Proper elbow arthroscopy portal placement in pediatric and adolescent patients

Jae-Sung Yoo, Seong-Jun Kim, Jae-Uk Jung, Joong-Bae Seo*

Department of Orthopedic Surgery, Dankook University College of Medicine, Cheonan, Republic of Korea

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ABSTRACT

We sought to evaluate proper elbow arthroscopy portal placement in pediatric and adolescent patients. Overall, 109 pediatric and adolescent patients who underwent elbow arthrography were included. Condylar width was measured and the proximal anterior joint capsule location was determined using the ulna-capsular distance. Condylar width and Bone mass index(BMI) also had a high positive correlation coefficient with the proximal joint capsule location.

Proximal ulnar border is recommended new bony landmark in pediatric and adolescent patients who undergo elbow arthroscopy. In particular, condylar width and BMI were found to have a high positive correlation with the proximal joint capsule location.

1. Introduction

With the advancement of experience, techniques, and instrumentation, elbow arthroscopy has emerged as a safe and effective option to treat patients with a wide range of acute and chronic elbow pathologies.¹ Previously, the role of elbow arthroscopy was primarily limited to treating patients with osteochondritis dissecans (OCD).² Given the minimally invasive nature of arthroscopic treatment for elbow pathology, pediatric patients stand to benefit from an expanded role of elbow arthroscopy by avoiding the complications and large dissections associated with open techniques.¹

However, arthroscopic procedures of the elbow are challenging due to the intimate relation between nerves, vessels, and capsule, as well as portal sites and narrow joint space.^{3,4} Iatrogenic nerve injury is one of the most common, and most serious, complications in elbow arthroscopy.³

Understanding the anatomy of the joint capsule is essential to create a proper arthroscopic portal, and perform a successful procedure without complications. Several adult cadaveric studies have been conducted on portal placement and anatomy of the elbow capsule.^{5,6} However, data on its anatomy and portal placement in pediatric and adolescent patients are limited.

The purpose of this study was to evaluate proper elbow arthroscopy portal placement in pediatric and adolescent patients undergoing elbow arthrography.

2. Methods

A total of 109 patients who underwent elbow arthrography between February 2005 and March 2017 were retrospectively enrolled. This study was exempt from Institutional Review Board approval (Dankook University Medical IRB: 2017-09-013).

The inclusion criteria were pediatric and adolescent patients (mean age years: 5.7, range 1–15 years) who underwent elbow arthrography due to injury around the elbow. Exclusion criteria were poor radiologic images; displaced fractures (> 2 mm) of the humerus after reduction, including lateral condyle, medial condyle, supracondyle, and epiphyseal injury; disruption of the elbow joint capsule; and previous surgery on the same elbow.

Correlations between demographic data, including age, sex, weight, height, and bone mass index (BMI), and the elbow joint capsule were evaluated.

2.1. Conventional arthrography

Patient laid down with the arm parallel to the radiograph table in the fluoroscopy or operation room. General anesthesia was performed in surgical cases. The skin was prepared and draped, and a 22-gauge 1.5-in needle was inserted perpendicular to the elbow at the radio-capitellar joint. The needle was advanced under fluoroscopy until resistance was felt upon entering the joint capsule, at which point the needle was advanced another 2 mm. This location is approximately

* Corresponding author at: Department of Orthopaedic Surgery, Dankook University College of Medicine 119, Dandae-ro Dongnam-gu, Cheonan-si, Chungnam 31116, Republic of Korea.

E-mail address: ssjb1990@dku.edu (J.-B. Seo).

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Fig. 1. Condylar width was measured the widest distance from medial to lateral condyle on elbow anteroposterior arthrogram.

1 cm from the joint surface.

2.2. Radiological evaluation

Radiologic measurements were evaluated on the anteroposterior and lateral views of the elbow on simple radiography. The condylar width was defined as the distance between the most prominent medial and lateral condyle (Fig. 1). The proximal anterior joint capsule location in lateral radiography was defined as the distance between the proximal ulna and most proximal contrast outline (Fig. 2).

Fig. 2. Ulna-capsular distance was measured the between the proximal ulnar border and proximal anterior capsule location condyle on elbow lateral arthrogram. A: anterior humeral line, B: perpendicular line of anterior humeral line at the proximal anterior capsule location, C: perpendicular line of anterior humeral line at the proximal ulnar border.

