



## Arthroscopic localization of the ulnar nerve behind the medial capsule is unreliable

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**Purpose:** Ulnar nerve injury is the most common neurologic complication of elbow arthroscopy. The purpose of this cadaveric study was to quantify the ability of surgeons to locate the ulnar nerve behind the posteromedial capsule during elbow arthroscopy using sole arthroscopic vision.

**Methods:** Twenty-one surgeons were asked to pin the ulnar nerve at the medial gutter and the posteromedial compartment using arthroscopic visualization of the medial capsule only. Pinning of the ulnar nerve was performed from extra-articular. Then, the cadaveric specimens were dissected and the shortest distances between the pins and ulnar nerve measured.

**Results:** Median pin-to-nerve distances at the medial gutter and posteromedial compartment were 0 mm (interquartile range [IQR], 0–3 mm) and 2 mm (IQR, 0–6 mm), respectively. The ulnar nerve was pinned by 11/21 surgeons (52%) at the medial gutter, and 7/21 surgeons (33%) at the posteromedial compartment. Three of 21 surgeons (14%) pinned the ulnar nerve at both the medial gutter and the posteromedial compartment. Surgeon's experience and operation volume did not affect these outcomes ( $P > .05$ ).

**Conclusions:** Surgeons' ability to locate the ulnar nerve behind the posteromedial capsule using sole arthroscopic visualization, without external palpation, is poor. We recommend to proceed carefully when performing arthroscopic procedures in the posteromedial elbow, and identify and mobilize the ulnar nerve prior to any posteromedial capsular procedures.

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No institutional review board approval is required for cadaveric studies at our institution. The cadaveric specimens used in this study were derived from bodies that entered the department of anatomy, University of Utrecht, through a donation program. From these persons written consent was obtained during life that allowed the use of their entire bodies for educational and research purposes.

The data sets used and/or analysed during the current study are available from the corresponding author on reasonable request.

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Treatment of elbow pathology is increasingly performed arthroscopically for an expanding range of indications. Cadaveric studies contributed to this gradual rise, because they have improved our understanding of elbow anatomy, leading to safer elbow arthroscopy techniques.<sup>3,9,18,20,28</sup> One of the most common, and potentially devastating, complications during elbow arthroscopy is nerve injury with a reported incidence between 0% and 10%.<sup>4,5,7,15–17,19,22,25,27</sup> The most frequently injured nerve around the elbow is the ulnar nerve (38%–42%).<sup>4,16</sup>

The ulnar nerve may be injured from inside-out when suction or motorized instruments are used in the posteromedial compartment or medial gutter.<sup>1,7,11,12</sup> This is because the ulnar nerve lies almost directly adjacent to the medial elbow capsule (Fig. 1).<sup>1,18</sup> Standard measures as elbow flexion and joint distension reduce the chance of ulnar nerve injury when creating anteromedial portals as they increase the nerve-to-portal distance.<sup>3,18</sup> However, these measures do not reduce the chance of inside-out ulnar nerve

injury during capsular procedures, as the nerve-to-capsule distance remains the same.<sup>18</sup> Further limiting the safe work zone for surgeons to treat posteromedial elbow pathology is the inability to arthroscopically locate the ulnar nerve and the lack of anatomic references (eg, medial epicondyle) inside the joint from which the location of the ulnar nerve could be derived.

Knowledge concerning the location of the ulnar nerve behind the medial capsule is essential in order to safely perform arthroscopic posteromedial capsular and bony procedures. Therefore, the purpose of this cadaveric study was to quantify the ability of surgeons to locate the ulnar nerve behind the medial capsule during elbow arthroscopy. The study hypothesis is that the ulnar nerve can be located precisely by at least 75% of surgeons based on arthroscopic visualization only.<sup>13</sup>

## Materials and methods

A cadaveric study was performed aiming to quantify the ability of surgeons to locate the ulnar nerve behind the medial capsule using sole arthroscopic vision. Twenty-one fresh-frozen cadaveric upper limbs were included. The specimens were evaluated for signs of previous surgery, deformity, extensive scarring, or contracture that could possibly alter the native course of the ulnar nerve. None of the specimens had a (sub)luxating or transposed ulnar nerve. The cadaver arms were mounted onto an arm holder mimicking the lateral decubitus position with the elbow in 90° flexion and the forearm hanging free with only gravity force.

