

**RESEARCH ARTICLE**

# The Prevalence, Zone, and Type of the Meniscus Tear in Patients with Anterior Cruciate Ligament (ACL) Injury; Does Delayed ACL Reconstruction Affects the Meniscal Injury?

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**Abstract**

**Background:** Meniscus tear is a common finding in patients with anterior cruciate ligament (ACL) injury and may affect the natural history of the injury and the outcomes of treatment. In the current study, the characteristics of meniscus tears in patients who underwent arthroscopic ACL reconstruction were investigated.

**Methods:** The hospital records of 1022 patients were reviewed. The measured variables included the presence of meniscus tear, ramp and root injury, the zone of injury based on the Cooper classification, and the type of tear. The ACL tears with delay more than 3 months for ACLR were recorded as chronic injuries.

**Results:** The incidence of meniscus tear was 44.4%; among whom, bucket-handle injury was the most common type (30.4%) and the ramp lesion was found in 20.5%. The meniscus was repaired in 56.6%. The incidence of medial meniscus injury was significantly higher in chronic ACL tears and vice versa ( $P<0.001$ ). The incidence of ramp lesion (9.1% Vs 20.5%) and root tear (1.3% Vs 2.9%) were significantly higher in the chronic and acute tears, respectively ( $P<0.001$ ).

**Conclusion:** Delay more than 3 months in ACLR was associated with the increased incidence of meniscal injury, specially the medial meniscus, and ramp lesion. It seems that early ACLR may be more helpful for the patients.

**Level of evidence:** IV

**Keywords:** Anterior cruciate ligament, Arthroscopy, Chronic injury, Meniscus, Ramp lesion

**Introduction**

The coincidence of meniscus tear with anterior cruciate ligament (ACL) injury has been reported as 51.9-63% (1, 2). In some other studies, the meniscus injury associated with acute and chronic ACL tear has been reported between 16% and 40% and more than 96%, respectively (3,4).

The importance of meniscus, especially the medial one, in knee stability in people with chronic ACL injury has already been reported (5). Meanwhile, some types of meniscus tears such as root, complete radial, and bucket-handle tears appear to cause more biomechanical complications (5-8). In some other studies, the role

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of the medial meniscus in reducing the anterior tibial translation has been investigated (9).

Appropriate repair of the meniscus injury in these cases can prevent degenerative changes such as osteoarthritis (10-12). Studies have shown that some types of meniscus tear such as a tear in the posterior horn of the medial meniscus are sometimes not diagnosed. Lack of treatment of such injuries may cause knee instability and increased tension on ACL graft (13).

Various studies have investigated the characteristics of the meniscus tear in patients with ACL tear resulted in considerable knowledge (1, 2, 14, 15). Considering these studies, it seems that acute ACL injury is associated with lateral meniscus tear while chronic ACL injury is associated with medial meniscus tear (4, 15-20). In addition, to the best of our knowledge, there is no appropriate data regarding the root tears in this patient population. Further, no study has investigated the location of the meniscus injury based on the Cooper classification (21). However, a study showed that 75% of the medial meniscus tears in patients with ACL defects occur in the peripheral region of the posterior horn which was confirmed by other studies (16,22, 23).

In spite of the large number of the studies, there is lack of knowledge about ramp and root injuries. Additionally, the previous studies had several limitations such as the investigation of only one meniscus (medial or lateral) or no investigation of the meniscus tear pattern. This is while the type and location of the meniscus tear can play an important role in determining the type of intervention as well as the prognosis of the treatment. It seems that the increased time interval between ACL tear and surgery may complicate the meniscus injury and reduce the chance of the repair (15, 26). We aimed to investigate the prevalence of various types of meniscus tear and the zone of these injuries in patients who underwent arthroscopic ACL reconstruction. In addition, it was investigated whether delayed ACL reconstruction could affect the characteristics of the meniscus tear.

