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ORIGINAL RESEARCH

Comparative Investigation Of Anatomical Ligament Repair Versus Triangular Ligament Reconstruction In Grade-III Medial Collateral Ligament Injuries Of Knee

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ABSTRACT

Introduction - Injuries to the medial aspect of the knee are the predominant type of knee ligament injuries. Most of these injuries result from motor vehicle collisions and sports-related incidents, with the typical mechanisms involving either a valgus force, tibial external rotation, or a combination of valgus and external rotation forces applied to the knee. For these reasons, it is essential that medial collateral ligament (MCL) injuries receive appropriate attention and optimal medical care.

Aim & objectives – (1) To evaluate and compare the clinical outcomes between Medial Collateral Ligament Anatomical Ligament repair and Triangular Ligament Reconstruction in treating Grade-III MCL injury. (2) To study the complications in MCL Reconstruction or Repair by above mentioned two different surgical techniques.

Methodology - Patients presenting with Acute Isolated Grade-III Medial Collateral Ligament (MCL) tears in conjunction with Anterior Cruciate Ligament (ACL) deficiency, who attended the Arogyashree Orthopedics Outpatient Department, Emergency Department, and the Department of Orthopedics and Sports Medicine at Kamineni Hospitals, L B Nagar, Hyderabad, between April 2016 and January 2018, were included in the study. A cohort of 50 patients diagnosed with Acute Isolated Grade-III Medial Collateral Ligament (MCL) Tear and concomitantly with Anterior Cruciate Ligament (ACL) injury was selected based on medical history, clinical evaluation, and radiological findings (radiography and magnetic resonance imaging). Purposive sampling was done to recruit patients in to ALR and TLR groups based on intraoperative findings that repair or reconstruction should be performed on primary surgeon's experience and protocol.

Results - Out of the 50 patients who underwent MCL Repair or Reconstruction (both TLR and ALR), 27 patients were in the age group of less than 30 years(15 patients in Anatomical Ligament Repair group and 12 patients in Triangular Ligament Reconstruction group),15 patients were in the age group 31 – 40 years (6 patients in Triangular Ligament reconstruction group and 9 patients in Anatomical Ligament Repair group) and 8 were in age group of more than 40 years(5 patients in Triangular Ligament Reconstruction group and 3 patients in Anatomical Ligament Repair group). In Triangular Ligament Reconstruction group, Median score of Lachman test at Pre-op period was 3, at Immediate Post-Op was 1, at 6 weeks was 1, at 12 weeks was 0 and at 24 weeks was 0. In Anatomical Ligament Repair group, Median score of Lachman test at Pre-op period was 3, at Immediate Post-Op was 1, at 6 weeks was 1, at 12 weeks was 0 and at 24 weeks was 0. In Triangular Ligament Reconstruction group, Slocum Test at Pre-op was positive in 100%, at Immediate Post Op period, 6 weeks, 12 weeks and 24 weeks 100% were negative. In Anatomical Ligament Repair group, Slocum Test at Pre-op was positive in 96.3%, at Immediate Post Op period and 6 weeks 100% were negative and at 12 weeks and 24 weeks 96.3% were negative. Triangular Ligament reconstruction group, IKDC Objective Score at pre-op period 21.7% had Grade C, 78.3% had Grade D. At Immediate Post-Op period, 60.9% had Grade A, 39.1% had Grade B. At 6 weeks, 78.3% had Grade A, 21.7% had Grade B, at 12 weeks 82.6% had Grade A and 17.4 % had Grade B and at 24 weeks 95.7% had Grade A and 4.3%had Grade B. Anatomical Ligament Repair group, IKDC Objective Score at pre op period 25.9% had Grade C, 74.1% had Grade D. At Immediate Post-Op period, 55.6% had Grade A, 44.4% had Grade B. At 6 weeks, 88.9% had Grade A, 11.1% had Grade B, at 12 weeks 88.9% had Grade A and 11.1% had Grade B and at 24 weeks 92.6% had Grade A and 7.4% had Grade B.