This study was performed after an hour-long arthroscopic training session in order to create an arthroscopic setting that increases the surgeons' dependency on the use of arthroscopic vision to locate the ulnar nerve. The soft tissue swelling that occurs during elbow arthroscopy limits surgeons' ability to estimate the course of the ulnar nerve based on external landmarks.

Subsequently, surgeons participating in a Dutch elbow course were recruited and asked to pin the ulnar nerve at 2 locations, the posteromedial compartment and the medial gutter based on arthroscopic visualization of the medial capsule only (Fig. 1). The posteromedial compartment was defined as the joint space between the trochlea, olecranon, and the posteromedial capsule, and the medial gutter was defined as the joint space between the

medial border of the trochlea and adjacent medial capsule. Each surgeon was assigned 1 elbow specimen.

First, surgeons navigated into the posterior compartment and established a view of the medial elbow capsule. The posteromedial capsule was to be kept intact at all times. For arthroscopic visualization of the medial capsule, a 30°-angle 4-mm arthroscope was used via either a direct posterior or proximal posterolateral portal, depending on the surgeon's preference. Surgeons were free to adjust their arthroscope position as they considered this necessary. Posterior viewing portals were already established during the training session by each corresponding surgeon; the direct posterior portal in the midline 3 cm proximal to the olecranon, and the posterolateral portal 2 cm proximal to the olecranon tip, just posterior and superior to the lateral epicondyle (Fig. 1).

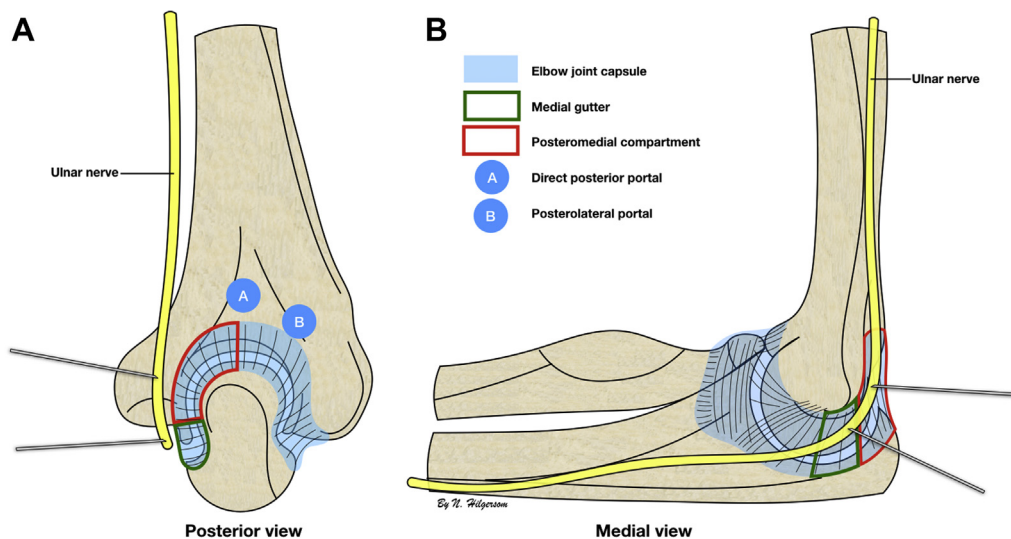
Then, each surgeon had 1 attempt to pin the ulnar nerve at the posteromedial compartment and at the medial gutter from outside-in using a 20-gauge needle (Fig. 2). Surgeons were instructed not to palpate the elbow for anatomic references.

After each specimen was pinned twice, all specimens were dissected using a standard open medial approach to expose the cubital tunnel. The ulnar nerve was identified, taking care not to move the pins. The shortest distances between the pins and ulnar nerve at the medial gutter and the posteromedial compartment were measured twice by two independent investigators using a ruler in millimeters. The average of both measurements was used for analysis.