### Materials and Methods

In this cross-sectional study, 1147 patients who underwent arthroscopic ACLR in three referral orthopedic hospitals in Tehran during 2016-2017 were enrolled. Before the study, institutional ethical committee approved the study protocol. The inclusion criteria were age between 18 and 45 years and a definite diagnosis of an ACL tear based on physical examination and MR images. Patients with multi-ligament injury, periarticular fracture, previous history of meniscal injury, perigenicular fracture and knee surgery were excluded. Furthermore, patients with revision ACLR were also excluded.

At first, patients with a history suggesting ACL tear were physically examined. If clinical findings confirmed increased anterior tibial translation, MRI was performed. If ACL tear was confirmed by MR images, arthroscopic ACL reconstruction was planned. Preoperatively, the chief surgeon reviewed the MR images to find any potential meniscal injury and determined its location. The demographic data including the age, gender, mechanism

of injury, athletic or nonathletic injury, and the time interval between trauma and surgery were recorded.

At the time of arthroscopy, the condition of the menisci was also carefully examined. Data regarding the meniscus injury including the affected meniscus, type of injury and tear zone were recorded based on Cooper's classification. In Cooper classification, each meniscus is divided to three regions named A to F. The ordering of regions is as follows: In medial meniscus, the posterior, middle and anterior regions are named A, B and C, respectively, while in lateral meniscus, the anterior, middle and posterior regions are named D, E and F, respectively. Each region is divided to zones 1 to 4 from lateral to medial (21). Further, the meniscocapsular or meniscopopliteal ligaments were arthroscopically observed to find any potential injury in these structures (ramp lesion). The ramp lesion was classified using Thaunat classification. Thaunat et al. classified the medial ramp lesion as follows: meniscocapsular lesion (type I), partial superior lesion (type II), partial inferior lesion (type 3), complete tear in red-red zone (type 4), and double tear (type 5) (27). We used this classification for the lateral meniscus except that type 1 was considered as meniscopopliteal lesion. Additionally, the presence of root tear, loose body in the joint, and chondral lesion were recorded.

In the current study, if the surgery was delayed for more than 3 months after the injury, the ACL tear was considered as chronic injury. Consequently, if the patient underwent ACLR during the first 3 months after the surgery, the ACL tear was considered as acute injury. The patients were divided into two groups based on the chronicity of the ACL injury. Different features of the meniscus injury were compared between the two groups.

### Statistics

Chi square test or Fisher's exact test were used to compare the qualitative data between the patients with acute and chronic ACL injury. It should be noted that in all the tables presented; percentages were calculated based on 470 meniscus tears, not the number of the patients with torn meniscus (454 patients). For this reason, in some cases, the figures presented for the prevalence may be slightly different from those shown in the tables.  $P < 0.05$  was considered significant.

### Results

One hundred and twenty-five patients were excluded due to missing data and the study was completed with 1022 patients. Table 1 represents the demographic characteristics of these patients.

The meniscus tear was found arthroscopically in 454 patients (44.4%). Sixteen (3.5 %) patients had a triple lesion. Thus, in total, 470 menisci were torn. Regarding these 16 patients, the medial meniscus was torn in 241 patients (51.3%) and the lateral meniscus in 229 cases (48.7%). In other words, the incidence of isolated medial or lateral meniscus in all 1022 patients was 22% and 20.8%, respectively, and the incidence of tear in both menisci was 1.6%. Of the patients with meniscus tear,

**Table 1. Demographic characteristics of the patients with ACL injury**

<b>No.</b>		1022
<b>Age (y)</b>		28.9 ±7 (18-45)
<b>Gender</b>	Male	938 (91.8%)
	Female	84 (8.2%)
<b>Side of injured knee</b>	Right	668 (65.4%)
	Left	354 (34.6%)
<b>Mechanism of injury</b>	Direct trauma	535 (52.3%)
	falling down	345 (33.8%)
	Knee torsion	142 (13.9%)

27.3% were assigned to the acute ACL tear group and the rest to the chronic ACL tear group (72.7%).

Bucket-handle tear was the most common type followed by radial and flap tears [Table 2]. Meniscus repair and meniscectomy were performed in 266 (57%) and 204 menisci (43%), respectively.

