Wrist arthroscopy: indications, portal anatomy and therapeutic advances

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Abstract

Wrist arthroscopy has revolutionized the management of wrist pathology in recent years. This article aims to provide the reader with an overview of the procedure, its indications, set-up, and its applications, both diagnostic and therapeutic. Good knowledge of anatomy is a prerequisite to performing safe arthroscopic surgery and thus decrease iatrogenic complications.

Keywords arthroscopy; portals; wrist joint

Introduction to arthroscopy of the wrist

Arthroscopy has become an integral part of modern joint surgery. Following the establishment of large joint arthroscopy as an essential and safe technique for treating various intra-articular pathologies, wrist arthroscopy has evolved to be an essential diagnostic and therapeutic tool for the wrist surgeon. In 1986, Whipple et al.[1] presented their technique, including the entry portals and their early encouraging results during the instructional course at the American Academy of Orthopaedic Surgeons meeting. Following this international exposure, the rapid development of new techniques and advancements in the lens, fibreoptics, arthroscopic instrumentation[2] ensued, leading to the acceptance of wrist arthroscopy into the mainstream of wrist surgery. The indications for wrist arthroscopy continue to expand, and the techniques continue to evolve. The purpose of this article is to review the current techniques and advances in the field of wrist arthroscopy.

Learning wrist arthroscopy

Arthroscopy requires the surgeon to perceive a three-dimensional environment from a two-dimensional camera image. The initial step to acquiring the requisite skills is through a cadaveric course. In the current coronavirus disease (COVID-19) pandemic, with reduced training and operating exposure, alternative and additional learning tools like e-learning and simulators (both box trainers, virtual reality simulators and augmented reality solutions) can enhance knowledge and performance.[3] Nonetheless, a proficiency-based progression (PBP) approach, which involves a stepwise approach and requires mastery of basic skills before advancing to more complicated tasks, is strongly recommended. PBP through the various stages: beginner, intermediate and advanced is an effective method to optimize learning of technical and procedural skills.[4]

Indications for wrist arthroscopy

Arthroscopy is an imperfect screening tool and must not replace taking a good history and performing a thorough clinical examination. However, no other tool allows you to visualize every corner of the radiocarpal and midcarpal joints like wrist arthroscopy does.

The indications for wrist arthroscopy can be divided into two broad categories — diagnostic and therapeutic procedures.

When starting to perform wrist arthroscopy, most procedures will be diagnostic and aids the surgeon to appreciate the normal anatomy and variants better. Both the radiocarpal and midcarpal joints need to be systematically and thoroughly examined. A ‘normal’ arthroscopy can help with reassuring the patient and also help guide postoperative hand therapy.

Diagnostic wrist arthroscopy has a high sensitivity for detecting chondral defects of both the radiocarpal and midcarpal joint and is an essential tool in evaluating persistent wrist pain when other imaging modalities have been inconclusive.[5] Arthroscopy has now become established in diagnosing triangular fibrocartilage complex (TFCC) injuries and evaluating ligamentous instability in the wrist.[6] It is crucial to stress the need to correlate clinical examination and arthroscopic findings to ensure that asymptomatic coincidental findings are not then the focus of further treatment.

As one progresses from a beginner to a surgeon with intermediate arthroscopy experience, the realm of therapeutic arthroscopy opens up. Therapeutic soft tissue arthroscopic procedures include excisional biopsy and sampling of soft tissue pathologies as synovitis, ganglia and washout of the septic wrist.[7] Osseous procedures include assisted reduction of intra-articular distal radius fractures, perilunate or lunate dislocations and scaphoid fractures,[8–11] including bone grafting of non-unions.[12]

The boundaries are now being pushed with arthroscopic options for advanced degenerative wrist pathology such as arthroscopic proximal row carpectomy,[13] arthroscopically assisted partial wrist fusions[14–16] and joint preserving procedures for Kienböck’s disease.[17] Arthroscopic-assisted and all arthroscopic scapholunate ligament and TFCC reconstruction[18,19] techniques are now being performed, though there is a steep learning curve and these are best reserved for the advanced arthroscopist.

Contraindications for wrist arthroscopy

These include compartment syndrome, neurovascular injury, open joint and severe soft tissue injury and severe soft tissue infections.

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Setting up for wrist arthroscopy

Wrist arthroscopy can be carried out under regional anaesthesia (interscalene, supraclavicular, infraclavicular or axillary block) or general anaesthesia. Recently, the application of the WALANT (Wide Awake Local Anaesthesia No Tourniquet) technique in arthroscopy of the wrist has been described.[20]

Spatial organization of the operating room is key to ease of performing the procedure (Figure 1). The patient is supine on the operating table with the arm abducted and supported on an arm table. The anaesthetist and anaesthetic machine are usually at the head end of the patient. The surgeon and assistant are usually at the shoulder level towards the top of the arm table. The scrub nurse and the instruments are on a separate table just away from the hand of the patient. The arthroscopy tower and the image intensifier screens are usually by the abdomen on the opposite side of the patient and should be visible to everyone at all times. The standard c-arm mobile image intensifier is used if required and usually introduced from the foot end of the patient towards the bottom of the arm table. It is positioned horizontal and parallel to the floor at an appropriate height above the arm table so as not to obscure the field of view of the screens. Some procedures require two experienced surgeons operating from both sides of the wrist, and this requires further careful organization of the set-up to prevent any obstacles to free movement.

A well-padded arm tourniquet is utilized and placed on the upper arm (closer to the elbow) and only elevated when one is ready to commence the arthroscopy (Table 1).

Joint distraction using a traction system is essential to permit portal placement and adequate visualization of the joints. Finger traps are usually placed on the index and middle fingers only. The little finger is usually avoided as there is a high risk of injury to this extensor tendon when on traction during placement of the ulnar sided portals. One must also ensure adequate padding between the patient and the traction tower at all times. The cable and pulley system is less expensive and allows free rotation of the forearm for access. Usually, about 2–5 kg (about 10 pounds) traction is all that is required, and excessive traction should be avoided.

Instruments

The standard set-up for wrist arthroscopy requires a short, light, small 1.9 mm or 2.7 mm 30° arthroscope with a camera attached, instruments for portal establishment (blade, curved blunt haemostat, trocar with a trocar sleeve), a light source with fibreoptic cable, irrigation set-up (no pump), and a traction system. Depending on the procedure performed, additional equipment required include a probe, grabber, punches, forceps, burrs, shavers and radiofrequency probes and freer elevator, osteotomes of varying angles and a mobile image intensifier (Figure 2).

Anatomy

The wrist joint consists of the radiocarpal, midcarpal and the distal radioulnar joint (DRUJ). An understanding of the anatomy is important in the management of ligamentous injuries to the wrist. In the radiocarpal joint, the ligaments visualized and thus suitable for examination on the volar aspect from radial to ulnar include the radioscaphocapitate (RSC)ligament, the long radiolunate ligament, the short radiolunate ligament (often masked by the ligament of Testut – a mesocapsule containing the terminal branches of the anterior interosseous nerve and rami from the radial arcade), the ulnolunate and the ulnotriquetral ligaments (Figure 3). Looking up, one visualizes the proximal row of bones – the scaphoid, scapholunate ligament, lunate, lunotriquetral ligament and the triquetrum in the same sequence. Looking down, one visualizes the ellipsoid radial surface with the scaphoid and lunate facets, which then continues ulnar as the smooth TFCC with its central articular disc, dorsal and volar radioulnar ligaments, the meniscal homologue sling and the deep

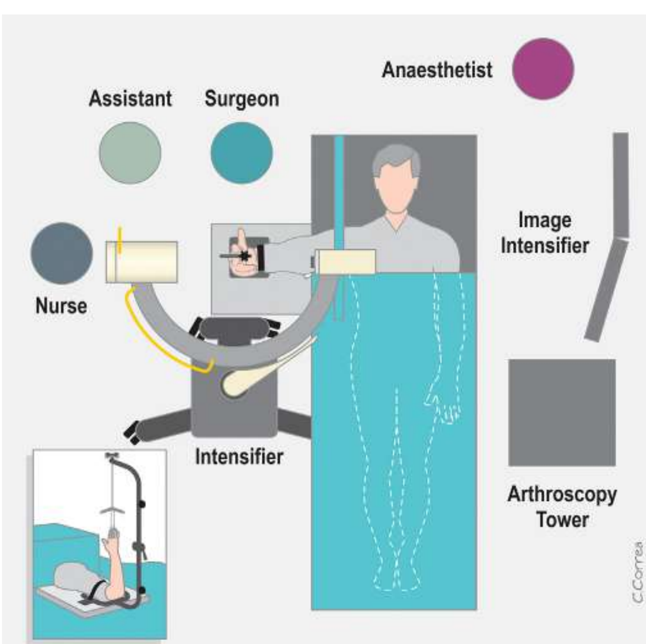

Figure 1 Operation theatre set-up.

