Complications of Wrist and Hand Arthroscopy

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KEYWORDS

• Wrist arthroscopy • Complications • Neurovascular structures • Tendon injury
• Surgeon experience

KEY POINTS

- A detailed review of the wrist arthroscopy literature yields a complication rate of 4.8%.
- A number of safety precautions have been identified to mitigate the incidence of iatrogenic injury with wrist arthroscopy.
- The rate of complications decreases when a surgeon performs more than 25 cases/year and also decreases significantly after more than 5 years of operative experience.

INTRODUCTION

Arthroscopy of the wrist continues to evolve and advance as a valuable clinical technique in hand surgery that facilitates effective diagnosis and therapy. First introduced in 1979[1] and further detailed in the literature in 1988,[2,3] wrist arthroscopy provides a wide range of current indications and continues to adapt and yield minimally invasive alternatives to open surgical procedures. With increasing adaptation of wrist arthroscopy and an escalating volume of cases performed worldwide, further insights have been gained regarding the complications of wrist arthroscopy over the past 5 years. Specifically, a systematic review of the incidence of complications,[4] systematic review of cadaveric studies reporting structures at risk,[5] and a large multicenter trial[6] have been introduced into the literature for wrist arthroscopy.

Largely regarded as a safe procedure, incidence of complications in the literature ranges from 1.2% to 7.9%.[4,7–14] The most recent study is a multicenter retrospective review of 10,107 cases by Leclercq and colleagues[6] with a finding of 5.98% complications, with 5.07% listed as serious and 0.91% as minor. Serious complications were defined as laceration of tendon, nerve, artery, large cartilage lesion, loose body requiring arthrotomy, hematoma formation, compartment syndrome, pyogenic arthritis, wrist stiffness, chronic regional pain syndrome, and newly defined "failure to achieve the procedure."[6] Minor complications include transient neuropraxia, small cartilage lesion, loose body not requiring arthrotomy, synovial fistula, local swelling, superficial sepsis, portal site pathology (ganglia, adhesion, pain), and miscellaneous self-limiting problems.

Possible complications may be related to traction and positioning of the arm, portal placement, procedure-specific injuries, and general complications involved in wrist arthroscopy.[8,15] Complications that are universal to wrist arthroscopy include infection, articular surface damage, and equipment failure.[15] The establishment of portals and introduction of instruments requires a thorough knowledge of the regional anatomy and appropriate tactile sensitivity of the surgeon. Poor positioning of portals and forceful insertion of instruments may damage articular cartilage,

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ligaments, tendons, cutaneous nerves, and vascular structures.[16]

An evolving figure, the true incidence of complications is likely dependent on the definition of complications as well as the willingness of surgeons to report their complications. Regardless, a thorough knowledge and understanding of the possible consequences of our interventions as surgeons can help to mitigate complications and optimize patient outcomes. The objective of this article is to summarize the current literature to guide clinicians implementing wrist arthroscopy into their respective practices.

A comprehensive review of the literature was performed, identifying 12 multiple patient trials that address complications of wrist arthroscopy (**Table 1**). There were 4 case reports that described unique incidence of wrist arthroscopy complications (**Table 2**).

Cadaveric Studies

Prior to overviewing the clinically reported wrist arthroscopy complications in the literature, a review of the relevant anatomy is warranted. This primarily pertains to the dorsal structures, as most arthroscopic procedures are performed via a dorsal approach (**Fig. 1**). The 6 extensor compartments delineate the margins for instrumentation into the wrist joint. The spaces intervening the compartments (1–2, 3–4, 4–5), as well as the ulnar and radial aspects of the sixth compartment comprise the primary portals. Structures of importance include the deep branch of the radial artery (RA), superficial branch of the radial nerve (SBRN), dorsal sensory branch of the ulnar nerve (DSBUN), and the distal posterior interosseous nerve (PIN).[11,15,17] The deep branch of the RA enters the anatomic snuffbox under the tendons of the first dorsal compartment and crosses the base of the thumb metacarpal to enter the palm.[8,18] The SBRN travels deep to the brachioradialis and changes course at the intersection of the first and second extensor compartments with arborization to supply sensation to the thumb, index, and long fingers.[8,15] The DSBUN arises from the ulnar nerve deep to the flexor carpi ulnaris tendon, runs subcutaneously and wraps around the distal ulna within 1 cm of the ulnar head. Near the level of the ulnar styloid, 5 variable branches of the DSBUN are typically noted, giving rise to higher risk of injury, particularly when using the 6U portal.[18–20] The DSBUN consistently travels intimately around the extensor carpi ulnaris (ECU) and can be found on either side of the tendon, in close proximity to the 6 radial (6R) and 6 ulnar

