"FUNCTIONAL OUTCOME OF ARTHROSCOPIC SINGLE-BUNDLE ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING SEMITENDINOSUS QUADRUPLED GRAFT FIXED WITH ADJUSTABLE LOOP ON FEMUR AND SUTURE DISC ON TIBIA: A PROSPECTIVE CLINICAL STUDY"

Submitted by

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Dissertation submitted to The

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In partial fulfillment of the requirement for the degree of

MASTER OF SURGERY

IN

ORTHOPAEDICS

UNDER THE GUIDANCE OF

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ABSTRACT

Background: The anterior cruciate ligament (ACL) is crucial for knee joint stability, and its rupture is common often resulting from sports or road traffic accidents. ACL reconstruction using hamstring autografts is commonly utilized, yielding positive clinical outcomes. A suspensory method is widely used, which an adjustable loop endobutton device providing various advantages over a fixed loop endobutton. This study aims to evaluate the functional outcomes of arthroscopic ACL reconstruction with a quadrupled semitendinosus autograft using an adjustable loop ebdobutton on the femur and a suture disc for the tibia.

Material and methods: A prospective clinical study was conducted from Auguest 2022 to January 2024 at Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura. The study included 33 patients with ACL tear operated with arthroscopic ACL reconstruction with quadrupled semitendinosus autograft using an adjustable loop endo-button on the femoral and a suture disc on the tibial side. Functional outcomes were assessed using the Lysholm and International Knee Documentation Committee (IKDC) scores preoperatively and at 6 and 12 months postoperatively.

Results: Significant improvements were observed in both Lysholm and IKDC scores at 6 and 12 months postoperatively ($p < 0.05$). The majority of patients (95%) returned to their pre-injury level of activity. The study observed minimal complications, with a low incidence of postoperative anterior joint laxity and no cases of tunnel widening.

Conclusion: The use of an adjustable loop endo-button and suture disc for ACL reconstruction with a semitendinosus quadrupled graft gives excellent functional outcomes, significant improvement in knee stability and predictably reproduces graft tunnel healing and maintaining its strength till healing is complete.

LIST OF ABBREVIATIONS

- mm – Milli meters
- cm – Centi meters
- ACL – Anterior Cruciate Ligament
- AP – antero-posterior
- IV – Intravenous
- BP – Blood pressure
- AM – Anteromedial
- PL – Posterolateral

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INTRODUCTION

The core complex of the knee joint accommodates the extra-synovial, intra-articular anterior cruciate ligament (ACL), playing a critical role in maintaining both static and dynamic stability of the joint[1].

Anterior cruciate ligament rupture is the most commonly injured knee ligament[2,] and injuries usually result from sports activities and road traffic accidents[3]. The general population is experiencing more ACL tears due to increased interest as well as engagement in sports[1]. Following an ACL injury, the likelihood of experiencing symptomatic knee instability varies from 16% to nearly around 100%.[1]

ACL reconstruction is one of the most commonly and frequently performed arthroscopic procedures, known for yielding good clinical outcomes[4-7]. Bone-patellar tendon-bone (BPTB) or hamstring constructs are mostly used for the reconstruction of the ACL. Previous research has demonstrated that a bone patellar tendon bone autograft is either superior to or equal to a hamstring autograft[8-10] with the advantages of fewer problems of anterior knee pain, quadriceps muscle deficits, donor site morbidity, fewer sensory deficits, and loss of extension than with BPTB autografts[8,11-13]. Excellent bio-mechanical graft properties in ACL reconstruction utilizing hamstring tendons can be credited to graft characteristics in conjunction with enhanced fixation of soft tissue grafts[13].

Two popular techniques for fixing grafts are suspensory fixation (involves attachment of the graft to bone outside cortex)[14] and aperture fixation (securing the graft to the bone through a tunnel by putting a screw)[14]. Presently, there are two common types of cortical suspension devices: fixed loop (initial generation) and adjustable loop (2nd generation)[15,16]. The fixed-loop device (FLD), fills the tunnel with graft without the need for an additional implant[16] by securing the graft to a continuous suture loop that is attached to a button that is flipped and locked at the distal femoral cortex[16]. Following graft tensioning, a cavity is left above the graft as the femoral socket has a 6-8mm longer drilling than required, accommodating the button's flip movement. This may contribute to the "bungee cord effect" and the windshield wiper effect, increasing the likelihood of tunnel widening (TW).[4,15,17]

Conversely, in an adjustable-loop device (ALD), which features a button fixed to the graft, there is no longer a need for extra tunnel length to flip the button because this loop is tightened to pull the graft through to the top of the femoral[16,18].

ALD was designed to adapt seamlessly to varying tunnel lengths; it features a unidirectional locking mechanism[4], with its length maintained by friction between the sutures. Utilizing an adjustable loop endo button facilitates better control and re-tensioning of the graft after passive knee cycling, ensuring no excess space within the tunnel[19,20]. Their widespread use is attributed to their simplicity, elimination of the need for additional incisions on the femoral side[21], their potential to accelerate tendon-to-bone healing[22,23,] and also protect the graft from damage caused by the insertion of screws[24,25]. Current biomechanical data suggest that adjustable loop devices are the strongest fixation devices at "time zero" in terms of load to mechanical failure[16]

Suspensory and aperture methods of fixation using adjustable loop endo-button for femur and suture disc for tibia tunnel fixation has been studied, and increased stiffness of the construction is related to aperture fixation compared with the suspensory method· [26,27] and increased graft ruptures, whereas suspensory fixation showed increased overall arthrometric stability and decreased graft ruptures[28].

Studies show that to facilitate graft tunnel healing and maintain its strength, it is better to use an adjustable loop endo button for the femur and suture disc for the tibia[29]. Hence, to substantiate the existing literature, we plan to conduct this prospective clinical study to assess the functional outcome of using the same.

AIM & OBJECTIVES

To study the functional outcomes of arthroscopic single-bundle anterior cruciate ligament reconstruction using semitendinosus quadrupled graft fixed with an adjustable loop on the femur and suture disc on the tibia

REVIEW OF LITERATURE

Galen[30] was the first to describe the fundamental characteristics of the anterior cruciate ligament that it acts as a joint stabilizer and limits excessive motion at the knee joint (Circa 170 AD)

James Stark[31], according to an Edinburgh-based general practitioner, in a couple of cases of cruciate ligament tears in the 19th century, the knee would give way with a snap, and the patient would lose control of the leg while lifting it. The first clinician to describe cases of anterior cruciate ligament insufficiency in English literature is frequently credited as “Stark.”

A study titled, Clinical and experimental inquiry into knee joint bloody effusions and in sprains" was published by Paul F. Segond[32] in 1879. Through his studies, he learned that anterior cruciate ligament tears were commonly seen alongside tibial plateau lateral margin avulsion fractures. He inspired the term of the fracture, ‘Segond fracture,’ which is now recognized as the pathognomonic sign of an Anterior Cruciate Ligament tear.

The 1st repair of ACL by catgut ligatures sewn to the tissues and synovial membrane on the inside of the external condyle in 1895 was reported by A W Mayo Robson[33].

The first Anterior Cruciate Ligament Reconstruction was done using an iliotibial band by retaining the upper attachment in the thigh and was passed through canals bored into the femur and tibia by Ernest W. Whey Groves[34] in 1917.

William C Campbell[35] published the first description of the use of medial-third patellar-tendon transplant in ACL reconstruction in 1935.

In 1939, Harry B. Macey[35] was the first to describe the semitendinosus auto-graft in ACL Reconstruction.

Extra-articular reconstruction using Tensor fascia-lata (Lateral Extra-articular Tenodesis) was done first by D L McIntosh[36] in 1972, and the Lateral Pivot shift was first described in his article.

Rubin, Marshall, and Wary[37], in 1975, used the first Dacron prosthetic in ACL-Reconstruction.

Joseph S. Torg[38], a trainee of John Lachman, first described the Lachman test in 1976, which aids ACL tear diagnosis, specifically those for the anteromedial bundle.

In 1979, Marshall et al.[39] described quadriceps tendon autograft usage for Anterior Cruciate Ligament Reconstruction.

In 1982, Lipscomb[40] performed the first ACL-Reconstruction by harvesting hamstring tendons.

In 1982, Jack Lysholm et al.[41] created a scoring system for knee ligament surgery follow-up that focused on assessing instability symptoms[41]. In their study, the scoring system mainly emphasized the patient's evaluation and function, and objective signs (instability of ligaments and range of motion) are to be noted separately. They suggested a strong correlation between patients' self-assessment of function and the scores obtained on their own scale and between examination findings of instability signs and low total scores.

A patellar-tendon-based graft was used for anterior cruciate ligament reconstruction by Clancy initially and turned out to be the strongest, having 160% of the normal anterior cruciate ligament's strength, according to Nayes et al. [42] in 1984.

In 1988, the arthroscopic Anterior Cruciate Ligament Reconstruction using quadrupled semitendinosus and gracilis autograft was first done by M.J. Fredman.[43]

In their article, Anterior cruciate ligament reconstruction with autografts in 1991, Tom Rosenberg[44] first described the use of Endobutton for graft fixation, and L Paulos explained the use of Polyethylene Anchor.

In 1993, F. Hefti[45] et al. published a paper titled "Evaluation of knee ligaments with the IKDC form". In 1987, a group of European and American knee surgeons assembled to establish the International Knee Documentation Committee (IKDC). Research on the outcomes of treating knee ligament injuries that are published in a scientific journal must, according to the International Knee Documentation Committee, include an evaluation in the format specified in the paper. Additionally, the committee also suggested using Noyes et al.'s [46] definitions describing knee ligament injuries.

In 1995, Gene R. Barrett[47] et al. conducted a study to evaluate the functional outcome of endobutton fixation in ACL reconstruction, and in their study, they concluded that endobutton fixation shows promise in anterior cruciate ligament reconstruction procedure and the pitfalls of screw fixation are avoided.

In 1996, Paolo aglietti[48] et al. conducted a prospective clinical study to evaluate semitendinosus and gracilis tendon autograft in arthroscopic anterior cruciate ligament reconstruction in athletes. The study included 69 patients and concluded that the operation is simple, effective, and has a low complication rate.

In 1997, John C. L'Insalata[49] et al. conducted a study to compare tunnel expansion in ACL reconstruction between hamstring and patellar tendon autografts. The study consisted of 60 patients (30 patients in each group), and they concluded that tunnel expansion was considerably more following ACL reconstruction utilizing hamstring autografts than those with patellar tendon autografts.

In 1997, Simonian P[50] et al. carried out a study on nine patients followed up for three years. The effect on knee function, flexion & extension strength, individual posterior thigh muscle size, and the degree of hamstring tendon retraction were specifically assessed. In conclusion, despite a more proximal insertion of the retracted tendons, tendon harvest of the hamstring muscles did not significantly impair function and strength.

In 1998, Wolfgang Nebelung[51] et al. conducted a prospective clinical study to evaluate bone tunnel expansion after ACL reconstruction with semitendinosus tendon using endobutton fixation on the femoral side in 29 patients with follow-up of 2 years and concluded that at 2 years follow-up, tibial and femoral bone enlargement was seen using an endobutton construct in ACL reconstruction[51].

In 2000, D.D.M spicer[52] et al. conducted a study to evaluate anterior knee symptoms after four-strand hamstring tendon anterior cruciate ligament reconstruction. 44 of 50 consecutive patients who had undergone four-strand hamstring tendon autograft arthroscopic ACL reconstruction were followed up for 24 months, and they concluded that ACL constructions using hamstring tendons can lead to anterior knee pain and associated symptoms, especially with kneeling, but they are rarely a limitation to activities.

In 2001, Vernon J. Cooley[53] et al. conducted a case series to study 5-year results in patients without meniscus loss in quadrupled semitendinosus ACL reconstruction of 184 patients and came to a conclusion that great clinical results are obtained with quadrupled semitendinosus tendon autograft for ACL reconstruction. None of the patients had re-injury and continued with their pre injury activities.

In 2003, Leo Chen[54] et al. conducted a 10-year clinical trial where the technique of ACL reconstruction using quadrupled semitendinosus autograft using Endo Button on femoral side was described. The senior author of this article, Dr. Rosenberg used this technique for more then ten years, with case of fixation failure on both femur and tibia. This technique using quadrupled semitendinosus tendon autograft reconstruction has little morbidity, low resurgery rate, and outstanding clinical outcomes[54].

In 2003, Kevin B. Freedman[55] et al. conducted a meta-analysis study that compared patellar tendon and hamstring tendon autografts in arthroscopic ACL reconstruction. 1348 patients were put in the patellar tendon autograft group (21 studies) and 628 patients in hamstring tendon autograft group (13 studies); they concluded that patellar tendon autograft group showed better static knee stability and better patient satisfaction which was a result of lower graft failure rate when compared with hamstring tendon autograft group. However, anterior knee pain was a major complication in patellar tendon reconstruction group[55].

In 2004, Tim Rose[56] et al. conducted a prospective clinical study to compare patient outcomes during the early rehabilitation phase in ACL reconstruction with ligamentum patellae and semitendinosus tendon autograft. The study included 50 patients, and it was concluded that ACL reconstruction with semitendinosus tendon results in advantages in regaining pain and function during the rehabilitation phase compared to ligamentum patellae. This can be recommended in ACL reconstruction of young, active patients and athletes.

In 2005, Chadwick C Prodromos[26] et al. conducted a retrospective clinical study to evaluate stability results of hamstring anterior cruciate ligament reconstruction when followed up at 2 to 8-years. They retrospectively reviewed 153 consecutive primary hamstring ACL reconstructions in skeletally developed patients with no other ligament reconstructions and concluded that Hamstring autograft ACL reconstructions in both males and females produce reliable and durable stability with no reported graft failures, good clinical scores, very good range of motion and low graft site morbidity, without any hardware problems.

In 2005, Samir Abdul Razik Ibrahim[57] et al. conducted a randomized prospective study for comparing bone patellar-tendon-bone vs semitendinosus tendon autografts for arthroscopic ACL reconstruction. Eighty-five patients with chronic ACL deficient knees underwent arthroscopic ACL reconstruction, and the study concluded that in terms of patient satisfaction, activity level, and knee function, both groups showed similar outcomes. Bone patellar-tendon-bone graft patients showed patellofemoral problems and loss of knee motion more frequently in comparison with semitendinosus graft patients.

In 2006, Matjaz Sajovic[58] et al. conducted a prospective, randomized comparison of hamstring versus patellar tendon autografts for ACL reconstruction with a 5-year follow-up; this study concluded that greater osteoarthritis prevalence is seen in patients operated with patellar tendon autografts after five years of surgery.

In 2006, Allen F. Anderson[59] et al. conducted a cross-sectional survey to provide clinicians as well as researchers with normative data to better evaluate the interpretation of results on IKDC subjective knee evaluation form. The form was mailed to 600 people, each of whom was divided into eight categories based on age and gender. The survey concluded that the IKDC Knee Form provides a valuable outlook into symptoms, function, sports activity and it is a well-standardized instrument.

In 2006, James J Irrgang[60] et al. conducted a cohort study to evaluate the responsiveness of International Knee Documentation Committee (IKDC) knee form; they concluded that the IKDC subjective knee form is a sensitive indicator of a patient's symptoms, function and level of sports participation.

In 2007, Gauti Laxdal[61] et al. conducted a prospective randomized comparative study of bone-patellar tendon-bone (BPTB) and hamstring grafts for ACL reconstruction in 134 patients. They concluded that two years after ACL reconstruction, the use of semitendinosus autografts rendered significantly less discomfort during the knee walking test than the use of BPTB autografts.

In 2007, Mattias Liden[62] et al. Conducted a prospective randomized study for* arthroscopic ACL reconstruction using central-third bone patellar tendon bone (BTB) autografts and quadruple semitendinosus (ST) autografts in 71 patients and concluded that subjective as well as objective outcome were similar after using the central third BTB autograft and quadruple ST autograft after seven years of ACL reconstruction. Additionally, no significance in difference in terms of donor-site morbidity was found between the two groups.

In 2007, Susan L. Keays[63] et al. conducted a cohort study comparing patellar tendon versus semitendinosus tendon graft with a 6 year follow-up considering the graft site's impact on function, strength, stability, range of motion, and joint deterioration following ACL reconstruction. The study included 62 patients (31 patients received patellar tendon grafts and 31 received semitendinosus grafts); it was concluded that 6-year outcomes were very satisfactory, and reconstruction using the semitendinosus tendons resulted in improved functional performance and a lower incidence of osteoarthritis.

In 2007. Gregory B. Maletis[8] et al. conducted a prospective randomized study of anterior cruciate ligament reconstruction comparing BPTB vs. Quadrupled semitendinosus tendon autografts. Forty-six patients in the BPTB group and 50 in the semitendinosus group were included. The study concluded that reconstruction of ACL with both BPTB and quadrupled semitendinosus graft can lead to success, although BPTB grafts led to an increase in anterior knee sensory deficit and difficulty kneeling.

In 2007, Matthias buchner[64] et al. conducted a 6-year follow-up clinical. Functional radiological and isometric results after arthroscopic ACL reconstruction with quadrupled semitendinosus tendon autograft of 85 patients and concluded that ACL reconstruction with quadrupled semitendinosus tendon autograft provides very good and good subjective, functional, and stability and can be recommended for the patient with active ACL deficiency.

Randy Mascarenhas[65] et al. performed a retrospective atudy in 2012 to look at clinically reported results and players under 25 years old's return to sports after ACL surgery using hamstring or BPTB tendon autograft. The study found that 70% of young athletes are able to resume some level of intense or extremely intense athletic activity after receiving either hamstring or bone-patellar tendon-bone autografts[65]. Better extension preservation, greater patient-reported outcome scores, and less radiological evidence of osteoarthritis are the results of hamstring transplants.

