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Clinical outcome of trans-portal anatomic anterior cruciate ligament reconstruction with quadrupled semitendinosus graft

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ABSTRACT

Introduction: The anterior cruciate ligament (ACL) injury is one of the most common injuries of knee. Arthroscopic reconstruction of ACL is standard approach, but controversy still remains regarding choice of graft.

Objective: The objective of study is to see clinical outcome of quadrupled semitendinosus graft for ACL reconstruction.

Methodology: This was a prospective clinical study of patients undergone single bundle ACL reconstruction with quadrupled semitendinosus autograft between February 2021 to July 2022 in our orthopedic department. All eligible patients who met inclusion criteria were evaluated in terms of knee stability subjectively and objectively before operation and at one year after operation.

Results: There was total 33 patients, out of which 27 were male and 6 were female. The mean age was 27.5±8.2 years and most common mode of injury was RTA in 14 patients (43%) followed by sporting activities in 13 patients (39%) and fall from height in 6 patients (18%). The average diameter of graft was 8.03±0.35mm. The mean Lysholm score was 92.3±5.1 (range 79–99). Seventy percent patients returned to preinjury activity level whereas 30% decreased their activity level. In our study 31 patients (94%) had negative pivot shift test which indicates very high rate of knee stability.

Conclusion: The quadrupled semitendinosus graft shows excellent result for ACL reconstruction both subjectively and clinically in our study. This method helps to save Gracilis tendon and also increases graft diameter.

INTRODUCTION

Anterior cruciate ligament (ACL) tears are common but devastating injury of knee joint in athletic population. Arthroscopic ACL reconstruction is well established standard approach and most commonly performed surgical procedure in sports medicine.¹⁻³ The risk of secondary meniscus tear (hazard ratio 18.0), osteoarthritis (OA, hazard ratio 14.2) and the need for total knee arthroplasty (hazard ratio 5.0) are significantly higher in ACL deficient knee without anterior cruciate ligament reconstruction (ACLR) than those without ACL tear.⁴ Although there are many auto and allograft options, the graft choice in ACL reconstruction is still matter of surgeon's preference. The most commonly used grafts in ACL reconstruction are quadriceps tendon, bone patellar tendon bone (BPTB) and semitendinosus/Gracilis (ST/G) tendons.⁵

Out of several available graft choices, the bone-patellar-tendon bone (BPTB) is still most commonly used graft in ACLR.⁶ However, there are several disadvantages of BPTB graft like anterior knee pain, quadriceps weakness, extension deficit of knee and patellar bone fracture.⁷ To avoid these postoperative donor site complications of BPTB, there has been increased use of hamstring tendon (HT) autograft. However, there are several

concern about use of HT graft : failure to achieve immediate rigid fixation to bone, lower stiffness compared to native ACL or BPTB graft, tunnel widening, risk of increased laxity in long term, reduced strength of hamstring in deep flexion and difficulty in controlling internal rotation of tibia.⁸ Comparing to combined semitendinosus/Gracilis(ST/G), the quadrupled semitendinosus graft is larger in diameter and provides a stronger graft.⁹ Furthermore, it also saves Gracilis tendon which is important flexor of knee and also helps to control internal rotation of knee. Therefore, we studied short-term evaluation of single bundle ACL reconstruction using quadrupled semitendinosus graft in our clinical setup. We hypothesized that quadrupled semitendinosus tendon graft provides comparable functional outcome as other grafts in ACL reconstruction do.

METHODOLOGY

This was a prospective case study conducted between February 2021 to July 2022, in department of orthopedics of Nobel medical college, after getting ethical clearance from IRC (Reference No. 25/021). An informed consent was taken from all patients before enrolment in this study. All patients having primary ACL tear presented to our department aged between 18 to 50 years were included in this study. Patients having multi-ligamentous knee injury requiring additional surgery for other ligaments, previous knee injuries and deformities and those patients having less than 28cm length of harvested semitendinosus (ST) graft were excluded. Patient's medical histories, mechanism of injury, demographics, post operative complications and concomitant knee pathologies, if any were recorded. Clinical examination was performed for signs of instability via Lachman and anterior drawer tests in outpatient department (OPD) and by pivot-shift test under anesthesia at the beginning of the surgery.² Findings were graded. The magnetic resonance imaging was done for each patient to confirm diagnosis of ACL rupture and to see any other associated knee pathologies preoperatively.