Based on the Cooper classification, B3 was the most involved meniscal zone (8.9%) followed by D1 (8.5%) and C1 (8.3%) [Table 3].

Ramp lesion was found in 93 patients (9.1% of all patients with ACL tear and 20.5% of patients with meniscus injury): meniscocapsular tear in 82 patients (88.2%) meniscopopliteal tear in 11 patients (11.9%). The most common type of ramp lesion was type I (56 patients, 60.2%) followed by type V (15 patients, 16.1%), IV (12 patients, 12.9%), II (6 patients, 6.4%) and III (4

**Table 2. The types of medial and lateral meniscus tear in patients with ACL injury**

	Medial meniscus	Lateral meniscus	Total
<b>Radial</b>	48 (1.9%)	79 (34.5%)	127 (27%)
<b>Bucket-handle</b>	86 (35.7%)	57 (24.9%)	143 (30.4%)
<b>Longitudinal</b>	34 (14.1%)	26 (11.4%)	60 (12.8%)
<b>Flap</b>	62 (25.7%)	47 (20.5%)	109 (23.2%)
<b>Horizontal</b>	11 (4.6%)	20 (8.7%)	31 (6.6%)
<b>Total</b>	241 (100%)	229 (100%)	470 (100%)

**Table 3. The frequency of torn zone based on Cooper classification in patients with ACL injury**

Zone of tear	Frequency	Percentage*
A1	21	4.5
A2	23	4.9
A3	24	5.1
B1	37	7.9
B2	19	4
B3	42	8.9
C1	39	8.3
C2	6	1.3
C3	29	6.2
D1	40	8.5
D2	10	2.1
D3	18	3.8
E1	28	5.9
E2	26	5.5
E3	33	7
F1	29	6.2
F2	19	4
F3	27	5.7

\* The percentages were calculated based on the total number of the torn menisci (470)

**Table 4. Comparing the incidence of medial and lateral meniscus tear, type of tear, type of treatment, and the incidence of ramp injury, root injury, chondral lesion and loose body between patients with acute and chronic ACL injury**

	Acute group	Chronic group	P-value
<b>Medial / Lateral meniscus</b>	35 (28.2%) / 89 (71.8%)	206 (59.5%) / 140 (40.5%)	<0.001
<b>type of tear</b>	Radial	44 (35.5%)	83 (24%)
	Bucket-Handle	36 (29%)	107 (30.9%)
	Longitudinal	7 (5.6%)	53 (15.3%)
	Flap	29 (23.4%)	80 (23.1%)
	Horizontal	8 (6.5%)	23 (6.6%)
<b>Ramp injury</b>	9 (7.25%)	84 (24.3%)	<0.001
<b>Root injury</b>	12 (9.7%)	1 (0.3%)	<0.001
<b>Chondral lesion</b>	12 (9.7%)	28 (8.1%)	0.587
<b>Loose body</b>	3 (2.4%)	5 (1.4%)	0.472

patients, 4.3%).

The bucket-handle injury was the most common type of tear in males (30%) followed by radial tear (7%) while in females the radial tear was the most common type (36%) followed by the bucket-handle tear (32%). Further, meniscocapsular injury was found in 77 males and five females. All 11 meniscopopliteal tears were found in males.

There were 103 athletes in the current study including 65 football players, 17 volleyball players, nine taekwondo players, five wrestlers, four boxers and three basketball players; among whom, 71 patients had meniscus tear (68.9%). The incidence of various types of meniscus tear in athletes was as follows: radial in 22.3%, bucket-handle in 19.4%, longitudinal in 9.7%, flap in 11.7%, and horizontal in 5.8%. The most commonly involved zones in the athletes were C3 (8 patients), C1 (7 patients), and E2 and F1 (each in 6 patients). Also, zones B3, E1 and E3 were involved each in 5 patients. The meniscocapsular and meniscopopliteal injuries were found in 8 and 1 athlete patients, respectively.

