ANATOMICAL AND FUNCTIONAL STUDY OF THE MEDIAL COLLATERAL LIGAMENT COMPLEX OF THE ELBOW

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ABSTRACT

Objective: To carry out an anatomical study of the medial collateral ligament, an important elbow stabilizer in different degrees of elbow flexion-extension. Methods: Forty elbows were dissected in order to analyze the functional behavior of the anterior, posterior and transverse ligament bands during valgus stress maneuvers of the elbow in different degrees of flexion and extension. Two groups were determined; in the group GPA the posterior band of the ligament was sectioned initially, then the articular capsule and finally the anterior band; in group GAP this order was reversed. Results: Instability was observed in GPA only in the third stage, when there was a greater mean elbow's opening during the flexion (between 50° and 70°); in GAP, the instability was present since the first stage; the degrees of flexion with greater instability were the same as in group GPA. Conclusion: The anterior band of the medial collateral ligament of the elbow is the most important stabilizer of the elbow valgus instability, and its principal action occurs between 50° and 70° of elbow flexion. ***Level of Evidence III, Diagnostic Studies – Investigating a diagnostic test.***

Keywords: Elbow/lesion. Articular instability. Human.

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INTRODUCTION

The elbow joint is one of the most congruent of the human body; as it is a ginglymus (hinge) joint it affords rotational stability in the sagittal plane and in varus and valgus motion. It is used extensively in various daily activities and constantly receives medial overloads, particularly when in extension. This overload can lead to acute or chronic injuries.[1-3]

The major elbow stabilizers are the medial and lateral collateral ligaments and the ulnohumeral joint.[4,5] The medial collateral ligament originates from the anterior inferior surface of the medial epicondyle and joins the ulna to the humerus, providing support and resistance in valgus overloads. This ligament is divided into an anterior band, which is stressed during the elbow extension movement; a posterior band, which is stressed during elbow flexion; and a transverse band, which joins the anterior and posterior bands. This ligament received the name of medial ligamentous complex of the elbow (MCL) due to its functional diversity and as it has three bands, anterior, posterior and transverse, whereas each band of this ligament presents different functions during elbow flexion and extension movements.[6-9]

It is important to emphasize that it is not possible to reach the MCL without harming the musculature and its aponeurosis; thus, the only way to visualize this ligament without affecting these structures is by arthroscopic approach.[10,11]

Due to its importance in elbow stability, it is essential to know the anatomy of this ligament and to understand its functional behavior during flexion and extension movement and in stabilization during valgus stress.

The goal of this survey is the anatomical study of MCL in different degrees of elbow flexion/extension, observing its medial stabilizing capacity by means of valgus stress tests, with selective and progressive sections of its structure.

MATERIAL AND METHOD

The study method involved the dissection of 40 elbows from 20 fresh cadavers, with age ranging from 22 to 74 years (average = 57.2 years), 18 of these (90%) male and two (10%) female, with non-traumatic *causa mortis*, coming from the Death Verification Service of the School of Medicine of Universidade de São Paulo. They were all examined before the dissection and presented cli-

All the authors declare that there is no potential conflict of interest referring to this article.

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Study conducted at the Institute of Orthopedics and Traumatology of Hospital das Clínicas of the School of Medicine of Universidade de São Paulo IOT-HC-FMUSP.
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nical signs of ligament laxity in the elbow joint. This study was approved by the Institutional Review Board of Hospital das Clínicas of the School of Medicine of Universidade de São Paulo - FMUSP, under protocol no. 065/96.

The cadavers were positioned in prone position, with the shoulder at 45° of abduction and maximum external rotation. The surgical incision was curvilinear, centered over the medial epicondyle and approximately 20 cm long. Then the tendons of the forearm flexor muscles were exposed up to their point of origin, and the ulnar nerve was isolated through the opening of the ulnar canal. The medial and lateral walls of the ulnar head of the flexor carpi ulnaris muscle constitute the ulnar canal, whose floor is formed by the posterior band of the MCL, which can only be observed after ulnar nerve anteriorization.

This procedure was followed by the dissection of the flexor digitorum superficialis muscle with its three expansions: the first in the direction of the medial epicondyle, the second in the direction of the tubercle of the coronoid process at the insertion of the MCL and the third that reinforces the actual MCL.

The aponeurosis was found around the flexor digitorum superficialis muscle and the flexor carpi radialis muscle, which bypassed the musculature and formed the superior fascia of the joint tendon. This tendon reinforcement was found precisely over the anterior portion of the MCL. (Figure 1)

To complete the anterior exposure of the insertions of the MCL and of the articular capsule in the ulna, the pronator teres and the brachialis were disinserted on the medial border of the coronoid process. The posterior exposure of the MLC was obtained when disinserting the medial portion of the triceps brachii muscle.