Conclusion - Satisfactory outcomes in both groups regarding IKDC Objective scores, ROM deficits, and anteromedial rotational stability, as evidenced by comparisons between preoperative and postoperative data. Adherence of the patient to postoperative instructions is crucial for preserving the range of motion. Consistent supervised physiotherapy and evaluation

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of the patient are essential components of postoperative care. There is no distinct advantage for the Triangular Ligament Reconstruction technique compared to Anatomical Ligament Repair regarding functional and radiological outcomes.

Keywords - Medial Collateral Ligament, Triangular Ligament Reconstruction, Anatomical Ligament Repair

Introduction

Injuries to the medial aspect of the knee are the predominant type of knee ligament injuries. Most of these injuries result from motor vehicle collisions and sports-related incidents, with the typical mechanisms involving either a valgus force, tibial external rotation, or a combination of valgus and external rotation forces applied to the knee. For these reasons, it is essential that medial collateral ligament (MCL) injuries receive appropriate attention and optimal medical care. Notwithstanding the essential role of this ligament in the stability and functionality of the knee, there exists a lack of standardized treatment protocols for medial collateral ligament ruptures. The most frequently injured ligament in the knee is the medial collateral ligament (MCL), which functions as the primary medial static stabilizer against valgus stress and offers resistance to external rotational forces exerted on the lower extremity.(1,2)

The collateral and cruciate ligaments constitute the principal supporting framework for the knee joint. As knee motion is characterized by its dynamic and multiaxial nature, stability during movement is achieved through an integration of static and dynamic components. The medial collateral ligament (MCL) complex serves as a fundamental stabilizer by integrating static and dynamic resistance—via its muscular connections—to mitigate valgus stress, while also providing considerable constraints against rotatory motion and anterior-posterior translation. The medial aspect of the knee has been relatively neglected, as a significant portion of contemporary research has emphasized injuries to the anterior cruciate ligament (ACL), posterior cruciate ligament (PCL), and posterolateral corner. The medial collateral ligament (MCL) is the most frequently injured ligament in individuals with knee dislocations or multi-ligamentous knee injuries (MLKIs). MLKIs are characterized by damage to a minimum of two of the four primary ligaments of the knee: the Anterior cruciate ligament (ACL), the Posterior cruciate ligament (PCL), the Posterolateral corner (PLC), and the Medial collateral ligament (MCL).(3). MLKIs pose a distinct challenge to orthopaedic specialists, and the effective management of these severe injuries remains a subject of ongoing discussion.(4)(5) Numerous research investigations have determined that isolated Grade III MCL injury is uncommon. In the presence of a severe Grade III MCL injury, the likelihood of concurrent ligament damage is 78%, with 95% of cases involving the anterior cruciate ligament (ACL).(6) ACL injuries are predominantly attributed to non-contact mechanisms, whereas ACL-MCL injuries typically arise from contact mechanisms involving valgus stress and external tibial rotation.

Individuals exhibiting valgus laxity (Hughston Grade-III: Complete ligament disruption accompanied by instability) or experiencing ligament injuries, or those with chronic conditions, are eligible for MCL repair or reconstruction.(7)(6)

Alternatively, some advocate for a two-stage methodology, commencing with prompt primary repair or reconstruction of the MCL, succeeded by the reconstruction of additional injured ligaments several weeks afterward. (4)(6)(8) A meticulously designed rehabilitation program can lead to outstanding functional outcomes for most patients.

In recent years, a novel triangular-vector MCL reconstruction technique has been introduced and demonstrated to restore both valgus and rotational stability.(9) Anatomic ligament repair (ALR) is acknowledged as a method for restoring anatomical integrity; however, it remains uncertain whether Acute Anatomic Augmented Repair can yield the same clinical outcomes. Therefore, the objective of my hypothesis is to assess and contrast the clinical outcomes of two methods—Triangular Ligament Reconstruction (TLR) and Anatomical Ligament Repair—in the management of Grade III Medial Collateral Ligament (MCL) injuries, with a focus on imaging and functional results. I propose that TLR might offer enhanced rotational stability compared to ALR. Following a comprehensive examination of existing literature, a comparable study was conducted by J. Dong et al.(10) in 2015, focusing on the Surgical Management of Acute Grade III Medial Collateral Ligament Injury Concomitant with Anterior Cruciate Ligament Injury: Anatomic Ligament Repair Versus Triangular Ligament Reconstruction. Given the absence of extensive comparative research on these techniques originating from India, I intend to undertake this investigation.

