially without a graft, the hamate can impinge with part of the lunate and cause residual pain, particularly in patients with a Viegas type II lunate. In this case, it is useful to resect the proximal head of the hamate with a burr in the MCU portal and the scope in the MCR portal.

5. Addition of Bone Graft

The arthrodesis procedure can be performed with or without a bone graft. However, adding a graft preserves carpal height, especially when performing scapholunate-capitate fusion. The scope is placed in the MCU portal. A shaver is used to complete the debridement of the joint. Any fluid in the joint must be aspirated completely. From that stage onward, the procedure is performed in a dry environment. Graft material is placed between the first and second row of carpal bones using the burr's barrel or a trocar. The graft material is pushed into the joint (**Figures 7 and 8**). The scrub technician or the assistant mills the scaphoid and prefills the tubes, coming from cut cups of normal cannulas (**Figure 9**).

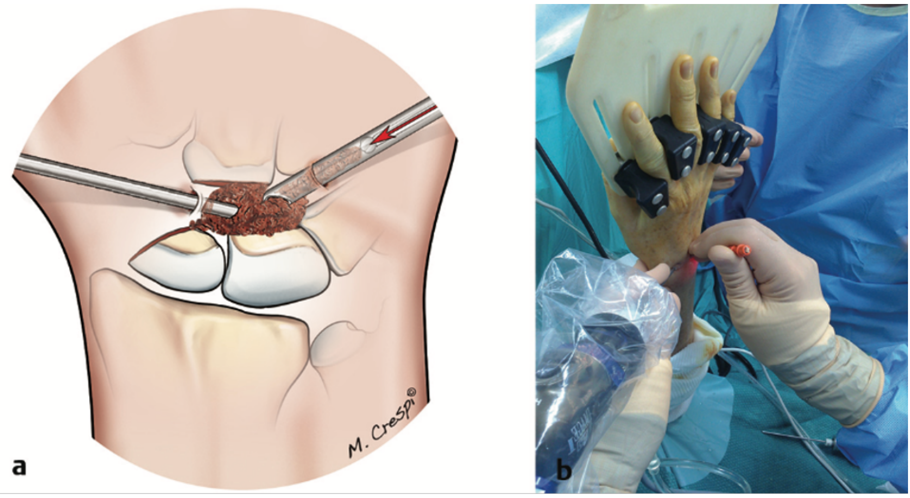


Figure 7.

Drawing (a) and intraoperative view (b) of bone graft material (harvested from the excised scaphoid) placed in the fusion area.

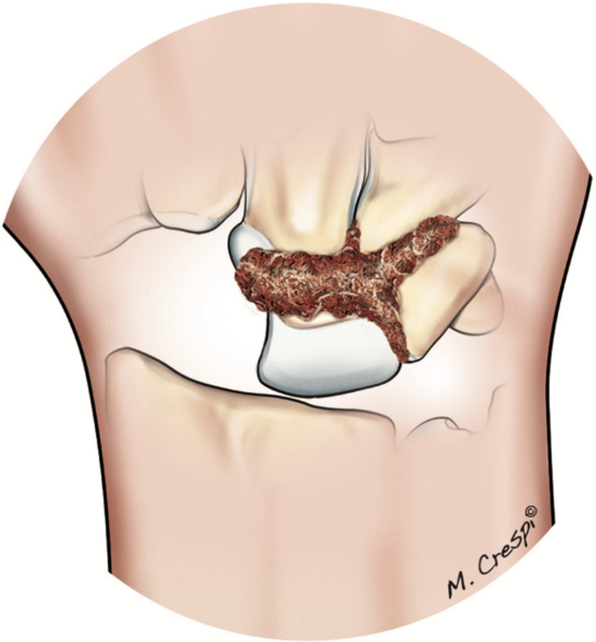


Figure 8.

Drawing showing the bone grafts in place for a four-corner fusion.

Figure 9.

The "Gun Barrel Trick". Left: Bone graft taken from the radius; Right: 20-Gauge syringe cut at a bevel and filled with bone graft material. The caps can be filled using an operating aid, which saves operating time. The caps are then introduced via the arthroscopic portal. The metal introducer of the arthroscope is used as a pusher to introduce the graft into the joint.

6. Fixation of Arthrodesis

Fixation is performed with dual thread cannulated, self-tapping screws (2–3mm in diameter) that compress the bones together. Kirschner wires are inserted under arthroscopic or fluoroscopic control, depending on the type of fixation chosen. In the meantime, the surgeon reduces the malposition of the carpal bones, especially of the lunate, according to the Linscheid maneuver to stabilize this temporarily with a radiolunate 1.4mm K-wire. Hamate-triquetral and capitolunate fixation is typically used, but this depends on the surgeon's preference: hamate-lunate and triquetrocapitate fixation, four-corner fusion, fixation between the capitate, scaphoid, and lunate in SNAC III wrists, etc. (**Figure 10**).