In 2012, H.E Bourke[66] et al. conducted a study to evaluate the outcome of isolated ACL ruptures treated with anatomical arthroscopic reconstruction by utilizing hamstring tendon autograft at a mean of 15 years. A total of 100 successive men and 100 successive women with ‘isolated’ ACL rupture went through four-strand hamstring tendon reconstruction, and the study concluded that using this technique 15 years post-operatively with respect to ligamentous stability, objective and subjective outcomes showed good results and did not seem to cause osteoarthritis.

In 2012, Dave Lee Yee Han[67] et al. conducted a systematic review for evaluating the effectiveness of suspensory vs aperture fixation in anterior cruciate ligament soft tissue graft fixation. Patients were followed up for two years and evaluated using IKDC, Lysholm knee scale and Tegner activity level, as well as anterior knee joint laxity measurements. The study displayed comparable outcomes between both suspensory and aperture fixation, and return to sports timing also did not show any differences.

In 2014, Akio Eguchi[68] et al., in their study Mechanical characteristics of suspensory fixation devices: comparing fixed and adjustable length loop devices for anterior cruciate ligament reconstruction[68]. Their study concluded that the fixed loop endo button provides greater mechanical strength than the adjustable loop endobutton[68]. The adjustable loop endo button caused noticeably more displacement during preloading in the isolated device testing than the fixed loop endo button. This could be attributed to the adjustable loop endo button's ability to stretch until a specific tension is applied[68].

In 2014, Evan J. Conte[69] et al. conducted a systematic review to determine whether the size of the hamstring autograft can be predicted and may be a risk factor for the failure of ACL restoration; the study concluded that failure rates are reduced in quadrupled-strand hamstring autografts with a diameter of at least 8 mm. Grafts larger than 8 mm were found to provide a protective effect in patients aged less than 20 years, a group identified as having an increased risk of failure.

In 2015, Chidanand KJC[70] et al. conducted a prospective clinical study to evaluate the clinical outcome of arthroscopic ACL reconstruction with suspensory fixation of quadrupled hamstring tendon autograft with endobutton on femur and suture disc on tibia. Thirty patients were included in the study, and they were operated on between September 2012 and March 2014. They were assessed clinically using IKDC at six months, one year, and two years[70]. According to the study's findings, the suture disc on the tibial side and the endo button on the femoral side would help the graft maintain its strength and aid in graft tunnel healing until good graft-to-bone healing fully occurs. This makes the device a strong and reliable suspensory type of fixation for ACL reconstruction[70].

In order to assess fixed and adjustable loop cortical suspension systems, Nam Hong Choi[18] et al. carried out a retrospective comparative study of radiological and clinical outcomes following Hamstring anterior cruciate ligament restoration in 2016. ACL reconstruction was performed on 117 patients in total; 67 of these patients had fixed loops, and 50 had adjustable loops. It was discovered that, in contrast to femoral fixation using a fixed loop device, femoral fixation using an adjustable loop device produced similar clinical results, but it did not lessen tunnel widening following hamstring ACL reconstructions[18].

In 2016, Mohtadi N[71] et al. conducted a study in 330 patients with isolated anterior cruciate ligament insufficiency. In total, 25 unique operations were necessary for 24 patients (7.3%), comprising 25 separate operations for the patellar tendon, quadrupled hamstring, and doubled hamstring. Meniscal tears (3.6%), intra-articular scarring (2.7%), chondral pathology (0.6%), and wound dehiscence (0.3%) all required repeat surgery. Overall, the quadrupled/doubled hamstring groups experienced more complications, but at two years, more patellar tendon patients reported moderate to severe knee.

In 2017, Vinod Jagtap[29] et al. studied the functional outcome of arthroscopic anatomical single-bundle ACL reconstruction using semitendinosus quadrupled graft with fixation using an endo button on the femoral side and suture disc on the tibial side. They found out that the functional outcome is good, and this method will help the graft to facilitate graft tunnel healing and maintain its strength until good graft-to-bone healing occurs completely.

In 2017, Hardik Sheth[72] et al. conducted a prospective study to evaluate the outcomes of arthroscopic ACL reconstruction using Fixed suspensory devices and Adjustable suspensory devices for femoral side graft fixation and concluded that ACL reconstruction using fixed loop and adjustable loop suspensory devices are equally effective fixation method.

In a study published in 2017, Etienne Cavaignac[73] et al. examined 95 patients who had isolated anterior cruciate ligament reconstruction; 50 of them underwent the procedure using the quadriceps tendon and 45 using the hamstrings. The study found that using a quadriceps tendon graft in anterior cruciate ligament reconstruction produces functional results that are on par with or better than those obtained with a hamstring graft without increasing morbidity.

To ascertain whether suspensory or aperture fixation of hamstring tendon autografts offered superior stability and clinical outcomes in ACL restoration, William M. Browning[28] III et al. performed a meta-analysis in 2017. Their study concluded that suspensory fixation provided better arthrometric stability and fewer graft ruptures compared with aperture fixation of a quadrupled hamstring tendon autograft in ACL reconstruction.

In 2017, Brent T Wise[74] et al. conducted a comparative clinical study to evaluate the consequence of ACL reconstruction with fixed versus adjustable loop button fixation. A total of 57 patients were included in the study: 33 in the adjustable loop and 24 in the fixed group. The study found no statistically significant difference, observed in the laxity of ACL grafts or in functional outcomes of grafts after surgery fixed when variable loop or fixed loop endo button technique were used.

In 2017, Manoj R kashid[75] et al. conducted a comparative study to access clinical and radiological outcomes in suspensory versus aperture fixation on femoral side using hamstring tendon autografts in anterior cruciate ligament reconstruction. Fifty patients were included in the study. 2 groups were randomly assigned to undergo arthroscopic ACL reconstruction using a quadrupled hamstring autograft on the femoral side with suspensory and aperture fixation[75].The study concluded that aperture and suspensory fixation methods of hamstring graft are clinically comparable, and there is no benefit of using one method over another; although suspensory fixation techniques, result in increased tunnel widening, this has little bearing on the overall clinical outcomes or functional knee ratings[75].

In 2018, Pokharel B[13] et al. conducted a prospective study to compare fixed versus adjustable length loop devices in ACL reconstruction. A total of 60 patients were taken, and it was found that fixed length and adjustable loop cortical suspension are equally effective in femoral fixation of graft in ACL reconstruction.

In 2018, Darby A. Houck16 et al. conducted a meta-analysis and concluded that the adjustable loop device in terms of ultimate load to mechanical failure is the strongest fixation device at “time zero”.

In 2018, Philippe colombet[17] et al. conducted a prospective study to evaluate clinical and functional outcomes of ACL reconstruction at a minimum of 2 years using adjustable suspensory fixation with quadrupled semitendinosus tendon autograft in 131 patients and concluded that adjustable loop cortical fixation device yielded acceptable anterior laxity and clinical results, with 2.1% failure rate. These results are in good comparison to the fixed loop devices.

In 2018, Christian Asmus Peter Asmussen[76] et al. conducted a cohort study to evaluate passive knee stability after ACL reconstruction using Fixed loop endobutton and adjustable loop endobutton as a femoral fixation device in 3175 patients and concluded that patients who underwent fixation with the adjustable loop had improved passive knee stability one year post surgery, measured by anterior tibial translation and pivot-shift test results, similar to patients who underwent fixation with the Endobutton. Both devices showed No difference was seen in knee stability or reoperation rates.

In 2018, Rahul Ranjan[77] et al. conducted a prospective randomized study to compare fixed loop and adjustable loop endobutton for femoral fixation of graft in ACL reconstruction in 102 patients and concluded that both fixed and adjustable loop endobutton gives substantially equivalent functional results and knee stability.

In 2018, Sharma et al.[78], conducted a case series using fixed and adjustable loop techniques for early outcome analysis of arthroscopic anterior cruciate ligament reconstruction. A total of 40 cases were included, of which 20 cases underwent fixed loop, and 20 cases underwent adjustable loop fixation. The study’s findings indicated that in an ACL deficient knee, both fixed and adjustable loop techniques offer reliable fixation, comparable graft laxity reduction, and comparable functional outcomes[78].

Joseph T. Gamboa[19] et al. concluded in a 2018 study on the graft re-tensioning technique using an adjustable loop fixation device in arthroscopic anterior cruciate ligament reconstruction that the graft tensioning technique is an easy and efficient way to reduce graft laxity and leave a snug ACL construct[19]. Furthermore, as re-tensioning will reduce the ensuing laxity, re-tensioning the graft following tibial fixation may eliminate the need for a posterior drawer on the knee[19].

In 2019, James Randolph Onggo[4] et al. conducted a multi-database search to study femoral fixation in ACL reconstruction using adjustable vs fixed loop devices. A total of 21 studies were taken for review, of which 11 studies showed a statistically significant large maximum irreversible displacement of the graft in the adjustable loop devices group. Five studies reported statistically significantly higher graft stiffness for fixed loop devices than adjustable loop devices, 2 showed no statistically significant difference, and three studies that examined knotting showed no statistically significant difference between Fixed loop devices and Adjustable loop devices.

In a study conducted in 2019 by John Nyland[79] et al., the quadriceps tendon group included 17 patients, whereas the hamstrings tendon group had 61 patients. Overall, pivot shift laxity was higher in Group 2. Greater pivot shift laxity was seen in Group 2 suspensory femoral fixation compared to Group 1 compression femoral fixation. Additionally, based on the initial and end subject numbers, Group 2 compression femoral fixation showed higher failure rates and more anterior knee laxity than Group 1 compression femoral fixation. Based on the initial and final subject numbers, hamstring tendon compression femoral fixation had a higher failure rate than suspensory femoral fixation.

In 2019, Adnan A Alim Al Sebaie[80] et al. conducted a study to determine the short-term clinical outcome of adjustable suspensory fixation for femoral graft in ACL reconstruction and found that there is no significant difference in tunnel widening of adjustable suspensory fixation for femoral graft in ACL reconstruction with excellent stability and functional and clinical outcome.

In 2019, Hyeon Wook Ahn[81] et al. conducted a comparative prospective study of clinical and radiological outcomes using fixed vs adjustable loop suspensory devices of 79 patients and concluded that both fixed loop and adjustable loop devices in ACL reconstruction provided good clinical and radiological outcomes with no significant differences.

In 2020, SJ Kabir[82] et al. conducted a prospective clinical study for evaluating the functional outcome of bone-patellar tendon autograft in arthroscopic ACL reconstruction, which included 25 patients with Chronic ACL deficient knee. Patients were followed for six months. The quadriceps muscle showed atrophy at the final follow-up, and five patients complained of anterior knee pain.

Ramy Said Assaad Mohamed[83] et al. performed a prospective study in 2020 to assess the outcomes of employing fixed and adjustable loop cortical suspension devices in arthroscopic ACL reconstruction[83]. The study employed Lysholm knee score 12 months after surgery. A total of 60 patients underwent ACL reconstruction with hamstring tendon autograft with fixed and adjustable loop endobutton in 30 patients each. The study concluded that cortical suspensory fixation devices are very effective methods, and although they have different biomechanical profiles, the clinical outcomes are the same[83].

The clinical outcomes of the adjustable loop device and fixed loop device were compared in a prospective randomized study by Naiyer Asif[84] et al. in 2021. They came to a conclusion that ACL reconstruction using fixed and adjustable loop suspensory devices for graft fixation produces comparable and satisfactory clinical results[84].

In 2021, Young Ji Kim[85] et al. conducted a prospective study to study the clinical and radiological results after ACL reconstruction using an adjustable loop device in 80 patients and concluded that ACL reconstruction using adjustable loop cortical suspensory fixation results in good clinical outcomes as well as gives good stability of the knee with relatively little tunnel widening in both Single bundle and Double bundle reconstruction group.

In 2021, Sai Phani Balijepalli[14] et al. conducted a prospective study to evaluate functional outcomes in arthroscopic ACL reconstruction by suspensory fixation in comparison with aperture fixation in 40 patients and concluded that ACL reconstruction by suspensory and aperture fixation methods seem to offer satisfactory results in terms of subjective scores and stability tests in patients with ACL tears, with no particular clinical advantage of one method over the other.

In 2021, Yoshimasa Ono[86] et al. conducted a randomized prospective comparative study of fixed versus adjustable loop endobutton in graft position maintenance in ACL reconstruction. Patients were randomized into two groups with 13 patients each; the study concluded that both fixed loop and adjustable loop had similar graft retaining ability in vivo for 12 months.

In 2021, Ramesh kumar[87] et al. conducted a study to determine the clinical reliability of adjustable femoral cortical suspensory fixation in anterior cruciate ligament reconstruction and the correlation of clinical outcomes with Demographic and Perioperative Factors in 100 patients and concluded that quadrupled hamstring graft with adjustable-loop fixation showed excellent subjective and objective outcomes with no residual laxity or failure of graft over mid-term follow-up. Postoperative laxity was not correlated with graft and tunnel dimensions.

In 2021, Lifeng yin[20] et al. conducted a retrospective study comparing fixed and adjustable loop cortical fixation on 1st day of surgery in 94 patients and concluded that compared to fixed loop endobutton, the adjustable loop endobutton had a reduced gap distance, improved bone preservation, and a similar graft insertion length in the femoral canal[20].

In 2022, Brinkman[88] et al. conducted a prospective randomized comparative study to assess mid-term outcomes of all-soft quadriceps tendon autografts are non-inferior to hamstring autografts in primary ACL reconstruction with a minimum five-year follow-up; study included 37 and 46 patients in quadriceps and hamstring autograft group respectively and concluded that both two and five years postoperatively, the groups showed comparable rates of reaching “minimal clinically important difference” (MCID) criteria. Similar rates of return to sports & post-operative complications were also seen across the two groups.

In 2022, SK Pandey[89] et al. conducted a prospective study for evaluating the functional outcome of arthroscopic anterior cruciate ligament reconstruction using adjustable loop cortical suspensory fixation in 22 patients and concluded that the procedure suggested is an easy, reliable and effective way to reduce graft laxity and maintain a rigid ACL construct. Furthermore, re-tensioning the graft following tibial fixation removes the need for a posterior drawer on the knee because it will reduce any laxity that results from the procedure.

In 2022, Sebastian Schutzenberger[6] et al. conducted a retrospective cohort study to evaluate ACL reconstruction with femoral and tibial adjustable versus fixed loop suspensory fixation. A total of 67 patients were included in the study, which concluded that the use of an adjustable-loop device and fixed-loop device on the femoral side and tibial side led to similar clinical results**.** Although the all-inside technique with adjustable loop fixation and popliteal harvesting did not demonstrate any quantifiable superiority to a technique with fixed loop fixation and anteromedial semitendinosus harvesting, it is less invasive causing a significantly lower rate of saphenous nerve lesions and might bring cosmetic benefits.

In 2022, Simone Birkebaek[5] Elmholt et al. conducted a meta-analysis and a systematic review of fixed loop vs adjustable loop cortical button devices for femoral fixation in ACL reconstruction. The study concluded no differences regarding knee laxity and patient-related outcomes, and both devices are safe to use in ACL reconstruction.

In 2023, Christian Hwee Yee Heng90 et al. conducted a prospective clinical study comparing fixed-loop device (FLD) vs adjustable-loop device (ALD) graft fixation outcomes with 2-year follow-up in patients undergoing primary ACL reconstruction. The study included 105 patients, and they concluded that FLDs and ALDs for suspensory fixation of hamstring tendon autograft in ACL Reconstruction had similar clinical outcomes with at least of 2-year follow-up. There was no evidence of graft loosening from loop lengthening.

In 2023, Ronak Yashwantbhai khatri[91] et al. conducted a randomized controlled study to evaluate functional outcomes of quadriceps tendon vs. hamstring tendon autograft using suspensory fixation at femoral and tibial sites for primary anterior cruciate ligament reconstruction. 34 patients were included in the study and randomization was done into two groups, and functional outcomes were assessed using Lysholm knee score and IKDC scores. The study concluded that at the end of 2 years of follow-up, both autografts showed similar outcomes, with no specific graft site complications.

A comparative study on the clinical outcome of femoral side graft fixation in primary ACL reconstruction was carried out in 2024 by R Prabhakar Singh[92] et al. Two endo button groups were created for a total of forty patients: group A had a fixed endo button, while group B had an adjustable loop endo button. It concluded that there were no significant differences in clinical outcomes in both fixed and adjustable loop endo buttons, but the benefit of an adjustable loop endo button is that it allows for intra-operative tibial fixation and post-cycling graft retightening[92].

In 2024, Ahmed M. Abdulwahab1[5] et al. conducted a meta-analysis to evaluate functional outcomes after ACL reconstruction using an adjustable femoral cortical suspensory fixation device. The meta-analysis included ten research studies with a total of 613 patients, and they concluded that using the adjustable loop suspensory fixation device for ACL reconstruction produces favorable functional outcomes in terms of knee stability and mobility.

In 2024, Janina kaarre[93] et al. conducted a study to determine whether interference screw (metal) fixation combinations manifest high revision rates in primary hamstring tendon ACL reconstruction. 23,238 patients that underwent primary hamstring tendon autograft between 2005 to 2018 were included and they concluded that metal interference screw fixation, especially when performed on both, femoral and tibial sides, most commonly resulted in a revision surgery.