Objective

- To evaluate and compare the clinical outcomes between Medial Collateral Ligament Anatomical Ligament repair and Triangular Ligament Reconstruction in treating Grade-III MCL injury.
- To study the complications in MCL Reconstruction or Repair by above mentioned two different surgical techniques.

Material And Methods

Patients presenting with Acute Isolated Grade-III Medial Collateral Ligament (MCL) tears in conjunction with Anterior Cruciate Ligament (ACL) deficiency, who attended the Arogyashree

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Orthopedics Outpatient Department, Emergency Department, and the Department of Orthopedics and Sports Medicine at Kamineni Hospitals, L B Nagar, Hyderabad, between April 2016 and January 2018, were included in the study.

A cohort of 50 patients diagnosed with Acute Isolated Grade-III Medial Collateral Ligament (MCL) Tear and concomitantly with Anterior Cruciate Ligament (ACL) injury was selected based on medical history, clinical evaluation, and radiological findings (radiography and magnetic resonance imaging).

Purposive sampling was done to recruit patients in to ALR and TLR groups based on intraoperative findings that repair or reconstruction should be performed on primary surgeon's experience and protocol.

Informed risk consent was taken from all the subjects for MCL Reconstruction/Repair and Arthroscopic ACL reconstruction with the need for Gracilis & Semitendinosus grafts from Ipsilateral or Contralateral leg in cases of MCL & ACL Reconstruction.

Inclusion Criteria:

(1) The patient having unilateral knee injury.
(2) Examination findings comprising the valgus stress test with the knee in extension, the anterior drawer test, Slocum test and the Lachman test should be positive.
(3) Medial opening displayed on radiographic stress-position imaging should be larger than 10 mm compared with the contralateral knee
(4) Magnetic resonance imaging showing Isolated Garde-III MCL Injury or Grade-III MCL injury associated with ACL tear.
(5) Patients having Menisci injuries associated with MCL injury were included in study.
(6) The patient consented to receive surgical treatment in an acute time frame, and the interval from injury to surgery.

Exclusion Criteria:
(1) Patients below 18 years and above 60 years of age.
(2) Patients having Incomplete ACL Tear.
(3) Patients having Intercondylar Spine Avulsion fracture
(4) Patient have underwent already Knee surgery.
(5) Patients not willing for graft reconstruction.
(6) Patients not willing for follow up.
(7) Patients not fit for surgery.

METHODOLOGY:
Clinical details
Valgus stress test, Slocum test, anterior drawer test, Lachman test, Radiographic stress-position imaging, and Range-of-motion (ROM) assessment findings of the cases were examined by me under the guidance of my guide, were recorded preoperatively and on follow-up studies.
Imaging done as-

- X-rays were taken under Valgus stress test and measuring the difference of Medial opening of the knee and comparing with contralateral normal knee pre-operatively, postoperative and follow up studies.
- MRI for clinical correlation to diagnose MCL-Grade-III injury with ACL injury and helping in exclusion tool.

IKDC Subjective symptom score-
The modified score was mainly focused on the patient's medial knee pain experience and was divided into Grades-
Grades A- No pain
Grade B- Slight Pain
Grade C- Pain
Grade D- Severe Pain.

IKDC objective score
To assess medial instability compared to normal contralateral knee-
Grades A -Excessive medial opening of 0 to 2 mm
Grade B - Excessive medial opening of 3 to 5 mm
Grade C - Excessive medial opening of 6 to 10 mm
Grade D -Excessive medial opening of greater than 10 mm

Knee ROM (Range of Motion) Deficit Scores-
A) Extension deficit score -
Grade A– ROM Loss of 0 to 30
Grade B– ROM Loss of 3 to 50
Grade C– ROM Loss of 6 to 100
Grade D – ROM Loss of more than 100

B) Flexion deficit score-
Grade A - ROM loss of 0 to 50
Grade B - ROM loss of 6 to 150
Grade C - ROM loss of 15 to 250
Grade D -ROM loss of Greater than 250

Other complications including medial numbness, allograft rejection, Arthrofibrosis and infection were registered.
Modified International knee documentation committee(IKDC) Subjective score, International knee documentation committee (IKDC) Objective score and Knee ROM Deficits scores were used for evaluation of the results of surgery and during follow ups.