After releasing wrist traction, the cannulated screws are placed under fluoroscopic control through small skin openings. Compression is provided via the screws.

<u>Regarding the osteosynthesis technique and decision-making for K-wires and/or screws:</u>

First, use a 1.4mm K-wire, since the wires from the cannulated screws are only 1.0 or 1.1mm thick and so very soft in the hard carpal bones. We do not always find the way where you want to put them.

If this wire is sitting “perfect” in all planes (fluoroscopy):

1) You can replace it with 1.0/1.1mm K-wire.

2) Drill over for the cannulated screw.

3) And put the screw in place.

If the 1.4mm K-wire is not perfect for screwing, but good enough, leave the 1.4mm K-wire in and restart with the next 1.4mm K-wire.

For the 2 or 3 or 4 bone fusion, we did not find ANY difference in bony healing using K-wires or screws. We no longer use crossing screws throughout the two columns as the longitudinal joints are not fused. K-wires are alright there, since they will be removed after a while.

K-wires may be removed, if they produce soft tissue problems, otherwise you can also remove them after 6 to 12 months.

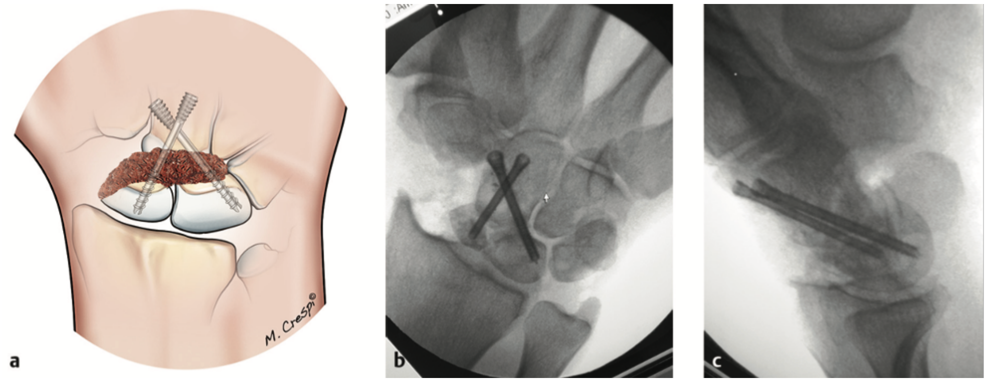


Figure 10.

Drawing (a) and A/P (b) and lateral (c) intraoperative X-rays of the fixation of a scapholunate-capitate fusion with cannulated screws in a stage III SNAC wrist.

7. Closure and postoperative care

None of the small dorsal incisions need to be closed. An anterior splint is worn until the bones have fused, typically 6 to 8 weeks later. Start (active!) exercise from week 3 or 4. This is not so important than in open access due to less/no scarring of the dorsal capsule and extensor tendons. Rehabilitation is initiated after bone union.

For control of bony healing and/or hardware: CT-scan in every patient after 6-8 weeks to check bony healing and in any doubt of the hardware position (it is easy that hardware protrudes into the carpal tunnel with the risk of tendon damage).

Tips & tricks

- Bring a children urinary catheter in the scaphoid hole to ensure not to lose too much bone graft in the former scaphoid hole.
- Open the tourniquet and take the wrist out from the traction tower to a horizontal plane. It is easier to perform the final osteosynthesis there.
- In case of very stiff and severe DISI deformity, the radiolunate wire can also be removed after 2 to 3 weeks postoperatively (very rare indication, as in arthroscopic procedures, reduction is easier than in open access).
- Dry arthroscopy for examination and "semi-wet" for bone/joint resection. For semi-wet use, a two-valve trocar or a thick needle is recommended for an extra portal; consequently, you can just flush the joint with water and close the water supply again, and through the second open valve/additional needle, the air is coming back into the joint. As a result, you have no swelling and "growing synovitis" and no bubbles through the procedure.
- Midcarpal portals: Be careful to have sufficient space in between the 2 portals to achieve sufficient "working space".
- The mini-open radiopalmar approach makes the scaphoid excision faster and you can use this as a bone graft. In very rare indications, you need an additional bone graft from the Iliac crest, distal radius, tibia, olecranon, etc.
- The preparation of the prefilled tubes is also enormously time-sparing.