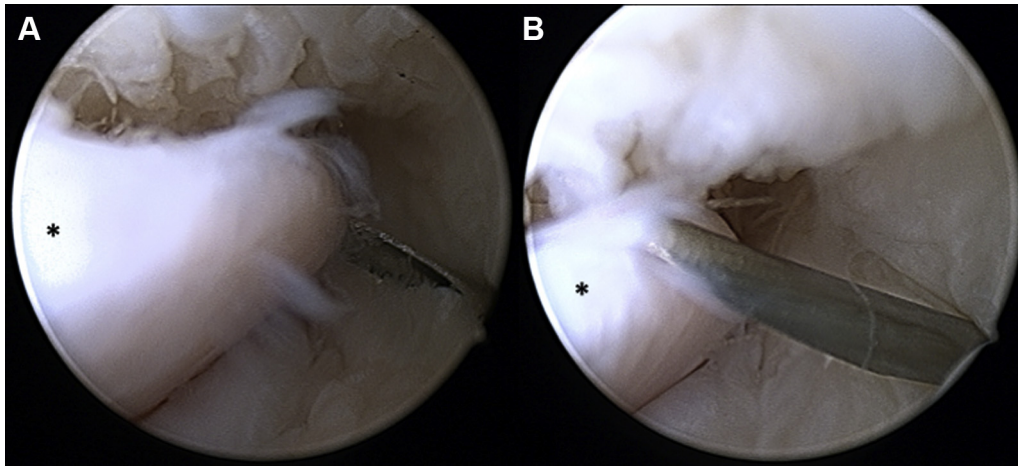
## Statistical analysis

Data analysis was performed using Stata, version 14.0 (StataCorp LP, College Station, TX, USA). Continuous variables are reported as mean and standard deviation (SD) or median and interquartile range, depending on the normality of the data. A Shapiro-Wilk test was performed to assess normality of the data. In addition, pin-to-nerve distances were dichotomized to hits (pin-to-nerve distance of 0 mm) and misses (pin-to-nerve distance >0 mm) to provide proportions of hits.

Associations of surgeon's experience with performing elbow arthroscopy (<5 years of experience; ≥5 years of experience) and operation volume (<10 elbow arthroscopies performed in the past



**Figure 1** Schematic representation of the elbow, the ulnar nerve and elbow capsule with the elbow positioned in approximately 90° flexion as is common during elbow arthroscopy from both a posterior and medial view. The green- and red-circumscribed areas mark the elbow capsule at the medial gutter and posteromedial compartment, respectively. A needle is shown hitting the ulnar nerve in both areas. The direct posterior portal (A) and proximal posterolateral portal (B) are provided as reference.



**Figure 2** Arthroscopic view of the medial compartment via a direct posterior portal in a right-sided elbow after an attempt to pin the ulnar nerve at the medial gutter (A) and the posteromedial compartment (B) using a needle from the outside-in. The asterisk (\*) marks the tip of the olecranon

12 months;  $\geq 10$  elbow arthroscopies performed in the past 12 months) in relation to the pin-to-nerve distance and proportion of hits were analyzed. Depending on normality of the data, a Student *t* test or Mann-Whitney *U* test was used to assess the association for the pin-to-nerve distance. A Fisher exact test was used to assess the associations for the proportion of hits. A *P* value of  $<.05$  was considered significant.

Twenty-one surgeons were recruited during a Dutch elbow course (Table 1). All surgeons were successful in placing both pins. The median distance between the pins and the ulnar nerve was 0 mm (interquartile range, 0-3; range, 0-10) at the medial gutter and 2 mm (interquartile range, 0-6; range, 0-13) at the posteromedial compartment. Eleven of 21 surgeons (52%) hit the ulnar nerve at the medial gutter, and 7 surgeons (33%) hit the ulnar nerve at the posteromedial compartment. Three of 21 surgeons (14%) were able to hit the ulnar nerve at both the medial gutter and the posteromedial compartment (Fig. 3).

No difference was found in the proportions of hits or pin-to-nerve distance at the medial gutter or posteromedial compartment between surgeons with less than 5 years of experience and 5 or more years of experience. Similarly, no difference was found between surgeons who performed fewer than 10 arthroscopies in the past 12 months and 10 or more arthroscopies in the past 12 months (Table II).

No problems were encountered during the pin placement, dissection, or measurements of the pin-to-nerve distances.

## Discussion

The main finding of this study is that surgeons are not able to locate the ulnar nerve using sole arthroscopic visualization, without external palpation. In a setting simulating an already initiated arthroscopic procedure, surgeons showed poor accuracy in locating the ulnar nerve behind the medial capsule in the medial gutter (11/21, 52%) and in the posteromedial compartment (7/21, 33%). Overall, only 3 of 21 (14%) surgeons located the ulnar nerve at both the medial gutter and the posteromedial compartment (Fig. 3), and pin-to-nerve distances ranged up to 13 mm. Accordingly, our hypothesis that more than 75% of surgeons would be able to locate the ulnar nerve is rejected.