Statistical analysis:
Data was entered in Microsoft excel data sheet and was analyzed using SPSS 22 version software. Categorical data was represented in the form of Frequencies and proportions. Chi-square test or Fischer's exact test (for 2x2 tables only) was used as test of significance for qualitative data. Continuous data was represented as mean and standard deviation. Independent t test or Mann Whitney U test was used as test of significance to identify the mean difference

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between two quantitative variables and qualitative variables respectively.

Graphical representation of data: MS Excel and MS word was used to obtain various types of graphs such as bar diagram.

p value (Probability that the result is true) of <0.05 was considered as statistically significant after assuming all the rules of statistical tests.

Results

In the present study, a total number of 50 patients were studied out of which 27 patients underwent Anatomical Ligament Repair (ALR) and 23 patients underwent Triangular Ligament Reconstruction (TLR) of MCL. All patients were followed up for period of 24weeks.

Out of the 50 patients who underwent MCL Repair or Reconstruction (both TLR and ALR), 27 patients were in the age group of less than 30 years(15 patients in Anatomical Ligament Repair group and 12 patients in Triangular Ligament Reconstruction group),15 patients were in the age group 31 – 40 years (6 patients in Triangular Ligament reconstruction group and 9 patients in Anatomical Ligament Repair group) and 8 were in age group of more than 40 years(5 patients in Triangular Ligament Reconstruction group and 3 patients in Anatomical Ligament Repair group).

Out of the 50 patients who underwent MCL Repair or Reconstruction, 43 (82.6%) patients were males and 7(17.4%) patients were females.

Out of the 50 patients who underwent MCL Repair or Reconstruction (both TLR and ALR), 25 patients were having Right side Knee injury (12 patients in Anatomical Ligament Repair group and 13 patients were in Triangular Ligament Reconstruction group) and 25 patients were having Left side Knee Injury (10 patients in Triangular Ligament reconstruction group and 15 patients Anatomical Ligament Repair group).

In the present study, out of the 50 patients - 20 patients (40%) had history of Road Traffic Accidents, 18 patients (36%) had injury during common sporting activities & 12 patients (24%) had injury due to other causes which include dancing, slip and fall, work related injuries etc.

The average surgical time in Triangular Ligament Reconstruction was **142 ± 3.2**minutes and **109.4 ± 4.8**minutes in Anatomical Ligament Repair. This is because in Triangular Ligament reconstruction the Semitendinosus graft was harvested from Contralateral knee and ACL Reconstruction as graft for it was harvested from ipsilateral knee. There was significant difference (p-value < 0.001) in Duration of Surgery comparison between two groups.

In Triangular Ligament Reconstruction group, Anterior Drawer Test at Pre-op was positive in 100%, at Immediate Post Op period, 6 weeks, 12 weeks and 24 weeks 100% were negative. In Anatomical Ligament Repair group, Anterior Drawer Testat Pre-op was positive in 92.6%, at Immediate Post Op period and 6 weeks 100% were negative and at 12 weeks and 24 weeks 96.3% were negative.

Valgus stress test was positive in all 50 patients at Pre-op and 100% negative at Immediate Postoperative, 6 weeks, 12 weeks and 24 weeks in both Triangular Ligament reconstruction group and Anatomical Ligament Repair group.