General tips for safe arthroscopy

1	When using the scope, rest a finger on the patient whilst holding the scope so you can gently (Figure 3) guide it around the wrist without pulling the scope accidentally out of the portal
2	Know the length of the tip of the probe as this is an important tool to help estimate the depth of steps and gaps in the articular cartilage
3	Connect the suction only after the shaver is inside the joint to avoid difficulty in entering the portals
4	Ensure that all the cables from the different instruments (e.g. shaver, scope, irrigation) are all well organized, so they do not get tangled mid-procedure
5	Do not push with excessive force on the instruments as this risks injury to tendons, nerves on entry or ligaments/cartilage once inside
6	If you get stuck, stop, restart and repeat the steps, and increase traction if needed

Table 1

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Figure 2 Instrumentation that can be used for wrist arthroscopy.

foveal attachment (this is not visualized through the radiocarpal portal but an important component in maintaining DRUJ stability) and the extensor carpi ulnaris tendon (ECU) sheath.

The midcarpal row forms an s-shaped joint between the already described proximal row and the distal row (trapezium, trapezoid, capitate and hamate). The midcarpal portion of the RSC ligament, though often covered by synovium, can be seen as a constant feature. The scapholunate and lunate triquetral intervals are best assessed through this joint.

The most important landmarks to identify and mark at the beginning of wrist arthroscopy include the extensor pollicis longus tendon, the extensor tendons to the digits, Lister's tubercle, the radial and ulnar styloid process and the ECU tendon (Figure 4). The dorsal portals, which are defined by their relationship to the extensor compartments of the wrist, can then be safely established.

Portals and approach

The basic sequence for establishing the wrist arthroscopy portals is (Figure 5):

1. Identify the portals by palpation. The 3–4 portal is identified by placing your thumb on Lister's tubercle and feeling the soft spot just distal to it.
2. A needle is placed into the palpated soft spot following the anatomical inclination of the distal radius articular surface in the coronal and sagittal planes.
3. Transverse or longitudinal small skin (only skin – reduces the risk of injury to dorsal sensory nerves and tendons) incision (just large enough for a cannula) is made with a 15 scalpel blade.
4. The soft tissue structures (mainly tendons and blood vessels or nerves) are gently separated by blunt dissection between the skin and the wrist capsule with a haemostat.
5. The capsule is then perforated with the haemostat.
6. Use a blunt trocar and cannula to enter the joint using the previously created path in step 5. This is usually in line with the radial inclination and volar tilt for the radiocarpal 3–4 portal and relatively more horizontal for the midcarpal portals (Figure 6).

In order to reduce the risk of damaging neurovascular structures around the wrist, the standard arthroscopic portals used are the dorsal portals. There are five radiocarpal, and two midcarpal arthroscopic portals which are generally accepted[21] (Table 2, Figure 4). The dorsal portals are based on the proximity to the six wrist extensor compartments. The 3–4 portal is usually the first located portal, and the primary portal used to perform diagnostic arthroscopy. 6R portal is the next portal made radial to the ECU tendon and is the main instrumentation portal. However, the scope is usually interchanged between portals to facilitate better visualization of the area of anatomy or pathology of interest. Volar radial and volar ulnar portals are less frequently used but nonetheless important in the armamentarium. The commoner and safer portals are the volar central portals described by Corella,[22] which provide much better visualization of the entire joint (Figure 7). Greg Bain has described the box concept to help our understanding of the joint as a box, and the portals allow viewing and instrumentation at varying entry points (Figure 4).[23]

Dry versus wet arthroscopy

The classical description of wrist arthroscopy technique was based on the belief that distending the wrist joint with fluids was crucial to maintain a 'working cavity' and to ensure visualization of the joint. The main disadvantages of using continuous fluid irrigation during wrist arthroscopy are the risks

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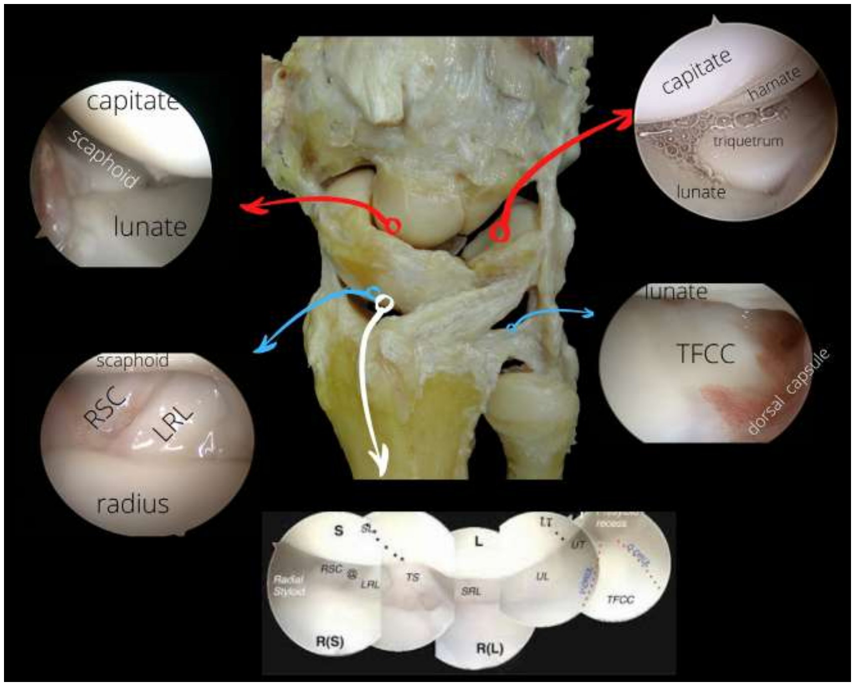

Figure 3 Surgeon's view from the different portals. Reproduced from reference 21 with permission from Springer Nature.

of tissue swelling, compartment syndrome secondary to fluid extravasation and loss of entry point for the portals when portals need to be exchanged. The resultant oedematous tissue also obscures the field if one has to then convert to an open procedure. If using irrigation, Ringer lactate is preferred to sodium chloride as it is suggested that the soft tissue swelling is less and there is a chondroprotective effect.[24] In 2007, 'dry' arthroscopy technique was first introduced and popularized by Dr Pinal for distal radius fractures,[25] and the indications expanded to most procedures over a period of time. He demonstrated that simple traction is sufficient to maintain the working space during wrist arthroscopy and that longer procedures could be performed without the risks of tissue oedema and compartment syndrome. The main disadvantage of dry arthroscopy is that at times the field of vision may be obscured in comparison to wet arthroscopy, but with certain simple techniques like wiping the scope on soft tissue and or using controlled irrigation with a 10 ml syringe of saline and suction from a shaver, adequate visualization can be restored to accomplish the goals of the procedure safely. The suction should be switched off when not required.

