Original Article

Can the Anterolateral Ligament be Clearly Identified in an Embalmed Cadaver?

Abstract

Introduction: In this study, it was aimed to determine the anterolateral ligament (ALL), especially in formalin-fixed cadaver knees using several dissection techniques. The ALL was described by Segond in 1879 as a "pearly, resistant, fibrous band" in the anterolateral aspect of the human knee. Hughston *et al*. described this anatomical structure as the mid-third lateral capsular ligament. Claes first described this structure as ALL. **Material and Methods:** The ALL was initially evaluated in six formalin-fixed cadaver knees and one fresh knee. Three different techniques were used in the formalin-fixed cadaver knees. **Results:** In one of the six formalin-fixed cadavers and in the fresh cadaver, the ALL was able to be explored. In the formalin-fixed cadaver knee, ALL was measured 5.5 mm distal, 3.4 mm mid, and 4.3 mm proximal. In the fresh cadaver knee, the ALL was measured 7.5 mm distal, 3.9 mm mid, and 5.4 mm proximal. **Discussion and Conclusion:** As a result of this study in which it was aimed to determine ALL, especially in formalin-fixed cadaver knees, it was only possible to clearly determine the ALL in one of the six formalin-fixed cadaver knees and in the fresh cadaver. In conclusion it is difficult to determine ALL in embalmed cadavers.

Keywords: *Anterolateral ligament, cadaver, formalin fixed, fresh frozen, pivot shift*

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Introduction

The human knee joint is stabilized by static and dynamic stabilizers.[1] The mechanism of the lateral ligaments of the knee during active movement is still not fully understood.[2] In 1879, Dr. Segond identified the lateral articulation fracture of the proximal tibia and described this as a result of the "pearly, resistant, fibrous band" at the anterolateral aspect of the human knee.[3] In 1976, Hughston *et al*. described this anatomical structure as the mid-third lateral capsular ligament,[4] and LaPrade *et al*. described the mid-third lateral capsular ligament as a thickening of the lateral capsule, attached to the femoral lateral epicondyle with capsular attachments to the lateral meniscus.[5] A later anatomical study by Claes *et al*. described this structure as the anterolateral ligament (ALL).[6] Much knowledge has been gained from that study.

This ligament has been examined in many studies using human, fresh frozen or embalmed cadavers. The ligament structure passes anterodistally from an attachment at the proximal and posterior of the lateral femoral epicondyle to the margin of the lateral tibial plateau, between Gerdy's tubercle and the head of the fibula.[1]

ALL deficiency is associated with internal rotation laxity, which is described as pivot-shift phenomenon.[7] The aim of this study was to examine the ALL in early postmortem and embalmed cadavers to determine whether it can be described as previously mentioned in embalmed cadavers.

Material and Methods

In this study, the ALL was initially evaluated in six embalmed cadaver knees and one early postmortem knee. The cadavers were obtained from Anatomy Department. The anterolateral structures of seven knees (four right and three left) of five body donors (four males and one female) were investigated. The male cadavers were embalmed, whereas the female was investigated early postmortem. Cadavers showing gross deformity in knee articulation or absence of the anterior cruciate ligament were excluded.

Three different techniques were used on the embalmed cadaver knees. A large cutaneous

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flap was made in all knees initially, then the iliotibial band (ITB) was dissected from its proximal origin, was carefully transected distally, then sharply cut from Gerdy's tubercle with a scalpel. In two knees, the quadriceps femoris was cut 5 cm proximal to the patella. In two knees, the patellar tendon was cut 3 cm distal to the patella, and classic dissection was applied to two knees [Figure 1]. All knees were positioned in varus and 30° flexion with the lateral collateral ligament (LCL) taut and palpable. The LCL was exposed at the lateral femoral epicondyle and was carefully transected posteriorly to the distal. It was then attempted to evaluate the ALL at the femoral attachment point. In one knee, ALL was clearly identified at the lateral femoral epicondyle origin and was carefully transected to its tibial origin between Gerdy's tubercle and the head of the fibula [Figure 2]. The ALL was isolated at its femoral origin, mid, and tibial origin. The length and thickness of the ALL were measured with digital calipers, and the slope was measured with a manual goniometer.

In the early postmortem knee, a large cutaneous flap was cut with a scalpel. After removal of the soft tissues, the ITB was cut from the proximal and was carefully transected to its tibial origin at Gerdy's tubercle and was sharply cut with a scalpel. With the LCL taut and palpable, the proximal origin was found at the lateral femoral epicondyle. The LCL was carefully transected posteriorly; the ALL femoral origin was found and the ALL was carefully transected [Figure 3]. The length and thickness of the ALL was measured with digital calipers at its femoral origin, mid, and tibial origin. The ALL slope was measured with a manual goniometer.

