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ELBOW

Anatomic relations between the lateral collateral ligament and the radial head: implications for arthroscopic resection of the synovial fold of the elbow

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Abstract
Purpose The purpose of this study was to determine the anatomic relationship between the radial head and the lateral collateral ligament (LCL) and when the LCL would be at risk of iatrogenic injury during arthroscopic resection of the synovial fold.
Methods Thirty-four formalin-fixed upper extremities were dissected. A projection of the LCL onto the radial head was marked with a needle. The percentage of the posterior border of the radial head overlaid by the LCL was digitally measured. A portion of the projection of the LCL was statistically correlated with the overall diameter of the radial head.
Results The overall diameter of the radial head was 21.2 mm ± 2.3. The proportionate projection of the medial border of the LCL onto the radial head was 5.3 ± 1.6 mm on average. The lateral 25 % of the radial head was overlaid by the LCL with a maximum value of 40 % on average. The inter- and intraobserver reliability showed very good accordance with the digital measurements ($r > 0.8$).
Conclusion Care must be taken when performing a resection in the lateral 40 % of the radial head, whereas resection in the medial 60 % of the radial head appears to be safe. The LCL is an important stabiliser of the elbow joint, a lesion of which by undeliberate arthroscopic dissection may lead to joint instability. Iatrogenic injury to the LCL presumably can be prevented when respecting the given data.
Level of evidence Experimental study.

Keywords Anatomy · LCL · Radial head · Elbow joint

The local Ethical Committee of the University Hospital of Cologne has approved the study (Study number: 12.315).

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Introduction

Hypertrophic synovial folds can be impinged between the radial head and the capitellum. This condition has been described by several authors and can lead to a painful snapping-in or locking of the elbow [2, 9]. Hence, the hypertrophic synovial fold has become an increasingly accepted differential diagnosis of lateral elbow pain. The treatment method of choice is arthroscopic resection, with the aim of completely removing the synovial fold. Clinical studies have shown good to excellent results in patients who were treated accordingly. However, the synovial fold is closely related to the lateral collateral ligament (LCL), which runs posterior and lateral to the joint and is an important stabiliser of the elbow joint [3, 4, 7]. It is suspected that during arthroscopic resection, a distinct differentiation between the tissue layers is difficult and, therefore, extensive resection of the synovial fold, especially by surgeons with only a small amount of experience in elbow arthroscopy of the synovial fold, places the LCL at risk. The projection of the LCL onto the radial head to our knowledge has not been investigated so far.

The goal of this study was to define landmarks on the radial head that can be used for intra-articular orientation

during arthroscopic resection of the synovial fold to evade the LCL. We hypothesised that the LCL spans the lateral part of the radial head.

Materials and methods

Specimens and dissection

A total of 34 formalin-fixed specimens harvested from 34 voluntary body donors (23 females and 11 males; average age 82.1 years, ±8.1) were available. The specimens were previously exarticulated at the shoulder joint and screened for pre-existing pathologies with a deformity or subluxation of the radial head.

After the removal of the soft tissue envelope, the common extensors of the wrist joint were carefully removed from their origin at the lateral epicondyle. Special care was taken when removing the extensor carpi radialis brevis muscle, which is intimately associated with the LCL and the annular ligament. The dissection spared the LCL in its complete course from the origin at the lateral epicondyle to the junction with the annular ligament and the medial border of the LCL, as represented by the lateral ulnar collateral ligament (LUCL), which inserts at the distal portion of the supinator crest.

The LUCL is the posterior border of the LCL-complex and its most medial extension (Fig. 1), and it was used to define the most medial part of the LCL with respect to the radial head. Therefore, a needle was inserted at the medial edge of the LUCL from the posterior in a full extension of the elbow; by palpating the edge of the radial head surface, the needle was advanced anteriorly into the joint below the synovial fold (Fig. 2). To achieve a standardised direction for the insertion of the needles, in every specimen, the needles were advanced under visual control after disarticulation of the joints in an exactly parallel direction to the proximal radio-ulnar joint (PRUJ). The orientation of the PRUJ was displayed by connecting the anterior and posterior edge of the radial notch with a second needle (Fig. 3). Then, the specimen was photographed in a standardised fashion at a neutral rotation of the forearm. Next to each specimen, a scale was placed to allow an exact referencing of the digital measurements.