By exposing the MCL completely we can observe the origin, the insertion and the location of the anterior, posterior and transverse bands. (Figures 2, 3 and 4)

Stability was analyzed in the movements of flexion at 135° to extension, at 0° of the elbow, with 20-degree intervals, i.e. in the angles of 135°, 110°, 90°, 70°, 50°, 30° and 0°.

The participants then determined the GPA and GAP groups, each with 20 elbows (10 right and 10 left). In GPA the sectioning direction of the MCL bands was from posterior to anterior in three stages: the initial step consisted of the sectioning of the anterior band, followed by the sectioning of the articular capsule up to the start of the anterior band and finalizing with the sectioning of the anterior band.

The sectioning was in the opposite direction in GAP, from anterior to posterior, and the three stages were repeated: the

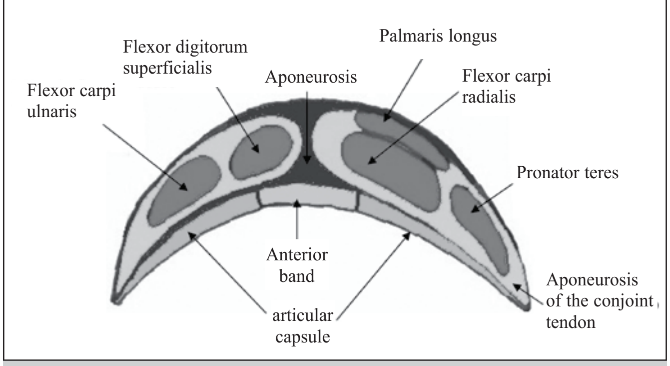

Figure 1. Diagram of the conjoint tendon with its structures, the articular capsule and the anterior band.

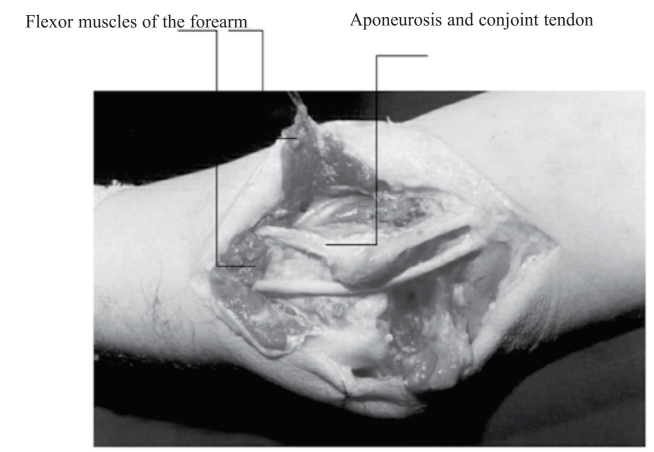

Figure 2. Conjoint tendon with its aponeurosis after removal of the flexor muscles of the forearm.

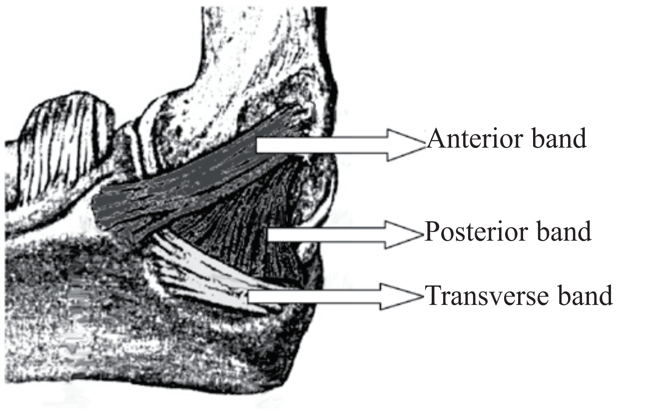

Figure 3. Diagram of the three bands of the MCL.