Arthroscopic findings confirmed the preoperative findings on MR images regarding the meniscus injury in 974 patients (95.3%). However, the preoperative diagnosis of meniscus tear was not possible in 48 patients utilizing the MR images. The zones in which these meniscal injuries had occurred were as follows:

b1, b2, c3 and f2 each in one case, f1 in two cases, c1 and d3 each in three cases, d1 in four cases, e1 in five cases, e2 and f3 each in six cases and e3 in 15 cases. In the current study, there was no case of false positive diagnosis of the meniscus injury.

The lateral meniscus tear was significantly higher than medial meniscus in patients with acute ACL injury ( $P<0.001$ ) [Table 4]. The incidence of radial and longitudinal meniscal tears were significantly different between acute and chronic groups ( $P=0.024$ ) [Table 4]. The incidence of the ramp lesion was significantly higher in chronic group (7.25% vs 24.3%;  $P<0.001$ ) [Table 4].

The incidence of the root tear was 1.3% in all patients (13/1022) and 2.9% in patients with a meniscus tear (13/454). The incidence of root tear in acute ACL injuries was significantly higher compared to the chronic injuries ( $P<0.001$ ) [Table 4]. The incidence of chondral lesion (40 patients) and loose body (8 patients) were 8.8% and 1.8% among patients with ACL and meniscus tears, respectively. As shown in table 4, there was no significant difference between acute and chronic groups in terms of the incidence of chondral lesion ( $P=0.587$ ) and loose body ( $P=0.472$ ).

Meniscal repair was performed in 52 patients (41.9%) and 152 patients (43.9%) in acute and chronic groups, respectively. Other patients underwent meniscectomy. Patients with triple lesions were all male and non-athletic; all of whom also had a chronic ACL tear.

## Discussion

Many surgeons and authors have investigated the incidence of meniscus tear in patients with ACL injury and tried to find the potential relationship between the chronicity of ACL injury and different features of meniscus tear. Identifying the meniscus tear is important as it can affect the prognosis and decision making for treatment. It has been shown that the presence of a concomitant meniscus tear treated with repair or meniscectomy in patients who underwent ACLR may increase the risk of knee osteoarthritis (28, 29). However, considering the lack of similar studies and shortcomings of the previous studies such as insufficient number of enrolled patients, the current study was conducted.

In the current study, the incidence of meniscal tear in patients with ACL injury was 44.4%. As this study was conducted in referral centers, the following results might be different from what is reported in general population and literature, particularly in athletics. The most common type of meniscus tear was the bucket-handle tear (more than 30%), followed by radial (27%) and flap (23%) tears. The incidence of isolated medial or lateral meniscus

tears was 22% and 20.8%, respectively. Furthermore, the incidence of both menisci tear was about 1.6%. On the other hand, 51.3% of total meniscus tears occurred in the medial meniscus and 48.7% in the lateral meniscus. The most common zones of meniscus tear were B3 (8.9%) in medial meniscus and D1 (8.5%) in lateral meniscus. The incidence of ramp injury in all patients with ACL tear was about 9.1% while it was about 20% in patients with ACL and meniscus tears. The majority of ramp lesions were found in the meniscocapsular region and only about 12% of them were in the meniscopopliteal region or the posterior meniscotibial ligament. Furthermore, the incidence of root tear in all patients with ACL injury was about 1.3% and about 2.9% in patients with a meniscus tear. It was found that more than half of the torn menisci were repairable, and for the other half, meniscectomy had to be performed due to the torn zone or the type of the tear. The incidence of ACL tear in athletes was significantly higher compared to all patients with an ACL injury (about 69% vs. 44%). The majority (about 3/4) of the patients with a meniscus tear suffered from a chronic ACL injury. In addition, it was found that the incidence of the lateral meniscus tear was higher in the acute ACL injury while the medial meniscus was more involved in chronic ACL injury. An interesting finding of the current study which was limitedly investigated in the previous studies was that the incidence of radial meniscus tear was significantly higher in patients with acute injury compared to the patients with chronic injury (35.5% vs. 24%). The incidence of ramp injury was significantly higher in the chronic ACL injuries while, reversely, the incidence of root tear was significantly higher in acute injuries.