Table 1
Multiple patient studies presenting wrist arthroscopy complications

Author, Year	Study Design	Level of Evidence	Number of Complications	Number of Patients in Study	Percentage
Lourie et al,[20] 1994	Prospective cohort	II	3	15	20.0
Warhold and Ruth,[15] 1995	Case series	IV	4	205	2.0
de Smet,[16] 1996	Case series	IV	2	129	1.6
Doi et al,[42] 1999	Randomized controlled study	I	7	34	20.5
Hofmeister et al,[10] 2001	Prospective cohort	II	1	89	1.1
Beredjiklian et al,[7] 2004	Case series	IV	11	211	5.2
Pell and Uhl,[27] 2004	Case series	IV	4	47	8.5
Darlis et al,[30] 2005	Case series	IV	2	16	12.5
Rocchi et al,[31] 2008	Prospective randomized study	I	2	20	10.0
Gallego and Mathoulin,[32] 2010	Case series	IV	6	114	5.3
Chen et al,[33] 2010	Case series	IV	1	15	6.6
Leclercq et al,[6] 2016	Multicenter case series	IV	605	10,107	6.0
Total			648	11,002	5.9

Table 2
Summary of case reports of wrist arthroscopy complications

Author, Year	Study Design	Level of Evidence	Description of Injury
del Piñal et al,[34] 1999	Case report	V	Avulsion of distal PIN at 3–4 portal
Tsu-Hsin Chen et al,[38] 2006	Case report	V	Strangulation of DSBUN with suture after TFCC repair (inside-out technique)
Shirley et al,[37] 2008	Case report	V	Extensor tendon sheath fistula formation
Nguyen et al,[41] 2011	Case report	V	Transection of ulnar nerve trunk at 6U portal

Abbreviations: DSBUN, dorsal sensory branch of the ulnar nerve; PIN, posterior interosseous nerve; TFCC, triangular fibrocartilaginous complex; 6U, 6 ulnar.

(6U) portals. The distal PIN travels along the floor of the fourth compartment and supplies sensation to the joint capsule. It is less mobile than the surrounding sensory nerves.[8,15]

In an effort to establish the anatomic basis for complications of wrist arthroscopy, Shyamalan and colleagues[5] conducted an anatomic study of 10 cadaveric wrists and simultaneously performed

Fig. 1. Portal anatomy of the dorsal aspect of the wrist. DRUJ, distal radioulnar joint; MCR, midcarpal radial; MCU, midcarpal ulnar; R, radial; U, ulnar. (*From* El-Gazzar Y, Baker CL. Complications of elbow and wrist arthroscopy. Sports Med Arthrosc 2013;21(2):80–8; with permission.)

a systematic review of cadaveric studies pertaining to wrist arthroscopy and the proximity of neighboring anatomic structures. The specimens underwent 60 to 180 minutes of arthroscopic surgery by experienced surgeons involving a diagnostic arthroscopy followed by repair of the triangular fibrocartilaginous complex (TFCC). During these procedures the 1–2, 3–4, 4–5, 6R, 6U, ulnar midcarpal, and radial midcarpal portals were created with aid of a 22-gauge needle. Additional portals including distal radioulnar joint (DRUJ), volar radial, and volar ulnar portals have been described,[21,22] although were not the focus of this study. Subsequent dissection of the cadaveric wrists was performed to identify the proximity of the DSBUN, SBRN, PIN, and extensor tendons to the portals. Digital calipers were used to measure the distances from the portals and damage to any nerves or tendons was recorded. The average distances of each sensory nerve from the portals was documented and is outlined in Table 3.