EMBRYOLOGY

Knee joint development begins around the fourth week of intrauterine life, with recognizable knee structures forming by the sixth week[94]. According to Wojciech Ratajczak's [95] studies of 43 embryos between developmental stages 18 and 23 (44–56 postovulatory days), at stage 18, embryos exhibit a uniform Interzone that will develop into the knee joint.

By stage 19, the cruciate ligaments originate within the medial region of this interzone, alongside the differentiation of the Interzone into dense, intensely stained peripheral areas, which are the meniscal primordia.

By stage 20, all internal structures of the knee joint are further defined, culminating in complete formation during stages 21 to 23.

Initially developing as a ventral ligament, the anterior cruciate ligament (ACL) advances as the intercondylar gap forms. It emerges prior to joint cavitation and remains outside the synovial space. The common developmental origin from the blastema underscores the coordinated development of both the meniscus and the cruciate ligament.[94]

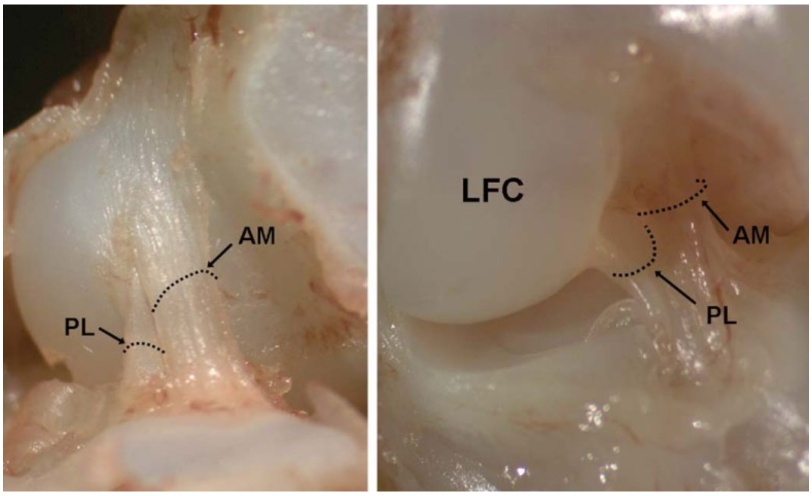


Figure 1. 16-week fetus demonstrating ACL with the knee in extension and flexion (AM- anteromedial, PL- posterolateral, LFC- lateral femoral condyle)[96]

ANATOMY

The anterior cruciate ligament (ACL) is situated intra-articularly but outside the synovial membrane, composed of multiple fascicles of robust connective tissue. It spans between the femur and tibia, originating from the medial aspect of the posterior part of the lateral femoral condyle. Its trajectory within the knee joint is oblique, terminating in a substantial area at the center of the tibial plateau. Throughout its path, the ligament fibers exhibit a slight external rotation.[97]

The anterior cruciate ligament (ACL) measures approximately 44 mm^3 in thickness at its mid-substance, with an average width of 11 mm[97], expanding nearly threefold at its attachment sites[98,99]. Its total length ranges from approximately 31 to 38 mm[100]. The precise anatomical positioning of the graft during ACL reconstruction is critical due to the isometric nature of its attachment sites.

The ACL originates on the medial surface of the posterior part of the lateral femoral condyle within an ovoid region measuring approximately 18 mm in length and 11 mm in width[101]. The anterior attachment is nearly linear, while the posterior attachment exhibits a convex curvature[97]

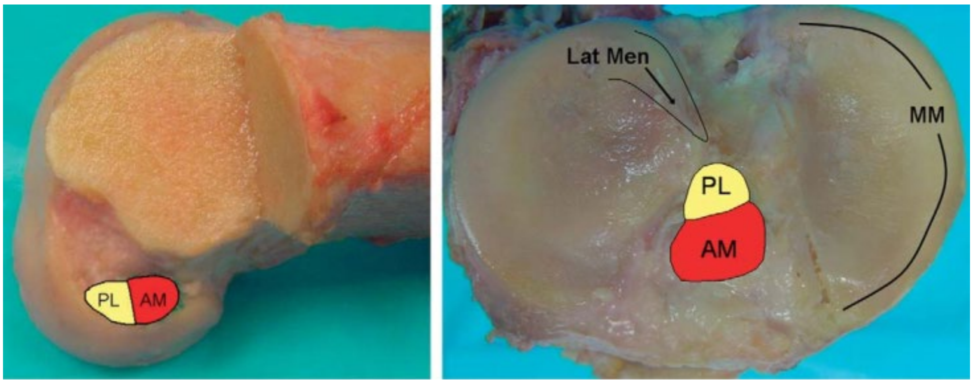


Fig 2.[105] ACL femoral and tibial insertion sites (MM- medial meniscus, Lat Men- lateral meniscus)

The tibial attachment of the ACL occurs at the medial and lateral tibial spines, positioned anterolaterally to the tibial tubercle within the intercondylar fossa. The axial dimensions of the ACL insertion measure approximately 11 mm in the coronal plane and 17 mm in the sagittal plane.[98,102]

The anterior cruciate ligament (ACL) has been the subject of various theories, including single, double, and triple bundle concepts. Presently, the prevailing understanding acknowledges two distinct functional bundles: the anteromedial (AM) bundle and the posterolateral (PL) bundle, distinguished by their respective tibial insertions. The PL bundle originates distally at the femoral attachment and inserts into the posterolateral aspect of the tibial insertion[98], while the AM bundle begins proximally at the femoral origin. These anatomical distinctions have garnered significant attention in the context of ACL reconstruction surgery.

The alignment of the anteromedial (AM) and posterolateral (PL) bundles of the anterior cruciate ligament (ACL) undergoes significant changes as the knee transitions from extension to flexion. In full extension, these bundles' femoral attachment sites are vertically oriented and parallel, whereas at 90 degrees of flexion, their orientation shifts to a horizontal position, resulting in a crossing pattern. Functionally, the PL bundle tightens during knee extension and loosens during flexion, whereas the AM bundle exhibits the opposite behavior.

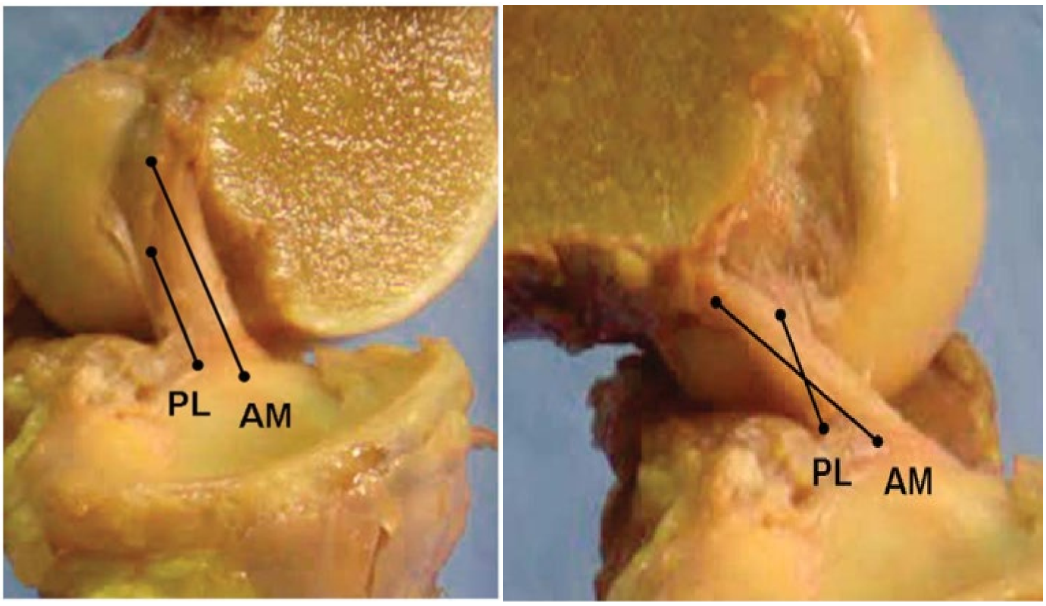


Fig 3[106]. Crossing pattern of Anteromedial (AM) and Posterolateral (PL) bundles in extension and in flexion

The differential functional roles of these bundles imply specific clinical implications. Failure of the PL bundle predominantly affects the Lachman test, which assesses anterior translation of the tibia due to its role in stabilizing the knee during extension. Conversely, isolated rupture of the AM bundle tends to impact the anterior drawer test more significantly, which evaluates anterior tibial translation. Additionally, the PL bundle plays a critical role in preventing both internal and external rotation of the knee[103,104], further highlighting its importance in overall knee stability.

Blood supply[107]:

The blood supply to the anterior cruciate ligament (ACL) primarily originates from the middle genicular branch of the popliteal artery. This branch enters the posterior capsule directly and extends distally to the junction of the joint capsule beyond the infrapatellar fat pad. Within this region, branches penetrate the synovial membrane, contributing to a synovial plexus that surrounds the entire ligament. Additionally, certain arteries may potentially nourish this synovial plexus by smaller terminal branches of the lateral inferior geniculate artery.

The ACL itself receives vascular penetration from finer branches, which anastomose with a network of longitudinally oriented vessels within the ligament. These vessels align parallel to the collagen bundles, supporting the ligament's vascular needs.

Nerve supply[108]: The posterior-articular branch of the posterior tibial nerve innervates the anterior cruciate ligament (ACL). The majority of neural structures are found in the sub-synovial levels and close to the origin of the ACL. Within the ACL, nociceptive receptors include Ruffini receptors resembling stretch receptors and free nerve terminals. The ligament's substance contains small nerve fibers involved in proprioception and nociception.

Histology[109]: The diameter of collagen fibrils that make up the anterior cruciate ligament (ACL) ranges from 150-250 nm arranged intricately to form a complex network. These fibrils exhibit distinctive organizational structures, including non-linear, parallel or twisted, helical, and planar configurations. The central fascicles within the ACL may present as either straight or distorted, whereas those peripheral to the ligament are typically organized in a helical pattern. The terms "crimp" and "recruitment" characterize the primary wave-like feature and the non-linear arrangement of ACL fibrils, respectively[110].

The matrix of the anterior cruciate ligament (ACL) exhibits a distinctive sinusoidal pattern known as the crimp, which acts as an accordion-like buffer. This design allows the ligament to withstand minimal extension without causing damage to its fibers, functioning akin to a shock absorber along its length[111]. Essentially, during tensile stretching, small stresses initially straighten the crimp in the fibrils, requiring larger stresses for further elongation. This recruitment of additional fibrils to bear the load results in a non-linear load-elongation curve, gradually increasing tissue stiffness with higher loads.

Microscopically, the anterior cruciate ligament (ACL) exhibits three distinct zones. The proximal section is characterized by a high cellular density containing fibroblasts, glycoproteins, and type II collagen. In the middle section, there are fusiform and spindle-shaped fibroblasts alongside dense collagen fibers. This region also features elastic fibers capable of enduring repeated maximum stress, as well as oxytalan fibers capable of withstanding multidirectional loads. The distal section of the ACL is notable for the prevalence of chondroblasts and ovoid fibroblasts.

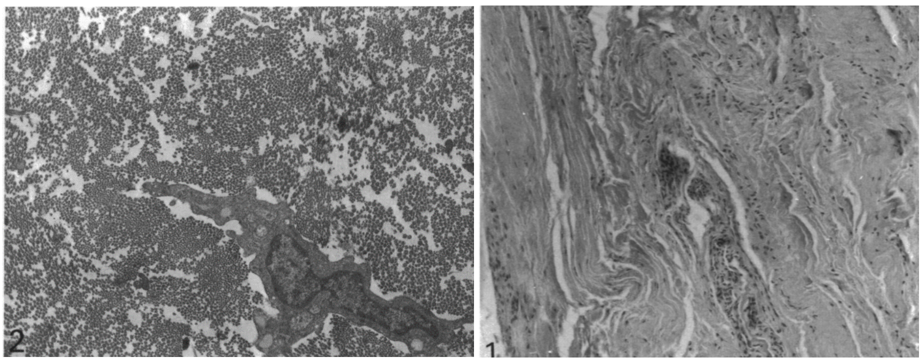


Fig 4[109]. Showing Transverse section of ACL (composed of collagen fibrils) & Fig 5[109], showing the Longitudinal paraffin section subdivided into fascicles.

The interface between pliable ligamentous tissue and rigid bone is a critical component of the anterior cruciate ligament (ACL) structure. This junction is facilitated by a transitional zone composed of fibrocartilage and mineralized fibrocartilage. Typically, this architectural region includes the ligament itself, the subchondral bone plate where the ligament attaches, and non-mineralized and mineralized cartilage zones. This microstructural transition not only accommodates a gradual shift in intrinsic elasticity but also effectively mitigates stress concentration at the attachment site.

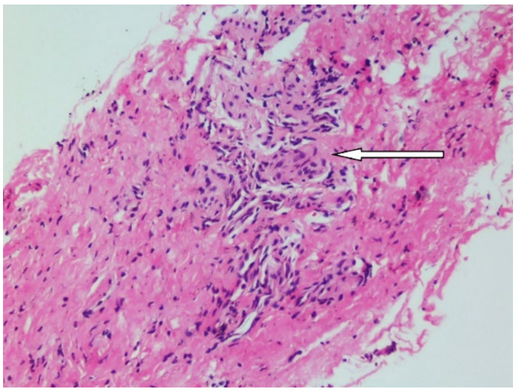


Fig 6[112]. ACL partial tear

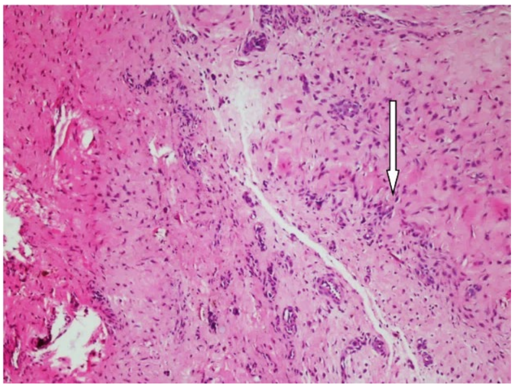


Fig 7[112]. ACL complete tear

Functions of Anterior Cruciate Ligament[113]:

In addition to its roles in proprioception and mechanical support, the anterior cruciate ligament (ACL) significantly contributes to both static and dynamic joint balance. Histological studies revealing nerve endings within the ACL affirm its proprioceptive function.

The ACL exhibits a maximum tensile strength of approximately 1725 +/- 270 N, which falls short of the peak forces encountered during vigorous sports activities. Dynamic stabilizers such as muscles play a crucial role in enhancing joint stability by distributing stress across the knee[97].

Mechanically, the ACL functions to resist anterior translations both during extension (posteromedial bundle) and at 90 degrees of flexion (anteromedial bundle). The posteromedial bundle also provides resistance against hyperextension. Furthermore, the ACL serves to control knee rotation by limiting internal rotation and stabilizing the joint as it nears full extension. Additionally, throughout the range of knee flexion, the ACL acts as an additional barrier against stresses from adduction and abduction.

Injury Mechanism:

The medial and lateral structures provide coronal plane stabilization to the knee joint, while the cruciate ligaments, in conjunction with capsuloligamentous structures, ensure sagittal plane and rotational stability. The roles of major and secondary stabilizers are influenced by the joint's positioning. During knee flexion, the femur rotates on the tibia, causing relaxation in the knee capsule and other ligamentous structures, thereby increasing the susceptibility to ligament injury.

Ligament damage occurs when sufficient force is applied, resulting in persistent distortion. The most frequent cause of anterior cruciate ligament (ACL) tears is rotational trauma, which includes mechanisms such as flexion-valgus-external rotation, flexion-varus-external rotation, forceful external rotation, or hyperextension trauma[115]. Rotational trauma often arises from abrupt changes in direction or deceleration and can occur as a non-contact injury (70%), such as during football or soccer, or as a contact injury (30%), such as in a car collision with bent knees.

For significant knee injury from valgus forces, the medial collateral ligament (MCL) must remain intact. However, when the MCL is damaged due to persistent abduction thrust, the ACL is also at risk. Additionally, when rotational forces are involved, the medial meniscus can become trapped between the femoral and tibial condyles, leading to the classic "Unhappy Triad of O'Donoghue," which includes injuries to the ACL, MCL, and medial meniscus.

Women are more susceptible to anterior cruciate ligament (ACL) injuries due to anatomical differences such as a smaller intercondylar notch, a greater Q angle, and a smaller and less strong ACL. Despite these predispositions, demographically, men sustain more ACL injuries overall.

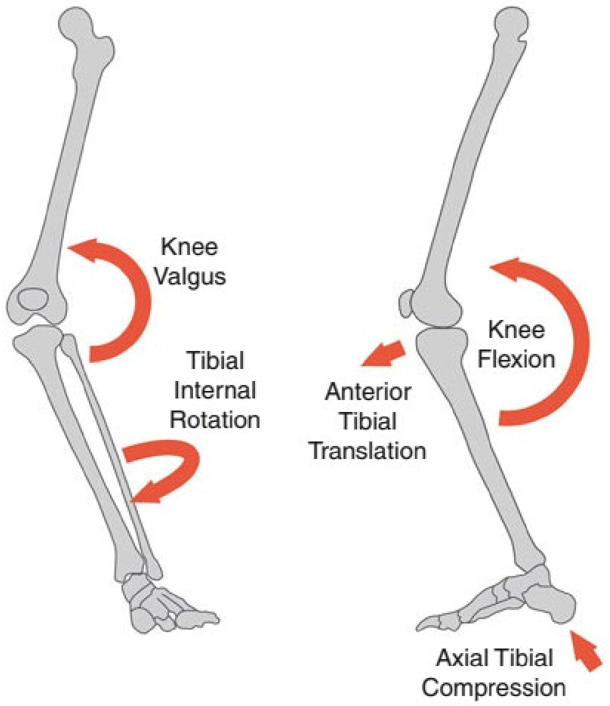


Fig. 8[114], Multidirectional mechanism of ACL injury

Natural history:

When compared to people without history of ACL injury before, the chance of having another one occurs fifteen times more frequently in the first year after ACL repair and returning to sports. Approximately 50 to 70 percent of acute ACL injuries are accompanied by meniscal injuries, with the lateral meniscus being most frequently affected in acute cases.