The most frequently injured nerve in the elbow during arthroscopy is the ulnar nerve (38%-42%), with other nerves at risk being the superficial radial (22%-33%), posterior interosseous (8%-

19%), median (0%-10%), anterior interosseous (5%-8%), and medial (5%-8%), lateral, and posterior antebrachial cutaneous nerves.<sup>4,16</sup> The ulnar nerve may be injured from outside-in by direct trauma due to placement of anteromedial or posteromedial portals.<sup>6,8</sup> Previous cadaveric studies have shown that joint distension, elbow flexion, and use of proximal instead of distal anteromedial portals increases the nerve-to-portal distance and as such reduce the risk of outside-in ulnar nerve injury.<sup>3,18</sup> In addition, based on the external palpability of the ulnar nerve, Sahajpal et al<sup>23</sup> and Park et al<sup>21</sup> could develop algorithms for safe anteromedial portal placement and thus reducing the risk of extra-articular ulnar nerve injury. Recently, Hilgersom et al<sup>13</sup> showed that the ulnar nerve can only be palpated accurately proximal of the medial epicondyle once soft tissue swelling has occurred during elbow arthroscopy, emphasizing the preference for use of a proximal over a distal anteromedial portal during later stages of elbow arthroscopy.

In contrast, no studies have been published investigating measures to reduce the risk of inside-out ulnar nerve injury or strategies to safely perform arthroscopic procedures in the posteromedial compartment. Inside-out injury of the ulnar nerve may occur when using suction or motorized instruments close to the medial capsule as the nerve lies almost directly behind it with an average nerve-to-capsule distance of 0-3 mm.<sup>1,7,11,12,18</sup> Standard measures as elbow flexion and joint distension do not reduce the chance of inside-out ulnar nerve injury as the nerve-to-capsule distance remains the same.<sup>18</sup> This limits the safe work zone for surgeons to arthroscopically treat posteromedial elbow pathology. In order to investigate the possibilities to safely perform arthroscopic procedures in the posteromedial elbow, this cadaveric study was performed with the purpose to quantify the ability of surgeons to locate the ulnar nerve behind the posteromedial capsule using sole arthroscopic vision.

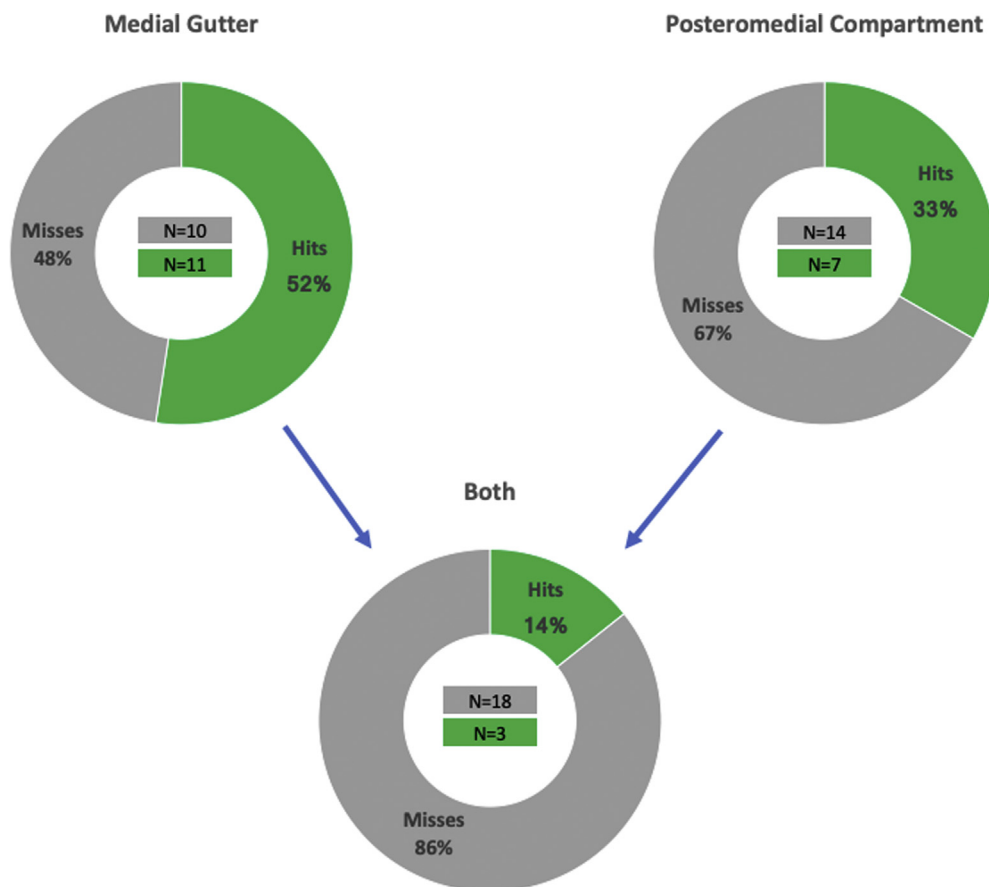
Protecting the ulnar nerve comes first when performing arthroscopic procedures in the posteromedial elbow. Current results show that surgeons have poor ability to locate the ulnar nerve behind the posteromedial capsule using sole arthroscopic visualization with pin-to-nerve distances up to 13 mm. Based on these results, we advise surgeons to proceed cautiously when performing arthroscopic posteromedial elbow procedures. In bony procedures, such as resecting posteromedial osteophytes, the ulnar nerve can be protected by keeping motorized instruments away from the medial capsule, preferably using hooded instruments facing away from the medial capsule and using retractors to keep the capsule