Results

It was attempted to determine the ALL with deep knee joint dissection to effectively reveal the deep knee structures in embalmed and early postmortem cadaver knees. In one of the six embalmed cadaver knees, dissected by the quadriceps cutting technique, and in the early postmortem cadaver, the ALL could be explored clearly. In the embalmed cadaver knee, the ALL orientation was at a slope of 40° from the lateral epicondyle of the femur to between Gerdy's tubercle and fibula head. Thickness was measured as 5.5 mm at the tibial origin, 4.3 mm at the proximal origin, and 3.4 mm at the mid-ALL. Length was measured as 24 mm from distal to proximal. In the fresh cadaver knee, the ALL orientation was at a slope of 30° from the lateral epicondyle of the femur to between Gerdy's tubercle and the fibula head. Thickness was measured as 7.5 mm at the tibial origin, 5.4 mm at the proximal origin, and 3.9 mm at mid-ALL. Length was measured as 30 mm from distal to proximal [Table 1].

Discussion

In this study, it was aimed to determine the ALL, especially in embalmed cadaver knees. The ALL was able to be

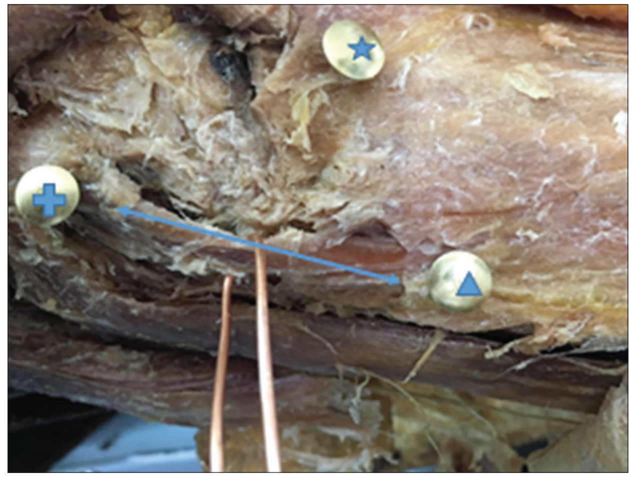

Figure 1: Embalmed cadaver right knee. Plus: lateral epicondyle, triangle: head of the fibula, star: Gerdy's tubercle, twoheaded arrow: lateral collateral ligament

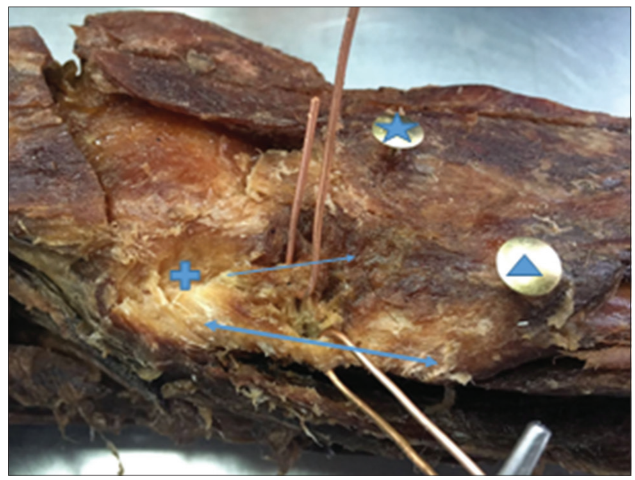

Figure 2: Embalmed cadaver right knee. Plus: lateral epicondyle, triangle: head of the fibula, star: Gerdy's tubercle, one headed arrow: anterolateral ligament, two-headed arrow: lateral collateral ligament

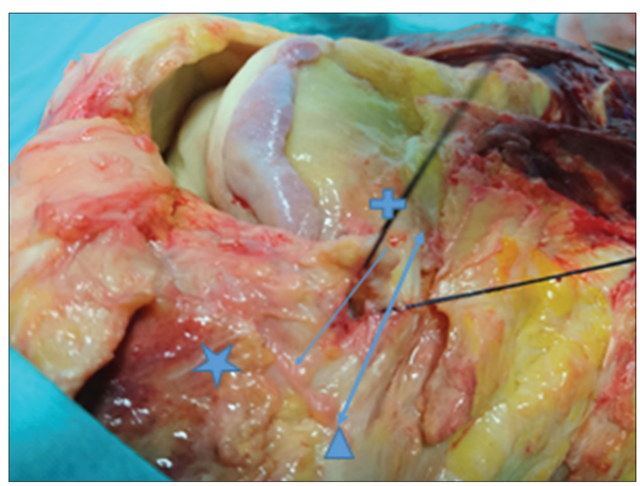

Figure 3: Early postmortem cadaver left knee. Plus: Lateral epicondyle, triangle: head of the fibula, star: Gerdy's tubercle, one headed arrow: anterolateral ligament, two-headed arrow: lateral collateral ligament