In knees with ACL deficiency, late meniscal injury is quite prevalent because of aberrant loading and shear forces.. In chronic ACL injuries, the medial meniscus is more commonly injured due to its close association with the capsule.

Research indicates that meniscal tears and chondral injuries, which can eventually lead to arthritis, are likely to develop in ACL-injured individuals who return to athletics and experience repeated episodes of instability. After an initial ACL injury, 21–31% of people suffer from osteochondral alterations. Both acute and chronic ACL injuries can be sensitively detected by magnetic resonance imaging (MRI), and these osteochondral abnormalities may be early signs of osteoarthritis.

Clinical Evaluation:

The initial step in the clinical examination of a patient with an ACL injury involves obtaining a comprehensive clinical history. Typically[115], ACL ruptures are most commonly a result of rotational trauma (flexion-valgus-external rotation, flexion-varus-internal rotation, forced external rotation) or hyperextension trauma.[115]

Common symptoms frequently described by patients in acute ACL injury are[115]:

- feeling or hearing a pop in the knee.
- being unable to resume the prior activity
- joint effusion developing quickly, usually within an hour
- mechanisms of injury that typically involve a change in direction (e.g., a noncontact injury incurred during a sudden change of direction in football)

If the test is done soon after the injury, it is easy. Muscular guarding would not have been developed by that point. Hemarthrosis, or an effusion, is frequently but not always present.[115]

During presentation, pain and knee giving way are common symptoms. Meniscal injuries are frequently identified by locking episodes or clicking or clunking sounds. Comprehending the unique state and requirements of a patient is essential to customizing the course of treatment.

Physical Examination:

The clinical examination involves a sequential approach, starting with inspection, followed by palpation, measurement, and movement assessment. To aid in diagnosis and the subsequent treatment plan, specific tests are performed for the menisci, collateral ligaments, and cruciate ligaments.

Tests performed for ACL injuries:

With the patient in a supine position with hip and knee flexed at 45 and 90 degrees, respectively, the **"Anterior Drawer Test"** is performed. The examiner stabilizes the patient's foot by sitting on the dorsal aspect. A gentle anterior and posterior force is applied to the proximal tibia, observing the relative movement of the tibia to the femur. This maneuver is repeated with the tibia in both 30 degrees of external rotation and 30 degrees of internal rotation.

An anterior displacement of approximately 5 to 7 mm compared to the contralateral side indicates an ACL injury. To avoid false positive results, it is essential to first check for posterior tibial sagging.

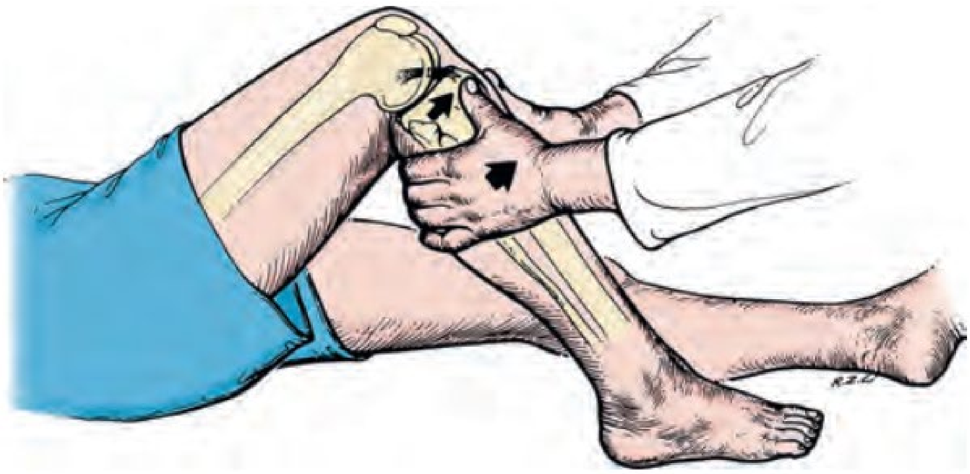


Fig. 9[117]: Anterior Drawer Test

Lachman test[116]: When an acutely sore knee prevents performing the Anterior Drawer Test due to the inability to achieve 90-degree flexion, the Lachman Test can be utilized as an alternative. In this test, the patient lies supine with the joint slightly externally rotated and flexed between 0 to 20 degrees.

The examiner stabilizes the femur with one hand while using the other hand to translate the proximal tibia anteriorly. The thumb should support the anteromedial joint edge of the proximal tibia[139]. A soft anterior translation of the tibia relative to the femur confirms an ACL injury.

The posterolateral (PL) bundle of the ACL is relaxed in flexion and tightest in extension, making the Lachman Test more sensitive for assessing the PL bundle. Conversely, the anteromedial (AM) bundle is relaxed in flexion and tightest at 60 degrees of knee flexion, making the Anterior Drawer Test more sensitive for evaluating the AM bundle.

The most sensitive and specific clinical test for ACL injury is the Lachman test[115]. The Lachman test is superior than the conventional anterior drawer test in several ways. It is very sensitive to ACl rupture, however haemarthrosis has very little effect on it.[115] It can be done with comparatively little pain, even in cases of acute injuries, because the slightly flexed position helps to relax the muscles surrounding the knee. In the event of a unilateral ruprure, this position also allows for more anterior tibial translation.[115]

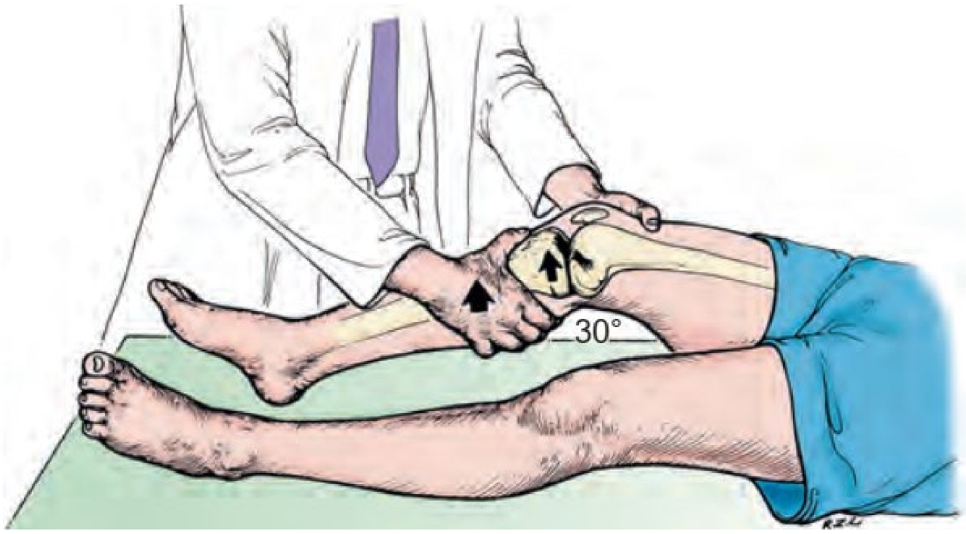


Fig. 10[117] : "Lachman Test"

Pivot shift test[116]:

The subluxation that occurs when the ACL is injured can be elicited using this indirect test for ACL damage. The typical pivot-shift manoeuvre, demonstrated by Callway and McIntosh, involves positioning the patient in a supine position.

The examiner lifts the affected limb from the table, holding the ankle and internally rotating it. The knee should be fully extended, and the limb should be completely relaxed. The test might not be accurate if the knee cannot extend fully due to discomfort or swelling[116].

Anterior subluxation of the tibia over the femur results from the femur dropping posteriorly due to gravity following an ACL rupture. With one hand, the examiner flexes the knee while applying a valgus force and gripping the lateral side of the proximal portion of the leg[116]. As the knee is flexed between 15 to 30 degrees, the anteriorly subluxed tibia will suddenly reduce to its normal position with an audible or palpable clunk.

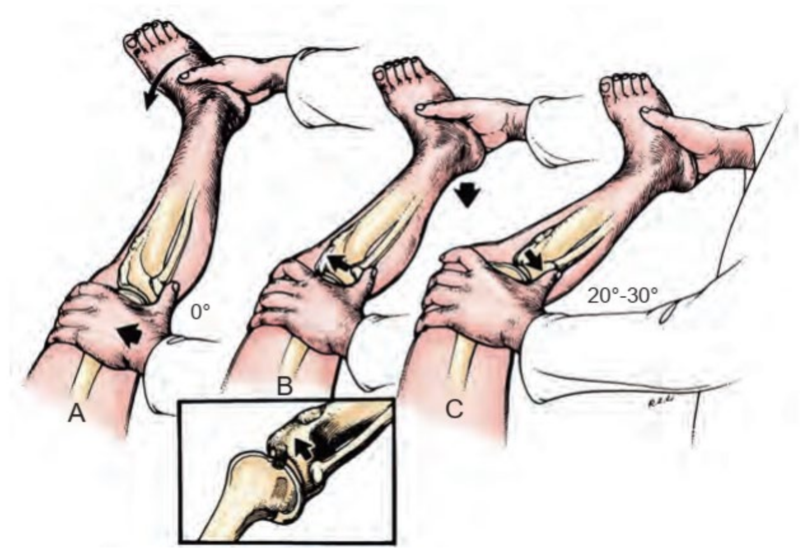


Fig. 11[117]: Pivot-Shift Test

McMurray test[117]:

The McMurray test produces a palpable click on the joint line[118]. Medially, this is demonstrated by externally rotating the tibia and passively moving the knee from flexion to extension.

Laterally, it involves internally rotating the tibia and passively moving the knee from flexion to extension. A posterior tear may cause a click within the initial degrees of movement from full flexion. If a click is felt later as the knee extends further, the tear is likely more anterior.

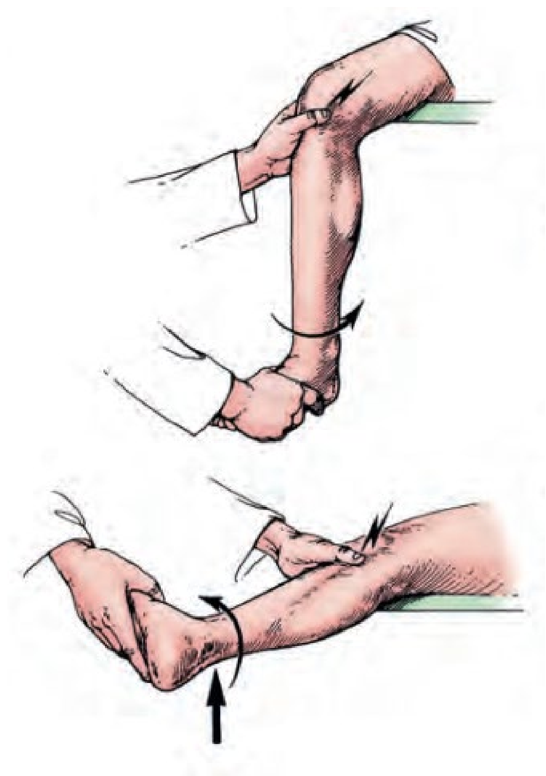


Fig. 12[117]: McMurray Test

Radiographic evaluation:

To evaluate for degenerative changes, fractures, alignment, and other associated injuries, anteroposterior (AP) and lateral X-rays should be taken. Radiographs may reveal Segond fractures, which involve the lateral tibial rim[119,120], and posterior lateral tibial plateau fractures [121-124], as well as tibial spine avulsion fractures[125], which are more common in patients with immature skeletons.

During the anterior drawer test, stress radiographs (lateral view) are used to demonstrate ACL injury. An abnormal anterior translocation is defined as greater than 5 mm. A discrepancy of more than 3 mm when compared to the contralateral knee is also considered significant. X-rays can occasionally show a prominent lateral condyle-patellar groove, known as the "deep lateral femoral notch sign," which results from a pivot-shift injury.

Magnetic resonance imaging:

Preoperative assessment of the patient is done by MRI, a non-invasive method that helps to see the ACL and other surrounding soft tissue components of the knee.

The obliquity of the ACL in the sagittal plane usually requires several images to be visualised[126]. Its normal orientation or slope runs parallel to the femoral intercondylar roof. ACL is diagnosed as normal when it appears as a band of fibers of low signal intensity[128] with a small divergence distally on T1, proton-density, or T2-weighted sagittal images.

The torn ACL is indistinct and appears lax[122]. When a disrupted ligament exhibits focal or generalized elevated signal intensity on T1. Proton density, or T2 weighted imaging and no sequencing demonstrates a normal ligament, the ligament is said to be torn.[128] The signal intensity in ACL tear is higher than that of the normal ligament, intermediate signal intensity on proton-density images and is mildly hyperintense on T2-weighted images.[127]

Normal ACL is seen in the coronal plane as a low signal intensity structure[128] on posterior images, extending to the tibial plateau on anterior images and next to the medial aspect of the lateral femoral condyle on posterior images[128]. ACL is diagnosed as torn when no sequence shows a normal ligament and when primary signs such as diffuse increased signal intensity in the ligament, rendering individual fibers unrecognizable or T1 or T2 weighted images show localized enhanced signal intensity in fibers at the femoral origin of the ACL despite the existence of a few intact fibers at the tibial plateau[128].

MRI detects associated injuries such as a lateral notch fracture and bone contusions or bruises[115]. Bone bruise denotes a collection of medullary signal intensity abnormalities resulting from subcortical infarction, oedema, or haemorrhage, and is diagnosed when a circumscribed area of low signal intensity on T1, along with area of increased signal intensity on T2-weighted images, is observed in trabecular bone without cortical fracture[128]. Bone bruises in the lateral compartment are seen in roughly half of acute ACL tears.[122,129]

In research by Adriaensen130 et al., 94% of patients were able to see the anteromedial and posterolateral bundles of the ACL when they underwent three-tesla field strength MRIs.

Primary Signs of ACL Injury[138]:

1. ACL not visible at its normal location
2. Interruption in Continuity
3. Nonlinearity or Angulation
4. Abnormal Axis of the ACL: Proximal poor visualization with a flattened distal ligament axis

The axis of the ACL is normally parallel to the "Blumensaat line" (intercondylar roof line) on the sagittal plane. If the ACL axis appears horizontal compared to Blumensaat's line, it is considered abnormal.

Fig. 13[122]: Normal ACL on oblique sagittal T2 weighted image (arrow)

Fig. 14[122]: Ill-defined and lax ACL within intercondylar notch on T2 Weighted image (arrow points to complete tear)

Secondary signs:

Secondary indicators are those that indicate ACL damage in addition to the actual abnormalities of the ACL.

1. Bone bruising & osteochondral fracture from pivot shift in the condyles (Fig. 15)
2. Counter-coup medial tibial bone bruising
3. The tibia's anterior translation (sagittal MRI)
4. LCL that is vertical
5. Segond's fracture (Fig. 16)
6. fractured tibial spine
7. Redundant or oddly curved PCL
8. Arcuate fibular head fracture

Fig. 15[126]: T1 image coronal view with arrow pointing at Segond fracture

Fig. 16[122]: T1 coronal image showing the lateral compartment Bone contusions

Chronic ACL tears:

Signs of chronicity include bone bruising and edema at the knee, though all signs of acute ACL tears may also be present.

Patients may report a history of instability, though this is not always the case. Instability classically occurs during pivoting movements, but symptoms can vary widely. Any indication of instability should prompt the orthopaedician to consider and evaluate for a potential ACL tear.[115]

The "empty notch sign" describes a condition where the ACL is absent, and the lateral intercondylar notch on the MRI shows only fat.

The MRI has sensitivity and specificity of 92 to 94% and 95 to 100%[131] for identifying ACL injuries.

INSTRUMENTATION

Arthroscopic ACL reconstruction necessitates specialized equipment both for knee arthroscopy and for the procedure itself.