All 7 portals were within close proximity of the 3 nerves (DSBUN, SBRN, and PIN). During dissection of the wrist following completion of the arthroscopy, one nerve injury was identified during a capsulodesis stitch placement; all 3 nerves were noted to run under a skin portal in at least 1 specimen. Six extensor tendon injuries were noted including the extensor digitorum communis (EDC) to the index finger, EDC to the middle finger, ECU, and extensor digiti minimi.

Seven publications were included in the systematic review of cadaveric studies addressing susceptibility to injury during wrist arthroscopy. Three of these were performed on fresh frozen cadavers[22–24] and 4 on preserved cadavers.[19,21,25,26]

Among these studies, the DSBUN was a risk from the 6U, 6R, and ulnar midcarpal portals in the study by Shyamalan and colleagues.[5] The 6R had a mean distance of 8 mm and the 6U portal was documented as a zero-distance due to several adjacent data points. Tryfonidis and colleagues[19] reported the DSBUN at risk only from the 6U portal, not the 6R or ulnar midcarpal portal. The DSBUN was documented as a mean of 2.4 cm (range 1.8–2.8 mm) from the ulnar styloid along a straight line in the trajectory of the fourth webspace. It was concluded that portal placement in the proximal fifth of this line was "safe."[26] The SBRN was at risk from the 1 to 2 portal with mean distance of 1.6 mm (range 0–8 mm) and the radial midcarpal portal was a close second with mean distance of 24 mm.[5] The reviewed studies supported this finding along with risk from the 3 to 4 portal.[19,23] The PIN was at risk in the study by Shyamalan and colleagues[5] at the 3 to 4 portal and had the shortest mean distance of 4.4 mm (range 0–10) and at the 4 to 5 portal with a distance of 12.6 mm (range 2–25).[5] This is a new finding, undocumented in the reviewed cadaveric literature.[14,19,21–23,25]

Clinical Studies

Lourie and colleagues[20] reported a series of 15 patients who underwent DRUJ arthroscopy. Three of these patients presented with transection of the transverse radioulnar branch of the DSBUN. Persistent dysesthesia with a positive Tinel sign, consistent with neuroma formation was noted for each of these instances. The patients were treated with secondary operative excision of the neuroma and this relieved all symptoms but left a small region of hypesthesia of the skin. The transverse radioulnar branch of the DSBUN is particularly vulnerable to injury in the region of the 6R portal because of its variable arborization. Injury to this nerve has potential to cause persistent pain due to neuroma formation.

A study by Warhold and Ruth in 1995[15] provided a review of complications from a series of 205 wrist arthroscopies. Four complications were described, amounting to a 2% incidence. These complications consisted of 1 suture abscess, which resolved on removal of the suture; 1 inclusion cyst, which required surgical removal 6 months after the initial arthroscopy; and 2 cases

Table 3
Anatomic distance of DSBUN, SBRN, PIN from arthroscopic portals (mm)

Nerve	1–2	3–4	4–5	6 Radial	6 Ulnar	Ulnar Midcarpal	Radial Midcarpal
DSBUN	51–82	30–60	13–32	2–14	0–8	9–56	27–54
SBRN	0–8	15–33	23–52	44–76	51–84	30–64	13–42
PIN	18–35	0–10	2–25	10–36	18–40	10–16	0–20

Abbreviations: DSBUN, dorsal sensory branch of the ulnar nerve; PIN, posterior interosseous nerve; SBRN, superficial branch of the radial nerve.