Digital Measurements: The photographs were stored as tiff images and analysed by digital image analysis software (Image-Pro Plus©; Version 6.0.0.260, MediaCybernetics Inc., MD, USA). To adjust the real distances of the radial head to the computer image calculation, the software was calibrated using the scale photographed in each image. The analysis was then performed in two steps. First, the diameter of the radial head perpendicular to the needle (RH-D) was measured in a neutral position. Then, the distance from the lateral edge to the crossing point of the RH-D with the inserted needle was measured and referred to as the PD (proportionate distance) (Fig. 3). The PD, given as a per cent, was transferred onto the overall diameter of the radial head to generate results according to four quadrants (Fig. 4). According to the quadrants, the extent of the LCL should be visible from the intra-articular

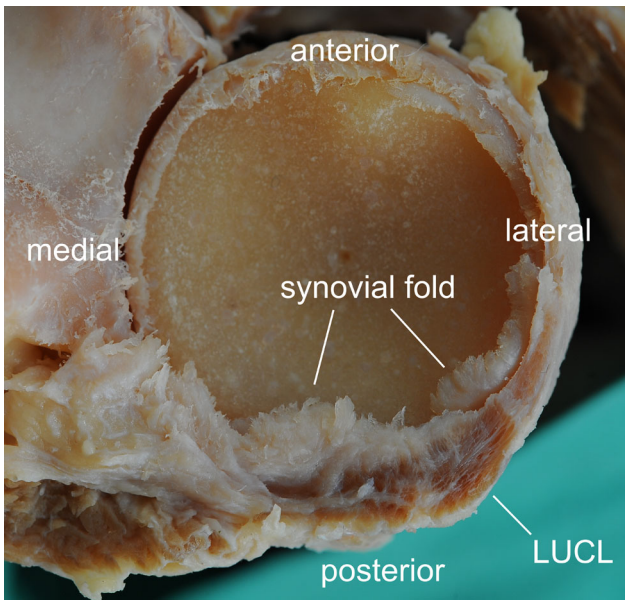

Fig. 1 Overview of the anatomic relation of the LCL/LUCL and the posterior synovial fold. Note the tissue of the fold almost merges with that of the ligament

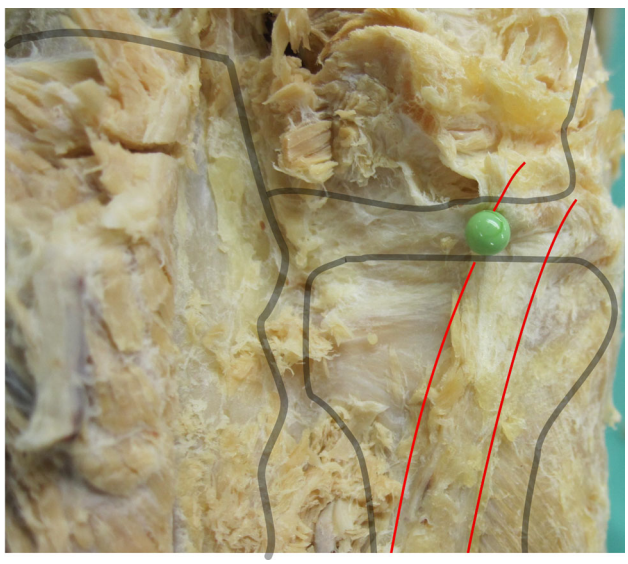

Fig. 2 Illustration of the dissected specimen from a posterolateral view. The bony borders of the capitulum, the radial head, and the olecranon are represented as schematic drawings. The *green tip* of the needle marks the medial border of the LUCL, which itself is highlighted by the red lines and represents the most medial aspect of the LCL