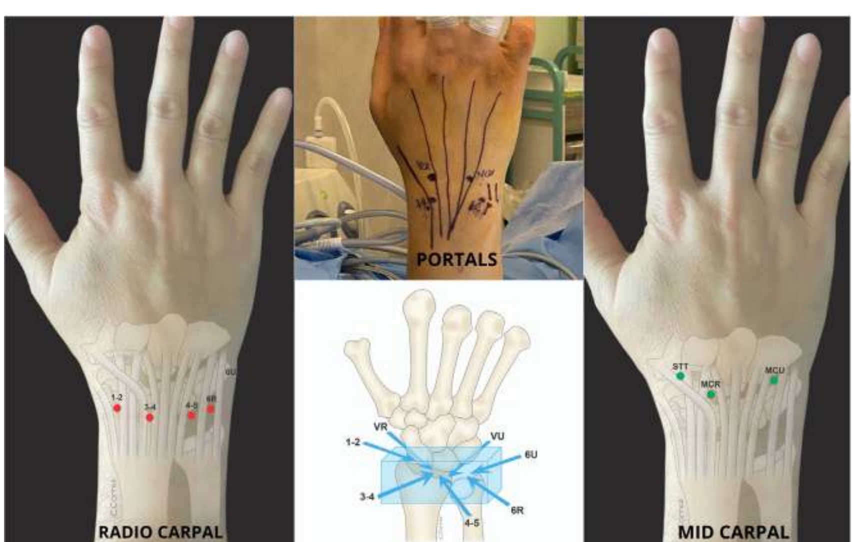

Figure 4 Radiocarpal and midcarpal portals. Reproduced from reference 23 with permission from Elsevier.

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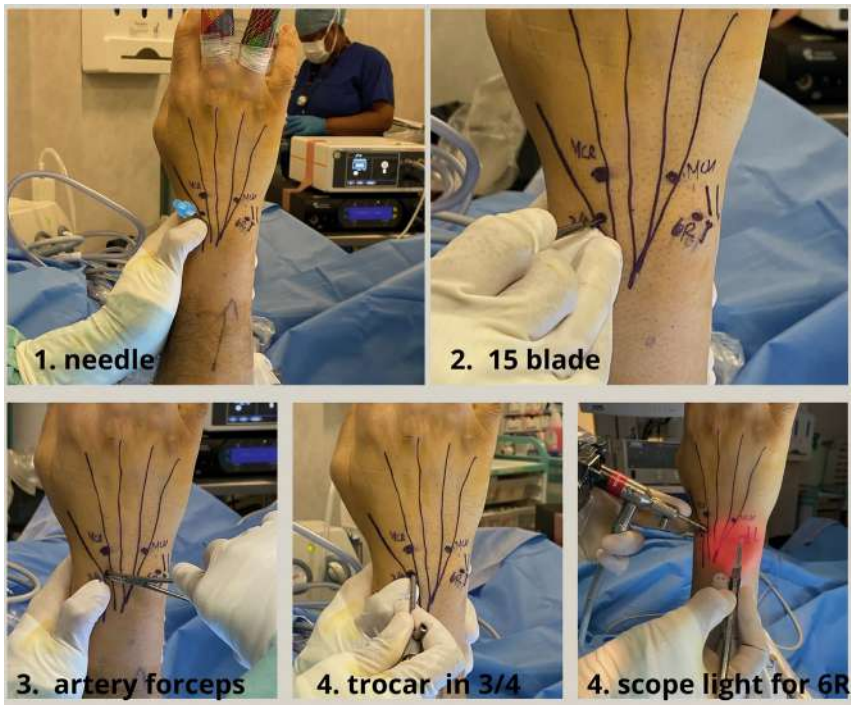

Figure 5 Steps to making a portal.

Diagnostic arthroscopy

Arthroscopy assessment of radiocarpal and midcarpal chondral defects (staging)

Determining the integrity of articular cartilage is an important part of the evaluation of wrist pain in patients without an established diagnosis and also in guiding decision-making through grading the degree of cartilage damage in the management of wrist arthritis. Although not specifically designed for assessment of the wrist, the Outerbridge's four-point assessment of the articular cartilage is widely used when describing the arthroscopy finding (Table 3).

Wrist arthroscopy is now considered the 'gold standard' for assessment of degenerative wrist disease, and studies that compared the accuracy of different modalities of MRI with the arthroscopy findings[5,26] have reinforced that although MRI is sensitive in identifying cartilage degeneration in the wrist, it was not as accurate as wrist arthroscopy. The most important locations to assess the integrity of cartilage are the scaphoid fossa, lunate fossa, proximal and distal lunate and proximal capitate. Palmar first described HALT (hamate arthrosis lunotriquetral tear) to explain a cause for ulnar sided wrist pain commonly seen in patients with type II lunate where active cartilage changes are seen on the proximal tip of the hamate. Similarly, in ulnar positive variance where pain results from ulnar impaction, chondral defects and 'kissing lesions' may be visualized on opposing contact surfaces of the lunate and ulnar head (usually seen through a defect in the TFCC).

Arthroscopy assessment of interosseous ligament tears and carpal instability

Wrist arthroscopy plays a valuable role in the diagnosis of carpal instability and may be the only way to definitely demonstrate pathological scapholunate instability, especially in pre-dynamic or dynamic pathologies.[27] Geissler's arthroscopic grading of wrist interosseous ligament injuries has become widely used[28] (Table 4).

Arthroscopic evaluation is done using the standard technique with 3−4 and 6R portals. The scapholunate interosseous ligament (SLIL) is best seen from the 3−4 portal, and the lunotriquetral ligament is best seen from the 4−5 or 6-R portal. These can then be individually probed to assess for any unstable partial or complete tears from the radial and ulnar sides of the ligaments.

Recent anatomic studies correlated with arthroscopic evaluation have helped identify a further structure the dorsal capsule −scapholunate septum visualized through the radiocarpal portals that is believed to play an important role in scapholunate

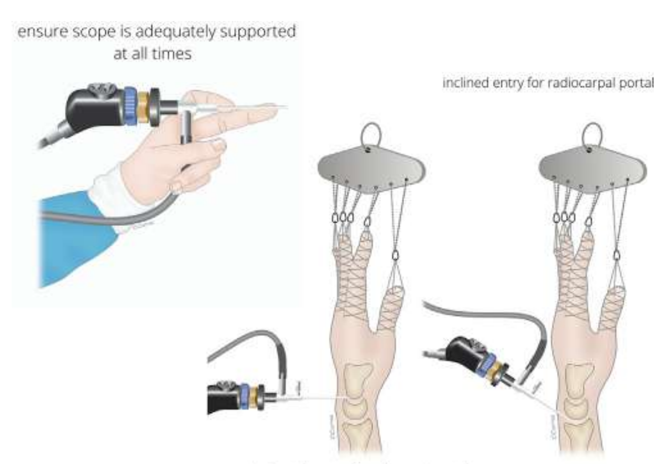

Figure 6 Correct direction of entry for portals.