Conclusion

Partial wrist fusion is a definitive palliative treatment that is commonly used in advanced wrist osteoarthritis cases. The objective is to avoid total wrist fusion and maintain a sufficient range of motion (**Figure 11**). By performing this arthrodesis procedure arthroscopically, the devascularization associated with standard open techniques is avoided, which improves fusion. It also simplifies postoperative recovery. Various types of partial fusions are amenable to arthroscopy. Arthroscopic (assisted) partial wrist fusions are possible, but they are demanding. The benefit is a good/better routine outcome monitoring (ROM) due to no/less scarring on soft tissues.

What you get at the end of the final osteosynthesis in the OR on the table, you will achieve at least as final result. We absolutely need to respect all orthopedic rules regarding sufficient resection of the surfaces to fuse, as well as good placement of the hardware. CT-scan control for bony healing, and in case of doubt for the hardware position, is mandatory. As always experience and training are helpful. To believe that the arthroscopic management of partial fusions will forgive the mistakes in denying the orthopedic rules will not work. Good luck!

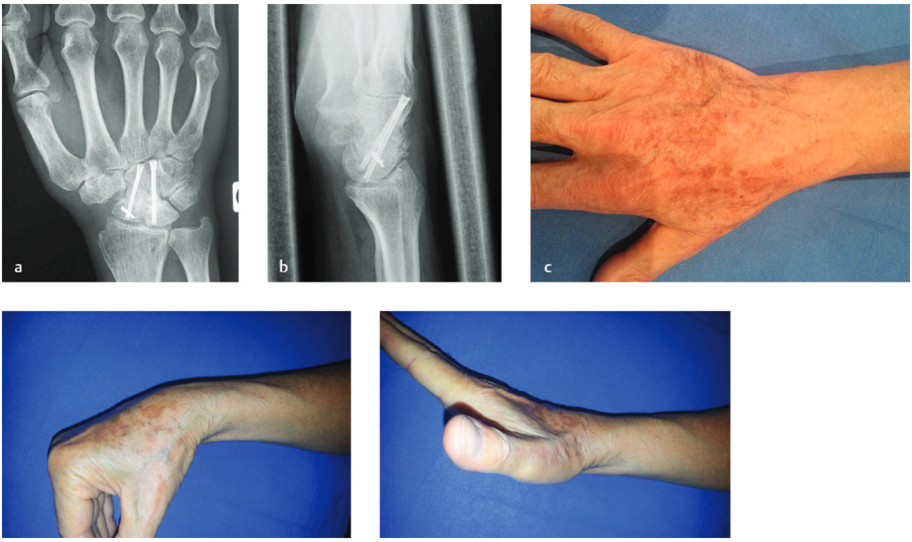


Figure 11.

X-rays (a, b) of a scapholunate-capitate fusion case with 3 years of follow-up; photograph (c) of dorsal side of the wrist for the same patient showing the absence of scars; photographs showing the flexion (d) and extension (e) range of motion in the same patient. Although these movements are modest, they are sufficient and pain-free.

Video 26: Arthroscopic partial arthrodesis in SLAC III wrist arthritis
https://vimeo.com/187974399

38.
ARTHOSCOPIC RESECTION ARTHROPLASTY OF THE RADIAL COLUMN (ARARC) FOR SCAPHOLUNATE ADVANCED COLLAPSE WRIST

TYSON COBB
JESSICA COBB

Introduction

The chapter describes the surgical technique to successfully complete a minimally invasive arthroscopic treatment for symptomatic advanced scapholunate advanced collapse (SLAC) wrists. This minimally invasive procedure can be performed through small portals and allows for minimal soft tissue dissection and, as a result, early recovery and less postoperative scarring, pain, and stiffness. Sutures, interposition, pins, and postoperative casts are unnecessary. As compared to four-corner fusion and proximal row carpectomy, this procedure allows for a more rapid recovery. Our research with 10 years of follow-up on this procedure has shown high patient satisfaction with no recurrences and an acceptable failure rate.

Surgical Technique

1. Patient Preparation and Positioning

General, regional, or wide-awake anesthesia can be used based on the surgeon's and patient's preference and medical needs. The patient is placed supine on the operating table with a tourniquet placed on the brachium. A tape is used to secure the brachium to the hand table **(Figure 1)**. Finger trap traction of 5 kg to the index and/or long fingers is used with a traction tower **(Figure 2)**. Standard radiocarpal and midcarpal arthroscopy can be performed using standard 3–4, 4–5, 6R, 6U, 1–2, volar flexor carpi radialis (FCR) portals, and midcarpal portals as indicated. However, the 1–2 and 3–4 or 4–5 portals are often all that is required. Portals are localized with 18-Gauge needles **(Figure 3)**; 10mL of 0.25% bupivacaine with epinephrine are injected at each portal site. Skin incisions are made with a No. 15 scalpel just through the dermis. Blunt dissection is performed with a hemostat to enter the joint **(Figure 4)**.