Surgical technique Anterolateral and slightly more medial anteromedial portals were used for single bundle reconstruction of ACL. A diagnostic knee arthroscopy was done to examine ACL tears and injury to other structures of knee. Semitendinosus graft was harvested through a longitudinal incision of 3cm to 4cm at 2cm medial to tibial tuberosity. To dissect pes anserinus a reverse L- shaped incision was given at sartorius fascia and flaps were reflected. The semitendinosus was isolated and harvested using open tendon stripper. To maximize the length of the graft, we included periosteum from the tendon insertion site, which added extra 1 to 2cm in length of graft. The ST graft were prepared and quadrupled and length and diameter were measured.

The torn ACL was debrided leaving tibial foot print as much as possible. Associated meniscus tear or chondral injuries were treated first. The guide wire was inserted in in femoral attachment site using femoral offset guide. The guide wire was over-drilled with a 4.5mm Endobutton drill through femur to emerge on lateral cortex of femur. The final closed femoral socket

of 18 to 20mm was created by cannulated drill equal to diameter of prepared graft. An ACL guide was used to create tibial tunnel at an angle of 50 degree. The ACL guide was positioned slightly medial to center of ACL stump. The guide pin was placed above the pes anserinus and anterior to MCL. The open tibial tunnel was created as same diameter as prepared graft. The graft was passed and femoral side was fixed with variable loop Endobutton (Figure.1 a-g). The tibial fixation was done with bioabsorbable interference screw only when quadrupled graft length was ≥ 7.5 cm. In those patients where quadrupled graft length was between 7 to 7.5cm and where we had any doubt regarding stability of tibial fixation of graft, additional cortical screw and washer were used for tibial fixation. The post-operative X-ray was done in every patient (Figure.2).

Range of motion of the knee, isometric muscle exercise and closed kinetic chain exercises were started the day after operation and gradually progressed based on accelerated rehabilitation program. Patients were permitted to bear weight with knee immobilizer as tolerated immediately after ACL reconstruction. Walking without support and brace and range of motion more than 90 degree were allowed at around 4weeks. Indoor swimming and cycling allowed after 4weeks. Open kinetic leg curl exercise started after 8weeks. Running allowed after 12weeks and sports activities and heavy works allowed after 9months.

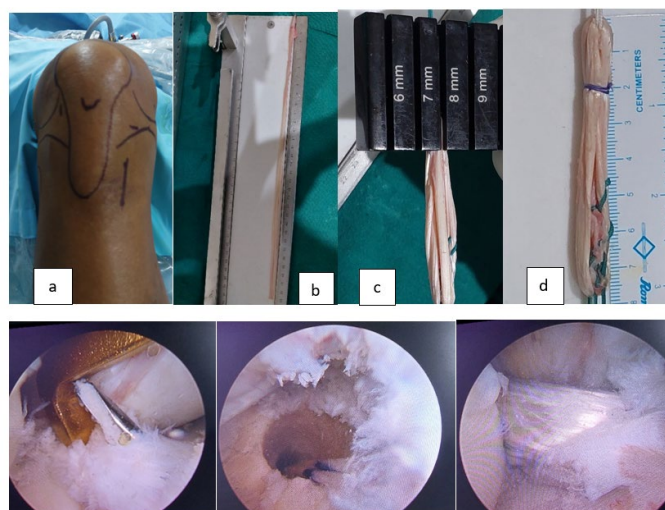


Fig 1: (a -g). ACL tear assessment. (a) surface markings. (b,c,d) ST graft harvested, prepared and measured. (e) Bony portals made. (f,g) Graft passed and fixed.

The final clinical examinations like Lachman, anterior drawer and pivot shift tests were done at 12months and findings were recorded. For overall evaluation, subjective knee scoring systems like Lysholm score and Tegner activity scale were used.¹⁰ Furthermore subjective evaluation was assessed by numeric rating scale (NRS) from 0 (very unsatisfied) to 10 (very satisfied).

Sampling technique and Sample size The total population

sampling method, a non-probability sampling method, was applied in this study. All of the patients, presenting during the study period, with primary ACL tears were assessed for eligibility and the patients meeting the inclusion criteria of the study were all included in this study after receiving their consent. In the study period from February 2021 to July 2022, a total of 33 patients met the inclusion criteria and thus the sample size of this study was 33.