The incidence of meniscus tear in patients who underwent ACLR has been reported between 51.9% to 63% (1, 2, 17). However, the incidence of isolated tear of the medial meniscus and lateral meniscus and rupture of the both menisci has been reported from 13.9% to 29%, 19% to 24.9%, and 9% to 15%, respectively (1, 2, 17). Like the current study, limited studies have confirmed that the risk of a complex meniscus tear in professional athletes is higher than that in others (1). Although controversial, it has been reported that the longitudinal tear was the most common type of meniscus tear in ACL patients (17). In another study, single longitudinal vertical split tear followed by flap and radial ones were the most common meniscal injuries (15). The incidence of ramp injury in previous studies was reported between 9.6% and 40% (20, 30). Furthermore, in similar studies, the incidence of tear of the posterior root of lateral meniscus was reported between 3.5% and 5.2% (31, 32).

The relationship between the chronicity of ACL tear and the risk of meniscus injury and its features remained controversial. Gadeyne et al. demonstrated that the time interval between trauma and ACLR was significantly correlated with the medial meniscus tear, while, in contrast to the current study, they did not find a correlation between the chronicity of ACL injury and the type of meniscus tear (17). Similarly, Demirağ et al also found that delay in ACLR could be associated with

an increased risk of meniscus injury (14). Yoo et al, in a study using serial MR images, showed that if the ACLR had been delayed, the probability of the medial meniscus tear would have increased (18). In contrast, Michalitsis et al. showed that the time interval between the ACL tear and surgery could not be a risk factor for meniscus tear (2). Feutch et al. reported that the root of lateral meniscus was torn in 10% of the patients with ACL injury who underwent ACLR within the first five months (33). Di Vico et al. found that the risk of Ramp injury was significantly higher in patients who underwent surgery during the first six months of ACL tear than other patients (20). In line with the current study, Liu et al. found that the ramp injury had a logarithmic correlation with the time passed from the injury (19). It may be possible that different definitions of chronic ACL injury can affect the outcomes resulting in these controversial findings. In addition, there are several features of the meniscus tear in ACL patients which have not been appropriately investigated in previous studies. To our knowledge, there was no study addressing the relationship between the chronicity of ACL tear and the risk of root tear or there was no study investigating the incidence of meniscus tear in different zones based on Cooper's classification which should be considered in future studies.

Like all other studies, the current study also had some limitations. As the most important limitations there was no possibility of the patients' follow up and we could not assess the effect of treatment (repair or meniscectomy) on the clinical and functional status of the patients, including knee pain. Another limitation, especially in chronic patients, was that patients did not remember the precise time interval between the injury and surgery and reported an approximate duration of time.

The current study showed that the meniscus tear is a common finding in patients with ACL rupture. Chronic ACL injuries can be associated with increased risk of the meniscus tear, especially medial meniscus, and ramp lesion. Therefore, it seems that earlier ACLR may be more helpful for the patients. However, root injuries were significantly higher in acute injuries. In the current study, no relationship was found between the reparability of the meniscus tear and the chronicity of ACL injury.