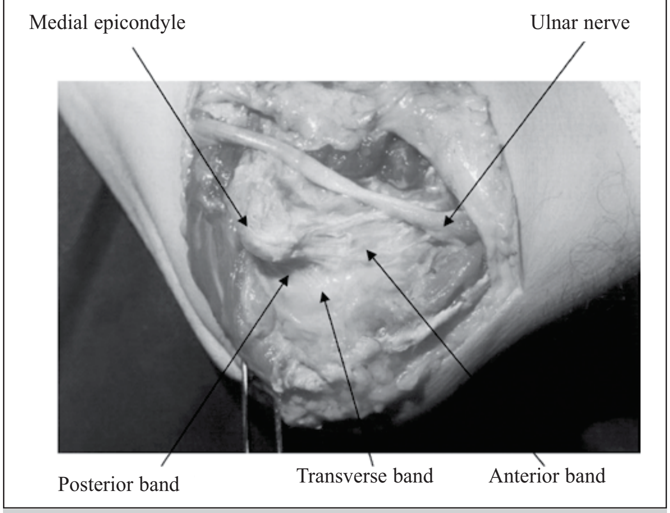

Figure 4. Three bands of the MCL with ulnar nerve anteriorization.

anterior band was sectioned first, followed by the articular capsule up to the start of the posterior band, finalizing with the sectioning of the posterior band.
The largest space between the trochlea and the trochlear notch was used as a parameter to measure the openings. The instruments employed to perform the measurement were the analog caliper and the goniometer.
Valgus stress was achieved through the action of gravity produced by the weight of the drooping forearm and hand, resting the lateral epicondyle of the elbow on the edge of the stretcher. A total of 20 measurements were taken for each group at each angle, calculating the mean.
The statistical analysis consisted of the distribution of frequencies of the nominal variables (qualitative) and of the descriptive statistical study of the quantitative parameters: mean (M), standard deviation (SD), standard error of the mean (SEM), maximum (MAX) and minimum values (MIN). The Student's t-test was employed in the comparison between two groups of quantitative data. The significance level of 5% ($p = 0.05$) was adopted in all the cases.

RESULTS

A detachment of the ulna from trochlea was observed in two planes: sagittal and transverse, after the selective sectioning of the MCL with valgus opening in the present study. The displacement in the sagittal plane was produced by the action of gravity, as the ligament was sectioned. In the transverse plan, the displacement was caused by the disengagement of the ulna from medial to lateral between the humeral condyles.
With the MCL intact, even with the valgus maneuver, the medial opening of the elbow remained unaltered during the flexion and extension movement.

GPA

With the MCL intact, the elbow remained stable; there was no opening between the trochlea and the trochlear notch.
In the first stage, after the sectioning of the posterior band, the elbow remained stable, not presenting opening at the angles of 135°, 110°, 90°, 70°, 50°, 30° and 0° of elbow flexion.
The second stage, after the sectioning of the posterior band, accompanied by the articular capsule up to the start of the anterior band, did not present any opening at any angle of flexion and during the maneuvers with and without elbow stress either. The sectioning of the posterior band and of the articular capsule up to the limit of the anterior band, executing the proposed maneuver, did not result in medial opening. The contribution of the posterior band to medial stabilization of the elbow was null.
In the third stage the entire MCL was sectioned, including posterior band and articular capsule up to the end of the anterior band. The flexion and extension movement was performed without stress, followed by the valgus stress maneuver. Table 1 shows the mean openings and the differences between the two tests.

GAP

The first stage started with the sectioning of the anterior band of the MCL accompanied by the flexion and extension movement without stress, followed by the valgus stress maneuver; the mean openings and the differences between the two tests were determined at this stage. (Table 2 and Figure 5)

The results obtained in the second stage can be observed in Table 3 that presents the mean openings and the differences between the two tests. (Figure 6)
Lastly the third stage, with the sectioning of the entire MCL, anterior band, ligamentous capsule up to the end of the posterior band, accompanied by the flexion and extension movement without stress, followed by the valgus stress maneuver; the mean openings and the differences between the two tests can be seen in Table 4 and Figure 7.
Table 5 shows the mean openings in the three stages of group B, all submitted to the valgus stress maneuver. (Figure 8).

Table 1. Mean openings in centimeters of GPA, after sectioning of the posterior band and of the articular capsule up to the end of the anterior band, without stress and with stress.

Angle	0°	30°	50°	70°	90°	110°	135°
PB+C+ABS	0.42	1.03	2.59	2.42	2.11	1.41	0.0
PB+C+ABC	0.53	1.62	2.88	2.82	2.51	1.71	0.0
D	0.06	0.59	0.29	0.4	0.4	0.3	0.0

BP = posterior band, C = capsule, AB = anterior band, S = without stress, C = with stress, D = difference between the tests.

Table 2. Mean openings in centimeters of GAP after sectioning of the anterior band of the MCL, without stress and with stress.

Angle	0°	30°	50°	70°	90°	110°	135°
ABS	0.30	0.49	0.75	0.73	0.60	0.54	0.0
ABC	0.47	0.62	0.87	0.89	0.79	0.68	0.0
D	0.17	0.13	0.12	0.16	0.19	0.14	0.0

AB= anterior band, S =without stress, C = with stress, D = difference between the tests.