Study tool and variables A structured questionnaire, with sections for demographic details; clinical outcomes that included Lachman, anterior drawer, and pivot shift tests; subjective scoring scales like Lysholm score, Tegner activity scale, and numeric rating scale from 0 (very unsatisfied) to 10 (very satisfied) was used. Independent variables of this study were the demographic details and the result of the pre-operative pivot shift test. Dependent variables of this study were the result of post-operative Lachman, anterior drawer, and pivot shift tests; Lysholm score, Tegner activity scale, and numeric rating scale.



Fig 2: a Tibial fixation with bioscrew. b. Tibial fixation reinforced with addition washer and screw.

Analytical strategy Descriptive statistics were used to present the independent and dependent variables. The normality of the data was checked through the Shapiro Wilk test. Categorical variables are presented in terms of proportion while appropriate measures of central tendency (mean/median) and dispersion (standard deviation/interquartile range) are used for continuous variables. The curated data were refined and imported to SPSS software version 20 for analysis.

RESULTS

A total of 35 patients underwent ACLR with quadrupled semitendinosus hamstring graft during our study period. Two patients lost follow up and hence excluded from study. There were 27 male and 6 female patients. The mean age was 27.5 ± 8.2 years ranging between 16 to 49 years. The right knee was involved in 18 patients and left in 15 patients. The commonest mode of injury was RTA in 14 patients (43%) followed by sporting activities in 13 patients (39%) and fall from height in 6 patients (18%). The mean duration from injury to surgery was 7.2 ± 5 months (Range from 3 to 24 months). The average diameter of graft was 8.03 ± 0.35 mm (Table.1).

Table 1: Demographic data of the patients

Total patients	33
Age (mean $\pm$ SD)	27.5 $\pm$ 8.2 years
Male/Female	27/6
Side (R/L)	18/15
Follow up duration	12-17 months
Graft diameter(mean $\pm$ SD)	8.03 $\pm$ 0.35 mm

Out of 33 patients, six (18%) had MMT and 3(9%) had LMT. Two MMT and one LMT were repaired while remaining were debrided. The associated chondral injury was found in 5 patients. Thirty patients had full range of motion and three patients had terminal deficit of 5 to 10 degree at last follow up. Out of 33, only two patients had positive grade 1 pivot shift test after operation (Table.2).

Table 2: Results of post-operative clinical (objective) tests

Objective tests	Positive	Negative
Lachman(grade I)	6(18%)	27(82%)
Anterior drawer test(grade I)	6(18%)	27(82%)
Pivot shift test(grade I)	2(6%)	31(94%)

The mean Lysholm score was 92.3 ± 5.1 (range 79–99) at follow-up. Twenty-four patients (70 %) were rated as very good (91–100 points), seven (23 %) as good (84–90 points) and two patients (7 %) as fair (65 to 83 points). None was assessed as poor.

Tegner activity score decreased from 8 points (range 4-9) pre-operatively to 7 points (range 4-9) post-operatively. Seventy percent patients returned to preinjury activity level whereas 30% decreased their activity level.

According to the numeric rating scale (NRS) the satisfaction with the operative result was 9 (median, range 4- 10). Twenty seven patients (82%) were very satisfied (NRS,8-10) and six patients (18%) were satisfied (NRS,4-7) with result of operation. None was dissatisfied (NRS, 0-3).

Two patients had superficial wound infection which subsided with dressing and antibiotics. One had knee effusion at 6 weeks and one had post operative stiffness which improved with analgesics and physiotherapy.

DISCUSSION

The goals of ACLR are to restore stability, full ROM and to prevent secondary injuries and knee arthrosis. The majority of patients in our study showed excellent results with stable knee and had returned to preinjury activity level. The Lysholm score of majority of our patients were excellent or good with a mean value 92.3 ± 5 , similar to other studies by ¹¹Charlton et al,¹² William et al,¹³ Gifstad et al, and many other studies who reported a Lysholm score of about 90.