1. Camera
2. Television monitor
3. Light source & fiber-optic cable
4. Endoscope (4mm 30^0)
5. Shaver system and handpiece
6. Pneumatic Tourniquet

Instruments needed for surgery include:

- 2.4 mm drill tip guide pins
- Beathed Pin (Extra-long 2.4 mm long with sutured eye)
- Trocar (5 mm)
- Cannula
- Probe
- Burrs and shaver system (motorized instruments)
- Tibial aimer
- Cannulated reamers (4.5 to 10 mm)
- Femoral aiming guide (6-7mm off-set)
- Depth-gauge
- Graft preparation board

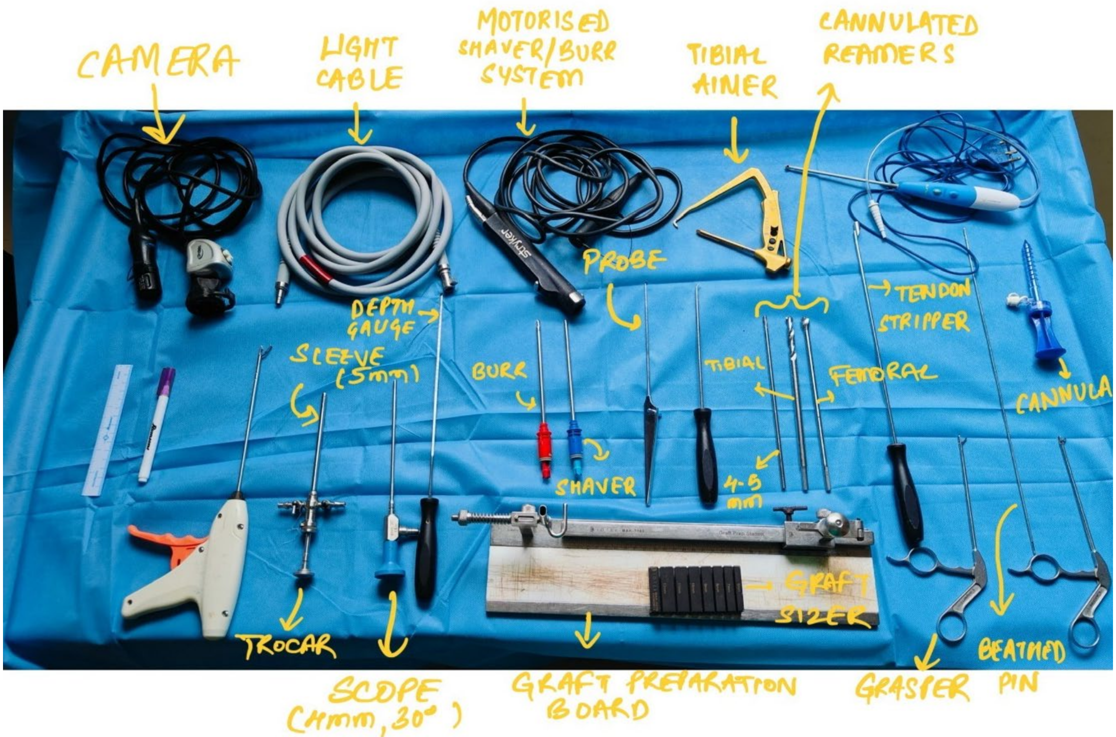


Fig. 17: Specialised equipment and instruments required for ACL reconstruction

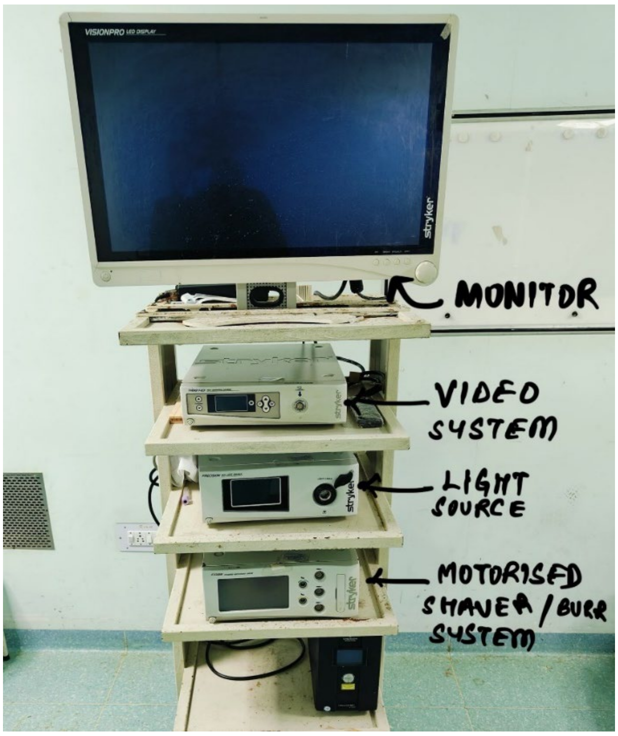


Fig. 18: Tower with monitor, light source, video system and motorized device system

AVAILABLE GRAFT OPTIONS

The most commonly used grafts for ACL reconstruction are chosen for their easy availability, the downside being donor-site morbidity:

1. Patellar Tendon with attached bone plugs (BPTB)
2. Semitendinosus/Semitendinosus + Gracilis tendons (HT)
3. Quadriceps tendon (QT)
4. Peroneus longus tendon (PL)

Semitendinosus:

Hamstring grafts are widely used for ACL reconstruction[132]. A four-strand semitendinosus is 280% as strong as the ACL. Overall, quadrupled semitendinosus and doubled semitendinosus with gracilis grafts are the strongest available grafts in common use.[133]

The advantage of Semitendinosus tendon autograft is a small incision (can be harvested through only a 3 cm incision), no extensor apparatus compromise (intact quadriceps muscle, patellar tendon and tibial tuberosity), unaffected post-operative kneeling, favourable elastic modulus (4 strand graft elastic modulus same as normal ACL)

Semitendinosus[115]

Disadvantages of semitendinosus tendon autograft donor site morbidity: intraoperative graft preparation is time-consuming and can prolong surgery time, and it is difficult to identify and harvest the tendon.[115]

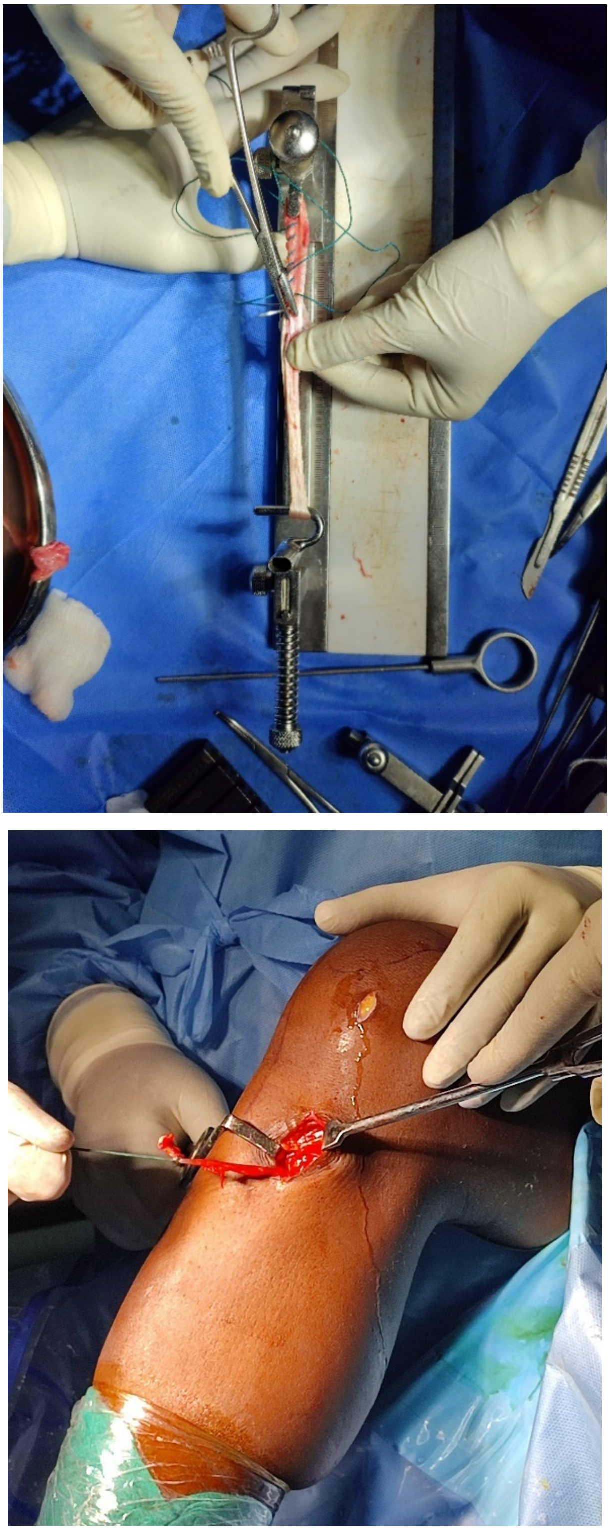


Fig. 19: Semitendinosus graft harvesting and preparation

Allografts :

Grafts (BPTB/HT/QT/PL) harvested from cadavers present a potential alternative to synthetic materials, particularly beneficial for revision surgeries or cases involving multiple ligament injuries. Their advantages include easy availability and the absence of donor-site morbidity. However, disadvantages include the potential for immune reactions that can lead to synovitis, as well as the costs associated with procurement and storage.

Synthetic Materials:

Prosthetic ligaments are typically braided and woven from various polymeric materials. However, they have largely been discontinued due to several disadvantages, including low biocompatibility leading to rupture, high cost, and the requirement for additional fixation inside the tunnel using interference screws, which often necessitates an extra lateral incision for screws or staples. Materials used by different manufacturers have included:

- Nylon
- Dacron
- Teflon
- Carbon Fiber

These materials were used in attempts to create durable synthetic ligaments, but their limitations and complications have led to their decreased usage in favor of autografts or allografts in ACL reconstruction surgery.

FIXATION METHOD AND IMPLANTS

There are three primary types of fixation methods for soft-tissue grafts, including:

1. Headless Interference Screws:

These fixation devices are used to secure the graft in place by being placed between the bone tunnel and the graft itself. There are two main types available: titanium interference screws and bio-absorbable interference screws.

Advantages:

- Low-profile design
- Enables intra-articular placement

Disadvantages:

- Potential for graft injury during screw advancement
- Graft can advance under tension during screw insertion
- Risk of graft position change during screw advancement
- Risk of screw dropping into the posterolateral recess during insertion
- Potential for blow-out of the posterior condylar cortex
- Difficulty in locating the screw during revision if it was inserted deeply into the tunnel

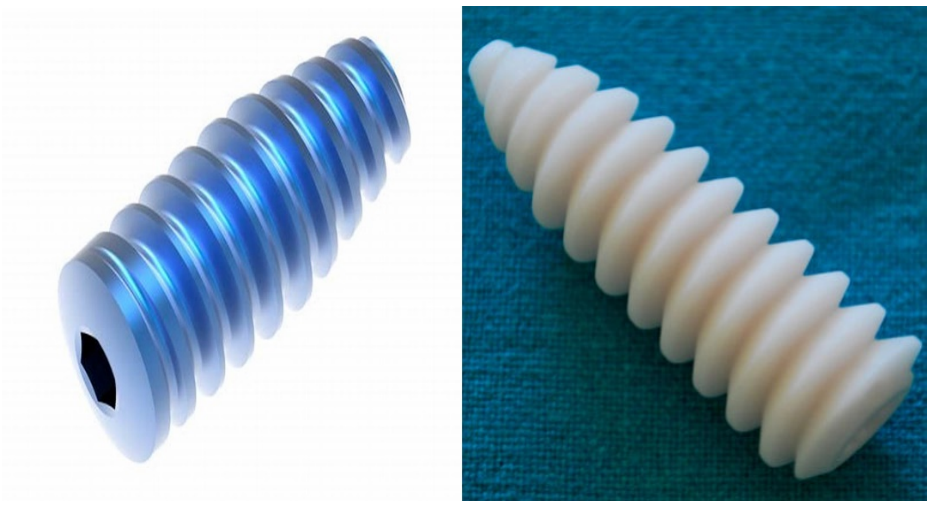


Fig. 20: Titanium and Fig Bio-degradable interference screw

Bio-degradable Screws:

These bio-screws have a fixation strength comparable to titanium screws while also ensuring controlled resorption and osteointegration to form structural bone through hydrolysis. They are typically composed of 75% PLDLLA (Poly-d, l-lactic Acid) and 25% BCP (Bathocuproine).

Advantages of Bio-screws:

- Removal is not necessary as they degrade over time
- MRI compatible

Disadvantages of Bio-screws:

- Potential for immune reactions
- Visco-plastic deformation can weaken the strength of fixation over time

2. Suspensory Extra Cortical buttons

Endobuttons and tibial base plates are types of fixation solutions commonly used in ACL reconstruction.

Advantages:

- Small size
- Stable fixation
- Ease of placement
- Compatible with most autografts
- Revision possible without complications to the tunnel

Disadvantages:

- Wide separation between fixation points
- Tunnel widening due to the "windshield wiper effect" (graft movement in the same direction as the tunnel) and the "bungee effect" (graft movement at right angles to the tunnel)

These fixation devices provide effective stabilization of the graft but may lead to tunnel widening over time due to the described mechanical effects.

Endobutton:

The endobutton is designed to secure the majority of the graft within the tunnel during ACL reconstruction. Usually, it has 4 holes, with a loop for the quadrupled graft formed by the two in the middle. The two holes in the periphery permit sutures to pass through, facilitating flipping of the endobutton if needed. They are easy to place, are small-sized sized and avoids a lateral incision.[115]

In terms of strength against cyclical stress, the endobutton is typically stronger than an interference screw. This strength and the design of the endobutton contribute to its effectiveness in maintaining graft stability and minimizing graft movement within the tunnel during knee motion.

Fig. 21: Adjustable Loop Endobutton

3. Cross Pins:

In addition to interference screws and endobuttons, other fixation tools used in ACL reconstruction include:

- Staples
- Polyester tapes
- Suture-posts
- Screws with washers

\

4. **Suture Disc (Fixation Button)[115]:**

Tibial fixation is achieved using a special round button that has two openings. Positioning of the button is at the inlet of the tibial tunnel, and the graft fixation sutures are threaded from the openings and tied over the button[115].

The suture disc is small in size and has a recess for burying the suture knots (unlike a screw). The fixation can be adjusted and further tightened even after the sutures have been tied by carefully rotating the button to increase tension.[115]

Fig. 22: Suture Disc

In our study, tibial base plates were used on the tibial side, while adjustable loop endo buttons were used on the femoral side.

DIFFERENT FEMORAL TUNNEL PREPARATION TECHNIQUES

In contemporary ACL reconstruction techniques, the preference in tunnel preparation is to place the graft in an isometric position relative to knee movements. This means that there should be minimal change, ideally not more than 1-2 mm, in the distance between the femoral and tibial attachments of the graft during flexion and extension of the knee.

Placing the femoral tunnel too far anteriorly can lead to a non-isometric condition, where the graft experiences different tensions throughout the range of motion. This non-isometric placement can cause difficulties, particularly during knee flexion, affecting the stability and function of the reconstructed ACL. Therefore, precise placement of the femoral tunnel is crucial to achieving optimal isometric conditions and functional outcomes post-surgery.

Access for Femoral tunneling:

1. **Trans Tibial:** The technique of trans-tibial tunneling in ACL reconstruction relies on drilling through the tibia to guide femoral tunnel placement, yet it may result in suboptimal positioning (11 or 1 o'clock) compared to preferred positions (10 or 2 o'clock), potentially compromising knee biomechanics and stability

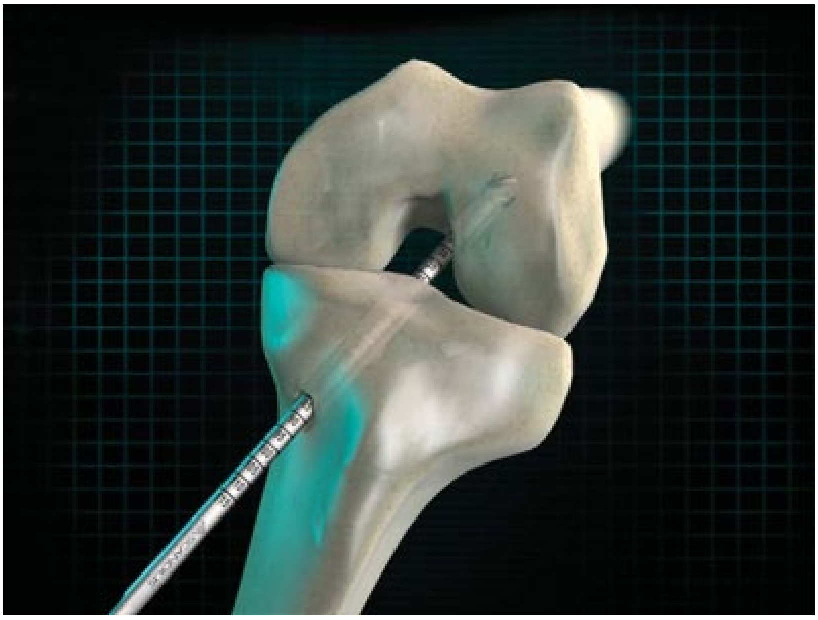


Fig. 23: Transtibial Femoral Drilling

2. **Trans Portal**: The technique of trans-tibial tunneling in ACL reconstruction involves knee hyperflexion and utilizes either the medial instrumental portal or accessory far medial portal, which poses risks of damaging the Vastus medialis obliquus. Additionally, there is a potential for injury to the medial femoral condyle and its cartilage during the drilling process.

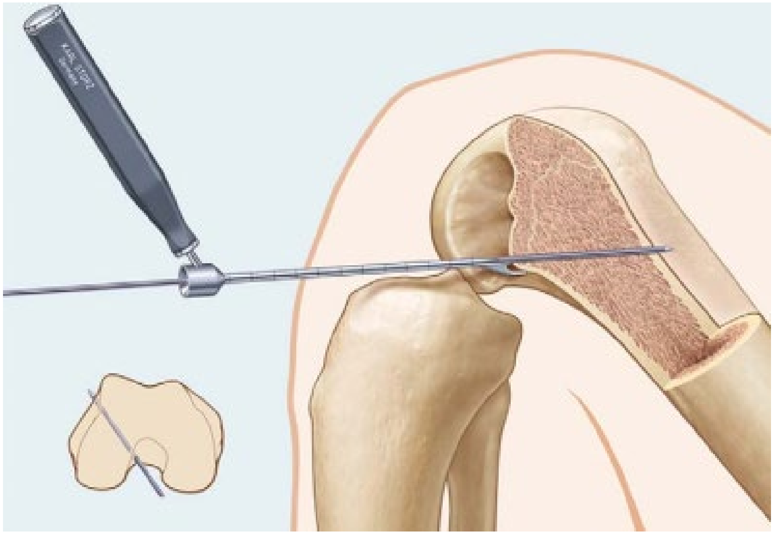


Fig. 24: Trans Portal tunnel technique, the femoral tunnel is created in 120-130 degrees of flexion

3. **Tunnel placement through lateral incision:** Old practice is not in use nowadays. Smaller incisions are required for interference screws, while longer incisions for headed screws with washers might be necessary.