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Wrist arthroscopy portals

Portal name	Location and relationship to palpable anatomy structures	Main indications	Risk of damaging NV structures
Dorsal radiocarpal portals			
3–4	Soft spot 1 cm distal and in line with Lister's tubercle Localizing of the entry point with the 'three circle method'[14] or 'rolling thumb method'[14]	Main radiocarpal arthroscopic viewing portal	Low risk of damaging NV structures Main risk: EPL, SBRN
4–5	In line with the fourth metacarpal and slightly proximal to the 3–4 portal	Main radiocarpal arthroscopic instrumentation portal	Low risk of damaging NV structures Main risk: EDC, EDQ, DBUN, SBRN [15]
6R	Radial to the ECU tendon	Instrumentation portal/ TFCC viewing portal	Main risk: TFCC, DBUN
6U	Ulnar to the ECU tendon	Mainly outflow portal	Moderate risk for the TBDBUN
1–2	Radial border of EPL and just distal to the radial styloid	Rarely used	Moderate risk: injury to the radial artery, SBRN
Dorsal midcarpal portals			
Radial Midcarpal Portal	1 cm distal to the 3–4 portal, in line with the third metacarpal	Visualization of the complete midcarpal joint	Extensor tendons, SBRN
Ulnar midcarpal portal	1 cm distal to the 4–5 portal, in line with the fourth metacarpal	Usually, the first midcarpal portal to be established	EDQ
Volar portals			
Volar radial	Proximal wrist flexion crease, radial to FCR tendon interval between RSC ligament and the long radiolunate ligament 'inside-out technique' with 3–4 portal	Arthroscopic arthrolysis of the dorsal wrist capsule	Palmar cutaneous branch of the median nerve
Volar ulnar	The interval between flexor tendons, FCU and ulnar neurovascular bundle	TFCC dorsal tears, distal radius fractures	Flexor tendons, the ulnar artery and ulnar nerve
Volar central radiocarpal	FDS to little finger identified (no finger trap traction on little finger) and all FDS moved radially; FDP to little and ring identified and moved ulnar and rest radially	PRC Arthroscopic arthrodesis ligamentoplasty	Flexor tendons Median nerve Ulnar NV bundle
Volar central midcarpal	Same as above but entry over the anterior horn of lunate Transillumination from dorsal portals helps visualize the volar capsule	PRC Arthroscopic arthrodesis ligamentoplasty	Flexor tendons Median nerve Ulnar NV bundle
DRUJ portals			
Direct foveal portal	1 cm proximal to 6 U portal, just palmar to ulna styloid; with the forearm in full supination	TFCC foveal tear debridement; suture anchor placement	DBUN
Mid-dorsal DRUJ portal (preferred portal)	Located at the midpoint between the standard proximal and distal DRUJ portals.	Assessment of foveal insertion, DRUJ arthrolysis	TBDBUN
Volar DRUJ portal	Between FCU and finger flexors, 5–10 mm proximal to ulnocarpal joint	Visualize dorsal radioulnar ligament, wafer procedure	Ulnar NV bundle

DBUN, dorsal sensory branch of the ulnar nerve; DRUJ, distal radioulnar joint; ECU, extensor carpi ulnaris; EDC, extensor digitorum communis; EDQ, extensor digiti quinti; EPL, extensor pollicis longus; FCR, flexor carpi radialis; FCU, flexor carpi ulnaris; FDP, flexor digitorum profundus; FDS, flexor digitorum superficialis; NV, neurovascular; PRC, proximal row carpectomy; RSC, radioscaphocapitate; SBRN, superficial branch of the radial nerve; TBDBUN, transverse branch of the dorsal branch of the ulnar nerve; TFCC, *triangular fibrocartilage complex*.

Table 2

stability and techniques to repair this structure arthroscopically have been described by Professor Mathoulin[29].

Geissler's assessment must nonetheless be done from the midcarpal portals. The normal appearance of the scapholunate interval is tightly congruent without any step-off as opposed to a frequently 1 mm normal step-off between the triquetrum and the lunate. A small joint probe is then introduced into the midcarpal joint, and the scapholunate and lunotriquetral joints

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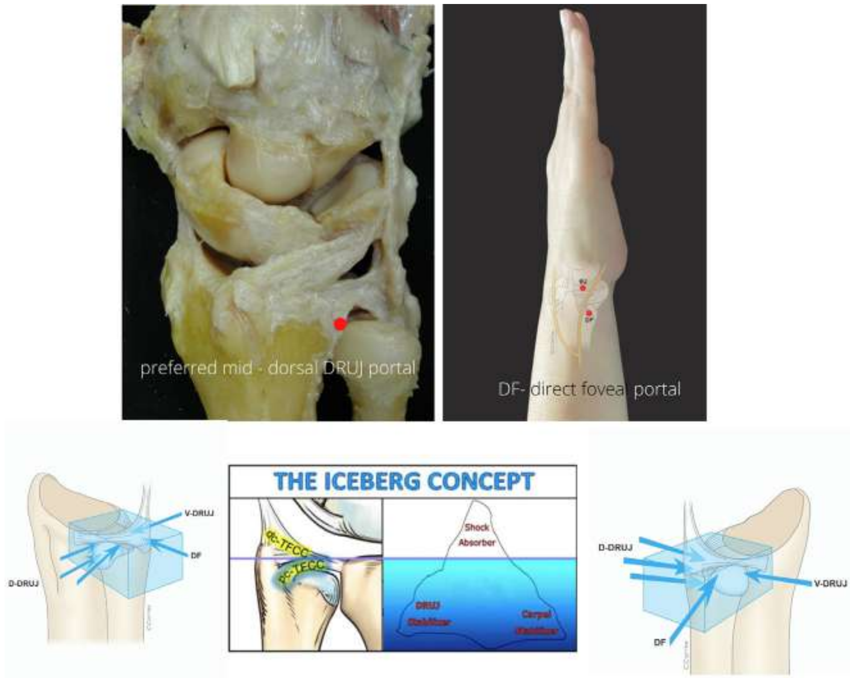

Figure 7 Distal radioulnar joint (DRUJ) portals. Reproduced from reference 54 with permission from SAGE Publications.

The Outerbridge classification for joint cartilage damage

Grade 0	Normal cartilage with softening and swelling
Grade 1	Cartilage with softening and swelling
Grade 2	Partial-thickness defect with fissures on the surface that do not reach subchondral bone or exceed 1.5 cm in diameter
Grade 3	Fissuring to the level of subchondral bone in an area with a diameter of more than 1.5 cm (crab meat appearance)
Grade 4	Exposed subchondral bone

Table 3

are individually probed to assess the grade of instability (Table 4).

The European Wrist Arthroscopy Society (EWAS) group described a newer, more detailed and systematic approach to the assessment of the individual wrist ligaments and this has helped further stratify the degree of instability. For example, the dorsal, intermediate and volar components are separately assessed as in reality, the partial tears of the SLIL may only affect one or more of three components resulting in lesser degrees for instability, and hence it makes sense to evaluate them individually and thus guide further rehabilitation[30] (Table 5).

Arthroscopy assessment of TFCC tears

Palmar described the TFCC as a three-dimensional anatomical structure that connects the distal radius, ulna and carpal bones. Wrist arthroscopy is the gold standard for diagnosis of TFCC tears as it enables direct and accurate visualization of the damaged structures with a diagnostic sensitivity of nearly 100%.

Two classification systems of TFCC injuries are used. The Palmer classification (Table 6)[31] was published in 1989 and categorized the lesions based on the nature of their formation (traumatic/degenerative) and the location of the tear in the traumatic cases or the chondromalacia in the degenerative cases.

Atzei introduced the new ‘iceberg’ concept[32] (Figure 7). Through the radiocarpal portals, we can see only the tip of the iceberg, that is, the peripheral tears of the TFCC. The stability of the DRUJ, however, is reliant on the integrity of the foveal attachment of the TFCC. With the description of the DRUJ and direct foveal portals (Table 1, Figure 7), we can better assess the foveal insertion of the TFCC and thus visualize the rest of the submerged iceberg. The Atzei classification (Figure 8)[19,32] focussed on the Palmer 1B tears and differentiated the repairable lesions of the single distal (peripheral)component from the tears of the proximal (foveal) component, which includes the foveal attachment of the TFCC.

Furthermore, Atzei highlighted the different techniques to evaluate the distal component of the TFCC (the disk, meniscus homologue and the ulnocarpal ligaments) by direct visualization with the scope in the standard 3—4 portal and using the trampoline test[33] (a compressive load is applied with the probe inserted through the 6R portal to visualize the TFCC bouncing in an intact peripheral/distal component of the TFCC) in contrast to the assessment of the foveal insertion of the proximal component of the TFCC with the hook test (in a positive test of the TFCC where the foveal attachment is torn, the TFCC can be lifted off the ulna head (distally and radially) by a probe inserted into the pre-styloid recess and then applying a radially and upward-directed force (Figure 9).