In Triangular Ligament Reconstruction group, Median score of Lachman test at Pre-op period was 3, at Immediate Post-Op was 1, at 6 weeks was 1, at 12 weeks was 0 and at 24 weeks was 0. In Anatomical Ligament Repair group, Median score of Lachman test at Pre-op period was 3, at Immediate Post-Op was 1, at 6 weeks was 1, at 12 weeks was 0 and at 24 weeks was 0. (Table -1)

Table 1: Lachman Test

Lachman Test	Surgery						P value
	Anatomical Ligament Repair			Triangular Ligament Reconstruction			
	Mean	SD	Median	Mean	SD	Median	
Pre-Op	3	1	3	3	1	3	0.832
Immediate Post-Op	1	1	1	1	0	1	0.581
6 weeks	1	1	1	1	0	1	0.581
12 weeks	0	1	0	0	1	0	0.711
24 weeks	0	0	0	0	0	0	0.217

In Triangular Ligament Reconstruction group, Slocum Test at Pre-op was positive in 100%, at Immediate Post Op period, 6 weeks, 12 weeks and 24 weeks 100% were negative. In Anatomical Ligament Repair group, Slocum Test at Pre-op was positive in 96.3%, at Immediate Post Op period and 6 weeks 100% were negative and at 12 weeks and 24 weeks 96.3% were negative.(Table 2)

Table 2: **Slocum Test**

Slocum Test (AMRI)		Surgery				P value
		Anatomical Ligament Repair		Triangular Ligament Reconstruction		
		Count	%	Count	%	
Pre-Op	Negative	1	3.7%	0	0.0%	0.351
	Positive	26	96.3%	23	100.0%	

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Immediate Post-Op	Negative	27	100.0%	23	100.0%	-
6 weeks	Negative	27	100.0%	23	100.0%	-
12 weeks	Negative	26	96.3%	23	100.0%	0.351
24 weeks	Negative	26	96.3%	23	100.0%	0.351

Triangular Ligament reconstruction group, IKDC Objective Score at pre-op period 21.7% had Grade C, 78.3% had Grade D. At Immediate Post-Op period, 60.9% had Grade A, 39.1% had Grade B. At 6 weeks, 78.3% had Grade A, 21.7% had Grade B, at 12 weeks 82.6% had Grade A and 17.4 % had Grade B and at 24 weeks 95.7% had Grade A and 4.3%had Grade B. Anatomical Ligament Repair group, IKDC Objective Score at pre op period 25.9% had Grade C, 74.1% had Grade D. At Immediate Post-Op period, 55.6% had Grade A, 44.4% had Grade B. At 6 weeks, 88.9% had Grade A, 11.1% had Grade B, at 12 weeks 88.9% had Grade A and 11.1% had Grade B and at 24 weeks 92.6% had Grade A and 7.4% had Grade B. (Table 3)

Table 3: **IKDC Objective Score**

IKDC Objective Score(Grades)		Surgery				P value
		Anatomical Ligament Repair		Triangular Ligament Reconstruction		
		Count	%	Count	%	
Pre-Op	C	7	25.9%	5	21.7%	0.730
	D	20	74.1%	18	78.3%	
Immediate Post-Op	A	15	55.6%	14	60.9%	0.704
	B	12	44.4%	9	39.1%	
6 weeks	A	24	88.9%	18	78.3%	0.307
	B	3	11.1%	5	21.7%	
12 weeks	A	24	88.9%	19	82.6%	0.524
	B	3	11.1%	4	17.4%	
24 weeks	A	25	92.6%	22	95.7%	0.650
	B	2	7.4%	1	4.3%	

One patient belonging to MCL ALR group had developed Arthrofibrosis of joint after 6 weeks for which she underwent Arthroscopic Fibrinolysis and has achieved improvement in range of movement of 93.2 degrees. Flexion deformity decreased from 10 to 5 degrees. 17 patients (33%) of our patients had Hypoesthesia in the anteromedial aspect of the operated leg. This was however only during the initial 12 weeks and patients regained sensations after a period. None of the patient had graft rejection and infection during the follow-up.

Discussion

Among the 50 patients, 43 (82.6%) were males (24 in the Anatomical Ligament Repair group and 19 in the Triangular Ligament Reconstruction group), while 7 (17.4%) were females (3 in the Anatomical Ligament Repair group and 4 in the Triangular Ligament Reconstruction group). In 2009, Brown et al. investigated the prevalence of gender and limb variations in anterior cruciate ligament injuries, noting that while females are predisposed to such injuries, their reduced exposure to strenuous environments results in a higher incidence among males compared to females. Our research further indicates that males exhibit a heightened predisposition for medial collateral ligament (MCL) and anterior cruciate ligament (ACL) injuries.