Figure 1.

Arm taped to the hand table.

Figure 2.

Arm hung in traction.

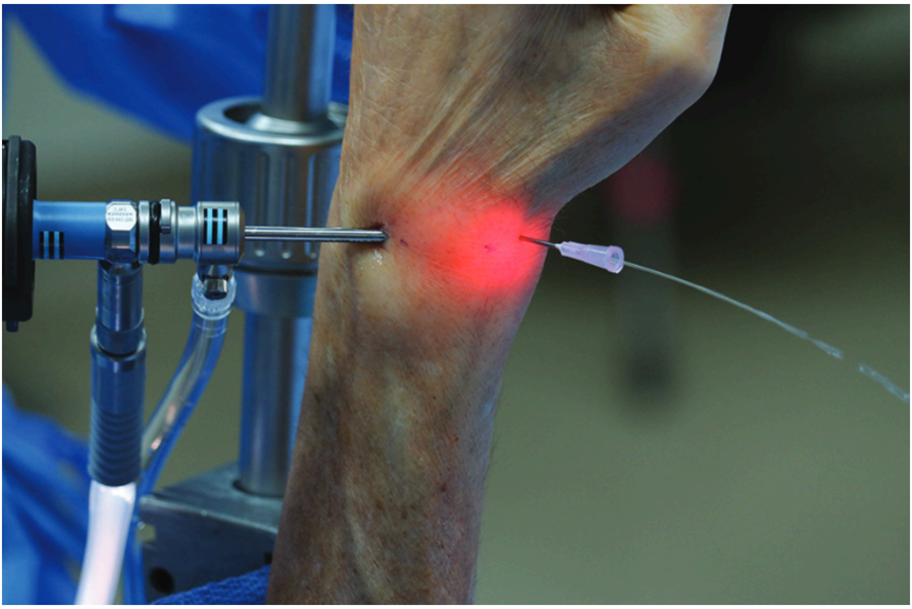


Figure 3.

The 1–2 portal is established with 18-Gauge needle.

Figure 4.

The incision is made with a No. 15 blade and the joint is entered with a hemostat.

2. Arthroscopy

Arthroscopy is performed with a 2.7mm, 30-degree arthroscope. A synovectomy and resection of debris and the torn scapholunate ligament with a 3.5mm aggressive shaver is performed (Stryker Endoscopy, San Jose, CA, United States) **(Figure 5)**. A radiofrequency ablation system (SERFAS 3.5mm, Stryker) is used to denervate the arthritic portion of the joint to be resected volarly, radially, and dorsally **(Figure 6)**. It is performed by resecting the sensory nerve endings as they enter the joint on the capsule. The capsule is vaporized from its attachment to the radius. High fluid flow protects the joint from overheating **(Figure 7)**. We believe that pain relief is partly due to a disrupting of the sensory nerve pathway.

Sensory contributions are included from the anterior interosseous nerve, lateral antebrachial cutaneous nerve, posterior interosseous nerve, palmar cutaneous branch of the median nerve, deep branch of the ulnar nerve, and superficial branch of the radial nerve. A 4mm 12-flute barrel burr (Stryker Endoscopy, San Jose, CA, United States) is inserted into the 1–2 portal for bone resection, using the 3–4 or 4–5 portal for initial viewing. The scope is moved as needed between the 4–5, 3–4, and 1–2 portals to enhance visualization from various perspectives **(Figure 8)**. Volar FCR portal is used infrequently as required for a better visualization of the dorsal aspect of the joint **(Figure 9)**.

Figure 5

The index finger helps to stabilize the scope.