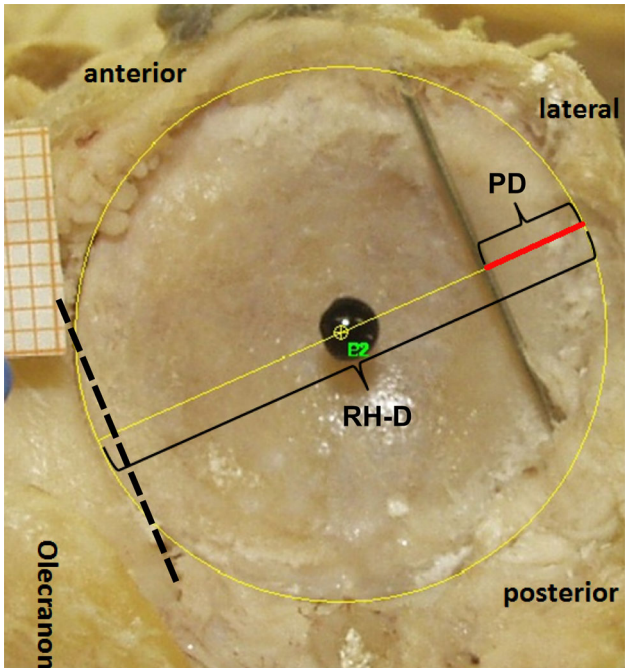

Fig. 3 Illustration of the digital measurements of the radial head diameter (*yellow line*) and the proportionate distance (*red line*) from the lateral edge of the radial head to the needle. The *needle* represents the projection of the medial border of the LUCL onto the radial head. The needle was inserted parallel to the radial notch of the ulna—marked by a *dotted line*

arthroscopic view to enable a "safe zone" in which an iatrogenic injury of the LCL is unlikely.

The main observer repeated the measurements, and the mean values of three sets of measurements were taken as the final results for each specimen; the intraobserver reliability was calculated. Two other observers also performed the measurements for 50 % of the images, twice, and the interobserver reliability was calculated.

The ethics committee of the University of Cologne, Nord-Rhein-Westphalen, Germany approved the present study with the approval number 12-315.

Statistical analysis

The data were analysed using SPSS 19 software© (SPSS Inc., Chicago, Il, USA). The mean, minimum, and maximum values as well as the standard deviation were calculated. The confidence interval (CI) was set at <0.05. The intraclass correlation coefficients (ICC) of the data were computed to determine the absolute agreement. The 95 % CI were calculated. Finally, the overall diameters of the RH were statistically correlated with the associated PD values using Spearman's correlation coefficient to analyse whether larger radial head diameters are accompanied by an LUCL that covers a larger portion of the radial head.

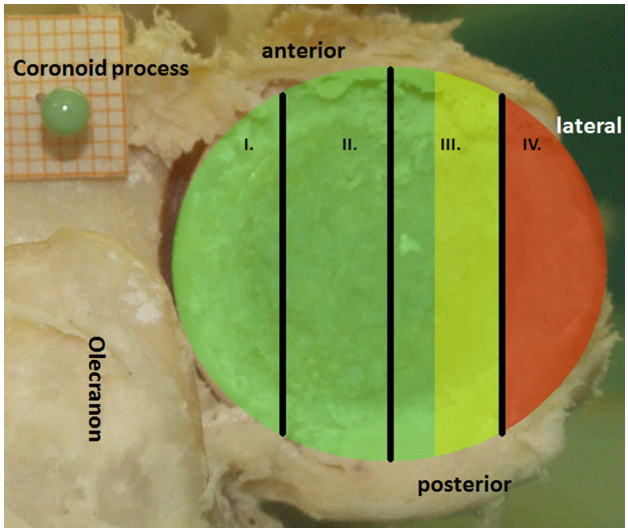

Fig. 4 Illustration of the safe zone at the radial head for the resection of the synovial fold. In far lateral quadrant IV, extensive resection of the synovial fold endangers the LCL, the structures of which run posteriorly to it. In quadrant III, however, it is possible to interfere with ligamentous structures when resecting the synovial fold, as the maximum values range up to 40 % of the RH-D

Results

The average of the three measurements of the RH-D collected by the main observer was 21.2 mm ± 2.3 (range 17.5–26.3). Both the intra- and interobserver reliability were excellent (Table 1). The three measurements of the PD collected by observer 1 averaged 5.3 mm ± 1.6 (range 2.4–8.6). The three measurements showed strong statistical correlation and excellent intra- and interobserver reliability (Table 1).

Analysis of gender differences showed significantly higher values for the male specimens compared to the female specimens for the RH-D ($p = 0.001$) and the PD ($p = 0.002$). The RH-D and PD values showed moderate correlation ($r_{\text{RH-D/PD}} = 0.51$), meaning that a smaller radial head is not necessarily accompanied by a reduced overlay by the LUL.

The average PD value was found to be 25 % of the average RH-D values, meaning that the LCL is often found beyond the lateral quadrant of the radial head. In quadrant III, however, ligamentous structures can already be encountered in a few specimens, such as in one specimen where the LUCL extended medially to the largest observed value of 8.6 mm from the lateral edge of the radial head, representing 40 % of the RH-D (Fig. 4). In quadrants I and II, the radial head was not overlaid by the components of the LCL.