From Shyamalan G, Jordan RW, Kimani PK, et al. Assessment of the structures at risk during wrist arthroscopy: a cadaveric study and systematic review. J Hand Surg Eur Vol 2016;41(8):854; with permission.

of mild reflex sympathetic dystrophy (RSD). The RSD resolved spontaneously in 1 patient; however, it remained as persistent wrist pain in the second patient. De Smet and colleagues[9] presented a retrospective review of 129 patients with wrist arthroscopy with 2 identified complications (1.6%). These were 1 case of tendon rupture over a Kirschner wire and 1 superficial infection at a portal site. Hofmeister and colleagues[10] presented a series of 89 wrist arthroscopies in 2001 with a single reported complication. This complication was a partial laceration of the EDC tendon to the small finger. An extension lag was noted immediately in the postoperative period but no treatment was necessary. Beredjiklian and colleagues[7] reviewed 211 patients with wrist arthroscopy, identifying 11 complications (5.2%). These complications were further categorized into major and minor complications based on whether the complications resolved with observation or conservative treatment. There were 2 cases of major complications: 1 patient developed permanent wrist stiffness (25° extension and 30° flexion) after 12 months of therapy. The other involved ganglion cyst development that required surgical excision 12 months postoperatively. Minor complications in the remaining 9 patients consisted of transient sensory neuropraxia of DSBUN, transient stiffness of the wrist and finger joints, superficial portal infection, first-degree burn, and ECU tendinitis.

Pell and Uhl[27] reviewed 47 patients who underwent thermal ablation procedures during wrist arthroscopy and reported 3 tendon ruptures and 1 case of a full-thickness skin burn as a result of use of the electrothermal frequency probe. Extensor tendon function was maintained immediately after arthroscopy and rupture was noted 1 to 3 months postoperatively. The minimal soft tissue between the dorsal wrist capsule and the surrounding structures places them at additional risk with use of the thermal ablation. Shellock and Shields[28] suggest that monopolar radiofrequency may not properly regulate the delivery of energy-induced heat, and bipolar devices are recommended due to a linear relationship between surface temperature and time. Ultimately, the extent of thermal injury is dependent on the surgeon's regulation.[29] A 2005 study by Darlis and colleagues[30] evaluated the treatment of partial scapholunate ligament injuries with arthroscopic debridement and thermal shrinkage. Two of 16 patients undergoing treatment experienced postoperative complications during the follow-up period: one instance of carpal tunnel syndrome (CTS) managed with splinting and another patient developed de Quervain tenosynovitis requiring a corticosteroid injection to alleviate symptoms. A direct correlation with the thermal capsulorrhaphy and CTS or de Quervain was not apparent, although the investigators advocated for judicious use of radiofrequency probe application for thermal shrinkage.

Rocchi and colleagues[31] present a prospective randomized study comparing the treatment of articular ganglia via arthroscopic resection and open excision. Among 20 patients in the arthroscopic resection group, there were 2 complications: 1 case of neuropraxia of the SBRN to the dorsal aspect of the thumb and 1 injury to a branch of the radial artery. The neuropraxia recovered spontaneously in 3 months and the arterial injury was converted to an open operation to obtain hemostasis. Gallego and Mathoulin[32] evaluated 114 patients for arthroscopic resection of dorsal wrist ganglia. Six arthroscopy-related complications were noted: 2 hematomas required surgical drainage, 1 case of tenosynovitis of the extensor pollicis longus tendon, 1 case of tenosynovitis of the EDC tendon, and 2 patients with transient neuropraxia of the SBRN and DSBUN. Fourteen patients experienced recurrence of the ganglion cyst, which were not classified as isolated wrist arthroscopy complication, although merits acknowledgment. Chen and colleagues[33] present a case series of 15 patients who underwent arthroscopic ganglionectomy with a mean follow-up of 15.3 months. There was a single arthroscopy-related complication, transient paresthesias along the radial side, which resolved in 1 month. Recurrence of the ganglion cyst was appreciated in an additional case, although not considered a complication of the arthroscopic procedure.