**Table 1**  
Demographic data

Surgeon	Expertise	Gender	Age (yr)	Experience (yr)	Number of elbow arthroscopies (past 12 mo)
1	Resident	Female	35	0.5	25
2	Fellow	Male	35	0.8	6
3	Surgeon	Male	51	5	3
4	Resident	Male	33	1	15
5	Surgeon	Male	40	6	2
6	Surgeon	Male	42	1	40
7	Surgeon	Male	44	10	20
8	Surgeon	Male	39	5	100
9	Surgeon	Male	50	15	10
10	Surgeon	Male	39	3	2
11	Surgeon	Female	48	16	30
12	Surgeon	Male	41	2	5
13	Resident	Male	31	0.4	0
14	Surgeon	Male	34	1	1
15	Resident	Female	31	0.5	10
16	Surgeon	Male	39	4	5
17	Surgeon	Male	34	3	3
18	Fellow	Male	36	0.5	2
19	Surgeon	Male	44	6	120
20	Surgeon	Male	38	3	10
21	Surgeon	Male	38	6	10
Median			39	3	10
Interquartile range			35–42	1–6	3–20
Range			31–51	0.4–16	0–120

away from the instruments.<sup>14</sup> To safely perform capsular procedures, such as a posterior capsulectomy, it is of utmost importance to know the exact course of the ulnar nerve behind the medial

capsule. We recommend to identify and isolate the ulnar nerve prior to any arthroscopic posteromedial capsular procedures, using an open approach.



**Figure 3** The upper 2 circle diagrams represent the proportions of surgeons who transfix the ulnar nerve at the medial gutter and posteromedial compartment, respectively. The lower circle diagram shows the proportion of surgeons who transfix the ulnar nerve at both locations.

**Table II**  
Association of surgeons' experience and operating volume in relation to the pin-to-nerve distance and proportion of hits

		P value
<b>Medial gutter</b>		
Median pin-to-nerve distance in mm (range)		
<5 yr of experience (n = 13)	1 (0-10)	
>5 yr of experience (n = 8)	0 (0-4)	.48*
<10 arthroscopies in the past 12 mo (n = 10)	0 (0-4)	
>10 arthroscopies in the past 12 mo (n = 11)	1 (0-10)	.11*
Proportion of hits (%)		
<5 yr of experience (n = 13)	46.2	
>5 yr of experience (n = 8)	62.5	.66†
<10 arthroscopies in the past 12 mo (n = 10)	70.0	
>10 arthroscopies in the past 12 mo (n = 11)	36.4	.20†
<b>Posteromedial compartment</b>		
Median pin-to-nerve distance (mm)		
<5 yr of experience (n = 13)	2 (0-13)	
>5 yr of experience (n = 8)	2.5 (0-6)	.88*
<10 arthroscopies in the past 12 mo (n = 10)	2.5 (0-12)	
>10 arthroscopies in the past 12 mo (n = 11)	2 (0-13)	.47*
Proportion of hits (%)		
<5 yr of experience (n = 13)	38.5	
>5 yr of experience (n = 8)	25.0	.66†
<10 arthroscopies in the past 12 mo (n = 10)	20.0	
>10 arthroscopies in the past 12 mo (n = 11)	45.5	.36†

