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Evaluation of Ligamentum Mucosum in Anterior Cruciate Ligament Injuries

Ön Çapraz Bağ Yaralanmalarında Ligamentum Mukozumun Değerlendirilmesi

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ABSTRACT

Objective: Over the past few years, histopathological studies have demonstrated that the ligamentum mucosum (LM) contains neural and vascular structures. These findings suggest that LM can be used for proprioception and revascularization in the repair of anterior cruciate ligament (ACL). The aim of this study was to evaluate the LM structure in knees with ACL injuries.

Methods: The data of patients who underwent knee arthroscopy at our clinic between 2017 and 2022 were retrospectively analyzed. Three groups were included in the study; acute ACL tears (n=89), chronic ACL tears (n=111) and intact ACLs (n=101). The arthroscopic video records of all patients were evaluated retrospectively. LM was defined in three different forms: (1) Intact, (2) ruptured, and (3) non-presence.

Results: The non-presence of the LM was significantly more common in chronic ACL tears compared to the other groups (p=0.021), while the presence of the LM (either intact or ruptured) was similar between acute ACL tears and intact ACLs. In acute tears, the number of intact LM was significantly lower than that of intact ACLs (p<0.001). However, it was significantly greater than that of chronic tears (p=0.001).

Conclusion: According to the present study, the likelihood of intact LM in chronic ACL tears is quite low. In this regard, we suggest that performing surgery in the acute phase of ACL injury will increase the chances of using the LM as a neurovascular source. In addition, because of the possible effect of the LM on proprioception, we recommend preserving the structure during knee arthroscopy procedures if a healthy LM is present.

Keywords: Ligamentum mucosum, anterior cruciate ligament injury, acute, chronic, knee arthroscopy

ÖZ

Amaç: Son yıllarda ligamentum mukozum (LM) üzerine yapılan histopatolojik çalışmalar, bu yapının nöral ve vasküler bileşenler içerdiğini ortaya koymuş ve LM'nin ön çapraz bağ (ÖÇB) onarımında propriyosepsiyon ve revaskülarizasyon amacıyla kullanılabileceği ifade edilmiştir. Sunulan çalışmanın amacı ÖÇB hasarı olan dizlerde LM varlığının değerlendirilmesidir.

Yöntemler: 2017-2022 yılları arasında kliniğimizce diz artroskopisi ameliyatı yapılan hastaların verileri retrospektif olarak incelenmiştir. Hastalar üç gruba ayrılarak incelenmiştir; akut ÖÇB yırtıkları (n=89), kronik ÖÇB yırtıkları (n=111) ve sağlam ÖÇB (n=101). Tüm hastaların artroskopik video kayıtları retrospektif olarak değerlendirilmiş ve LM, gruplarda üç farklı formda tanımlanmıştır: (1) Sağlam, (2) yırtık ve (3) LM yoktur.

Bulgular: LM yokluğu, kronik ÖÇB yırtıklarında diğer gruplara kıyasla anlamlı derecede daha yaygındı (p=0,021). Ayrıca, LM varlığı (sağlam ya da yırtık) akut ÖÇB yırtıkları ile sağlam ÖÇB'ler arasında benzerdi. Akut yırtıklarda, sağlam LM bulunma oranı, sağlam ÖÇB'lere göre anlamlı derecede daha azdı (p<0,001) iken kronik yırtıklara göre anlamlı derecede daha fazlaydı (p=0,001).

Sonuç: Sunulan çalışmadan elde edilen verilere göre kronik ÖÇB yırtıklarında sağlam LM görülme olasılığı oldukça düşüktür. Bu bağlamda, ÖÇB yaralanmalarında cerrahinin erken evrede yapılmasının, LM'nin nörovasküler bir kaynak olarak kullanılma şansını artıracağına inanmaktayız. Ayrıca, LM'nin propriyosepsiyon üzerindeki olası etkisi nedeniyle, diz artroskopisi sırasında sağlıklı bir LM varlığında yapının korunmasını önermekteyiz.