The largest study of wrist arthroscopy complications to date was presented by Leclercq and colleagues[6] in conjunction with the European Wrist Arthroscopy Society (EWAS) in April 2016. A large multicenter retrospective review identified 36 series comprising 10,107 wrist arthroscopy procedures; 605 complications (5.85%) were noted, of which 5.07% were considered major and 0.91% minor. The review was performed by the administration of a questionnaire to members of the EWAS, with contribution from 36 of 180 members. Scrutiny of the data for each surgeon's experience with wrist arthroscopy and its relation to complications demonstrated that average complication rate is 6 times greater in small series (<50 cases: 22.6% complications) than in large series (>600 cases: 3.7% complications). Higher incidence of complications was correlated with less than 25 wrist arthroscopy procedures performed annually or less than 5 years of practice of wrist arthroscopy. This finding supports the existence of a learning curve, as with all acquired technical skills

in surgery. The most common complication (118 cases, 1.17%) was "failure to achieve the procedure," defined as need to proceed with open surgery to achieve surgical goals. More than 50% of these cases involved ganglion excision. Nerve lesions were the second most common (0.8% incidence), with 59 nerve lacerations (0.59%) occurring at the site of the wrist portals. Most of these were sensory nerve injuries, although 2 involved the median nerve proper during volar ganglia excision. Fifteen of these lesions required revision surgery. Cartilage lesions were further categorized as minimal (unlikely to create future problems) and large (more than 5 mm^2). Minimal cartilage lesions occurred in most series (33 of 36) with 51 total large lesions identified throughout the total cohort (0.5%). The presence of a "tight wrist," making navigating within the joints difficult, irrespective of procedure, was most likely to generate a cartilage lesion.

Chronic regional pain syndrome, wrist stiffness, loose bodies, hematoma formation, and tendon lacerations were noted in declining incidence. Finger traction and arm countertraction were also identified as sources of complication, responsible for neuropraxia at the finger or arm level. Also, there were 3 reported cases of burns due to the hot traction tower.[6,8] This emphasizes the importance of diligence throughout each part of the procedure, including preparation, draping, and patient positioning.

In 1999, del Piñal and colleagues[34] presented a case report of distal PIN avulsion following wrist arthroscopy. Instrumentation into the wrist joint was performed via the 3–4, 6R, and radial midcarpal portals. A scapholunate injury was visualized and an open repair was deemed necessary.[35] On an open approach with a longitudinal incision centered at the Lister tubercle, the distal PIN was found to be avulsed at the level of the 3–4 portal. This is the only reported case of this injury in the literature. The lack of other reports may be attributed to the rarity of the injury or that most arthroscopies do not require an open procedure that may reveal distal PIN injury that may otherwise remain occult. This study presents the possibility of distal PIN injury during wrist arthroscopy that may lead to chronic dorsal wrist pain. On the contrary, it is possible that complete avulsion of the distal PIN provides symptomatic relief via partial sensory denervation for patients experiencing prior chronic dorsal wrist pain.[36]

Shirley and colleagues[37] presented a case report of extensor tendon sheath fistula formation in a 45-year-old man who underwent diagnostic arthroscopy after sustaining a scapholunate ligament (SL) disruption. When the patient returned for SL ligament reconstruction, a tender fluctuant swelling (6 × 3 × 1 cm) was noted on the dorsum of the hand. The collection of fluid was identified around the extensor pollicis longus tendon within the tendon sheath. A patent opening from the tendon sheath into the radiocarpal joint was noted at the location of the previous 3–4 portal. This was treated with fluid evacuation and surgical diathermy to preserve the tendon sheath. A case report of DSBUN injury during repair of a Palmer Class 1B TFCC lesion has been presented in the literature by Tsu-Hsin Chen and colleagues.[38] The mechanism of injury involved strangulation of the nerve during arthroscopic TFCC repair by a pull-out suture placed in the joint capsule. Three percutaneous sutures were used with an arthroscope-assisted inside-out technique, the most distal of which entrapped the nerve. Postoperatively, the patient experienced severe pricking pain in the distribution of the DSBUN and local tenderness over the TFCC scar, worsening with forearm pronation/supination and percussion. Treatment entailed the segmental excision of the nerve 2 cm proximal and distal to the suture site. In a cadaveric study of arthroscopic TFCC repair, it has been demonstrated by McAdams and Hentz[39] that the inside-out sutures may be as close as 0.4 mm to the main trunk of the DSBUN, suggesting that if the nerve is not located and protected before passing of the sutures, there is an approximately 50% chance of nerve branch strangulation. Because of this, they proposed a longitudinal open incision on the ulnar wrist to identify the DSBUN before suture application. Bednar and Osterman[40] recommend a 1-cm incision radial to the ECU tendon for safe suture retrieval and tying the suture at the level of the capsule, as opposed to the use of a suture button. As previously mentioned, the arborization pattern of the DSBUN is quite variable, and nerve injury is possible even with correct portal placement. This places the utmost importance on diligent spreading with a fine-point hemostat during portal establishment and diligent soft tissue dissection techniques for instrumentation.[8,38]