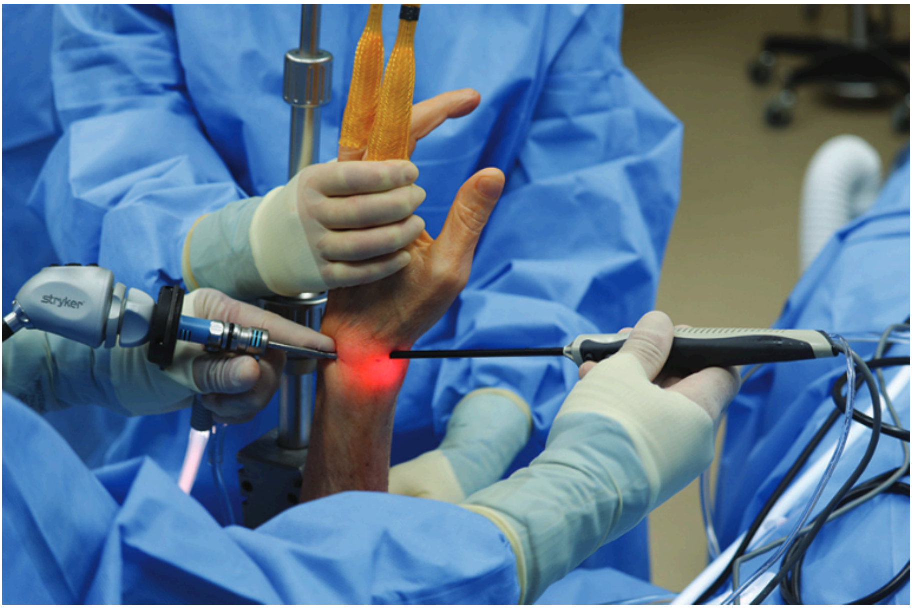


Figure 6.

SERFAS (Stryker, San Jose, CA, United States) ablation system used for denervation.

Figure 7.

Cannula and trocar placed in the joint following the normal volar tilt of the distal radius; the 4–5 portal may be difficult to enter in some patients with SLAC wrists since the lunate may not be distally distracted.

Figure 8.

SERFAS (Stryker, San Jose, CA, United States) ablation system used for denervation.

Figure 9.

The volar portal can be established with inside-out technique as necessary to better visualize the dorsal side of the joint.

3. Resection

Resection begins with the burr perched on the radial edge of the styloid to ensure that a ridge of bone is not left behind. Synovium and capsule tissue are removed to define the margin of bone clearly prior to starting the bony resection. Bone resection is facilitated by making the 1–2 portal slightly below the joint line, which results in the instrument slightly angled upward as it enters the joint. The styloid is resected to a depth of 4mm. A trough of bone is resected by oscillating the burr volarly and dorsally using a windshield-wiper motion, advancing from the radial to the ulnar side until the entire abnormal portion of the radius is removed. Precautions are taken to protect capsular ligaments by carefully burring away the cortical bone until the volar wall becomes pliable, up to but not through the soft tissue envelope **(Figure 10)**. The entire radial column up to healthy-appearing cartilage on the lunate fossa of the radius is resected **(Figure 11)**. The transition to the lunate fossa is an abrupt change to normal cartilage starting at the ridge separating the scaphoid and lunate fossae. The proximal two thirds of the arthritic scaphoid is commonly resected (**Figure 12)**. Fluoroscopy is implemented to ensure an adequate amount of bone resection **(Figure 13)**. Most failures occur because of inadequate resection. As a result, aggressive bone removal is recommended. Failure to remove the impinging portion of the scaphoid will also result in persistent postoperative pain. Midcarpal resection is unnecessary.

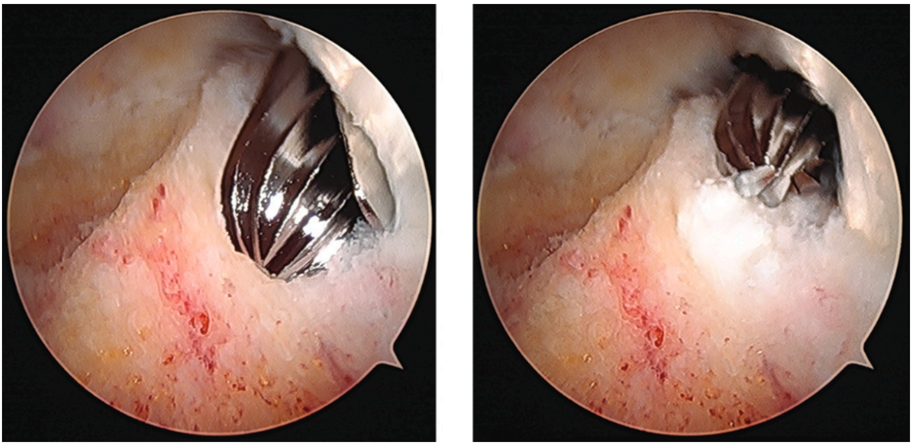


Figure 10.

(a, b) *Showing how to protect the volar ligament with the hood on the shaver.*

Figure 11.

Small bone rongers may be helpful when removing bone.