Table 1: Anterolateral ligament thickness, length, slope

	Proximal thickness (mm)	Mid-thickness (mm)	Distal thickness (mm)	Length (mm)	Slope (°)
Embalmed	5.5	3.4	4.3	24	40
Early postmortem	7.5	3.9	5.4	30	30

Table 2: Summary of anterolateral ligament studies

	Cadaver	*n*	Pair	Side	Gender	Age (years)	Prevalence (%)
Vincent *et al*.	Fresh-frozen	10	UP	6 left/4 right	2 males/8 females	85	100
Claes *et al*.	Embalmed	41	UP	18 left/23 right	22 males/19 females	79	97.6
Helito *et al*.	Fresh-frozen	20	UP	7 left/13 right	16 males/4 females	62	100
Dodds *et al*.	Fresh-frozen	40	UP	18 left/22 right	21 males/19 females	75	83
Caterine *et al*.	Fresh-frozen	19	UP13-P6	-	13 males/7 females	70	100
Stijak *et al*.	Embalmed	14	UP	7 left/7 right	6 males/8 females	78	50
Kosy *et al*.	Fresh-frozen	11	UP	3 left/8 left	2 males/9 females	79	90.9
Runer *et al*.	Embalmed	44	UP	-	22 males/28 females	78	45.5
Roessler *et al*.	Fresh-frozen	20	P	10 left/10 right	10 males/10 females	79	60
Brockmeyer *et al*.	E/EPM	E2/EPM3	UP1/P2	3 left/2 right	1 male/2 females		100
Yucens *et al*.	E/EPM	E6/EPM1	UP3/P3	4 right/3 left	6 males/1 female	74	28.6

UP: Unpaired, P: Paired, EPM: Early postmortem, E: Embalmed

clearly located in one of the six embalmed cadaver knees and in the early postmortem cadaver knee. It is difficult to determine ALL in embalmed cadaver knees because of the adhesive structure of tissues in embalmed cadavers.[8]

ALL was described by Segond in 1879 as a "pearly, resistant, fibrous band" at the anterolateral aspect of the human knee.[3] To date, ALL has been investigated by many authors (LaPrade, Claes, Kosy, Runer, Seebacher, Roessler, Brocmeyer, Stijak, Caterine, Helito).[5-14]

In a study by Claes, 41 embalmed cadaver knees were examined, and ALL was found at the rate of 97%.[6] In that study, the ITB was cut and then the superficial lamina of the capsule and LCL and the ALL could be visualized (Layer 2–3).[6] In the current study, the LCL was visualized and transected posteriorly, but in five knees, there was no ALL at the lateral epicondyle of the femur and no trace of it. In contrast to the Claes study, Seebacher *et al*. showed a relationship between the ALL and ITB.[9] If the ALL is a part of the ITB or related to it, then it should be possible to cut it together with the ITB and its deep layers during dissection in embalmed cadavers. Vincent *et al*. described the structure as the capsular ligament rather than ALL.[2] In embalmed cadavers, the capsule of articulation is generally adhered to superficial tissues, so it is difficult to separate the capsule from tissues. In a study by Roessler *et al*., ALL was found at a prevalence of 60% in fresh-frozen cadaver knees, and bilateral ALL was determined in 20% of the cadavers.[10] Brockmeyer *et al*. studied embalmed and early postmortem cadaver knees (two embalmed and three early postmortems) and explored ALL at a prevalence of 100%.[11] Stijak *et al*. and Runer *et al*. studied embalmed cadavers and reported that ALL was found in 50% and 45%, respectively.[8,12]

With the exception of Claes *et al*., previous studies which have investigated ALL in fresh-frozen cadavers have reported a higher rate of ALL compared to embalmed cadavers [Table 2]. In the current study, ALL was determined in 17% of the embalmed cadaver knees and in 28.6% totally. Limitations of this study are that the sample size was small and only one fresh cadaver was explored.

Conclusion

The exploration of ALL on fresh cadavers may be considered to be more effective than the use of embalmed cadavers. In conclusion it is difficult to determine ALL in embalmed cadavers and we suggest the ALL exploration in fresh cadavers.

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Conflicts of interest

There are no conflicts of interest.

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