All measurements were performed electronically on simple radiography using a measurement software for picture archives and communication system. All image measurements were performed by two blinded observers via a consensus readout (K.S.J. and L.J.Y.). Measurements were performed independently, and the results were not disclosed to the other surgeon. The mean value of the duplicate scores was used as the representative value.

2.3. Statistical analysis

Spearman's correlation coefficient was used to estimate the correlation between proximal joint capsule location, and age, sex, weight, height, BMI, and condylar width. The weighted kappa (k) coefficient was used to estimate inter-observer reliability, which was classified based on the k coefficients as follows: slight agreement, 0.00–0.20; fair agreement, 0.21–0.40; moderate agreement, 0.41–0.60; substantial agreement, 0.61–0.80; and almost perfect agreement, 0.81–1.00. All statistical analyses were performed with SPSS version 20.0 (SPSS Inc., Chicago, IL, USA). The level of significance was set to $P < 0.05$.

3. Results

Condylar width showed the highest positive correlation coefficient with the proximal anterior joint capsule location ($r = 0.783$, $p < 0.001$, Fig. 3). BMI also had a high positive correlation coefficient ($r = 0.717$, $p < 0.001$, Fig. 4), while weight had a low positive correlation coefficient with the proximal anterior joint capsule location ($r = 0.328$, $p = 0.001$).

Sex ($p = 0.774$), age ($p = 0.271$), and height ($p = 0.719$) were not correlated with proximal anterior joint capsule location.

Cases were divided according to the condylar width and BMI to present the mean value of the proximal anterior joint capsule location. They were divided into 9 groups based on condylar width, in 5-mm increments (Table 1). Cases were also divided into 5 groups based on BMI, in increments of 5 (Table 2).

Inter-observer reliability of measurements A and B were in almost perfect agreement, with a weighted kappa coefficient of 0.87 and 0.83, respectively.

4. Discussion

In this retrospective study, we demonstrated that condylar width and BMI showed a high positive correlation coefficient with the proximal anterior joint capsule location.

Elbow arthroscopy is a safe and effective procedure, and has

Fig. 3. Ulna-capsular distance according to the condylar width. It shows the highest positive correlation coefficient.

Fig. 4. Ulna-capsular distance according to the body mass index. It also shows high positive correlation coefficient.

Table 1
Mean values of Ulna-capsule distance according to condylar width.

Condylar width (mm)	Mean(SD) of UCD* (mm)	Number of Cases (N = 109)
< 20	28.6(0)	1
≥ 20, < 25	31.82(3.32)	4
≥ 25, < 30	32.73(3.38)	15
≥ 30, < 35	35.66(4.09)	34
≥ 35, < 40	41.54(4.44)	39
≥ 40, < 45	45.22(3.95)	9
≥ 45, < 50	51.42(4.61)	3
≥ 50, < 55	52.65(3.66)	2
≥ 55	55.71(2.59)	2

* UCD: ulna-capsular distance.

Table 2
Mean values of Ulna-capsule distance according to body mass index.

BMI	Mean(SD) of UCD* (mm)	Number of Cases (N = 109)
< 10	28.54(0)	1
≥ 10, < 15	32.00(2.66)	18
≥ 15, < 20	39.05(5.34)	73
≥ 20, < 25	45.60(5.78)	14
> 25	49.29(7.35)	3

* UCD: ulna-capsular distance; BMI: body mass index.

recently been applied to various elbow procedures in adults.^{7–9} Despite its advantages, there are technical difficulties with the approach due to proximal major neurovascular or limited joint capsule range.^{7–9}

The position of the anterolateral portal is important to obtain a good visual field while avoiding iatrogenic injury to the neurovascular. Savoie et al¹⁰ have shown that anterolateral portal placement 2-cm proximal and 1-cm anterior to the lateral epicondyle in adults can provide a good visual field without radial nerve damage and joint distention.