Anahtar Sözcükler: Ligamentum mukosum, ön çapraz bağ yaralanması, akut, kronik, diz artroskopisi

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INTRODUCTION

The ligamentum mucosum (LM) is a structure located anterior to the anterior cruciate ligament (ACL) between the intercondylar notch of the femur and Hoffa's fat pad (1). LM, also known as the infrapatellar plica, was once thought to be a remnant of embryonic development (2,3). However, recent histological studies have indicated that the LM, similar to other ligaments in the knee, has an elastic structure and is composed of dense and regular connective tissue consisting mainly of type 1 collagen (4-8). Recent studies have revealed the presence of neurovascular tissue components within the structure of the LM. The presence of neural tissue components suggests that the LM may have a role in proprioception, similar to that of the ACL (7,9-11). The LM may also have a well-developed vascular structure, especially in the distal part of the ligament (11,12). Based on these properties, studies have suggested that LM could be used as a potential donor of vascular and neural tissue for ACL repair (12). To the best of our knowledge, clinical studies on the LM have only investigated its association with anterior knee pain and cartilage damage (11,13-15). Recent research on the relationship between LM and ACL injuries has increased, with a better understanding of the neurovascular structure of the LM. However, no clinical studies have been conducted on this subject. The aim of presented study was to evaluate the structure of the LM in knees with ACL injuries. Our hypothesis was that the presence of an intact LM in knees with chronic ACL injuries would likely be reduced by damage and subsequent degeneration.

MATERIALS AND METHODS

Retrospective evaluation was conducted on the arthroscopic video recordings of patients who underwent arthroscopic surgery at the current center between 2017 and 2022. The data of 435 patients were collected prospectively. Patients with inflammatory arthritis, tumors, patellofemoral malalignment, a history of previous knee surgery, or tears that were not in the acute or chronic phase of ACL injury (more than 6 weeks and less than 27 weeks) were excluded from the study. The groups included in the study were selected from the remaining 301 patients. Demographic data, including age and gender, were analyzed. The arthroscopy records of the patients were reviewed to determine the presence of ACL injury. The time period between the injury and surgery was assessed. If the time period was less than 6 weeks, the injury was considered acute; if the time period was more than 27 weeks, it was considered chronic (16). According to this classification, patients were divided into three groups: acute ACL tears (89 patients), chronic ACL tears (111 patients), and intact ACLs (101 patients) (85 meniscal injuries and 16 osteochondral defects).

During the arthroscopy, an experienced orthopaedic surgeon examined the intercondylar notch and Hoffa's fat pad, which are the attachment sites of the ligament, to assess the structure of the LM. If there was continuity in the ligament, it was considered to be intact (Figure 1a). If there was no continuity but fragments of the ligament were present, the ligament was considered ruptured (Figure 1b). If no ligament fragments were observed, they were considered non-presence (Figure 1c).

The arthroscopic surgery video recordings were evaluated by two knee surgeons with at least 10 years of experience. To investigate intraobserver reliability, the same observer re-evaluated all video records at intervals of more than 2 weeks from the initial evaluation. To evaluate interobserver reliability, another observer similarly evaluated all the video records randomly. The study was approved by the Gazi University Ethics Committee (approval number: 15, date: 09.01.2023), and written informed consent was obtained from all patients.

Statistical Analysis

The statistical analyses were performed using IBM SPSS Statistics for Windows, version 26.0 (IBM Corp., Armonk, N.Y., USA). Categorical variables were described as numbers and percentages, whereas continuous variables were presented as mean ± standard deviation-median (minimum-maximum value). The normality of continuous variables was assessed using visual methods (histograms and probability plots) and analytical methods (Kolmogorov-Smirnov and Shapiro-Wilk tests). One-way analysis of variance and least significant difference tests were used to compare age among 3 independent groups. The chi-square test was used to compare categorical variables between the independent groups. Interobserver and intraobserver reliability were determined using Cohen's kappa (κ).

RESULTS

A retrospective review was conducted for a total of 301 patients who were included in the study. Of these patients, 186 were male and 115 were female, with a mean age of 31.26±11.90 years and a median age of 31 years (range, 11-65 years) at the time of surgery. There were no statistically significant differences between the groups in

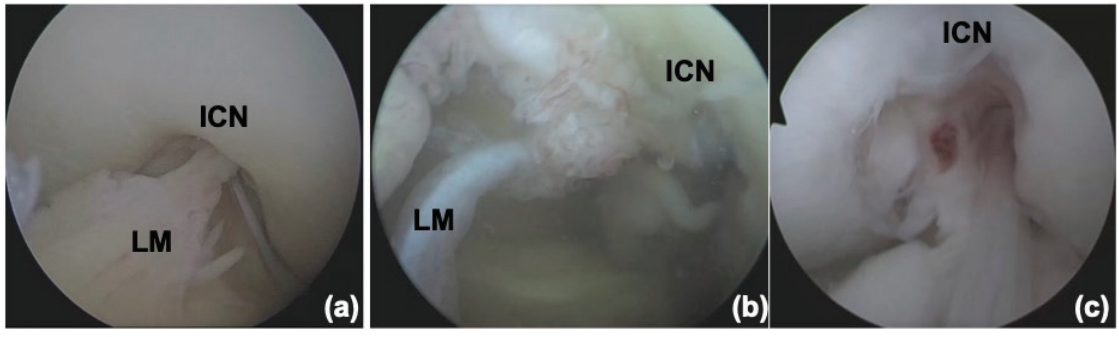

Figure 1. Arthroscopic imaging of the knee: The LM is intact and extends in front of the anterior cruciate ligament (a), ruptured LM fragments (b) and LM is not in presence (c).