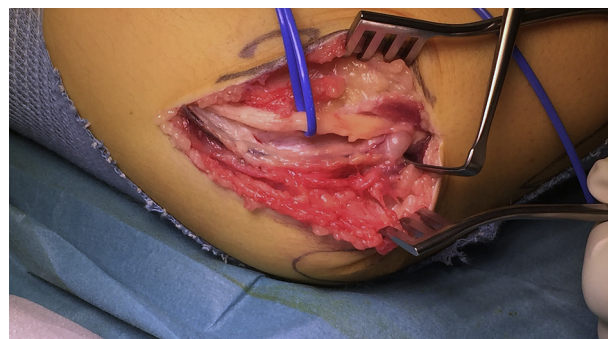
n, number of surgeons.

\* Mann-Whitney U test.

† Fisher exact test.

This study has several limitations. First, pinning of the ulnar nerve was performed by placing needles using an outside-in technique. It would have been optimal to place these needles from intra-articular, but placing large enough needles with the ability to properly control them inside the joint is difficult. Second, cadaveric specimens are usually stiffer than living patients possibly influencing the course and course variation of the ulnar nerve. However, as this study cannot be performed on live patients without the risk of ulnar nerve damage, cadaveric specimens are the next best option. Third, one can reason that this study would be more realistic if surgeons were allowed to palpate for the ulnar nerve as this is (or should be) standard practice before starting elbow arthroscopy. However, we did not allow participants to palpate for the ulnar nerve as this could easily bias the accuracy of locating the ulnar nerve using arthroscopic visualization only. According to previous research regarding the palpability of the ulnar nerve, it would be easy for the surgeons, although involuntarily, to rely more on their palpation than their arthroscopic visualization when trying to pin the ulnar nerve from outside-in.<sup>13,21,23</sup> Last, because no previous studies have used sole arthroscopic vision to locate the ulnar nerve, the sample size of this study was based on previous publications regarding anatomic dissections of peripheral nerves around the elbow. A recent systematic review by Cushing et al<sup>3</sup> investigating the safety of anteromedial portals with regard to nearby neurovascular structures included successfully conducted cadaveric studies with sample sizes ranging from 5-20 cadaveric specimens. In addition, several other open, arthroscopic, and image-controlled cadaveric studies have been completed successfully using relatively small sample sizes.<sup>2,9,10,13,26</sup> Based on these experiences, a minimum of five cadaveric specimens was considered as suitable to conduct this study. The number of elbow specimens available at the course determined the sample size to a final number of 21.

The strengths of the current study lay in the readily large number of surgeons and cadaveric upper limbs included. In addition, because of the varying levels of experience among the



**Figure 4** This image shows a left-sided flexed elbow after identification and mobilization of the ulnar nerve via an open medial approach.

surgeons, the results may represent a larger group of surgeons. The latter is strengthened by the fact that surgeon's experience did not influence pin-to-nerve distance or proportion of hits in this study.

This study is of clinical importance because we quantified the ability of surgeons to arthroscopically locate the ulnar nerve behind the medial capsule and found it to be poor, thus emphasizing the danger of posteromedial arthroscopic procedures, especially capsular procedures. This corresponds with the current tendency to avoid posteromedial procedures.<sup>24</sup> Our take-home message: the ulnar nerve cannot be accurately located behind the medial capsule using sole arthroscopic vision; therefore, we recommend to proceed carefully when performing arthroscopic procedures in the posteromedial elbow and identify and mobilize the ulnar nerve prior to any posteromedial capsular procedures (Fig. 4).

**Conclusions**

Surgeons' ability to locate the ulnar nerve using sole arthroscopic visualization is poor at both the medial gutter (11/21, 52%) and the posteromedial compartment (7/21, 33%). Overall, only 3 of 21 surgeons (14%) were able to locate the ulnar nerve at both the medial gutter and the posteromedial compartment. Therefore, we recommend to proceed carefully when performing arthroscopic procedures in the posteromedial elbow, and identify and mobilize the ulnar nerve before any posteromedial capsular procedures.

**Disclaimer**

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