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## References

1. Cain Jr EL, Fleisig GS, Ponce BA, Boohaker HA, George MP, McGwin Jr G, Andrews JR, Lemak LJ, Clancy Jr WG, Dugas JR. Variables associated with chondral and meniscal injuries in anterior cruciate ligament surgery. *The journal of knee surgery*. 2017;30(07):659-67.
2. Michalitsis S, Vlychou M, Malizos KN, Thriskos P, Hantes ME. Meniscal and articular cartilage lesions in the anterior cruciate ligament-deficient knee: correlation between time from injury and knee scores. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2015;23(1):232-9.
3. Bellabarba C, Bush-Joseph CA, Bach JB. Patterns of meniscal injury in the anterior cruciate-deficient knee: a review of the literature. *American journal of orthopedics (Belle Mead, NJ)*. 1997; 26(1):18-23.
4. Warren RF, Levy IM. Meniscal lesions associated with anterior cruciate ligament injury. *Clinical orthopaedics and related research*. 1983(172):32-7.
5. Forkel P, Herbolt M, Sprenger F, Metzclaff S, Raschke M, Petersen W. The biomechanical effect of a lateral meniscus posterior root tear with and without damage to the menisiofemoral ligament: efficacy of different repair techniques. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*. 2014; 30(7):833-40.
6. LaPrade CM, Jansson KS, Dornan G, Smith SD, Wijedicks CA, LaPrade RF. Altered tibiofemoral contact mechanics due to lateral meniscus posterior horn root avulsions and radial tears can be restored with in situ pull-out suture repairs. *JBJS*. 2014; 96(6):471-9.
7. Ode GE, Van Thiel GS, McArthur SA, Dishkin-Paset J, Leurgans SE, Shewman EF, Wang VM, Cole BJ. Effects of serial sectioning and repair of radial tears in the lateral meniscus. *The American journal of sports medicine*. 2012; 40(8):1863-70.
8. Schillhammer CK, Werner FW, Scuderi MG, Cannizzaro JP. Repair of lateral meniscus posterior horn detachment lesions: a biomechanical evaluation. *The American journal of sports medicine*. 2012; 40(11):2604-9.
9. Papageorgiou CD, Gil JE, Kanamori A, Fenwick JA, Woo SL, Fu FH. The biomechanical interdependence between the anterior cruciate ligament replacement graft and the medial meniscus. *The American journal of sports medicine*. 2001; 29(2):226-31.
10. Jin Hwan A, Lee YS, Yoo JC, Chang MJ, Koh KH, Kim MH. Clinical and Second-Look Arthroscopic Evaluation of Repaired Medial Meniscus in Anterior Cruciate Ligament—Reconstructed Knees. *The American journal of sports medicine*. 2010; 38(3):472-7.
11. Melton JT, Murray JR, Karim A, Pandit H, Wandless F, Thomas NP. Meniscal repair in anterior cruciate ligament reconstruction: a long-term outcome study. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2011; 19(10):1729.
12. Stein T, Mehling AP, Welsch F, von Eisenhart-Rothe R, Jäger A. Long-term outcome after arthroscopic meniscal repair versus arthroscopic partial meniscectomy for traumatic meniscal tears. *The American journal of sports medicine*. 2010; 38(8):1542-8.
13. Ahn JH, Bae TS, Kang KS, Kang SY, Lee SH. Longitudinal tear of the medial meniscus posterior horn in the anterior cruciate ligament-deficient knee significantly influences anterior stability. *The American journal of sports medicine*. 2011; 39(10):2187-93.
14. Demirağ B, Aydemir F, Daniş M, Ermutlu C. Incidence of meniscal and osteochondral lesions in patients undergoing delayed anterior cruciate ligament reconstruction. *Acta orthopaedica ET traumatologica turcica*. 2011;45(5):348-52.
15. Keene GC, Bickerstaff D, Rae PJ, Paterson RS. The natural history of meniscal tears in anterior cruciate ligament insufficiency. *The American journal of sports medicine*. 1993; 21(5):672-9.
16. Cerabona F, Sherman MF, Bonamo JR, Sklar J. Patterns of meniscal injury with acute anterior cruciate ligament tears. *The American journal of sports medicine*. 1988; 16(6):603-9.
17. Gadeyne S, Besse JL, Galand-Desme S, Lerat JL, Moyon B. Analysis of meniscal lesions accompanying anterior cruciate ligament tears: a retrospective analysis of 156 patients. *Revue de chirurgie orthopedique ET reparatrice de l'appareil moteur*. 2006;92(5):448-54.
18. Yoo JC, Ahn JH, Lee SH, Yoon YC. Increasing incidence of medial meniscal tears in nonoperatively treated anterior cruciate ligament insufficiency patients documented by serial magnetic resonance imaging studies. *The American journal of sports medicine*. 2009;37(8):1478-83.
19. Liu X, Feng H, Zhang H, Hong L, Wang XS, Zhang J. Arthroscopic prevalence of ramp lesion in 868 patients with anterior cruciate ligament injury. *The American journal of sports medicine*. 2011;39(4):832-7.
20. Di Vico G, Di Donato SL, Balato G, Correria G, D'Addona A, Maffulli N, Rosa D. Correlation between time from injury to surgery and the prevalence of ramp and hidden lesions during anterior cruciate ligament reconstruction. A new diagnostic algorithm. *Muscles, ligaments and tendons journal*. 2017;7(3):491.
21. Rao AJ, Erickson BJ, Cvetanovich GL, Yanke AB, Bach Jr BR, Cole BJ. The meniscus-deficient knee: biomechanics, evaluation, and treatment options. *Orthopaedic journal of sports medicine*. 2015;3(10):2325967115611386.
22. Smith III JP, Barrett GR. Medial and lateral meniscal tear patterns in anterior cruciate ligament-