Discussion

The most important finding of the present study was that landmarks on the radial could were defined, which can

Table 1 Results for the measurements of each of the three observers with intraobservers reliability (ICC) and interobservers reliability (Pearson's coefficient)

	Observer 1	Observer 2	Observer 3
PD	5.3 mm ± 1.6 (range 2.4–8.6)	5.4 mm ± 2.0 (range 0.8–9.4)	5.0 ± 2.0 (range 2.4–8.4)
ICC	99 %; CI 95 % = 0.98–0.99, $p < 0.001$	95 %; CI 95 % = 0.86–0.98, $p < 0.001$	95 %; CI 95 % = 0.86–0.98, $p < 0.001$
RH-D	21.2 mm ± 2.3 (range 17.5–26.3)	21.5 mm ± 2.4 (range 18.2–26.5)	21.3 mm ± 2.5 (range 16.9–26.5)
ICC	99 %; CI 95 % = 0.98–0.99, $p < 0.001$	95 %; CI 95 % = 0.86–0.98, $p < 0.001$	95 %; CI 95 % = 0.86–0.98, $p < 0.001$

Pearson's coeff.	Observer 1/2	Observer 1/3	Observer 2/3
PD	0.84	0.87	0.91
RH-D	0.85	0.82	0.92

PD proportionate distance, *RH-D* radial head diameter

presumably be of use to evade the LCL when performing arthroscopic resection of the synovial fold. The most medial extension of the ligament was measured in relation to the radial head, showing that iatrogenic injury to the LCL in the medial two quadrants of the radial head is unlikely when performing a resection. Despite the fact that the average values showed that the LCL only extended to the far lateral quadrant IV, it is necessary to remove quadrant III from the potential safe zone, as the maximum value that was measured reached that part of the radial head as well. Gender differences were expected, and higher values were found for male specimens compared to female ones. However, it should be noted that correlation analysis did not find higher values for LCL extension in larger radial heads. Additionally, small radial heads can still show wide overlap by the ligament.

The relevance of the study is emphasised by the recent increasing interest in the arthroscopic treatment of elbow pathologies [1, 5, 8–10, 13]. Different authors have shown the effectiveness of the resection of the plica, and the risks and complications of the procedure have been analysed [12]. The authors believe, however, that extensive resection of the synovial fold endangers the LCL, as they are closely related.

Smith et al. [11] reported on the anatomic relationships in arthroscopic common extensor release when treating epicondylitis. The authors performed an arthroscopic release of the common extensors at the lateral epicondyle. When performing releases in the posterior half of the radial head, they encountered increasing posterolateral rotatory instability in the cadaveric specimens, depending on the extent of posterior debridement. This finding indicates a problematic relationship between the arthroscopic debridement of the posterolateral corner of the elbow joint and the stabilising structures, and according to the authors, joint instability may follow arthroscopic interventions at the elbow.

It was possible to obtain a good number of specimens for the investigation. The fact that the specimens were formalin-fixed represents a limitation. During formalin fixation, the tissue is dehydrated and shrinks, which may lead to a deformation of the native tissue and may have a negative influence on the measurements taken in this study. The specimen ligaments may show an altered anatomic relationship with the radial head compared to native tissue and may likely be smaller than those in fresh specimens. This fact could lead to an underestimation of the extension of the LCL on the posterior aspect of the radial head.

The average age of the investigated specimens, approximately 82 years of age, is high. The specimens, therefore, may show alterations of the collateral ligaments that could give rise to incorrect measurements when applying the landmarks to patients of a significantly younger age.

The accuracy of the digital measurements was affirmed by the high intra- and interobserver reliability. However, the interobserver reliability is based on only 50 % of the data, which limits its statistical power.

The differentiation of the tissues beyond the radial head during the arthroscopic resection of the plica is extremely difficult—even for skilled surgeons. The fold, the joint capsule, and the ligament are arranged in layers, as shown by Isogai et al. [6].

However, whether iatrogenic injury to the LCL during the resection of the synovial fold can lead to instability of the elbow joint has not been shown in the present study; it merely offers an orientation guide for the procedure.

Conclusion

Arthroscopic resection of the synovial fold is performed in cases of hypertrophy and snapping pain. Our data suggest that the procedure should be performed with special care for the structural integrity of the LCL in the lateral 40 % of the radial head. Using the reported quadrants of the radial head as landmarks during arthroscopy may prevent iatrogenic injury to the LCL. In further studies, the layered

structure of the synovial fold, the joint capsule, the ligaments, and the muscles beyond should be displayed in an arthroscopic view to assist with distinguishing the tissues intraoperatively.

Conflict of interest The authors declare that they have no conflict of interest.

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