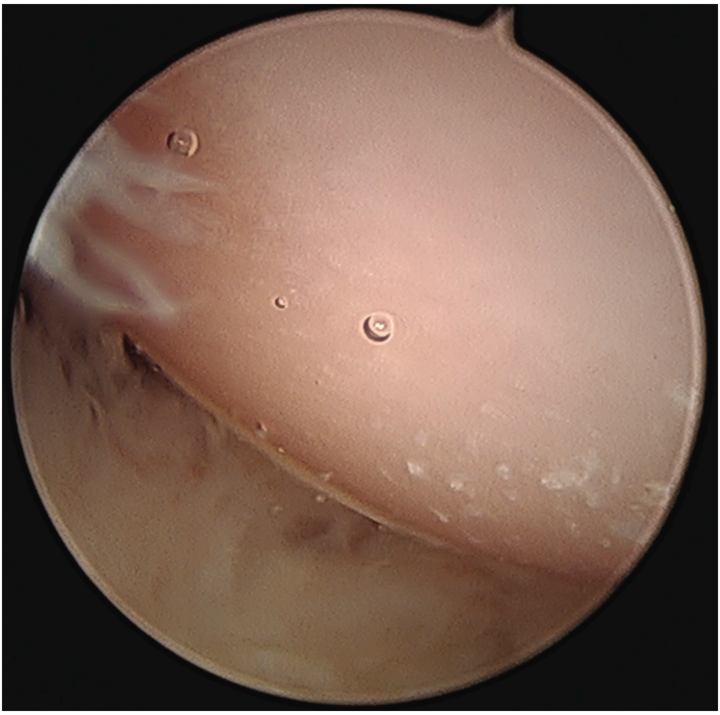


Figure 12.

Typical appearance of arthritic scaphoid.

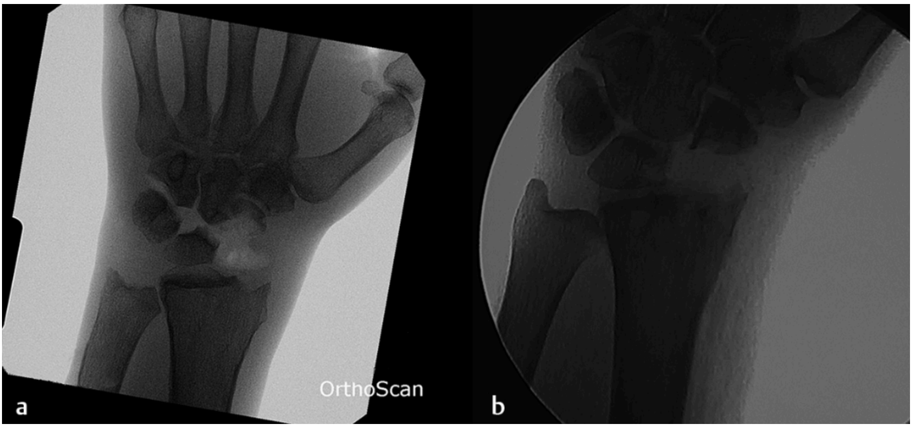


Figure 13.

(a, b) *Postoperative X-ray 1, 2, 3.*

4. Completion

Traction is released at the end of the procedure to ensure the resolution of impingement of the proximal pole of the scaphoid on the radius. Portals are plugged by the assistant's fingers to prevent leakage and additional 0.25% bupivacaine with epinephrine or 1% lidocaine with epinephrine injected into the resected joint (if not contraindicated). We typically use a total of 60mL of 0.25% bupivacaine with epinephrine. Portals are closed with adhesive strip skin closures and the patient is placed in a well-padded volar splint with compressive ACE bandage.

5. Postoperative Care

Patients are instructed to ice and elevate the extremity. The wrist is splinted for 7 to 10 days. Thereafter, the patients are placed in a removable splint and encouraged to begin a range of motion exercises. Use is allowed as tolerated after one week. Formal therapy is used as required for patients requiring more supervision.

Early motion encourages stem cells to form fibrocartilage, which provides a gliding surface and cushion for the joint.

39. ARTHROSCOPIC ASSESSMENT OF KIENBOCK'S DISEASE

GREG BAIN

SIMON MACLEAN

Introduction

We regard arthroscopy as the gold standard for the assessment of the articular surfaces in patients with Kienbock's disease. Imaging is also mandatory in the work-up of such patients, although the extent of articular cartilage damage is often underestimated on plain radiographs. High-resolution or contrast-enhanced MRI and CT-scanning provide excellent details on lunate vascularity, necrosis, and the presence of fracture, but poorly delineate articular surface integrity, which is best assessed with direct arthroscopic visualization and probing. In some cases of osseous ischemia and necrosis, an intact chondral envelope is still present. In such cases, lunate preservation surgery may be indicated. In all cases of Kienbock's disease where we have performed arthroscopy, synovitis is present, and an arthroscopic synovectomy can then be easily performed.