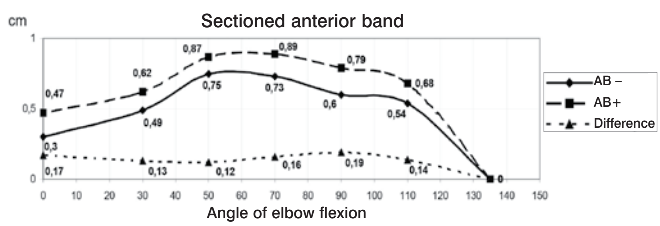

Figure 5. Behavior of the curves with stress and without stress and their difference, in the first stage of GAP. Larger openings between 50º and 70º of elbow flexion.

Table 3. Mean openings in centimeters sectioning the anterior band and the articular capsule up to the start of the posterior band of the MCL, in GAP, without stress and with stress.

Angle	0°	30°	50°	70°	90°	110°	135°
AB+CS	0.41	0.84	1.26	1.13	0.89	0.68	0.0
AB+CC	0.41	0.93	1.86	1.72	0.98	0.71	0.0
D	0.0	0.09	0.60	0.59	0.09	0.03	0.0

C = capsule, AB = anterior band, S = without stress, W = with stress, D = difference between the tests.

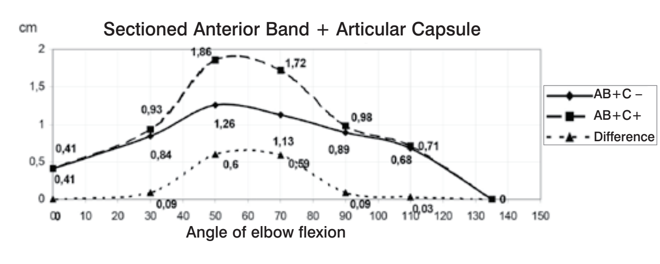

Figure 6. Behavior of the curves with stress, without stress and their difference, in the second stage of GAP. Larger medial opening at the angles of 50° to 70° of elbow flexion.

Table 4. Mean openings measured in centimeters, in GAP, after sectioning of the anterior band and of the articular capsule up to the end of the posterior band, without stress, with stress and their difference.

Angle	0°	30°	50°	70°	90°	110°	135°
AB+C+PBS	0.42	1.03	2.59	2.42	2.11	1.41	0.0
AB+C+PBC	0.53	1.62	2.88	2.82	2.51	1.71	0.0
D	0.06	0.59	0.29	0.4	0.4	0.3	0.0

PB = posterior band, C = capsule, AB = anterior band, S = without stress, C = with stress, D = difference between the tests.

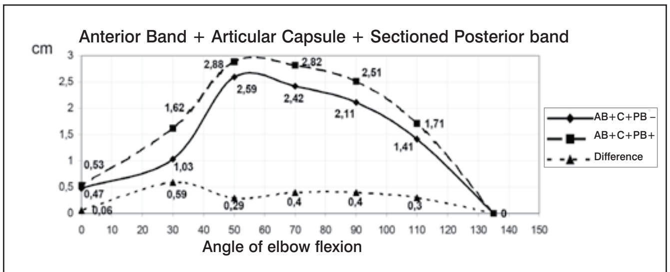

Figure 7. The curves of the third stage of GAP with and without stress and the difference. Maximum medial opening between 50° and 70° of elbow flexion, after sectioning of the entire MCL.

Table 5. Mean openings in centimeters of GAP, with the three stages submitted to valgus stress maneuver.

Angle	0°	30°	50°	70°	90°	110°	135°
BAC	0.47	0.62	0.87	0.89	0.79	0.68	0.0
BA+CC	0.41	0.93	1.86	1.72	0.98	0.71	0.0
BA+C+BPC	0.53	1.62	2.88	2.82	2.51	1.71	0.0

AB = anterior band, C = capsule, PB = posterior band, C = with stress.

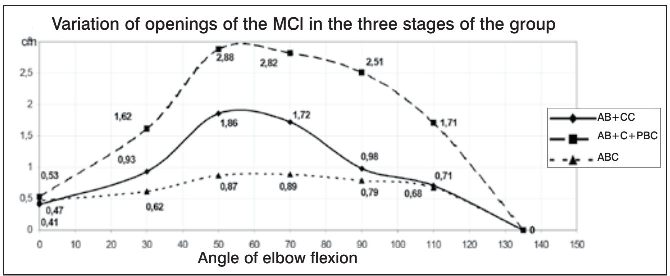

Figure 8. Variation of opening of the MCL in the three stages of the GAP group with stress.