The successful and fast return to preinjury level depends on rehabilitation protocol. There is no significant association between postoperative brace treatment with better outcome.¹⁴ We had similar conclusion in our study and postoperative rehabilitation was started as soon as possible. Our study reports 70% (23 patients) return to pre-injury activity level. Anderson et al and Sajovic reported 78% and 81% of return to pre-injury activity level respectively.^{15,16} whereas, in a study by Kropft et al. nineteen (82.6%) patients were able to perform strenuous activity but only 10 (43.5%) of them were able to return to pre-injury activity levels in terms of frequency and type of activity.¹⁷ The literatures do not show consistent rate of return to sports.^{18,19}

In this study, 6 (18%) patients had positive grade I Lachman test. Gifstad and William reported 33% and 11% positive Lachman respectively in their studies.^{13,12} In our study 31 patients (94%) had negative pivot shift test which indicates very high rate of knee stability. It had been observed that two patients who had grade 1 pivot shift postoperatively showed lesser Lysholm score and overall satisfaction. In a study by Omid Shahpari et al. 72 patients (87%) had negative pivot shift test.²⁰ Kocher et al could not find any correlation between instrumented knee laxity and Lachman examination and any subjective variables of symptoms and function.¹⁹ But Pivot shift test had significant association with patient satisfaction whereas Peterson et al did not find any statistically significant correlation between pain, giving way, Lachman and pivot shift results or arthrometer. The pivot shift test may be better measure of functional instability than instrumented knee laxity or Lachman test after anterior cruciate ligament reconstruction.²¹

Three patients (9%) had terminal flexion deficit of 5 to 7 degree but no patients had extensor lag in our study. In study by Beynnon et al, they had flexion deficit of five degree or more in 17% of patients and extensor lag of 3 degree in 3% in their patients in hamstring autograft group.²²

Gifstad et al reported re-rupture rate of 6%.¹³ In another study by Sajovic et al. showed ACL revision rate of 7%.¹⁶ The overall rate of graft failure was 4.9% and in hamstring graft group it was 4.1% in Freedman et al study.²³ We had no graft failure in any patients at 1 year follow up. It might be because of less follow up duration.

Even if we reconstructed the ACL with an ST graft alone, the patients obtained at least the same level in the clinical outcome scores compared to other studies using an STG graft.^{24,25} Similar findings were seen in review by Samuelsson et al.²⁶ They could not quote any differences between the selected graft and the self-reported data including the Lysholm score.

CONCLUSION

Anterior Cruciate Ligament Reconstruction using quadrupled semitendinosus graft only has good clinical outcomes and it also increases diameter of graft. It also helps to save Gracilis tendon which is important in deep flexion of knee. We recommend quadrupled ST graft for ACL reconstruction if length of graft is

adequate.

LIMITATIONS OF THE STUDY

Although we have found excellent results comparable to other studies, there are several limitations. The sample size is less and there are drawbacks of non-probability sampling method. The other is that it is not comparative study with other graft.

CONFLICT OF INTEREST

None

FINANCIAL DISCLOSURE

None

REFERENCES

1. Olsson O, Isacsson A, Englund M, Frobell RB. Epidemiology of intra- and peri-articular structural injuries in traumatic knee joint hemarthrosis-Data from 1145 consecutive knees with subacute MRI. *Osteoarthritis Cartilage*. 2016; 24: 1890-1897. DOI: [10.1016/j.joca.2016.06.006](https://doi.org/10.1016/j.joca.2016.06.006) PMID:27374877
2. Roger J, Bertani A, Vigouroux F, Mottier F, Gaillard R, Have L, Rongi  ras F. ACL reconstruction using a quadruple semitendinosus graft with cortical fixations gives suitable isokinetic and clinical outcomes after 2 years. *Knee Surg Sports Traumatol Arthrosc*. 2020; 28: 2468-2477. DOI: [10.1007/s00167-020-06121-2](https://doi.org/10.1007/s00167-020-06121-2) PMID:32699919
3. Nordenvall R, Bahmanyar S, Adami J, Stenros C, Wredmark T, Fell  nder-Tsai L. A population-based nationwide study of cruciate ligament injury in Sweden, 2001-2009: Incidence, treatment, and sex differences. *Am. J. Sports Med*. 2012; 40: 1808-1813. DOI: [10.1177/0363546512449306](https://doi.org/10.1177/0363546512449306) PMID:22684536
4. Sanders TL, Pareek A, Kremers HM, et al. Long-term follow-up of isolated ACL tears treated without ligament reconstruction. *Knee Surg Sports Traumatol Arthrosc* 2016;25:1-8. DOI: [10.1007/s00167-016-4172-4](https://doi.org/10.1007/s00167-016-4172-4) PMID:27221641
5. Middleton KK, Hamilton T, Irrgang JJ, Karlsson J, Harner CD, Fu FH. Anatomic anterior cruciate ligament (ACL) reconstruction: A global perspective. Part 1. *Knee Surg Sports Traumatol Arthrosc*. 2014; 22: 1467-1482. DOI: [10.1007/s00167-014-2846-3](https://doi.org/10.1007/s00167-014-2846-3) PMID: 24497054
6. Hospodar SJ, Miller MD. Controversies in ACL reconstruction: bone-patellar tendon-bone anterior cruciate ligament reconstruction remains the gold standard. *Sports Med Arthroscopy*. 2009; 17 (4):242-246. DOI: [10.1097/JSA.0b013e3181c14841](https://doi.org/10.1097/JSA.0b013e3181c14841) PMID:19910782