POST OPERATIVE REHABILITATION PROTOCOL

Our post-operative rehabilitation protocol consists of six phases:

Phase 1 (0-14 Days):

- Initiation of quadriceps strengthening (static), dynamic exercises, and straight leg raises as tolerated; consideration of electric stimulation for inadequate quadriceps strength.
- Patellar mobilization (superior-inferior).
- Ankle pumps.
- Gradual increase in range of motion up to 90 degrees by the end of the second week, with emphasis on achieving full extension using ankle support and passive techniques.
- Initiation of partial weight-bearing with crutches, progressing to full weight-bearing as tolerated.

Phase 2 (2-10 weeks):

- Gradual increase in range of motion up to 120 degrees by the end of the sixth week, with emphasis on cycling to enhance flexibility.
- Discontinuation of crutches and achievement of full weight-bearing without a limp by the fourth week.
- Progressive quadriceps strengthening through dynamic exercises, straight leg raises with weights and hamstring curls.
- Therapist-assisted extension from 90 to 40 degrees with manual resistance.
- Introduction of lunges by the eighth week.

Phase 3 (3-4 months):

- Knee extension exercises with high repetitions or low weight.
- Isokinetic quadriceps exercises until full extension is achieved.
- Implementation of slow and controlled drills for lateral sports.

Phase 4 (4-5 months):

- Commencement of jogging and jump rope exercises if there is no effusion, full range of motion, and a stable knee with sufficient quadriceps strength.

Phase 5 (5-8 months):

- Initiate sports-specific drills, including cutting and figure-of-eight exercises.
- Agility testing.

Phase 6 (> eight months):

- Full return to sports contingent upon achieving 0-130 degrees of range of motion, with at least 90% strength in hamstrings and 85% strength in quadriceps.
- Completion of sports-specific agility training.
- Continuation of exercises three times weekly.
- Time frames are approximate, and any phase may be extended based on associated lesions or individual circumstances.

POSTOPERATIVE COMPLICATIONS

Complications following ACL reconstruction can be categorized into early, delayed, and late phases:

Early Complications:

- Risk of pulmonary embolism with prolonged tourniquet use.
- Hematoma formation at the graft harvest site.
- Infection.
- Metallosis from implant or instrument breakage.
- Potential for residual laxity due to graft advancement in the tunnel or advancement of endobutton into soft tissue.

Delayed Complications:

- Continued risk of residual laxity from partial or complete graft tears.
- Formation of ganglion cysts, detachment, and soft tissue migration of endobutton.
- Reduction in range of motion due to arthrofibrosis or graft impingement.
- Potential for deep vein thrombosis.
- Persistent pain resulting from complex regional pain syndrome (CRPS), untreated meniscal tears, or articular surface laceration of the femoral condyle from drilling.
- Diminished hamstring strength due to inadequate rehabilitation.
- Extension lag.
- Synovitis leading to recurrent knee effusion.

Late Complications:

- Graft or implant failure necessitating revision surgery.
- Biceps femoris tendinopathy, due to increased load on the tendon due to inadequate hamstring function.

METHODOLOGY

We have done a "Prospective Clinical Study" conducted on patients admitted in the Department of Orthopaedics in B.L.D. E (DEEMED TO BE UNIVERSITY) Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura, with diagnosed Anterior cruciate ligament rupture from 5th August 2022- 31st January 2024

In our study, 33 patients were involved, of whom 30 (91%) were male and 3 (9%) were female. Twenty-one patients (64%) sustained a right-side injury, whereas 12 patients (36%) sustained a left-side injury. A minimum of 12 months and a maximum of 21 months of follow-up were achieved.

Young and middle-aged patients visiting the orthopedic emergency and outpatient departments at B.L.D. E (Deemed to be University) Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura, with complaints of knee pain as well as instability after a history of twisting or injury to the same side, underwent a thorough examination. The affected knee was evaluated following assessment of the unaffected knee while the patient lay supine to diagnose ligament injuries.

To identify an ab-normal ACL, the following particular tests were carried out:

1. Lachman's test
2. Anterior Drawer
3. Pivot-shift test

Associated structure injuries of the knee were examined by:

1. Apley's grind test and McMurray's test (to test Meniscus)
2. Varus and valgus stress test (to test collateral ligaments)
3. Posterior Drawer test (for Posterior cruciate ligament)

Regular X-rays of the afflicted knee were taken in both lateral and anteroposterior views. For confirmation, an MRI of the knee was performed in every case of ACL tears.

INCLUSION CRITERIA:

1. Patient aged between 18-45 years.
2. Clinically, an MRI confirmed the diagnosis of Anterior cruciate ligament ruptures.
3. Associated meniscal injury who have undergone repair.

EXCLUSION CRITERIA:

1. Anterior cruciate ligament ruptures, which needs meniscectomy
2. Multi Ligament knee injuries.
3. Associated neurovascular injury.
4. Polytrauma.
5. Patients medically unfit for surgery.
6. Ligament reconstruction of the contralateral knee.
7. Chondral lesion that modifies the postoperative rehabilitation protocol. (grade III and grade IV cartilaginous lesions)

SAMPLING:

With anticipated proportion according to Lysholm score good result of 80% [ref] in ACL injury patients, the study required a sample size of 33 with a 95% level of confidence and 85% power with an Effect size of 0.05 using G* Power software version 3.1.9.7

Statistical Analysis

- The data that was collected was entered into a Microsoft Excel sheet, and a statistical package for the social sciences was used for statistical analysis, Version 20.
- Mean (Median) ±SD, counts and percentages, and graphs would be used to present the results.
- Odd's ratio and Multivariate analysis will be used to assess the significant association between risk factors and ROP development.
- $p<0.05$ will be considered as statistically significant. All statistical tests will be performed two-tailed.

Pre-Operative work-up:

Patients with Anterior Cruciate Ligament tears that have been clinically and radiologically confirmed were admitted to the Orthopaedics Department at the B.L.D. E (DEEMED TO BE UNIVERSITY) Shri B.M Patil Medical College, Hospital and Research Centre, in Vijayapura. Routine tests such as complete blood count, Blood sugar, CXR & Electro Cardiography were checked, and a pre anaesthetic examination was done.

Pre-Operative Rehabilitation:

1. The knee joint's pre-operative strength & ROM recorded.
2. Patients were taught static and dynamic quadriceps exercises while they were waiting for surgery.
3. Post-operative rehabilitation was explained to all patients

Consent:

Each participant in this study received a detailed explanation of their injury, diagnosis, treatment options, complications associated with non-operative care and surgical intervention, intraoperative & post-op complications, damage to structures nearby, infections & movement restrictions.

All study participants gave their consent before getting surgery. Prior to the operation, all consents were obtained. The benefits and drawbacks of the treatment were thoroughly addressed to patients and attenders. The ratio of risk to benefit was explained.

Examination after anaesthesia & positioning:

In our study, patients received supine spinal or epidural anesthesia. Anaesthesia facilitated the performance of the Lachman test, anterior drawer test, and posterior drawer test and pivot shift test. Following appropriate padding, a pneumatic tourniquet was applied and positioned over proximal thigh. Knee was positioned slightly beyond the typical distal edge of the operating [132] table while the patient lay supine. The unaffected limb was supported in an upright position. Each patient received a preoperative dose of ceftriaxone + sulbactam (1.5 g) as a prophylactic antibiotic treatment before tourniquet inflation. Prior to tourniquet inflation, the limb was elevated to facilitate exsanguination.

Fig. 25: Examination being done after anaesthesia

Arthroscopy Portals[134]:

Prior to joint distension, the portal entry locations must be accurately marked. This includes marking both femoral condyles, the patella, its tendon, the tibial tuberosity, and the tibial plateaus. The surgeon should draw these landmarks and portals to ensure proper positioning.

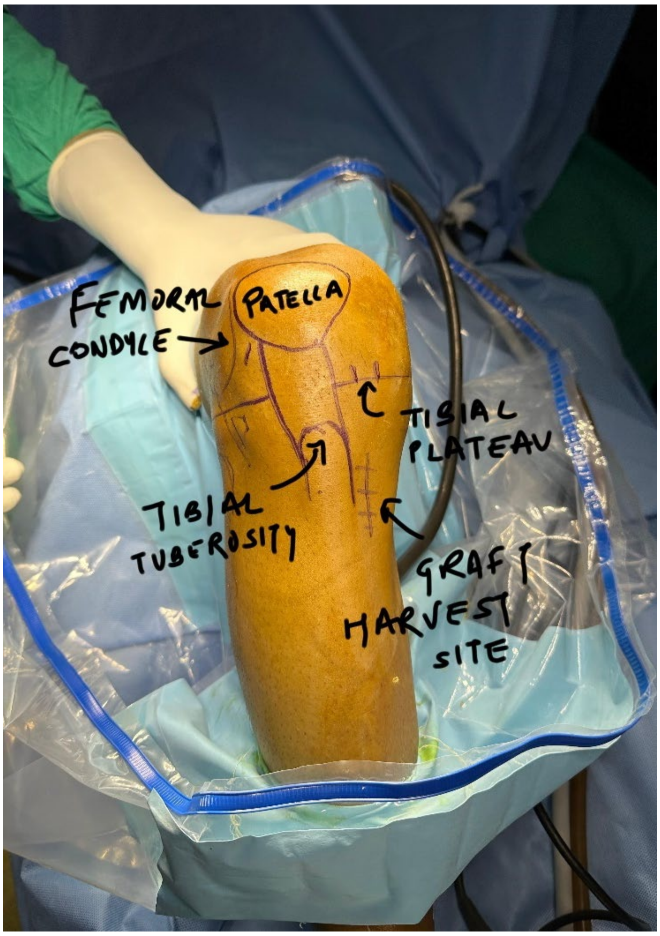


Fig. 26: Skin Marking

Portals used:

Antero-lateral portal[140]:

The anterolateral portal is situated at the highest feasible position, situated immediately off the inferior border of the patella and lateral edge of the patellar tendon[140]. In addition to providing an excellent panoramic view of the intraarticular structures, including the intercondylar notch, this portal enables the surgeon to avoid the infrapatellar fat pad (IFFP) and is typically used for diagnostic arthroscopy[140].

Antero-medial portal:

This portal is primarily used to provide additional views of the lateral compartment and to utilize a probe for palpating both the medial and lateral compartments. It is positioned 1 cm medial to the patellar tendon, 1 cm distal to the inferior pole of the patella, and 1 cm superior to the medial joint line. A spinal needle can be inserted percutaneously to precisely locate the portal while being visualized through the anterolateral portal.

Accessory anteromedial portal:

An accessory portal was created medial to the anteromedial portal, ensuring at least a 1 cm skin bridge between the two portals to facilitate trans-portal drilling of the femoral tunnel.

Diagnostic Arthroscopy[134]:

Prior to graft harvesting, a diagnostic arthroscopy was performed. Skin markings were made, and an anterolateral portal (viewing portal) was created using a no. 11 blade with the knee flexed at 90 degrees at the patella's inferior pole level, immediately lateral to the patellar tendon, Scope was then inserted for diagnostic arthroscopy, allowing visualization of all intra-articular structures to identify any abnormalities. The presence of an ACL tear was confirmed, and other lesions, such as meniscal tears or loose bodies, were noted.

Once all abnormalities were documented, the anteromedial (working) portal was established. Probing was conducted to confirm the diagnosis. Concurrent pathologies were addressed accordingly, including the removal of loose bodies and meniscal repair for meniscal tears.

Semitendinosus tendon autograft Harvest & Preparation:

An oblique incision, preferred for its reduced risk of damaging the infrapatellar branch of the saphenous nerve, is made one finger breadth medial to the tibial tuberosity. This approach allows for a broader exposure of the pes anserinus. Through this incision, both graft harvesting and tibial tunnelling are performed.

To locate the superior boundary of the pes anserinus, fingertips are used. The fascia is incised and elevated along this superior border. The tendons are palpated from top to bottom, with the semitendinosus tendon being the least palpable. The sartorius fascia is incised in line with semitendinosus tendon, ensuring the preservation of the inner layer containing the MCL. The semitendinosus tendon is hooked out using right-angled artery forceps. A double-loop knot is used to secure the tendon end for traction.

The knee is flexed to 90 degrees, and blunt dissection with fingers is employed to dissect the tendon proximally up to the musculotendinous junction, removing vinculae and adhesions while maintaining continuous traction through the thread. The major band connecting the medial head of the gastrocnemius is typically severed with scissors. The absence of posterior dimpling over the gastrocnemius is confirmed as the tendon is pulled distally.

The distal end of the tendon is released with the sleeve of periosteum using surgical blade. A tendon stripper is then advanced along the tendon, applying traction by grasping the threads and maintaining firm, constant, and gentle pressure. The stripper is retracted, adhesions are cut, if resistance is encountered and the stripper is advanced again to finish the tendon harvest. Harvested semitendinosus graft is put on the graft master board, and any remaining muscle fibers are removed from the tendons using the blunt end of a blade.

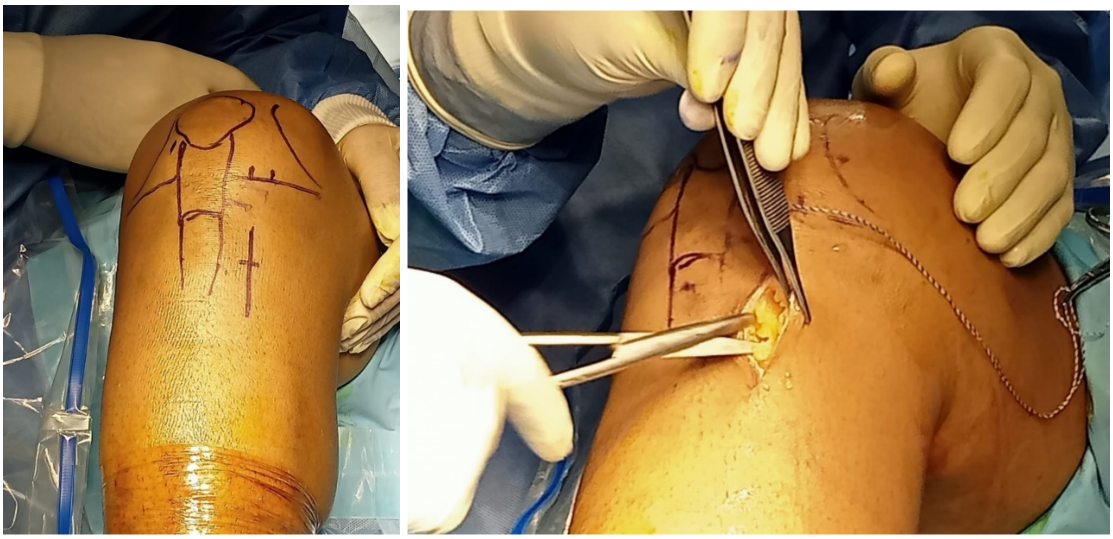


Fig. 27: Semitendinosus graft harvest incision and exposure of tendon

Fig. 28: Tendon identified and adhesions removed

To ensure uniform size, the ends of the tendon are trimmed. Each end of the tendon is secured with a whipstitch. The two ends of the tendons are then sewn together over a length of approximately 3–4 cm. Umbilical tape is looped over the combined tendons. The composite graft is then measured using a graft sizer. The tunnel diameter should match the smallest sleeve size to allow the quadrupled graft to pass through with minimal resistance.

The length of the graft to be inserted into the tunnel is measured to ensure correct placement when viewed arthroscopically.

Fig. 29: Semitendinosus graft preparation

Intra-articular preparation:

The joint cavity was visualized when the arthroscope was inserted through the anterolateral portal. The anteromedial portal was used to introduce the shaver blade, and the ligamentum-plicae, fat pad, and synovial reflection, which obstructed full examination of the medial side of the lateral femoral condyle and the ACL's tibial footprint, were removed. Care was taken to protect the intact PCL from harm during the joint debridement.

Femoral tunnel preparation:

With the knee flexed at 90 degrees, the entry location of the ACL can be seen on the medial surface of the lateral femoral condyle. To achieve the anatomical insertion point on the lateral femoral condyle, the Resident's Ridge (Lateral Intercondylar Ridge) is identified, and the Bifurcate Ridge is visualized. The proximal and posterior cartilage margins are also taken into consideration. Using a femoral aimer or a freehand beath pin, the entry point is marked below the Resident's Ridge and behind the Bifurcate Ridge, ensuring the correct distance from the posterior cartilage margin.