DISCUSSION

According to Bennet et al.,[12] elbow stability is provided by the static and dynamic stabilizers. Static stability depends on the relation between humerus and radius, humerus and ulna and radius and ulna, components of the elbow joint. Dynamic stability depends on the forearm flexor and extensor muscles, on the articular capsule and on the medial and lateral collateral ligaments. The flexor muscles, the medial capsule and the medial ligaments are stronger and more resistant than the extensor muscles and the lateral capsular and ligamentous structures, implying that the medial compartment is the key to dynamic stability of the elbow.

Both in the survey conducted by Schwab et al.[13], and in that conducted by Sojbjerg et al.,[14] it was evidenced that elbow stability in the range of motion from 0° to 20° and from 120° to 140° is provided by the bone socket between the ulna and the humerus; in the range of motion between 30° and 110° stability is dependent on the integrity of the MCL, as reported by Conway et al.[15]

Richard et al.[6] monitored, for ten years, eleven athletes who had suffered medial collateral ligament tears without a history of dislocation and noted that they all presented, upon clinical examination, instability in valgus and enlargement of the medial joint space in the radiograph in valgus.

The results observed in GPA are consistent with the survey conducted by Pollock et al.,[16] who evaluated the stress resulting from varus and valgus stress and internal and external rotation maneuvers, after the sectioning of the posterior bundle of the medial collateral ligament. The abovementioned author did not observe in the active flexion movement the increase of the angle resulting from the varus and valgus maneuvers after the sectioning of this bundle; hence they concluded that the function of the posterior bundle of the medial collateral ligament in elbow stability is not yet well defined.

According to Morrey and An[4] this posterior bundle is under stress after 60 degrees of elbow flexion; according to Vieira and Caetano[17] this degree is 120, and according to Schwab et al.[13] the sectioning does not interfere significantly in medial stability of the elbow.

In the GAP Group, it can be seen that after the complete sectioning of the anterior band, of the articular capsule and of the posterior band, the participants found the value of total opening, regardless of the sectioning direction. These findings are in line with the survey by Pichora et al.,[18] where it is clear that the anterior bundle of the medial collateral ligament is the principal elbow stabilizer in valgus stress. These refer to Hotchkiss and Weiland,[19] who in their surveys noted that the anterior portion of the medial collateral ligament is the primary stabilizer of the elbow in valgus stress.

In the studies carried out by various authors such as Cage et al.,[20], Morrey,[21] and Motta Filho and Malta,[22] it was evidenced that the anterior portion of the medial collateral ligament is accountable for 30% to 50% of the valgus stress, according to the degree of elbow flexion. According to Vieira and Caetano,[17] the anteromedial portion of the MCL is under stress in the flexion-extension movement of the elbow at 30, 60 and 90 degrees, being the main stabilizer of the elbow in valgus effort.

According to Lech et al.[9] the anterior band is more important than

the posterior band, in view of the stability that it provides to the elbow during valgus stress; this was verified by Jobe and Attracha.[23]
The transverse band is of no importance during the sectioning, as its origin in the medial surface of the ulna in the olecranon process, and its insertion in the coronoid process, are in the actual ulna, reinforcing the insertion of the capsule medially.
Although the angular variation obtained in this study cannot be compared with the variation found by the other authors, in relation to the linear distance, the maximum openings were obtained close to the angular intervals of 60° to 90° and between 50° and 70°, in conformity with other studies.
Medial instability of the elbow is rarely observed in clinical practice. The injury mechanism of radial head fractures can, potentially, jeopardize the integrity of the MCL. Medial instability is not always investigated when elbow dislocations or fractures occur, yet the standardization of the MCL injury investigation should be systematic.
The contribution of this anatomical study concerns the recognition of the stabilization role of the MCL, which had not theretofore been considered in full detail.
Having reached the end of this discussion, it is worth emphasizing that a definitive conclusion regarding the topic should not be made based on a single study. Accordingly, we perceive the need for repetitions of studies, since repeated studies do not always lead to the same results.

CONCLUSION

The anterior band is the only structure of the MCL whose isolated sectioning allows the valgus opening of the elbow, acting as the main elbow stabilizer in valgus instability.
When the posterior band is sectioned separately or in association with the sectioning of the articular capsule, keeping the anterior band intact, valgus opening of the elbow does not occur.
In the interval from 50° to 70° of elbow flexion there is maximum valgus opening when the anterior band, articular capsule and posterior band of the MLC are sectioned.

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