Nguyen and colleagues[41] present a case report in which near complete transection of the trunk of the ulnar nerve was caused by the trocar used for drainage at the 6U portal. Complete sensorimotor paralysis of the ulnar nerve was noted on the first postoperative day. Surgical exploration was performed, and on visualization of the injury, resection to healthy tissue was carried out and an epineural coaptation was performed. Histologic analysis of the resected nerve segment suggested trauma from the bevel of the infusion trocar placed in the 6U portal for fluid drainage. The 6U portal has

been implicated with an increased risk of injury to the DSBUN due to its variable position and winding between the pisiform and ulnar styloid.[8] This report is unique for injury to the ulnar nerve proper. It is important to consider the anatomic and positional variation of the ulnar nerve with pronation/supination movements of the forearm. The ulnar nerve is more susceptible to injury from trocar shearing movements in forced pronation due to increased tension. To ensure safe application of a drainage portal, the investigators advocate to set up by mini-open access of the 6U portal after meticulous identification of anatomic structures, use of a small-diameter trocar (>20 gauge), and avoidance of arthro-pump for water intake.[41] We currently do not use drainage portals and we avoid the routine use of the 6U portal for these reasons.

SUMMARY

This article aimed to summarize the current literature regarding complications of wrist arthroscopy. The 2016 multicenter trial[6] reported a complication rate of 5.9%, greater than the previously documented systematic review of 4.7%.[4,8,15,16] Although, if further scrutinized, 110 of those complications were "failure to achieve the procedure." Extracting these numbers yields a complication rate of 4.8%, in accordance with the prior literature.

A variety of complications have been cited; including nerve injuries, tendon injuries, tendon sheath fistulae, arterial injury, development of cysts, development of CTS, de Quervain tenosynovitis, cartilage injury, chronic loss of mobility, hematoma development, equipment-related burns, and local infections. Although a clear distinction is not made, many of the complications may be classified as minor, as they resolve with little or no intervention, whereas others are more severe and subject patients to revision procedures to alleviate the deleterious consequences.

A variety of safety precautions can minimize the incidence of iatrogenic injury. These precautions include the use of a hypodermic needle to confirm portal placement; insufflation of the joint with saline before portal placement; a longitudinal incision that penetrates only the dermis; spreading of the soft tissue with a blunt, fine-tip hemostat to allow for important structures to retract; insertion of trocar with minimal resistance; and continuous monitoring of traction.[8,15,16] Avoidance of the 6U portal and appropriate placement of percutaneous needles used in ligament repairs is important to avoid nerve entrapment.

Arthroscopy of the wrist remains a valuable and safe surgical procedure for experienced surgeons and provides a broadly applicable minimally invasive approach. The likelihood of associated injuries during wrist arthroscopy is dependent on the surgeon's mastery of the anatomy coupled with correct operative technique and a thorough understanding of the equipment.[8] The literature suggests that a learning curve exists for the execution of wrist arthroscopy. Case volume and duration of experience are variables that correlate with mitigating iatrogenic injury and optimizing patient outcomes. The rate of complications decreases when a surgeon performs more than 25 cases per year and also decreases significantly after more than 5 years of operative experience.[6]

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