ICN: Intercondylar notch, LM: Ligamentum mucosum.

terms of mean age or gender (p=0.489 and p=0.150, respectively) (Table 1). The mean time from injury to surgery was 4 weeks for acute ACL tears, 65 weeks for chronic ACL, and 42 weeks for intact ACLs.

When the groups were evaluated separately; in acute ACL tears, the prevalence of patients with intact and ruptured LM was similar and significantly higher than that of patients without LM (p<0.001). In chronic tears, the prevalence of intact and ruptured LM was similar, but the prevalence of no LM was significantly higher in this group (p=0.03). In intact ACLs, the majority of patients had intact LM (p<0.001) (Table 2).

When comparing the groups, it was found that intact LM was significantly more common in the intact ACL group than in the other groups (p<0.001). In acute ACL tears, intact LM was significantly lower compared to intact ACLs (p<0.001). However, it was significantly higher compared to chronic tears (p=0.001). While ruptured LM was most frequently observed in acute tears, they were least common in intact ACLs. There were significantly more patients without LM in the chronic tear group than in the other groups (p=0.021). The presence of LM (intact or ruptured) was found to be similar between in acute tears and intact ACLs (Table 2).

Intra- and interobserver Cohen's kappa values were assessed and found to demonstrate excellent agreement, with an interobserver kappa value of 0.856±0.036 and an intraobserver kappa value of 0.891±0.026.

DISCUSSION

The present study revealed two significant findings: First, the presence of an intact LM was significantly lower in knees with chronic ACL than in knees with acute injury and intact ACLs. Second, knees with acute ACL injuries had a similar percentage of LM presence as knees without ACL injuries. However, there is a significantly greater probability of damage to the LM in knees with acute ACL injury. We conclude that early surgical planning in patients with ACL injuries can increase the likelihood of using LM as a source for neurovascular purposes.

We believe that there may be two reasons for the higher incidence of LM rupture in knees with ACL injuries, particularly acute tears. First, Abreu et al. (6) showed that patients with ACL injuries have a higher prevalence of Hoffa fat pad pathology, which is due to the instability of the knee structure. By the similar mechanism LM attached to the Hoffa fat pad may also be at risk of damage due to instability in the knee. The second reason may be that the LM, which runs anteriorly and parallel to the ACL, can be torn by the same trauma that damages the ACL (17-19). It is possible that the damaged LM may degenerate over time. Amiel et al. (20) have shown that the ACL in the knee can degenerate after a tear. We are convinced that the LM, which has a ligamentous structure similar to that of the ACL, may also degenerate when injured. In conducted study, we also observed that patients in the acute phase had a high rate of LM rupture, whereas patients in the chronic phase had a high rate of LM absence instead of rupture.

The prevalence of LM has been studied using different methods, such as magnetic resonance imaging (MRI), cadaver dissection, and arthroscopic examination. A study conducted on cadavers to determine the prevalence of LM during early human life revealed that LM was present in all 70 knees examined (21). In another study that analyzed 51 cadaver knee joints, LM was observed in 66.7% of the specimens (7). In an arthroscopic study of 200 patients, it was found that 85% of them had LM (22). An MRI-based study revealed that this structure was present in 78.3% of knees (23). Degeneration is typically the cause of the observed decrease in LM incidence. The estimated prevalence of LM in young adults ranges between 65% and 80%. However, in the elderly population, this prevalence decreases to 37% (6,22,24). In the present study, the prevalence of LM (61%) was slightly lower than that in the general population in

Table 1. Comparison of demographic characteristics in 3 groups

	Group 1, (n=89)	Group 2, (n=111)	Group 3, (n=101)	p
	Mean ± SD	**Mean ± SD**	**Mean ± SD**	
Age	32.31±12.75	29.15±7.31	32.64±9.18	0.489
	n (%)	**n (%)**	**n (%)**	
Gender				0.150
Male	58 (65.2%)	80 (72.1%)	60 (59.4%)	
Female	31 (34.8%)	31 (27.9%)	41 (40.6%)	

Significant at 0.05 level; One-Way ANOVA for age, chi-square test for categorical data. SD: Standard deviation.