Elbow arthroscopy has also recently been applied in pediatric patients. For surgeons, the approach in pediatric elbow joints is more challenging than in adults.^{1,11–14} Because the position of the major neurovascular and size of elbow joints varies with age and growth, it is difficult to quantify the entry of portals in this patient population. In addition, although the lateral and medial epicondyles are used as bony

landmarks in the general elbow scope, they can be difficult to identify because the formation of the ossification center varies with age. Several authors have attempted to apply pediatric elbow arthroscopies to various fields, but complications occurred because of the non-quantified location of portals. Vavken et al¹⁴ performed 50 pediatric elbow arthroscopies in Switzerland and reported OCD treatment, arthrofibrosis, post-traumatic complications were indications for the procedure. Despite the small number of cases included in their study, the authors reported a complication rate of 6% for neurovascular injuries (3 of 50). Steven et al¹ performed 64 pediatric elbow arthroscopies in the United States and reported radial (n = 1) and ulnar (n = 1) neuropathia. Neuropathia resolved with conservative treatment and the incidence of neurovascular injuries was not high in either study. However, these complications may cause major problem to physicians, caregivers, and patients. To avoid these complications, an accurate understanding and index of the joint capsule in pediatric and adolescent elbows is needed.

In 1985, Andrews and Carson¹⁵ reported the location of the portal in elbow arthroscopy for the first time in adults. Since then, several cadaveric studies have reported on the proximity and safety of portals to the nerve around the elbow joint in elbow arthroscopy.^{5,16,17} However, the anatomy of pediatric and adult patients is different, and it is difficult to confirm the anatomy of the elbow joint capsule through cadaveric studies in pediatric and adolescents. Elbow arthrography has been practiced since 1955.¹⁸ It is a useful and safe tool for confirming correct needle positioning during a diagnostic joint aspiration, detecting intra-articular loose bodies, evaluating OCD, and assessing intra-articular fracture.^{19,20} Furthermore, elbow injuries of pediatric and adolescent patients including intra-articular elbow fracture, subluxation, ligament injury were evaluated using elbow arthrography in this institution. Therefore, we decided to use elbow arthrogram as evaluation method retrospectively.

We acknowledge several significant limitations in our study. First, this was a retrospective study that included a relatively low number of cases. Second, radiologic measurements of the elbow joint capsule were evaluated using simple radiography of the elbow. Magnetic resonance arthrography (MRA) would be more accurate, however sedation is frequently needed for children to obtain good quality images.^{21,22} Conventional elbow arthrography is an easy, safe, and cost-effective method in children. Furthermore, measurements were performed independently by a consensus readout from two blinded observers, and the mean value of the duplicate scores was used as the representative value to obtain accurate results and minimize observer bias. Fourth, there is a lack of consensus regarding the location of the joint capsule with bony landmark in pediatric and adolescent patients. Because the arthroscopic bony landmarks of the medial and lateral epicondyles are not proper in pediatric and adolescent patients due to ossification of medial and lateral epicondyles, we choose the proximal ulnar border as an arthroscopic bony landmark because it is easy to palpate and is not affected by ossification according to the age.

In this study, proximal anterior joint capsule of almost all cases were located just proximal to the coronoid fossa. Therefore, pre-operative measurement of the distance from the proximal ulna border to the proximal coronoid fossa without arthrography is helpful to confirm portal location (Fig. 5). In addition, the mean value of the ulna-capsular distance based on condylar width and BMI can be a helpful index to determine portal location in pediatric and adolescent patients (Tables 1 and 2).

Altogether, these data are meaningful because they demonstrate a correlation between joint capsule location and various patient factors. This may be helpful to better understand joint capsule location and correlated factors in pediatric and adolescent patients.

5. Conclusion

Proximal ulnar border is recommended new bony landmark in pediatric and adolescent patients who undergo elbow arthroscopy. Also,

Fig. 5. Measurement of anterior proximal capsule location on simple elbow lateral radiography without arthrogram. A: anterior humeral line, B: perpendicular line of anterior humeral line at the proximal anterior capsule location, C: perpendicular line of anterior humeral line at the proximal ulnar border.

UCD is a useful method to measure the proximal anterior joint capsule location. In particular, condylar width and BMI were found to have a high positive correlation with the proximal joint capsule location. In particular, condylar width and BMI were found to have a high positive correlation with the proximal joint capsule location.

Conflict of interest

None.

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