7. Mohtadi NG, Chan DS, Dainty KN, Whelan DB. Patellar tendon versus hamstring tendon autograft for anterior cruciate ligament rupture in adults. *Cochrane Database Syst Rev*.2011; 7(9).
DOI: [10.1002/14651858.CD005960.pub2](https://doi.org/10.1002/14651858.CD005960.pub2)
PMID:21901700 PMCID:PMC6465162
8. Reinhardt KR, Hetsroni I, Marx RG. Graft selection for anterior cruciate ligament reconstruction: a level I systematic review comparing failure rates and functional outcomes. *Orthop Clin North Am*.2010; 41(2):249-262 6.
DOI: [10.1016/j.ocl.2009.12.009](https://doi.org/10.1016/j.ocl.2009.12.009)
PMID:20399364
9. Chen L, Cooley V, Rosenberg T. ACL reconstruction with hamstring tendon. *Orthop Clin North Am*.2003; 34:9-18.
DOI: [10.1016/S0030-5898\(02\)00016-0](https://doi.org/10.1016/S0030-5898(02)00016-0)
PMID:12735197
10. Tegner Y, Lysholm J. Rating systems in the evaluation of knee ligament injuries. *Clin Orthop Relat Res*. 1985;198:43-9.
DOI:[10.1097/00003086-198509000-00007](https://doi.org/10.1097/00003086-198509000-00007)
PMID: 4028566.
11. Charlton WP, Randolph DA Jr, Lemos S, Shields CL Jr. Clinical outcome of anterior cruciate ligament reconstruction with quadrupled hamstring tendon graft and bioabsorbable interference screw fixation. *Am J Sports Med*. 2003; 31(4):518-21.
DOI: [10.1177/03635465030310040701](https://doi.org/10.1177/03635465030310040701)
PMID:12860538
12. Williams RJ 3rd, Hyman J, Petrigliano F, Rozental T, Wickiewicz TL. Anterior cruciate ligament reconstruction with a four-strand hamstring tendon autograft. *J Bone Joint Surg Am*. 2004; 86- A(2):225-32.
DOI: [10.2106/00004623-200402000-00003](https://doi.org/10.2106/00004623-200402000-00003)
PMID:14960665
13. Gifstad T, Sole A, Strand T, Uppheim G, Grontvedt T, Drogset JO. Long-term follow-up of patellar tendon grafts or hamstring tendon grafts in endoscopic ACL reconstructions. *Knee Surg Sports Traumatol Arthrosc*. 2013; 21(3):576-83.
DOI: [10.1007/s00167-012-1947-0](https://doi.org/10.1007/s00167-012-1947-0)
PMID:22407182
14. Wright RW, Fetzter GB. Bracing after ACL reconstruction: a systematic review. *Clin Orthop Relat Res*. 2007; 455(1):162-8.
DOI: [10.1097/BLO.0b013e31802c9360](https://doi.org/10.1097/BLO.0b013e31802c9360)
PMID:17279043
15. Genuario JW, Faucett SC, Boublik M, Schlegel TF. A cost-effectiveness analysis comparing 3 anterior cruciate ligament graft types: bone-patellar tendonbone autograft, hamstring autograft, and allograft. *Am J Sports Med*. 2012; 40(2):307-14.
DOI: [10.1177/0363546511426088](https://doi.org/10.1177/0363546511426088)
PMID:22085728
16. Sajovic M, Strahovnik A, Dernovsek MZ, Skaza K. Quality of life and clinical outcome comparison of semitendinosus and gracilis tendon versus patellar tendon autografts for anterior cruciate ligament reconstruction: an 11-year follow-up of a randomized controlled trial. *Am J Sports Med*. 2011; 39(10):2161-9.
DOI: [10.1177/0363546511411702](https://doi.org/10.1177/0363546511411702)
PMID:21712483
17. Mascarenhas R, Tranovich MJ, Kropf EJ, Fu FH, Harner CD. Bone-patellar tendon-bone autograft versus hamstring autograft anterior cruciate ligament reconstruction in the young athlete: a retrospective matched analysis with 2-10 year follow-up. *Knee Surg Sports Traumatol Arthrosc*. 2012; 20(8):1520-7.
DOI:[10.1007/s00167-011-1735-2](https://doi.org/10.1007/s00167-011-1735-2)
PMID:22048746
18. Aglietti P, Buzzi R, D'Andria S, Zaccherotti G. Patellofemoral problems after intraarticular anterior cruciate ligament reconstruction. *Clin Orthop Relat Res*. 1993; 288(1):195-204.
DOI:[10.1097/00003086-199303000-00025](https://doi.org/10.1097/00003086-199303000-00025)
PMID: 8458134.
19. Kocher MS, Steadman JR, Briggs KK, Sterett WI, Hawkins RJ. Relationships between objective assessment of ligament stability and subjective assessment of symptoms and function after anterior cruciate ligament reconstruction. *Am J Sports Med*. 2004; 32(3):629-34. DOI: [10.1177/0363546503261722](https://doi.org/10.1177/0363546503261722)
PMID:15090377
20. [20] Omid S, Moslem F, Hamid H K, Farshid B, Mohammad H. E. Clinical Outcome of anatomical trans-portal Arthroscopic Anterior Cruciate Ligament Reconstruction with Hamstring Tendon Autograft. *The archive of bone and joint Surg*.2018;6(2):130-8. PMID: 29600266
21. Peterson RK, Shelton WR, Bomboy AL. Allograft versus autograft patellar tendon anterior cruciate ligament reconstruction: a 5-year follow-up. *Arthroscopy*. 2001; 17(1):9-13.
DOI: [10.1053/jars.2001.19965](https://doi.org/10.1053/jars.2001.19965)
PMID:11154360
22. Beynnon BD, Johnson RJ, Fleming BC, Kannus P, Kaplan M, Samani J, et al. Anterior cruciate ligament replacement: comparison of bone-patellar tendon bone grafts with two-strand hamstring grafts. A prospective, randomized study. *J Bone Joint Surg Am*. 2002; 84-A(9):1503-13.
DOI: [10.2106/00004623-200209000-00001](https://doi.org/10.2106/00004623-200209000-00001)
PMID:12208905
23. Spindler KP, Kuhn JE, Freedman KB, Matthews CE, Dittus RS, Harrell FE Jr. Anterior cruciate ligament reconstruction autograft choice: bone-tendon-bone versus hamstring: does it really matter? A systematic review. *Am J Sports Med*. 2004; 32(8):1986-95.