Table 2. The relationship between the ligamentum mucosum and groups

	Acute ACL tears	Chronic ACL tears	Intact ACLs
	n (%)	**n (%)**	**n (%)**
LM			
Intact	35 (39.4%)	25 (22.5%)	71 (70.3%)
Rupture	36 (40.4%)	29 (26.1%)	11 (10.9%)
Non-presence	18 (20.2%)	57 (51.4%)	19 (18.8%)

LM: Ligamentum mucosum, ACL: Anterior cruciate ligament.

the literature. We believe that the significant percentage (67%) of our study group comprised knees with ACL injuries.

In recent years, histological studies have provided a detailed understanding of the neurovascular structure of LM (7,11,21,25). It has been suggested that the LM may play a role in proprioception similar to that of the ACL due to its neural tissue. Furthermore, similar to ACL remnant tissue, the LM could be used to enhance proprioception in ACL reconstruction (7,11,25). In addition to neural tissue, the presence and location of vascular elements are also notable. The most hypovascular area of the ACL is the anterior part of its distal attachment (26). Gonera et al. (25) proposed that the LM, due to its vascular tissue, especially in the distal part, could be sutured to the ACL during repair procedures to provide vascular support. The blood supply and revascularisation process have a crucial role in the viability of the graft (27). Claes et al. (28) suggest that new blood vessels developing from the LM and infrapatellar fat pad could be involved in graft revascularization. As a consequence, suturing the LM to the ACL graft could provide a more effective vascularization process and increase the success rate of the reconstruction. Further anatomical and mechanical studies on the abovementioned methods are needed.

Study Limitations

The current study had several limitations, including its retrospective design, even if the data were collected prospectively. Hypotheses about the role of neural tissue in the LM in proprioception and its potential use in ACL revascularization owing to its vascular structure have been suggested based on histopathological studies. Although the literature suggests that suturing the LM to the ACL may be an effective surgical technique, no research has compared the healing time of the ACL and the improvement in proprioception between patients who have undergone this method and those who have not. Another limitation of the present study was that knees without ACL damage, rather than completely healthy knees, were included in the control group. Therefore, further clinical research is needed to better understand the role of the LM in ACL repair.

CONCLUSION

The present study concluded that the probability of an intact LM in chronic ACL tears was relatively low. Therefore, we suggest that early surgical intervention for ACL injuries could increase the chances of using the LM as a source of neurovascular supply. In addition, because of the possible effect of the LM on proprioception, we recommend preserving the structure during knee arthroscopy procedures if a healthy LM is present.

Ethics

Ethics Committee Approval: The study was approved by the Gazi University Ethics Committee (approval number: 15, date: 09.01.2023).

Informed Consent: Written informed consent was obtained from all patients.

Authorship Contributions

Concept: M.A.T., E.B.O., Design: M.Ş.C., Supervision: M.B.A., U.K., Resources: A.K., U.K., Materials: A.K., Data Collection or Processing: E.B.O., M.B.A., Analysis or Interpretation: M.A.T., M.B.A., Literature Search: E.B.O., Writing: E.B.O., M.Ş.C., Critical Review: U.K., A.K.