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Geissler arthroscopic classification of carpal instability

Grade	Description	Management
I	Attenuation/haemorrhage of the interosseous ligament as seen from the radiocarpal joint. No incongruency of carpal alignment in the midcarpal space	Immobilization
II	Attenuation/haemorrhage of the interosseous ligament as seen from the radiocarpal joint. Incongruency/step-off as seen from midcarpal space. A slight gap (less than the width of a probe) between carpals may be present	Arthroscopic reduction and pinning
III	Incongruency/step-off of carpal alignment is seen in both the radiocarpal and midcarpal spaces. The probe may be passed through the gap between carpals.	Arthroscopic/open reduction and pinning
IV	Incongruency/step-off of carpal alignment is seen in both the radiocarpal and midcarpal spaces. Gross instability with manipulation is noted. A 2.7-mm arthroscope may be passed through the gap between carpals	Open reduction and repair

Table 4

Therapeutic use of wrist arthroscopy

Arthroscopic management of TFCC injuries

The initial management of TFCC injuries with stable DRUJ is non-surgical treatment for 3—6 months with splinting, therapy and possible corticosteroid injection. Surgical options are considered only when this fails.

In acute TFCC tears, wrist arthroscopy and the new classification proposed by Atzei helps guide us in treating the different types of injuries. Peripheral tears can be repaired by inside out, outside in or all inside techniques.[34—36] Foveal tears need to be reattached, and again a variety of techniques to achieve this have been described.[19,37] The reader is directed to the bibliography for further detailed descriptions of the various surgical techniques. (Table 6 and Figures 8 and 10)

Arthroscopic excision of ganglia

The dorsal ganglia are benign tumours associated with mucous dysplasia and usually intracapsular and extra synovial and located at the dorsal scapholunate ligament complex. They are classically seen in front of the midcarpal joint, but they can extend radially in between the dorsal intercarpal ligament and the radiotriquetral ligament dorsally.

Arthroscopic stage (EWAS)	Arthroscopic testing of SLIL from MC joint	Anatomo-pathological findings
I	No passage of the probe	Not found in these cadaver specimens
II Lesion of membranous SLIL	Passage of the tip of the probe in the SL space without widening (stable)	Lesion of proximal/membranous part of SLIL
III A Partial lesion involving the volar SLIL	Volar widening on dynamic testing from MC joint (anterior laxity)	Lesion of the anterior and proximal part of SLIL with or without lesion of RSC/LRL
III B Partial lesion involving the dorsal SLIL	Dorsal SL widening on dynamic testing (posterior laxity)	Lesion of the proximal and posterior part of SLIL with a partial lesion of DIC
III C Complete SLIL tear, the joint is reducible	Complete widening of SL space on dynamic testing, reducible with removal of the probe	A complete lesion of SLIL (anterior, proximal, posterior), complete lesion of one extrinsic ligament (DIC lesion or RSC/LRL)
IV Complete SLIL with SL gap	SL gap with the passage of the arthroscope from MC to RC joint No radiographic abnormalities	A complete lesion of SLIL (anterior, proximal, posterior), lesion of extrinsic ligaments (DIC and RSC/LRL)
V	Wide SL gap with the passage of the arthroscope through SL joint. Frequent X-ray abnormalities such as an increased SL gap, DISI deformity	A complete lesion of SLIL, DIC, LRL, RSC, involvement of one or more other ligaments (TH, ST, DRC)

Abbreviations: DIC, dorsal intercarpal ligament; DISI, dorsal intercalated segmental instability; DRC, dorsoradiocarpal; EWAS, European Wrist Arthroscopy Society; LRL, long radiolunate; MC, midcarpal; RC, radiocarpal; RSC, radioscaphocapitate; SLIL, scapholunate interosseous ligament; SL, scapholunate; ST, scaphotrapezial; TH, triquetrohamate.

Table 5

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Palmer classification of triangular fibrocartilage complex (TFCC) injuries

Class 1 - Traumatic TFCC Injuries		
1A	Central perforation or tear	Debride
1B	Ulnar avulsion (without ulnar styloid fx)	Further classified by Atzei
1C	Distal avulsion (origin of ulnolunate and ulnotriquetral ligaments)	Sparse literature: debride favoured, over repair
1D	Radial avulsion	Intraosseous repair/rare
Class 2 - Degenerative TFCC Injuries		
2A	TFCC wear and thinning	Debride ± ulnar shortening
2B	Lunate and/or ulnar chondromalacia + 2A	Debride ± ulnar shortening
2C	TFCC perforation + 2B	Debride ± Feldon wafer
2D	Ligament disruption + 2C	Reconstruct vs salvage
2E	Ulnocarpal and distal radioulnar joint arthritis + 2D	Salvage: excise vs replace

Table 6

Arthroscopic excision of dorsal ganglia can be performed with less scarring in order to theoretically reduce the postoperative wrist stiffness.

The technique preferred by the authors is to use a triangulation technique with two radiocarpal portals. The 1–2 portal is usually used for visualization of the stalk of the ganglion at the dorsal capsule adjacent to the scapholunate ligament.[38] When the stalk or a redundant capsule around the distal-dorsal portion of the SLIL has been observed, decompression of the cyst is performed by placing a shaver through the 6R portal, leaving a 1-cm full-thickness capsular defect without injuring the scapholunate ligament itself.

It is crucial to understand that in contrast to the traditional open ganglion excision, which usually involves excising the whole cyst sac, the aim of the arthroscopy procedure is to disrupt the communication between the cyst and the joint by creating the capsular defect and excising the stalk of the cyst whilst leaving the cyst sac decompressed, which will be reabsorbed over time.

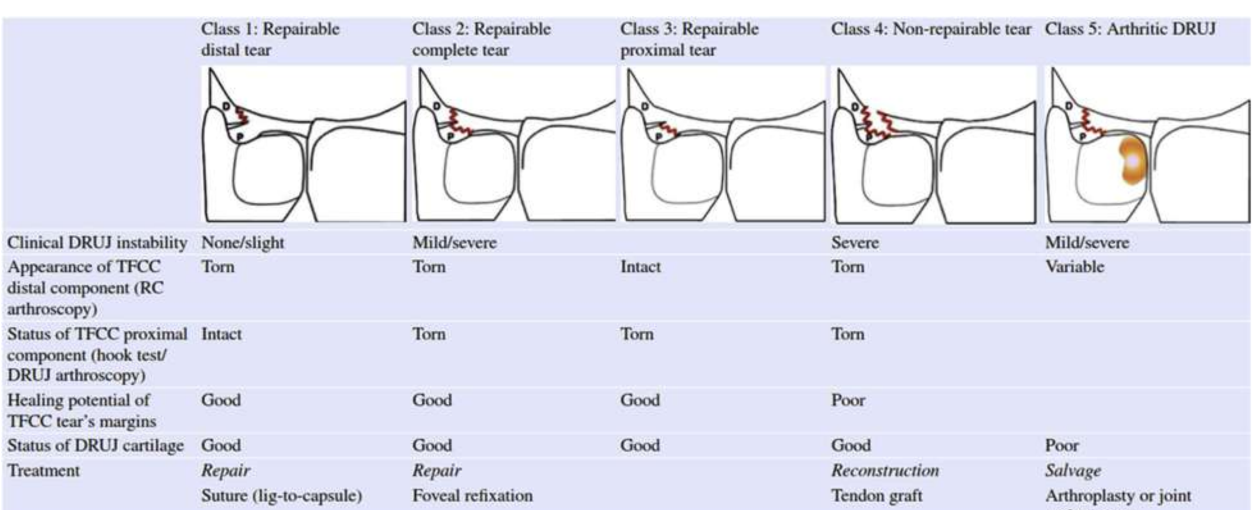
The volar wrist ganglion is the second most common lesion occurring around the wrist and is usually seen between the volar radiocarpal ligaments, namely the radioscaphocapitate and the long radiolunate ligaments.[8] The scope is usually inserted in the 1–2 or 3–4 portal and the shaver through the 3–4 or 4–5 portals to debride the capsule between the ligaments whilst exerting pressure on the ganglion externally; once the interval is sufficiently enlarged, a gush of mucinous material is seen. Care must be taken to prevent aggressive debridement to avoid injury to the radial artery, which is in close proximity (Figure 11).