We introduced the Bain and Begg classification to hone surgical decision-making based on the integrity of articular surfaces evaluated during arthroscopy **(Figure**

1) Functional surfaces are defined as those with a normal arthroscopic appearance, often smooth and glistening. Non-functional articulations are those with degeneration; fibrillation, fissuring, chondral detachment, or subchondral fracture. This is crucial as it brings the articular surface into the assessment of Kienbock's disease. Armed with this information, the surgeon can make an informed decision on treatment, which includes osseous findings identified on X-ray and CT-scan.

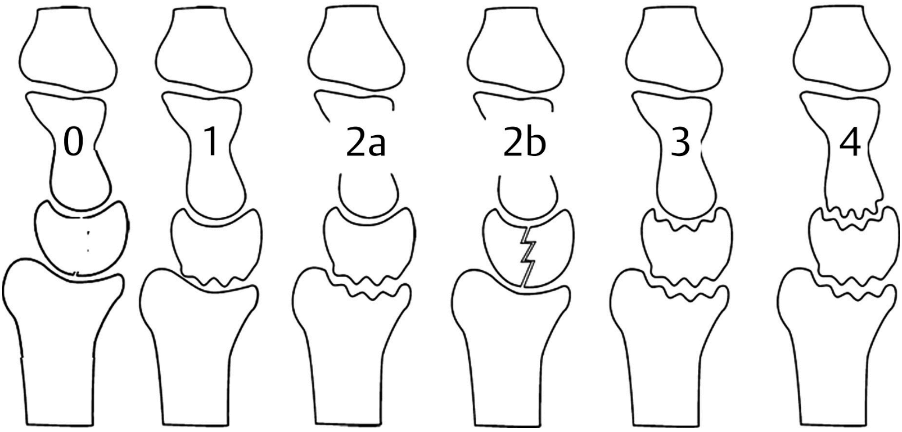


Figure 1.

The Bain and Begg articular-based classification of Kienbock's disease (Copyright Dr. Greg Bain).

The aim of surgical treatment is to bypass or excise nonfunctional surfaces to reduce pain and maintain functional wrist motion between intact articular surfaces. Our recently published Lichtman-Bain algorithm is a framework for the surgeon based on the osseous, vascular, and chondral components of the disease **(Figure 2)**. Surgical treatment can then proceed based on both patient and surgical factors. The algorithm emphasizes 5 key components for decision-making including the patient's age, the state of the lunate, the state of the wrist, what the surgeon can offer, and what the patient wants.

A. Patient's age?

A1. < 15 years – Non-operative

A2. 16 -20 years – Attempt non-operative. Consider unloading procedure.

A3. > 70 years – Attempt non-operative. Consider synovectomy and /or follow algorithm below.

B. Stage of the lunate?

B1. Lunate intact (Cortex and cartilage intact – Lichtman 0, I, II, Schmitt A, Bain 0)
Protect / unload the lunate:

- Orthosis or cast (trial for 2–3 months)
- Radial shortening osteotomy, capitate shortening for ulnar positive variance (radial epiphysiodesis*)
- (Alternatives – Lunate decompression, vascularized bone graft*, radius forage*)

B2. Lunate compromised (Localized lunate disease – Lichtman IIIA, Schmitt B, Bain 1)

Lunate reconstruction:

- MFT*, lunate replacement*, PRC (RSL fusion, SC [or STT] fusion)

B3. Lunate not reconstructable (Advanced lunate disease - Lichtman IIIC, Schmitt C, Bain 2b)

Lunate salvage (excision):

- Lunate replacement*, capitate lengthening, PRC (SC fusion)

C. State of the wrist?

C1 - Carpal instability with intact articulations - Stabilize

Typical scaphoid flexion, with RSA > 60° (Lichtman IIIB)

- Stabilize radial column (SC fusion)

C2 - Localized carpal degeneration - Reconstruct

C2a. Radiolunate articulation compromised **(Lichtman IIIA, Bain 2a)**

- Bypass (SC fusion)
- reconstruct (MFT graft)
- replace (lunate prosthesis)
- Fuse (RSL fusion)

C2b. Radioscaphoid articulation compromised

- PRC if lunate facet intact
- RSL fusion if lunate facet compromised and midcarpal joint intact

C3 - KDAC, Advanced carpal collapse and degeneration - Salvage

Wrist not reconstructable (Advanced wrist disease – Lichtman IV, Bain 4)

- Salvage (fusion or arthroplasty)

Figure 2.