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REFERENCES

1. Gallagher J, Tierney P, Murray P, O'Brien M. The infrapatellar fat pad: anatomy and clinical correlations. Knee Surg Sports Traumatol Arthrosc. 2005; 13: 268-72.
2. Ogata S, Uhthoff HK. The development of synovial plicae in human knee joints: an embryologic study. Arthroscopy. 1990; 6: 315-21.
3. Cothran RL, McGuire PM, Helms CA, Major NM, Attarian DE. MR imaging of infrapatellar plica injury. AJR Am J Roentgenol. 2003; 180: 1443-7.
4. Boot-Handford RP, Tuckwell DS. Fibrillar collagen: the key to vertebrate evolution? A tale of molecular incest. Bioessays. 2003; 25: 142-51.
5. Duthon VB, Barea C, Abrassart S, Fasel JH, Fritschy D, Ménétrey J. Anatomy of the anterior cruciate ligament. Knee Surg Sports Traumatol Arthrosc. 2006; 14: 204-13.
6. Abreu MR, Chung CB, Trudell D, Resnick D. Hoffa's fat pad injuries and their relationship with anterior cruciate ligament tears: new observations based on MR imaging in patients and MR imaging and anatomic correlation in cadavers. Skeletal Radiol. 2008; 37: 301-6.
7. Gonera B, Kurtys K, Wysiadecki G, Podgórski M, Olewnik ŁH. The ligamentum mucosum: A new classification. Clin Anat. 2023; 36: 242-9.
8. Kim SJ, Choe WS. Pathological infrapatellar plica: a report of two cases and literature review. Arthroscopy. 1996; 12: 236-9.
9. Relph N, Herrington L, Tyson S. The effects of ACL injury on knee proprioception: a meta-analysis. Physiotherapy. 2014; 100: 187-95.
10. Mir SM, Talebian S, Naseri N, Hadian MR. Assessment of Knee Proprioception in the Anterior Cruciate Ligament Injury Risk Position in Healthy Subjects: A Cross-sectional Study. J Phys Ther Sci. 2014; 26: 1515-8.
11. Norris M, Corbo G, Banga K, Johnson M, Sandig M, Smallman T, et al. The biomechanical and morphological characteristics of the ligamentum mucosum and its potential role in anterior knee pain. Knee. 2018; 25: 1134-41.
12. Gonera B, Wysiadecki G, Kurtys K, Brzeziński P, Borowski A, Olewnik Ł. Immunohistochemical analysis of the ligamentum mucosum is the key to understand its clinical usefulness. Ann Anat. 2023; 249: 152106.
13. Ozcan M, Copuroğlu C, Ciftdemir M, Turan FN, Calpur OU. Does an abnormal infrapatellar plica increase the risk of chondral damage in the knee. Knee Surg Sports Traumatol Arthrosc. 2011; 19: 218-21.
14. Boyd CR, Eakin C, Matheson GO. Infrapatellar plica as a cause of anterior knee pain. Clin J Sport Med. 2005; 15: 98-103.
15. Demirag B, Ozturk C, Karakayali M. Symptomatic infrapatellar plica. Knee Surg Sports Traumatol Arthrosc. 2006; 14: 156-60.
16. Flint JH, Wade AM, Giuliani J, Rue JP. Defining the terms acute and chronic in orthopaedic sports injuries: a systematic review. Am J Sports Med. 2014; 42: 235-41.
17. Kiapour AM, Murray MM. Basic science of anterior cruciate ligament injury and repair. Bone Joint Res. 2014; 3: 20-31.
18. Kobayashi H, Kanamura T, Koshida S, Miyashita K, Okado T, Shimizu T, et al. Mechanisms of the anterior cruciate ligament injury in sports

activities: a twenty-year clinical research of 1,700 athletes. J Sports Sci Med. 2010; 9: 669-75.

19. Ishibashi Y, Adachi N, Koga H, Kondo E, Kuroda R, Mae T, et al. Japanese Orthopaedic Association (JOA) clinical practice guidelines on the management of anterior cruciate ligament injury - Secondary publication. J Orthop Sci. 2020; 25: 6-45.
20. Amiel D, Ishizue KK, Harwood FL, Kitabayashi L, Akeson WH. Injury of the anterior cruciate ligament: the role of collagenase in ligament degeneration. J Orthop Res. 1989; 7: 486-93.
21. Gonera B, Borowski A, Zielinska N, Palac W, Paulsen F, Olewnik Ł. Embryological approach to the morphology of the ligamentum mucosum of the human knee joint. Ann Anat. 2022; 244: 151983.
22. Kim SJ, Min BH, Kim HK. Arthroscopic anatomy of the infrapatellar plica. Arthroscopy. 1996; 12: 561-4.
23. Lee YH, Song HT, Kim S, Kim SJ, Suh JS. Infrapatellar plica of the knee: revisited with MR arthrographies undertaken in the knee flexion position mimicking operative arthroscopic posture. Eur J Radiol. 2012; 81: 2783-7.
24. Apostolopoulos AP, McConnell B, Manta A, Zafiropoulos G. The incidence of infrapatellar plicae in the elderly Welsh population. Folia Morphol (Warsz). 2012; 71: 194-7.
25. Petersen W, Tillmann B. Structure and vascularization of the cruciate ligaments of the human knee joint. Anat Embryol (Berl). 1999; 200: 325-34.
26. Petersen W, Tillmann B. Structure and vascularization of the cruciate ligaments of the human knee joint. Anat Embryol (Berl). 1999; 200: 325-34.
27. Yao S, Fu BS, Yung PS. Graft healing after anterior cruciate ligament reconstruction (ACLR) Asia Pac J Sports Med Arthrosc Rehabil Technol. 2021; 25: 8-15.
28. Claes S, Verdonk P, Forsyth R, Bellemans J. The "ligamentization" process in anterior cruciate ligament reconstruction: what happens to the human graft? A systematic review of the literature. Am J Sports Med. 2011; 39: 2476-83.