DOI: [10.1177/0363546504271211](https://doi.org/10.1177/0363546504271211)

PMID:15572332

24. Pinczewski LA, Lyman J, Salmon LJ, Russell VJ, Roe J, Linklater J. A 10-year comparison of anterior cruciate ligament reconstructions with hamstring tendon and patellar tendon autograft: a controlled, prospective trial. *Am J Sports Med.* 2007; 35(4):564- 574.
DOI:[10.1177/0363546506296042](https://doi.org/10.1177/0363546506296042)
PMID:17261567
25. Holm I, Oiestad BE, Risberg MA, Aune AK. No difference in knee function or prevalence of osteoarthritis after reconstruction of the anterior cruciate ligament with 4-strand hamstring autograft versus patellar tendon-bone autograft: a randomized study with 10-year follow-up. *Am J Sports Med.* 2010; 38(3):448-454.
DOI: [10.1177/0363546509350301](https://doi.org/10.1177/0363546509350301)
PMID:20097928
26. Samuelsson K, Andersson D, Karlsson J . Treatment of anterior cruciate ligament injuries with special reference to graft type and surgical technique: an assessment of randomized controlled trials. *Arthroscopy.*2009(October); 25(10):1139-1174.
DOI: [10.1016/j.arthro.2009.07.021](https://doi.org/10.1016/j.arthro.2009.07.021)
PMID:19801293