Arthroscopic management of carpal instability

Carpal instability is a complex pathological process that involves biomechanical imbalance due to attenuation or tear of the intrinsic and extrinsic carpal ligaments.

Acute tears of the SLIL or lunotriquetral interosseous lunotriquetral interosseous ligament (LTIL) with incongruency or step-off seen in midcarpal space can be managed by arthroscopic-assisted pinning once reduction is achieved by k-wire joysticks in the scaphoid and lunate or by arthroscopic repair of the DSCC as described by Mathoulin.[39–42]

For Geissler grade 4 acute injuries, 'open' direct primary repair through a small arthrotomy is still the mainstay of treatment.



	Class 1: Repairable distal tear	Class 2: Repairable complete tear	Class 3: Repairable proximal tear	Class 4: Non-repairable tear	Class 5: Arthritic DRUJ
Clinical DRUJ instability	None/slight	Mild/severe		Severe	Mild/severe
Appearance of TFCC distal component (RC arthroscopy)	Torn	Torn	Intact	Torn	Variable
Status of TFCC proximal component (hook test/ DRUJ arthroscopy)	Intact	Torn	Torn	Torn	
Healing potential of TFCC tear's margins	Good	Good	Good	Poor	
Status of DRUJ cartilage	Good	Good	Good	Good	Poor
Treatment	*Repair* Suture (lig-to-capsule)	*Repair* Foveal refixation		*Reconstruction* Tendon graft	*Salvage* Arthroplasty or joint replacement

Figure 8 Atzei's Comprehensive classification of TFCC peripheral tears. DRUJ, distal radioulnar joint; RC, radiocarpal; TFCC, triangular fibrocartilage complex. Reproduced from reference 32 with permission from Elsevier.

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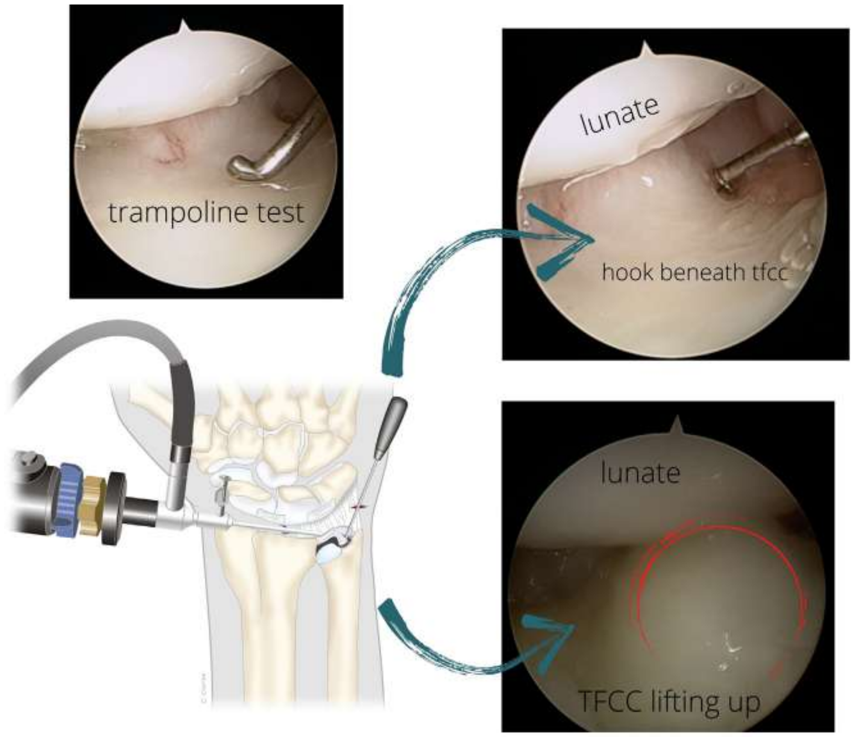

Figure 9 Trampoline and Hook tests. TFCC triangular fibrocartilage complex.

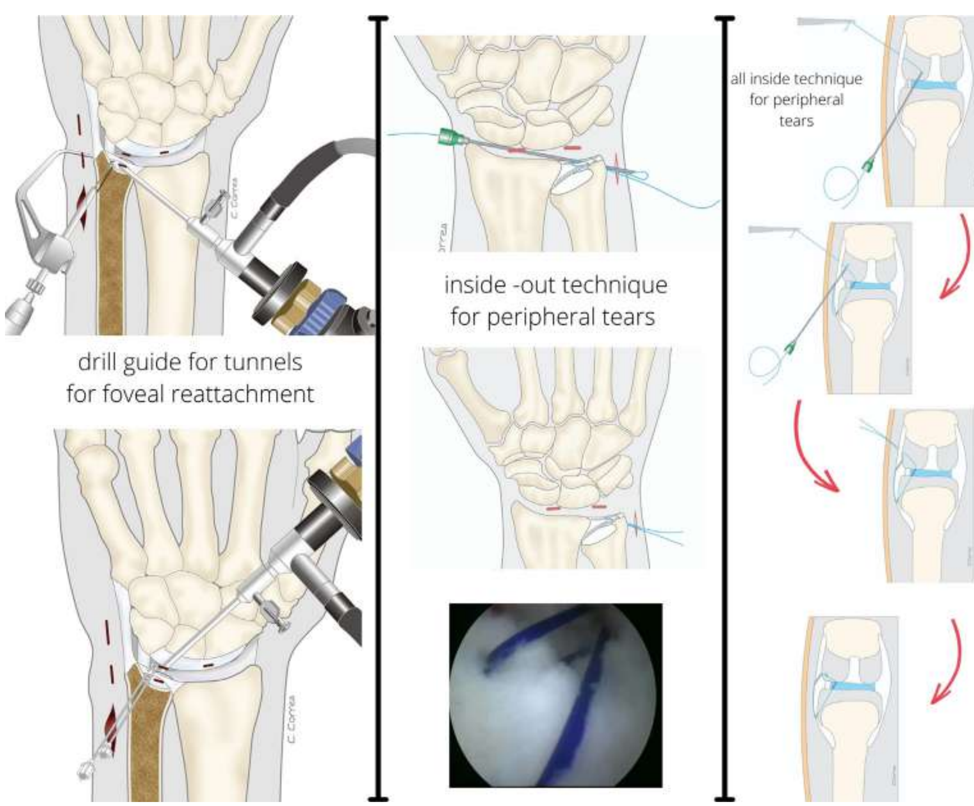

Figure 10 Foveal re-attachment; inside out and all inside technique for peripheral tears.

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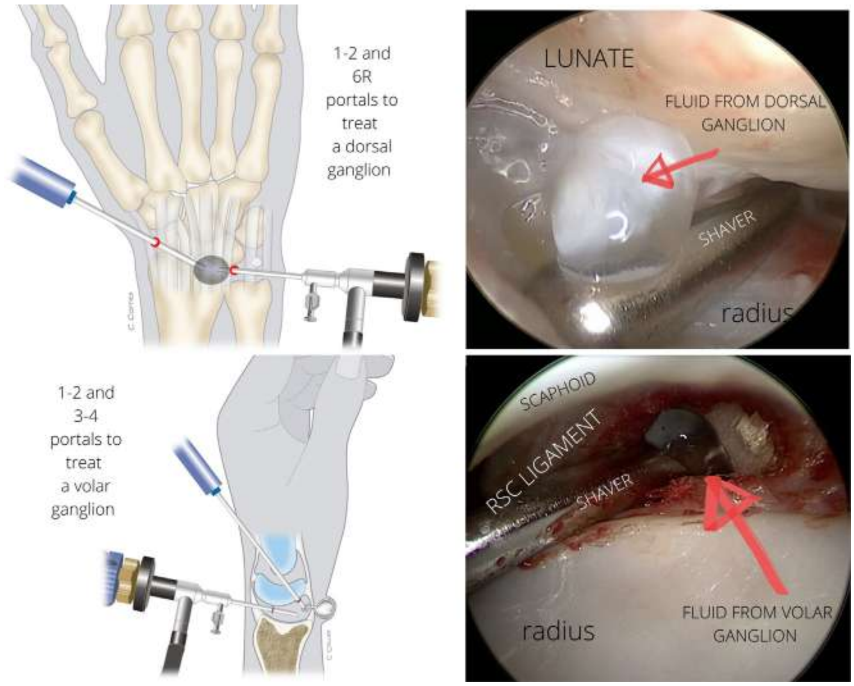

Figure 11 Dorsal and volar ganglia. RSC, radioscaphocapitate.