The mean surgical duration for Triangular Ligament Reconstruction was 142 ± 3.2 minutes, while it averaged 109.4 ± 4.8 minutes for Anatomical Ligament Repair. This is attributed to the fact that in Triangular Ligament reconstruction, the Semitendinosus graft is obtained from the contralateral knee, whereas the ACL Reconstruction graft is derived from the ipsilateral knee. At the conclusion of the results, a notable difference (p-value < 0.001) was observed in the duration of surgery when comparing the two groups.

In our study IKDC Objective Score(Medial Knee Joint opening) in Triangular Ligament reconstruction group at 24 weeks was 2.8 +/- 1mm while for Anatomical Ligament Repair group, was 3.0 +/- 1mm on statistical analysis there was no significant difference on comparison between two groups, while comparing with study of Dong et al in there study on ALR versus TLR in Acute Grade-III MCL injury associated with ACL injury showed IKDC Objective score at final follow up in ALR - 2.9 +/- 0.9mm & in TLR – 3.2 +/- 1.3mm and found no significant difference between the two, thus their results showing similar results on comparing to our study. In 2015 Dong J et al did a Prospective Randomized study on 64 patients with an Acute Grade III MCL tear Combined with ACL tear treated with TLR and ALR for MCL injury and Single bundle ACL Reconstruction have concluded that there was no major difference in clinical outcomes of ALR and TLR groups based on IKDC Subjective and Objective scores and ROM deficits scores in short-term period.

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However, TLR offered better rotatory stability than ALR in their final follow-up. Compared with our study there was no significant difference of AMRI between the two surgeries. As our study was for short term period, we recommend long term follow up for better comparison of functional outcomes between two.

Conclusion

Satisfactory outcomes in both groups regarding IKDC Objective scores, ROM deficits, and anteromedial rotational stability, as evidenced by comparisons between preoperative and postoperative data. Adherence of the patient to postoperative instructions is crucial for preserving the range of motion. Consistent supervised physiotherapy and evaluation of the patient are essential components of postoperative care. There is no distinct advantage for the Triangular Ligament Reconstruction technique compared to Anatomical Ligament Repair regarding functional and radiological outcomes. Statistical comparison of the two groups indicated that both surgical techniques are significant; however, no definitive superiority of one group over the other was established, suggesting that both methods are equally effective in achieving postoperative outcomes. Extensive research with prolonged follow-up and substantial sample sizes is necessary to validate the study's results and assess the long-term functional outcomes of the two groups, as the current study only provides a six-month follow-up period.