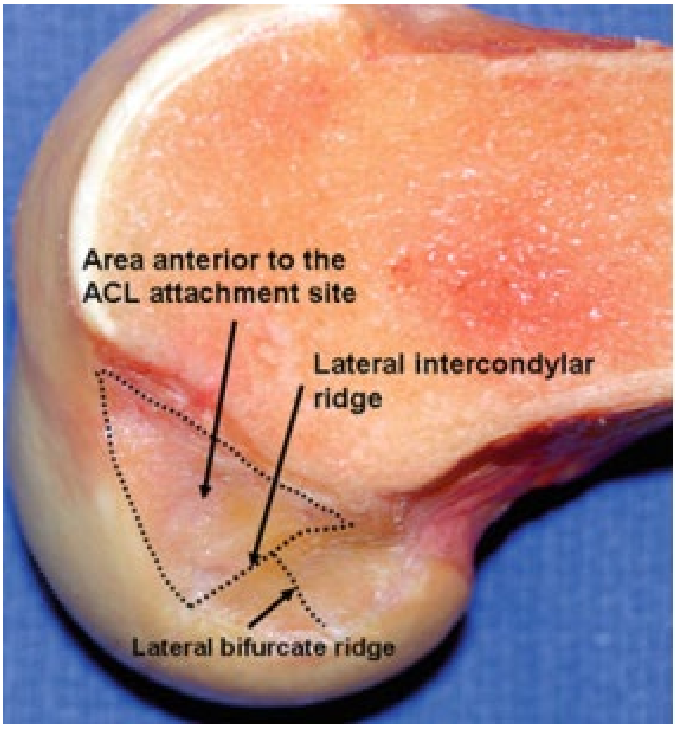


Fig. 30[135]: ACL femoral attachment site

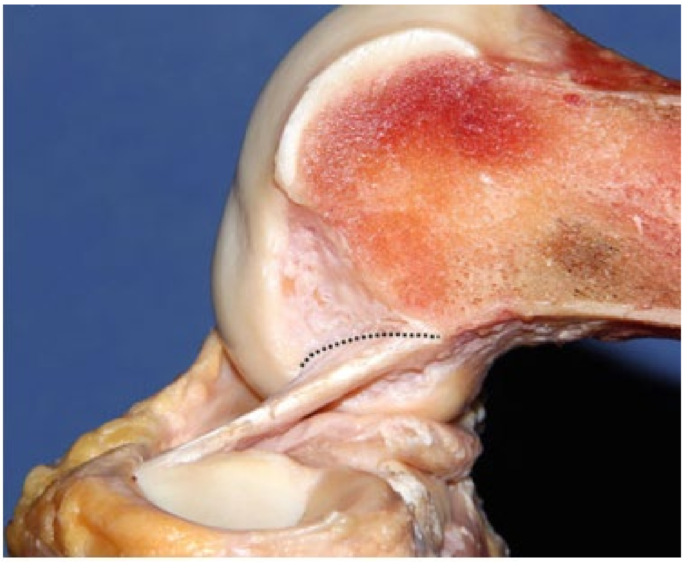


Fig. 31[135]: ACL attachment is seen inferior to in the inner wall of lateral femoral condyle lateral intercondylar ridge

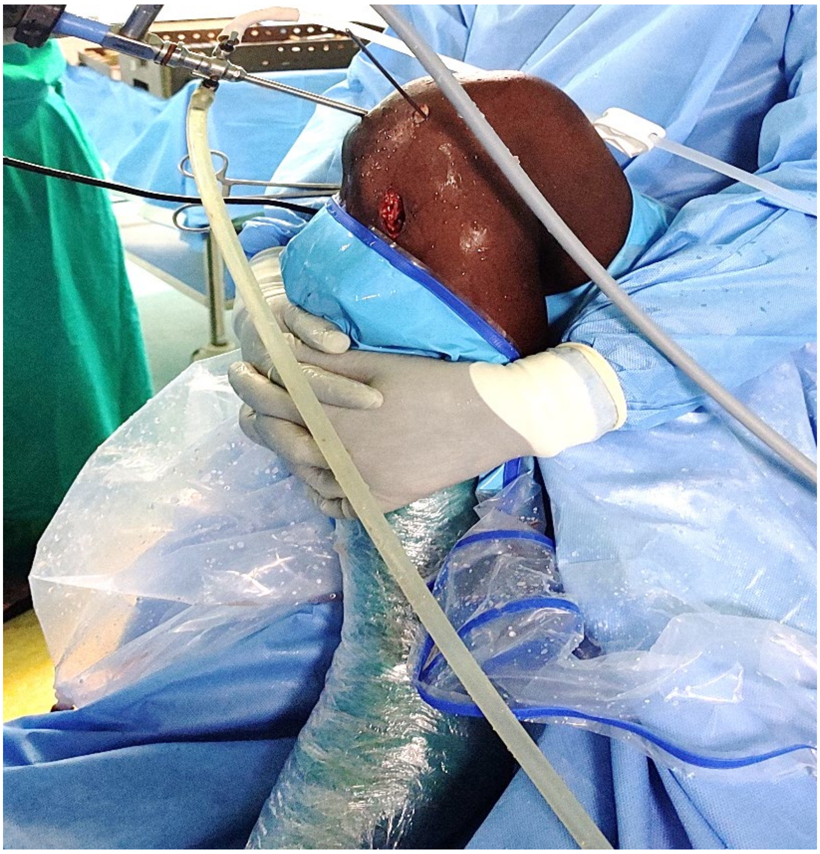


Fig. 32: Femoral Tunnel preparation

The entry location is then drilled with a beath pin while the knee is in 120 degrees of hyperflexion, using a femoral offset aimer device that has been placed through the anteromedial portal. Drilling continues until the tip of the guide wire is visible through the skin.

The preparation of the femoral tunnel begins by reaming with a 4.5mm cannulated reamer over the guide pin, which is drilled through the accessory anteromedial portal in all cases, extending up to the far cortex of the lateral femoral condyle. The length of the tunnel is then determined using a depth gauge. Sequential reaming is performed until the diameter of the graft size is achieved. Length of the femoral socket is decided based upon the measured graft length (intra articular length of minimum 25mm), and leaving 4.5 mm of the far cortex.

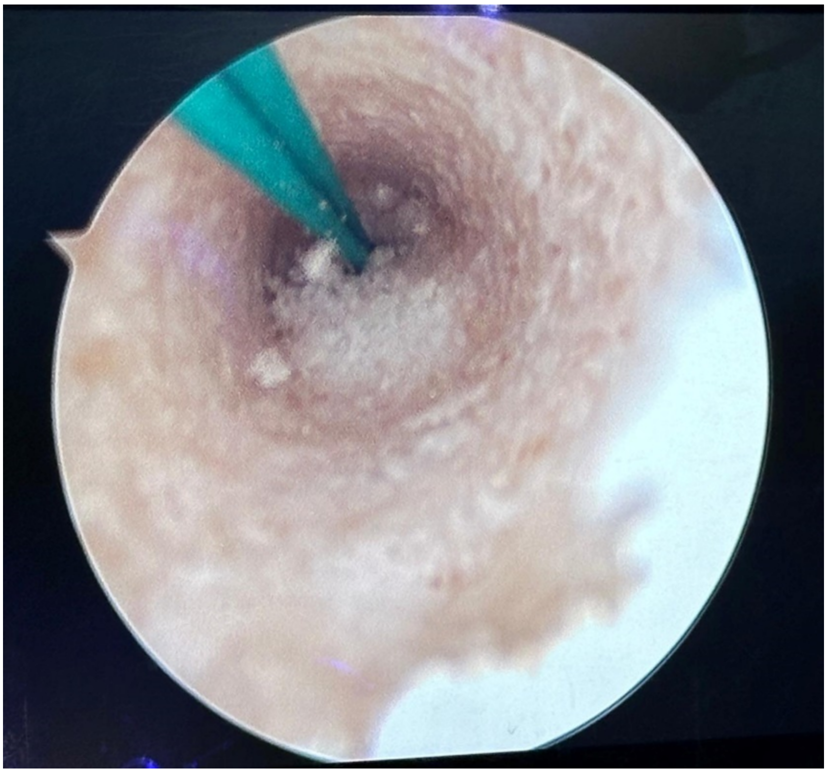


Fig. 33: Femoral tunnel seen post-reaming by Antero medial portal

Tibial tunnel preparation:

The tibial guide assists in the creation of the tibial tunnel. With the knee flexed at 90 degrees, the tibial guide's tip is placed slightly medial to the midline of the tibial attachment site of the ACL and 2-3 mm posterior to posterior border of the lateral meniscus' anterior horn. After that, the tibial tube is reamed to fit the graft's diameter. The edges of the tunnel are smoothed using a shaver to enhance proprioception, with any remaining tissue near the ACL attachment site on the tibia left in place.

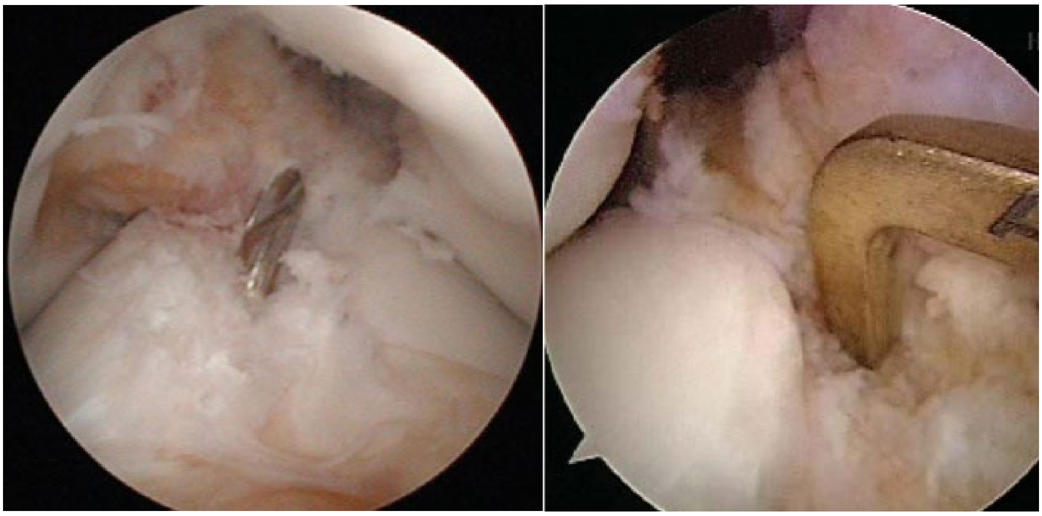


FIG. 34[136]: Position of the tibial guide wire and director guide

Fig. 35: Tibial Guide set at 55 degrees

Graft passage and fixation:

After preparing the femoral socket, the graft is secured to an adjustable loop endobutton by passing the quadrupled semitendinosus graft through the loop. In all cases, an adjustable loop endobutton was utilized. The length of the graft to be inserted into the femoral tunnel is marked with a pencil marker. The length of the femoral tunnel is marked on the adjustable loop. Typically, approximately 20mm of the graft was positioned within femoral tunnel. Once the designated portion of the adjustable loop is within the tunnel, the endo button is flipped, and its positioning is verified by pulling on the tibial end of the graft. The graft is cynched into the femoral tunnel.

The graft is gradually drawn into the tibial tunnel after undergoing 20-30 cycles of knee flexion and extension. After this, arthroscopic visualization is performed, inspecting for proper alignment, absence of any impingement, and other considerations. To secure the tibial side of the graft, a tibial base plate is employed with the knee flexed at 10 degrees and leg in neutral position with posterior drawer.

Subsequently, the wounds and portals are closed in layers, followed by the application of a sterile dressing. A knee brace is utilized to immobilize the affected limb.

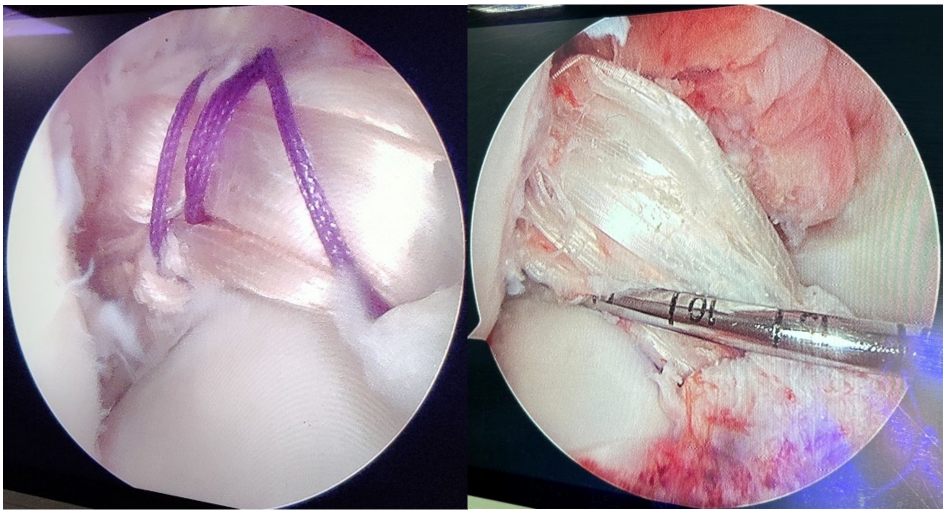


Fig. 36: Hamstring graft pulled into the femoral tunnel

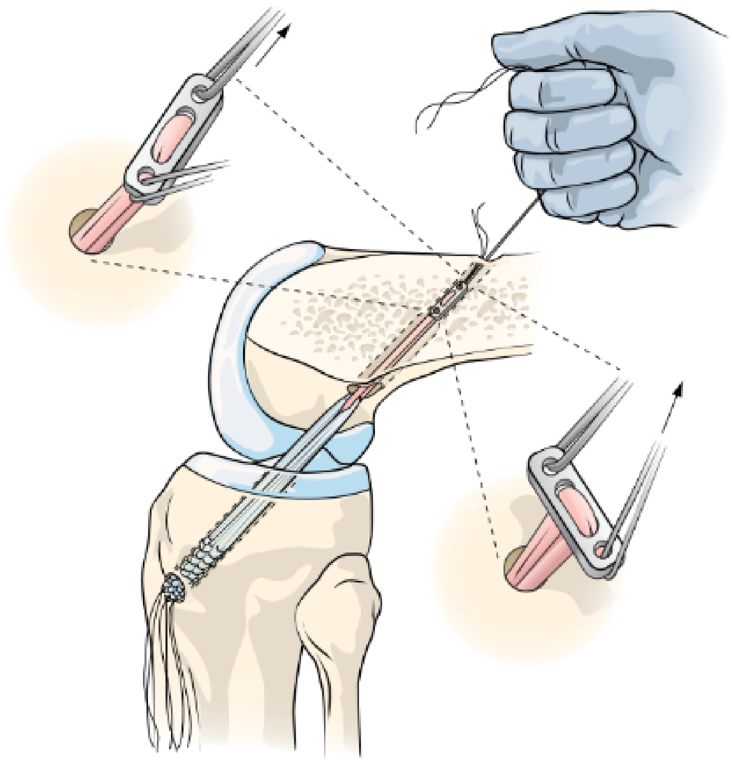


Fig. 37[137]: Endobutton passage in the femoral tunnel

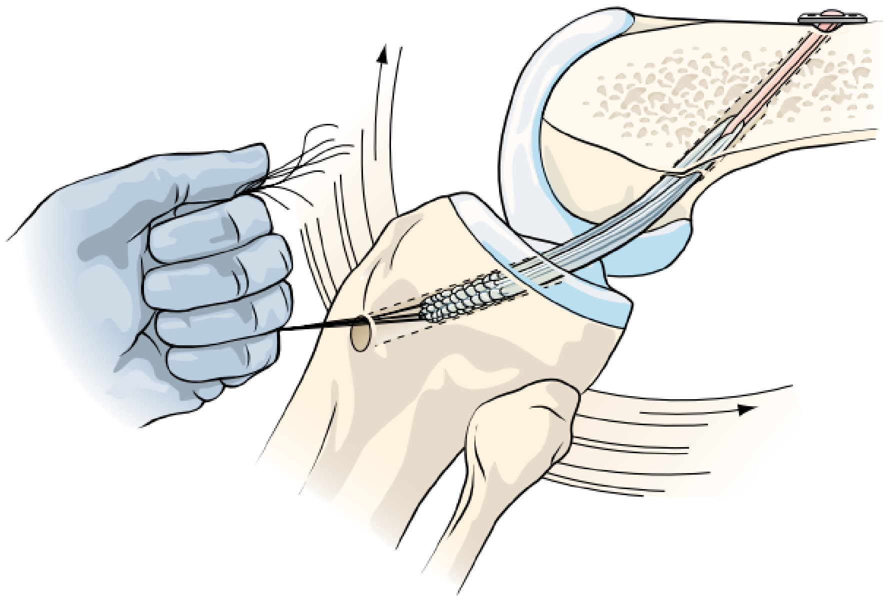


Fig. 38[137]: Strong retrograde tension not able to dislodge graft once fixed with Endo button

Fig.39: Fixation with a suture disc

Post-operative management:

In the initial days following surgery, the patient's knee was immobilized with a knee brace and limb elevation was maintained. Intravenous antibiotics were administered for three days post-surgery. The wound was inspected on the second and seventh postoperative days, with sutures removed on the twelfth day. Rehabilitation commenced promptly after suture removal.

Evaluation:

To confirm the placement of tunnels and positions of implants, all patients underwent postoperative anteroposterior and lateral radiographs. Functional outcomes were assessed at six weeks, three months, six months, and one year post-operatively.

The evaluation was conducted using the **IKDC** (International Knee Documentation Committee) and **Lysholm** Knee Scoring Scale.

IKDC Subjective Score:

- Parameters: This score includes various subjective parameters assessed through a well-prepared questionnaire. These parameters contribute to a total score of 87 when summed.
- Conversion: The total score is converted to a percentage format for evaluation of knee function. A score of 100% indicates no restrictions on daily activities or athletic endeavors and the absence of symptoms.