- deficient knees: a prospective analysis of 575 tears. *The American journal of sports medicine*. 2001; 29(4):415-9.
23. Indelicato PA, Bittar ES. A perspective of lesions associated with ACL insufficiency of the knee. A review of 100 cases. *Clinical orthopaedics and related research*. 1985; (198):77-80.
  24. Pujol N, Beaufils P. Healing results of meniscal tears left in situ during anterior cruciate ligament reconstruction: a review of clinical studies. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2009; 17(4):396-401.
  25. Ahn JH, Wang JH, Yoo JC. Arthroscopic all-inside suture repair of medial meniscus lesion in anterior cruciate ligament—deficient knees: results of second-look arthroscopies in 39 cases. *Arthroscopy: The Journal of Arthroscopic & Related Surgery*. 2004; 20(9):936-45.
  26. Fok AW, Yau WP. Delay in ACL reconstruction is associated with more severe and painful meniscal and chondral injuries. *Knee Surgery, Sports Traumatology, Arthroscopy*. 2013; 21(4):928-33.
  27. Thaunat M, Fayard JM, Guimaraes TM, Jan N, Murphy CG, Sonnery-Cottet B. Classification and surgical repair of ramp lesions of the medial meniscus. *Arthroscopy techniques*. 2016; 5(4):e871-5.
  28. van der Hart CP, van den Bekerom MP, Patt TW. The occurrence of osteoarthritis at a minimum of ten years after reconstruction of the anterior cruciate ligament. *Journal of orthopaedic surgery and research*. 2008; 3(1):24.
  29. Neuman P, Englund M, Kostogiannis I, Friden T, Roos H, Dahlberg LE. Prevalence of tibiofemoral osteoarthritis 15 years after nonoperative treatment of anterior cruciate ligament injury: a prospective cohort study. *The American journal of sports medicine*. 2008; 36(9):1717-25.
  30. Sonnery-Cottet B, Conteduca J, Thaunat M, Gunepin FX, Seil R. Hidden lesions of the posterior horn of the medial meniscus: a systematic arthroscopic exploration of the concealed portion of the knee. *The American journal of sports medicine*. 2014 Apr; 42(4):921-6.
  31. Pan F, Hua S, Ma Z. Surgical treatment of combined posterior root tears of the lateral meniscus and ACL tears. *Medical science monitor: international medical journal of experimental and clinical research*. 2015; 21:1345.
  32. Forkel P, Petersen W. Posterior root tear fixation of the lateral meniscus combined with arthroscopic ACL double-bundle reconstruction: technical note of a transosseous fixation using the tibial PL tunnel. *Archives of orthopaedic and trauma surgery*. 2012; 132(3):387-91.
  33. Feucht MJ, Bigdon S, Bode G, Salzmann GM, Dovi-Akue D, Südkamp NP, Niemeyer P. Associated tears of the lateral meniscus in anterior cruciate ligament injuries: risk factors for different tear patterns. *Journal of orthopaedic surgery and research*. 2015; 10(1):34.