For chronic grade 3 or grade 4 injuries without significant cartilage damage, various arthroscopic-assisted techniques to reconstruct the scapholunate ligament with tendon grafts have been described but have a steep learning curve and does involve longer tourniquet times. These, however, have less soft tissue disruption than open surgery and include repair of the volar components of the ligament as well.[18,43]

Thermal shrinkage, though controversial, has had success in the management of midcarpal instability. The principle of the technique is to 'tighten' or cause acute shortening of the ligaments and the dorsal or volar wrist capsule by thermal denaturation of the collagen triple helix using radiofrequency electrical modalities.[44]

Arthroscopic-assisted fracture reduction

Arthroscopic management of distal radius fractures

Most distal radius fractures are wrist injuries associated with additional soft tissue disruption rather than a fracture alone, and the main challenge remains to ensure anatomical reduction of the

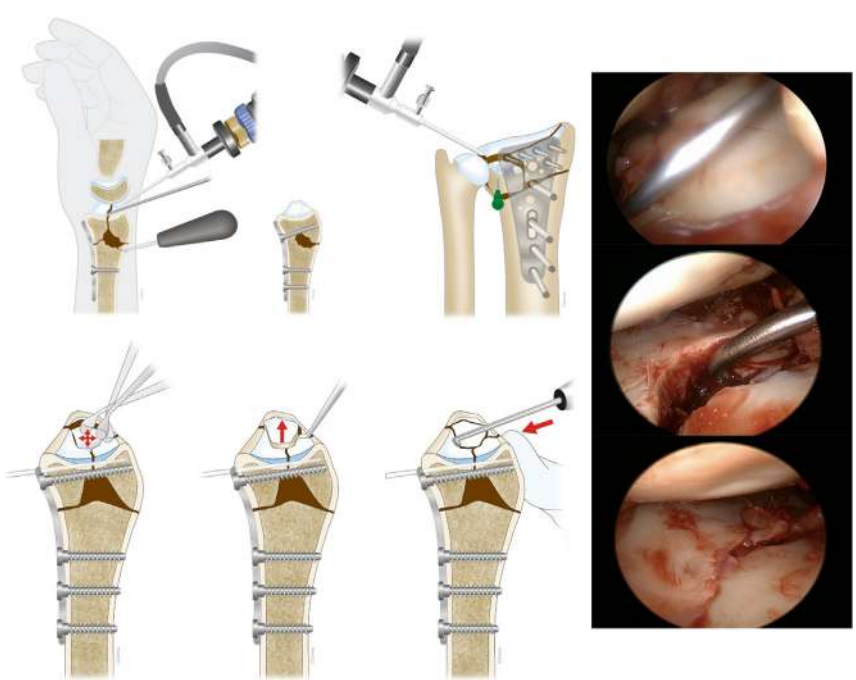

Figure 12 Arthroscopic-assisted distal radius fracture treatment.

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joint and identifying and treating the associated ligament injuries. There are no level 1 studies proving improvement in functional outcomes with arthroscopy assisted surgery for distal radius fractures. However, with respect to the assessment of associated ligamentous injuries, articular reduction and management of intraarticular injuries, the superiority of using wrist arthroscopy assistance has been demonstrated. Further, joint washout with evacuation of haematoma, removal of debris and loose fragments reduces the risk of secondary arthrosis. Arthroscopy also assists in checking screw positioning and avoiding intra-articular placement but permits accurate subarticular placement of raft screws which are essential in preventing collapse.

Access to the joint is via the standard 3–4, 6-R portals. The procedure starts joint lavage and debridement using a 10 ml saline syringe to the arthroscopy cannula and using a shaver with suction attached as described by Dr Pinal.[45] The intra-articular joint fragments are visualized and correlated with the radiographs and CT images. Additional 1–2 and 6-U portals can be used to improve visualization and assist instrumentation.

Standard volar approach to the distal radius is performed and attention paid to reducing the ulnar column, restoring the volar cortex and preventing coronal translation. The volar plate is applied with a screw in the elliptical hole. Next, k-wires are inserted as joysticks into the two fragments (radial styloid and lunate fragment), and arthroscopic-assisted reduction is performed. This may involve using various instruments like a freer elevator, a small joint probe and a needle into the joint to guide k-wire placement. Fluoroscopic guidance is essential. Central depressed fragments are best visualized arthroscopically and can be elevated using the above-mentioned instruments, and accurate reduction can be visually confirmed. Often this is difficult to appreciate with just radiographs alone (Figure 12). Once good joint alignment has been achieved, temporary fixation is performed with k-wires advanced through to the distal fragment. The distal screws are then placed into the subchondral bone of the distal radius. Two surgeons operating together is advisable in challenging cases, and the screws can be placed under combined arthroscopic and fluoroscopic control to ensure no intra-articular encroachment. Headless cannulated screws can permit fragment specific fixation with larger fragments as an alternative to plate fixation and can allow early mobilization.

One must not forget to complete the process by assessing the intrinsic and extrinsic ligaments and TFCC for associated injuries, and these must be addressed appropriately. Lindau et al.[9] arthroscopically evaluated 51 distal radius fracture and demonstrated associated TFCC injury (78%), SLIL injury (54%) and LTIL injury (16%).

Arthroscopic management of scaphoid fractures

Arthroscopic evaluation of the reduction of the scaphoid has been described as a valuable adjunct to percutaneous screw fixation to ensure accurate anatomical reduction. Direct visualization aids anatomic reduction before screw fixation, and various techniques have been described.[46] More recently, it has been used in the management of scaphoid fracture non-unions. The stability of the fibrous non-union can be assessed with a probe and can help decide on the use of just screw fixation if stable or on the additional need for bone grafting if unstable.

Bone graft can be harvested by percutaneous methods from the distal radius, and a burr can be used in the midcarpal portal to open the fracture site on the scaphoid. The bone graft is introduced under direct visualization and is tightly packed before insertion of the cannulated screws.[12] The prominence of the screw heads can also be assessed by intra-articular evaluation arthroscopically at the end of the procedure.

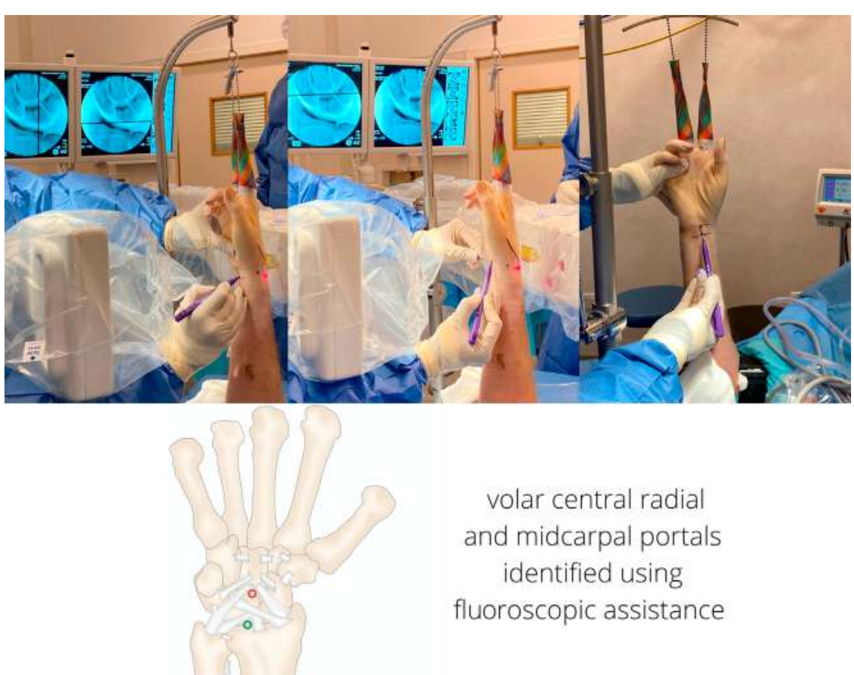

Figure 13 Volar central portals.