References

1. Robinson JR, Sanchez-Ballester J, Bull AMJ, de W.M. Thomas R, Amis AA. The posteromedial corner revisited. J Bone Jt Surg [Internet]. 2004;86(5):674–81. Available from: http://www.bjj.boneandjoint.org.uk/cgi/doi/10.1302/0301-620X.86B5.14853
2. Jacobson KE, Chi FS. Evaluation and treatment of medial collateral ligament and medial-sided injuries of the knee. Sports Med Arthrosc. 2006;14(2):58–66.
3. Fanelli GC, Orcutt DR, Edson CJ. The multiple-ligament injured knee: Evaluation, treatment, and results. Arthrosc - J Arthrosc Relat Surg. 2005;21(4):471–86.
4. Miyamoto RG, Bosco J a, Sherman OH. Treatment of medial collateral ligament injuries. J Am Acad Orthop Surg. 2009;17(3):152–61.
5. Hanley JM, Anthony CA, Demik D, Glass N, Amendola A, Wolf BR, et al. Patient-reported outcomes after multiligament knee injury: MCL repair versus reconstruction. Orthop J Sport Med. 2017;5(3):1–5.
6. Kovachevich R, Shah JP, Arens AM, Stuart MJ, Dahm DL, Levy BA. Operative management of the medial collateral ligament in the multi-ligament injured knee: An evidence-based systematic review. Knee Surgery, Sport Traumatol Arthrosc. 2009;17(7):823–9.
7. Wijdicks CA, Griffith CJ, Johansen S, Engebretsen L, LaPrade RF. Injuries to the medial collateral ligament and associated medial structures of the knee. J Bone Jt Surg - Ser A. 2010;92(5):1266–80.
8. Bin S, Nam T. Ligament Injuries After Knee Dislocation. 2007;23(10):1066–72.
9. Dong JT, Chen BC, Ph D, Men XQ, Wang F, Ph D, et al. Application of Triangular Vector to Functionally Reconstruct the Medial Collateral Ligament With Double-Bundle Allograft Technique. YJARS [Internet]. 2012;28(10):1445–53. Available from: http://dx.doi.org/10.1016/j.arthro.2012.03.024
10. Dong J, Wang XF, Men X, Zhu J, Walker GN, Zheng XZ, et al. Surgical Treatment of Acute Grade III Medial Collateral Ligament Injury Combined With Anterior Cruciate Ligament Injury: Anatomic Ligament Repair Versus Triangular Ligament Reconstruction. Arthrosc J Arthrosc Relat Surg. 2015;
11. Hughston JC, Andrews JR, Cross MJ, Moschi A. Classification of knee ligament instabilities Part I. The medial compartment and cruciate ligaments. J Bone Jt Surg Am Vol. 1976;58–A(2):159–72.
12. Kannus P. Long-term results of conservatively treated medial collateral ligament injuries of the knee joint. Clin Orthop Relat Res [Internet]. 1988 Jan [cited 2018 Jun 7];(226):103–12. Available from: http://www.ncbi.nlm.nih.gov/pubmed/3335084
13. Robins A, Newman A, Burks R. Postoperative return of motion in anterior cruciate ligament and medial collateral ligament injuires The effect of medial collateral ligament rupture location. Am J … [Internet]. 1993;20–5. Available from: http://ajs.sagepub.com/content/21/1/20.short
14. Yoshiya S, Kuroda R, Mizuno K, Yamamoto T, Kurosaka M. Medial Collateral Ligament Reconstruction Using Autogenous Hamstring Tendons. Am J Sports Med [Internet]. 2005;33(9):1380–5. Available from: http://journals.sagepub.com/doi/10.1177/0363546504273487
15. Lind M, Jakobsen BW, Lund B, Hansen MS, Abdallah O, Christiansen SE. Anatomical reconstruction of the medial collateral ligament and posteromedial corner of the knee in patients with chronic medial collateral ligament instability. Am J Sports Med. 2009;37(6):1116–22.
16. LaPrade RF, Bernhardson AS, Griffith CJ, MacAlena JA, Wijdicks CA. Correlation of valgus stress radiographs with medial knee ligament injuries: An in vitro biomechanical study. Am J Sports Med. 2010;38(2):330–8.
17. Grant JA, Tannenbaum E, Miller BS, Bedi A. Treatment of combined complete tears of the anterior cruciate and medial collateral ligaments. Arthrosc - J Arthrosc Relat Surg [Internet]. 2012;28(1):110–22. Available from: http://dx.doi.org/10.1016/j.arthro.2011.08.293
18. Wijdicks CA, Michalski MP, Rasmussen MT, Goldsmith MT, Kennedy NI, Lind M, et al. Superficial medial collateral ligament anatomic augmented repair versus anatomic reconstruction: An in vitro biomechanical analysis. Am J Sports Med. 2013;41(12):2858–66.
19. DeLong JM, Waterman BR. Surgical Techniques for the Reconstruction of Medial Collateral Ligament and Posteromedial Corner Injuries of the Knee: A Systematic Review. Arthrosc - J Arthrosc Relat Surg [Internet]. 2015;31(11):2258–2272.e1. Available from: http://dx.doi.org/10.1016/j.arthro.2015.05.011

DOI: 10.69605/ijlbpr_14.5.2025.121

20. Dienst M, Burks RT, Greis PE. Anatomy and biomechanics of the anterior cruciate ligament. Orthop Clin North Am. 2002;33(4):605–20.