The Lichtman-Bain algorithm for the management of Kienbock's disease (Copyright Dr. Greg Bain).

Technique

1. Set-Up

We suspend the arm on a traction tower. A 2.7mm, 30-degree arthroscope is used. Portal sites are injected with 15–20mL of 1% lidocaine, a 1:200,00 adrenaline mixture, 20 to 30 minutes before the procedure. A tourniquet is applied, but not inflated. Portals used include the 3–4 portal, 6R portal, radial midcarpal portal, and ulnar midcarpal portal. Dry arthroscopy is then performed, allowing for a better visualization and resolution of the articular surfaces. Tissue perfusion is best assessed dry, as fluid insufflation compresses the capillaries within the synovium.

2. Inspection

A meticulous inspection of the joint is then performed. Ballottement with the probe allows for the assessment of the integrity of chondral surfaces. Correlating this information from arthroscopy with preoperative imaging assists the surgeon in making a better treatment decision. Bain and Begg reported that synovitis was present in all cases and the degree of synovitis correlated with the degree of articular damage. Plain radiographs will often underestimate the severity of the articular changes and the findings at arthroscopy will commonly change the recommended treatment. Bain *et al.* reported that in 82% of cases, there was at least one nonfunctional articulation, and 61% had at least two nonfunctional articulations. Cases were identified with an intact chondral envelope, although softening and collapse of the subchondral bone plate were noted. This is a major subgroup as attempts at revascularization and unloading of the lunate can then provide a good functional outcome.

- Chondral softening, fibrillation, fissure, or fracture can then be identified.
- A “concealed fracture” may be present if a coronal fracture is present with an intact chondral envelope (Figure 3).
- A “floating surface” may be present if there has been osseous necrosis and collapse, but an intact chondral surface remains. In this instance, the surface “floats” when the wrist is tractioned, creating a potential space between the intact articular surface and collapsed bone.

The scapholunate and lunotriquetral ligaments may tear as a result of lunate collapse and tilt. We find perilunate ligament tears are a common finding during arthroscopy in such cases.

Figure 3

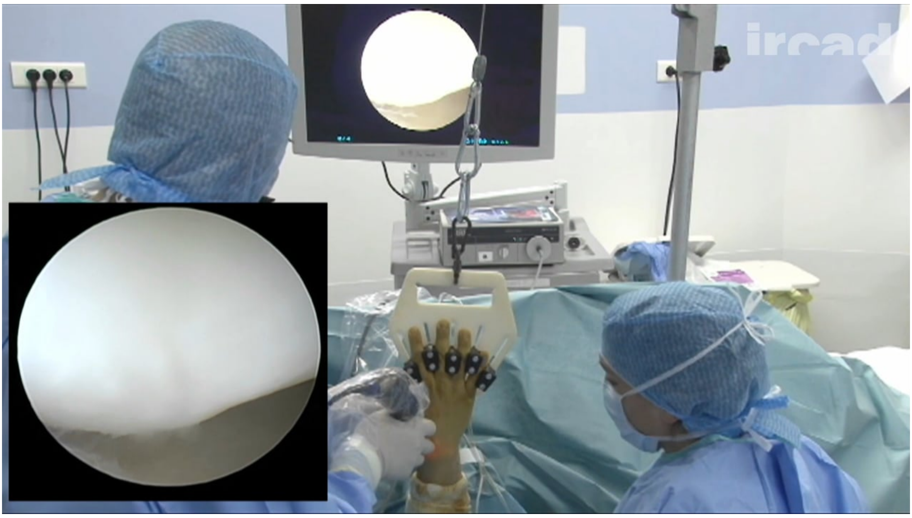
Arthroscopic assessment of nonfunctional articular surfaces. On probing the proximal lunate, a concealed fracture is identified. Irregular surfaces with exposed bone may also be present (Copyright Dr. Greg Bain).

3. Simple Procedures and Decision-Making

A synovectomy is performed in every case. In patients with early disease, this may be definitive treatment, and in patients with more advanced disease, this may be a pain-relieving intervention. Loose fragments and flaps are debrided using shavers, baskets, or pituitary rongeurs. The chondral articulating surfaces are then classified using the Bain and Begg classification. The state of the articulations, wrist, and treatment options can then be determined using the Lichtman-Bain algorithm.

Conclusion

Wrist arthroscopy best defines the status of the articulating surfaces in Kienbock's disease. Chondral changes do not always mirror the osseous or vascular status of the lunate. After arthroscopic assessment, synovectomy and debridement can then be performed, and in some cases, definitive arthroscopic management performed.



Video 27: Arthroscopic management of Kienbock's disease
https://vimeo.com/209913456

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