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Arthroscopic management of perilunate dislocation

Perilunate injuries, which often result from high-energy trauma, are severe wrist injuries and their well-described surgical treatment includes open reduction of the carpal bones, repair or reconstruction of the ligaments and internal fixation of the fractures (in greater arc injuries). Recently, arthroscopic-assisted minimally invasive management of lunate and perilunate dislocations has been described, with the benefit of allowing anatomic reduction and precise percutaneous internal fixation of the carpal bones with minimal tissue dissection. Arthroscopic-assisted reduction of the capito-lunate joint for failed closed reduction can be performed using the ‘shoehorn manoeuvre’, which includes reduction of the lunate with Freer elevator or small joint probe through the 4–5 portal[10] with a visual inspection from the standard 3–4 portal. The interval between the scaphoid and lunate and between the lunate and triquetrum must be carefully debrided and soft tissue or bony fragments removed to facilitate the reduction of the intercarpal joint, followed by percutaneous wire fixation, under fluoroscopy and direct visualization of the scapholunate and lunotriquetral interval through midcarpal portal. The scapholunate ligament can be further reinforced by a mini-open approach with suture anchors placed a cm wide of the SLIL in the scaphoid and lunate, and sutures are tied on the top of the dorsal capsule.

Procedures for wrist arthritis

Arthroscopic radial styloidectomy

Radioscaphoid impingement occurs in the early stage of arthritis in scapholunate advanced collapse (SLAC) or scaphoid nonunion advanced collapse (SNAC) or as a complication of distal radius fractures as malunion or pseudoarthrosis. Radial styloidectomy, which is commonly combined with wrist denervation, is indicated for young, active patients with painful but good wrist motion in whom salvage procedures (PRC, partial and full wrist fusion) are better to be avoided. Arthroscopic radial styloidectomy allows preservation of the ligamentous supports (radioscaphocapitate and long radiolunate ligaments) of the wrist due to enhanced visualization. The common technique involves using the standard 3–4 as a viewing portal and an initial synovial debridement with the shaver through the 1–2 portal to obtain a better view of the planned resection site on the styloid. Then a 3 mm burr is used through the 1–2 portal to resect 3 mm (the width of the burr) of the arthritic portion of the styloid. You can switch between the burr and the shaver[47] as required. It is recommended that this is performed with fluoroscopic assistance to confirm adequate resection and prevent over resection, which risks injury to the RSC ligament.

Arthroscopic proximal row carpectomy

In the management of more advanced stages of wrist arthritis, PRC is a well-established option. This is usually done as an open procedure. Arthroscopic PRC has the advantages of minimal disruption to the dorsal and volar capsules and hence facilitates early mobilization. It has not gained popularity as it is technically challenging and can take longer to perform. This has been made easier by Correllas introduction of the volar central portals[13,22] (Figure 13, Table 2). Standard dorsal portals are utilized to visualize and assess the chondral surfaces of the radiocarpal and midcarpal joints. The volar central portals are used for instrumentation, and the 3 mm burrs are used to remove the proximal row of carpal bone with a mix of dry and wet arthroscopy. Pituitary rongeurs aid the removal of loose fragments. Extreme care must be taken during the procedure to avoid any chondral damage to the proximal surface of the capitate, the radio lunate fossa and to the volar wrist extrinsic ligaments.

Arthroscopic partial wrist fusion

PC Ho’s pioneering work led to the acceptance of the use of arthroscopy to perform common partial wrist fusions. Pinal and Tandioy-Delgado refined this procedure with the use of dry arthroscopy techniques.[15,16] Use of additional clever instruments like a Foley catheter inflated in the joint to prevent spillage of the graft into uninvolved areas and use of an ear, nose and throat speculum[14] and pituitary rongeurs; and inventing a new scapholunate portal between the midcarpal radial and 3–4 portals, use of volar portals have all helped make the process easier. The steps still remain the same as in an open procedure, and one must not forget to correct the carpal alignment prior to inserting the canulated screws and compressing the graft between the intended fusion surfaces. Again, this procedure must be reserved for the experienced arthroscopist. Recently Nazerani et al.[48] have presented a case series of five patients with good results following arthroscopic wrist fusion.

Complications

Wrist arthroscopy is a minimally invasive procedure that is considered to be safe with a low complication rate. However, a thorough knowledge of the anatomy, proficiency base progression, and adherence to safe techniques like the use of blunt dissection, avoiding use of excessive traction, no traction on the little finger can help limit complications. Complications may be due to traction and positioning, due to the creation of portals and passage of instruments or due to specific procedures.

The complications of wrist arthroscopy[49] can be divided into two groups: major and minor. Major complications include compartment syndrome, permanent nerve injury, post-surgical joint infection, vascular injury, complex regional pain syndrome (CRPS), permanent wrist or finger stiffness, tendon rupture and any complication leading to repeat surgical intervention. Minor complications include transient nerve injury, prolonged (longer than 5 days) portal site drainage or infection, transient stiffness and extensor tendon irritation.

The overall rate of wrist arthroscopy complication is around 5%),[49,50] and there is a significant relationship between the surgeon experience and the rate of complications, with a threshold for a lower complication rate being approximately 25 arthroscopies a year and/or greater than 5 years of experience.

Few important steps were emphasized in order to prevent complications of wrist arthroscopy, including careful portal planning, using blunt trocars to prevent iatrogenic damage of the articular cartilage and using soft tissue guides during percutaneous wire fixation to prevent damage to sensory nerve branches.

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Recent advancements

Wide-awake wrist arthroscopy

Don Lalonde popularized a wide-awake approach to hand surgery with the use of large volume local anaesthetic infiltration with adrenaline and no tourniquet (WALANT).[20] PC Ho successfully modified this with a much smaller dose infiltration of local anaesthetic with adrenaline (2 ml) to each portal site only (PSLA),[51] permitting safe access and visualization of the wrist joints arthroscopically in wide-awake patients. A further 4 ml intra-articular infiltration of local anaesthetic with adrenaline as required facilitated completion of therapeutic procedures like excision of ganglia where capsular stretch produced pain.

This has opened up a new avenue of dynamic assessment of the wrist D_WAWA (dynamic wide-awake wrist arthroscopy[52] with visualization of carpal mobility when the patient moves or clenches their wrist. This may require the development of new grading systems to assess the instabilities visualized as our understanding of what is normal and abnormal improves.

Nanoscope

One of the biggest challenges of small joint arthroscopy is preventing bending and damaging the arthroscope during the procedure. Recently, The NanoScope™ visualization system was presented by Arthrex is a 1.9 mm diameter chip-on-tip sterile, single-use device with 0° viewing angle and 120° field of view. It provides an alternative to MRI imaging and second-look arthroscopy and offers precise, direct visualization of small tight and curved spaces.[53]

Summary

Wrist arthroscopy is a minimally invasive diagnostic and important therapeutic tool in the surgeon's armamentarium. There is a learning curve that is steep for the more advanced procedures. The use of safe techniques and a thorough knowledge of anatomy will help reduce complications. With further improvements in instrumentation and surgical technique, wrist arthroscopy will transform our ability to diagnose and manage various wrist pathology. Arthroscopy, however, should not replace a thorough clinical history and clinical examination. ◆

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