Lysholm Knee Scoring Scale:

Parameters: The Lysholm score evaluates knee function based on eight parameters:

1. Limp
2. Walking aid
3. Locking of knee
4. Instability
5. Pain
6. Swelling
7. Ability to climb stairs
8. Ability to squat

Each parameter is scored based on the patient's ability to function, with a higher score indicating better function. Scores are typically categorized into excellent, good, fair, and poor based on the total score achieved.

Both these scoring systems are valuable in assessing the outcomes of knee surgeries, rehabilitation progress, and overall knee function over time.

CASE ILLUSTRATION

CASE 1

Three month old case of Complete ACL deficiency was operated with adjustable loop endobutton on femoral side and suture disc on tibial side.

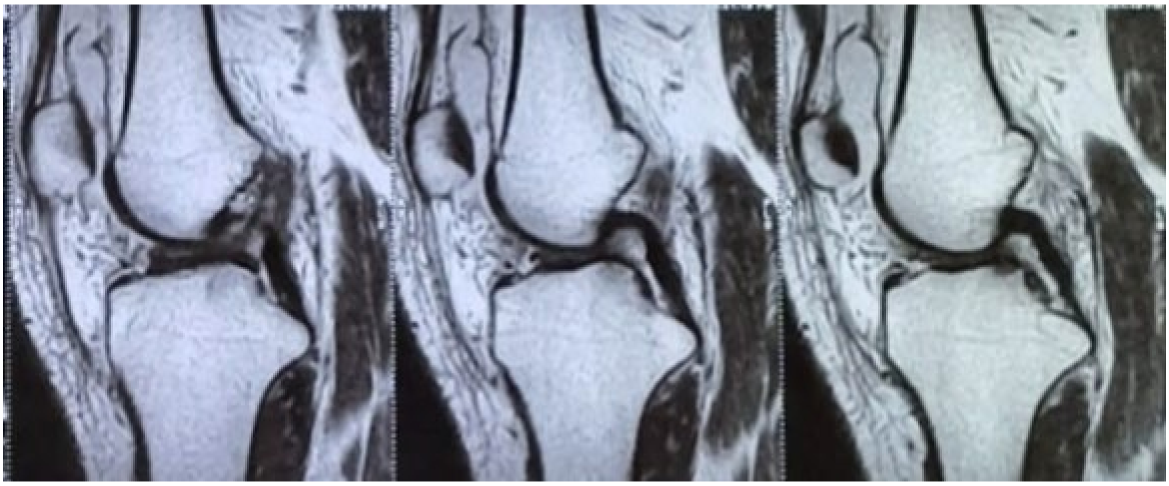


Fig. 40A: Preop MRI showing ACL deficiency

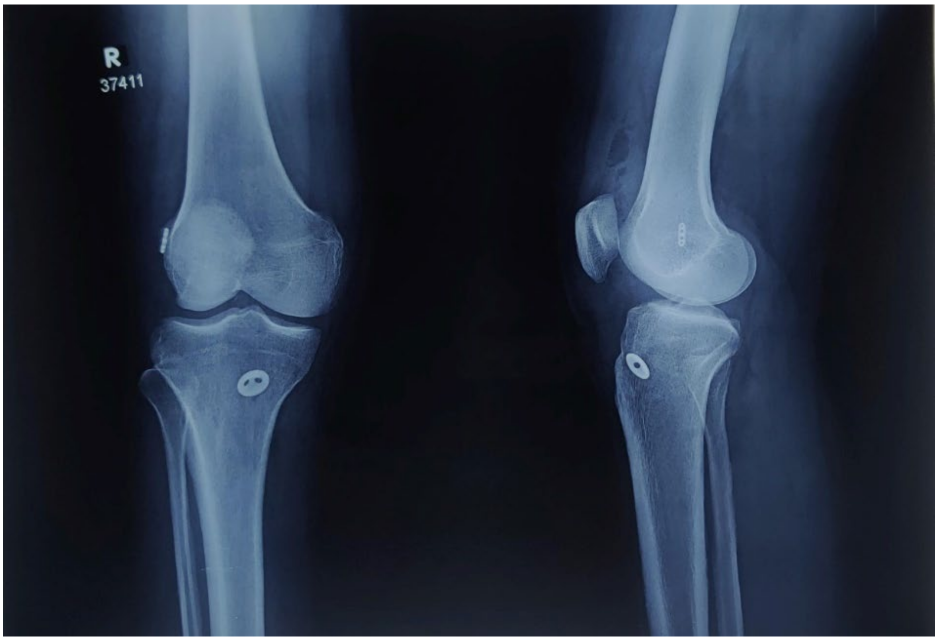


Fig.40B: Post-operative radiograph with adjustable loop endo button and suture disc

Fig. 40C: Post-operative knee range of motion and SLRT

CASE 2

One-month-old case of complete ACL deficiency operated with adjustable loop endobutton on femoral side and suture disc on tibial side.

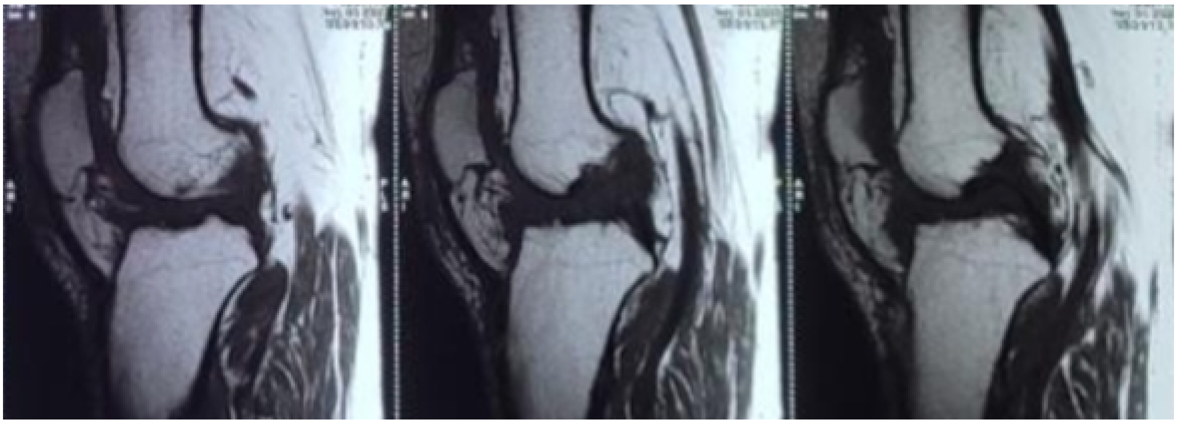


Fig. 41A: Preoperative MRI showing ACL deficiency

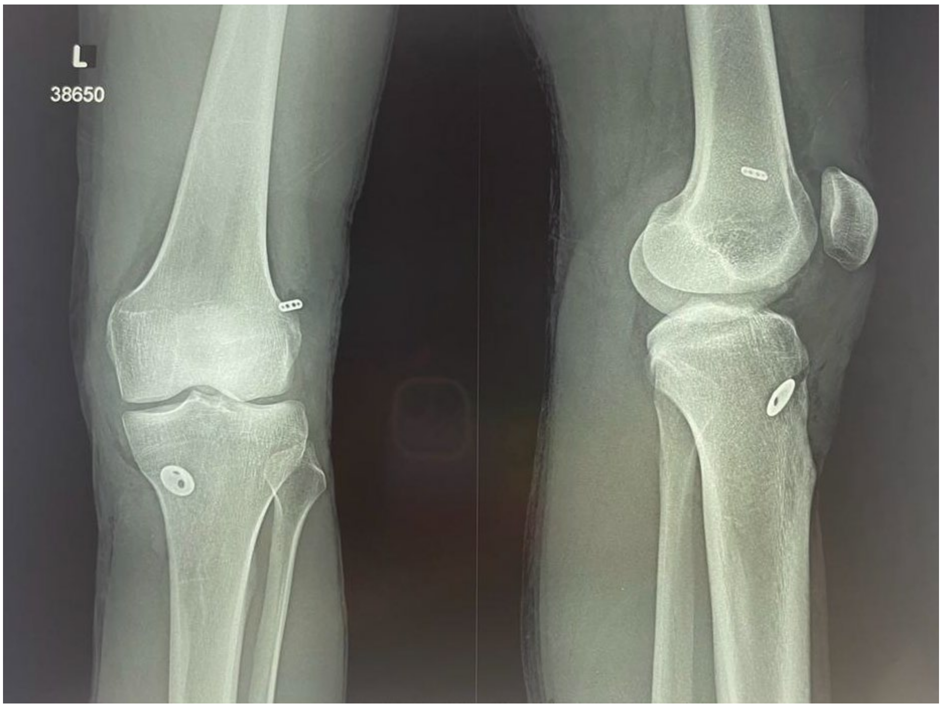


Fig. 41B: Postoperative radiograph with Adjustable loop endo button and suture disc

Fig.41C: Postoperative Knee range of motion and SLRT

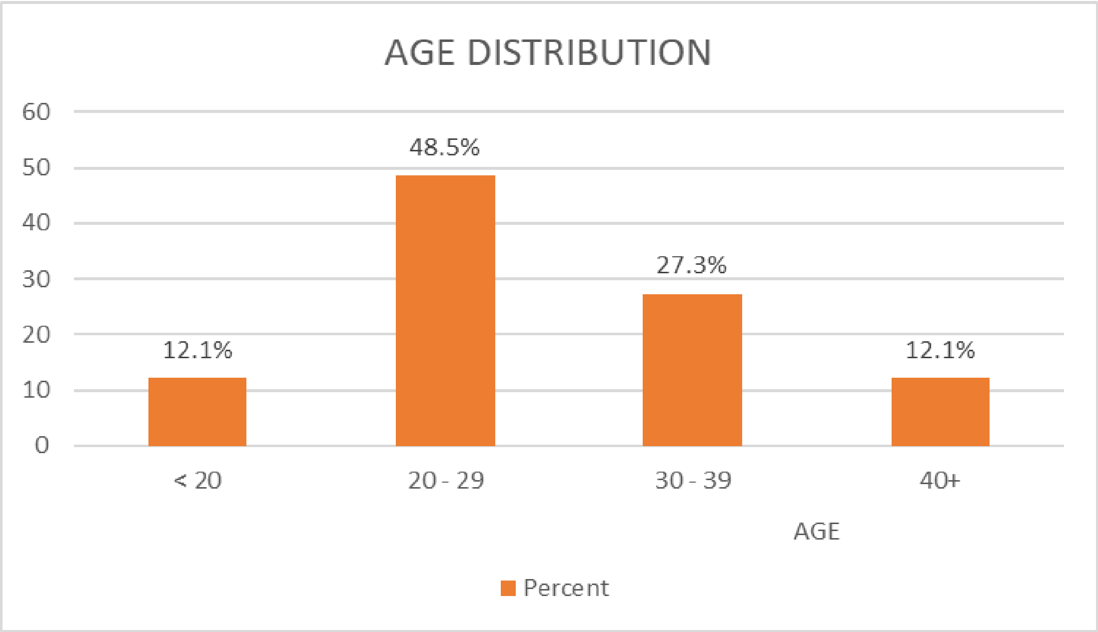
RESULTS

Thirty-three cases of arthroscopic ACL reconstruction with semitendinosus autograft were followed up regularly for a period of 24 months and 12 months minimum in B. L. D. E (DEEMED TO BE UNIVERSITY) Shri B.M Patil Medical College, Hospital and Research Centre, Vijayapura (from August 2022 to January 2024).

Age Distribution:

AGE	FREQUENCY	PERCENTAGE
<20	4	12.1
20-29	16	48.5
30-39	9	27.3
40+	4	12.1
TOTAL	33	100.0

Table 1. Age Distribution

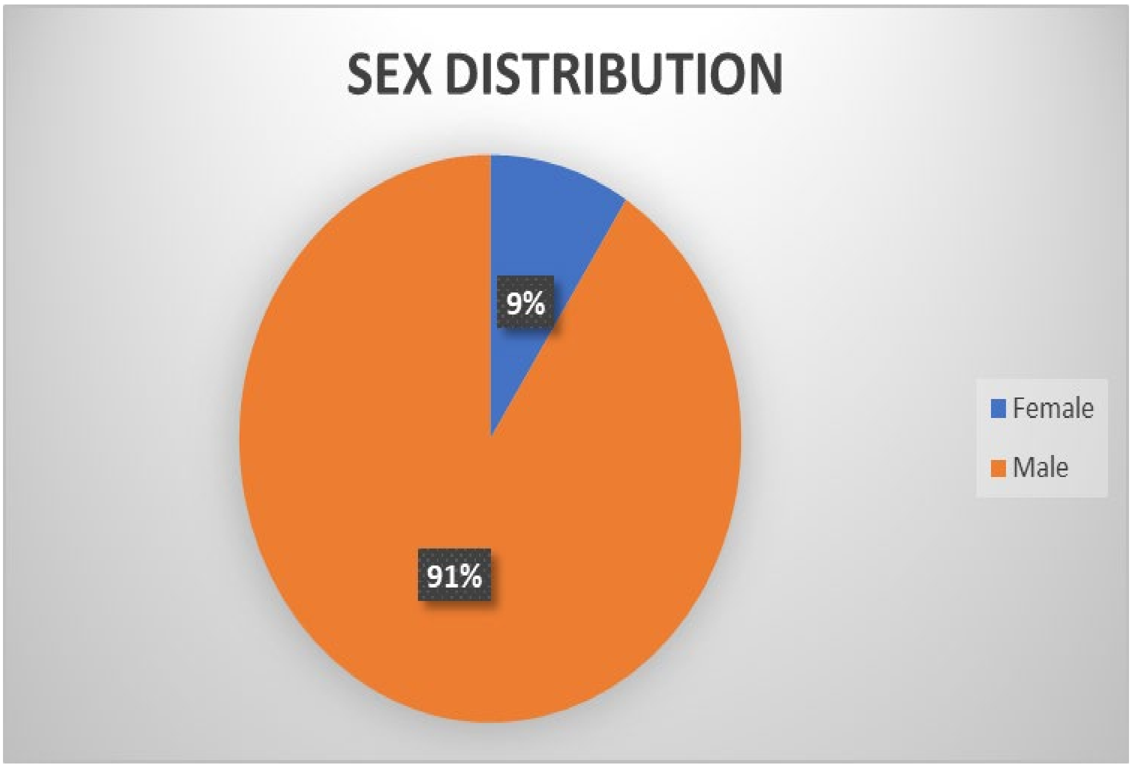


Most patients presented to us were young, with below 20 years comprising four patients in the age group of 20-29 years, 16 (48.5%) patients, nine patients in the age group of 30-39, and 4 patients above 40 years.

Sex distribution:

SEX	FREQUENCY	PERCENTAGE
MALE	3	9.1
FEMALE	30	90.9
TOTAL	33	100.0

Table 2. Sex Distribution

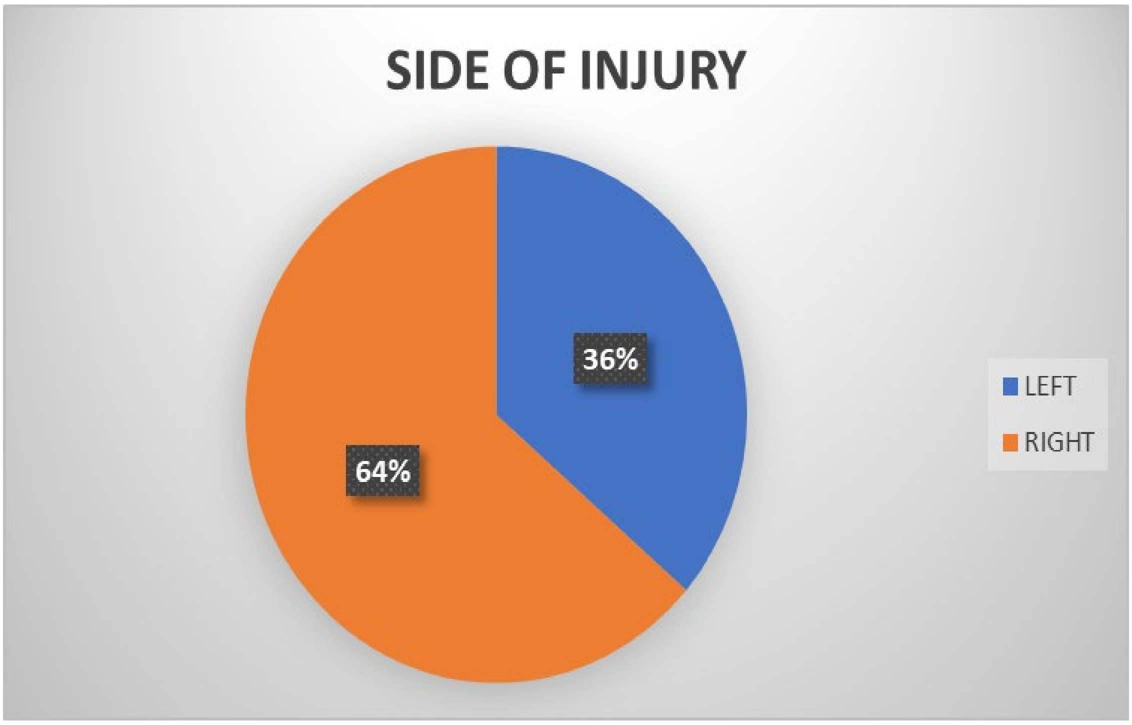


Males experienced this injury significantly more often than females. 30 out of 33 operated for ACL reconstruction with quadrupled semitendinosus autograft were males, and 3 were females

Side of injury:

SIDE	FREQUENCY	PERCENTAGE
LEFT	12	36.4
RIGHT	21	63.6
TOTAL	33	100.0

Table 3. Side of Injury

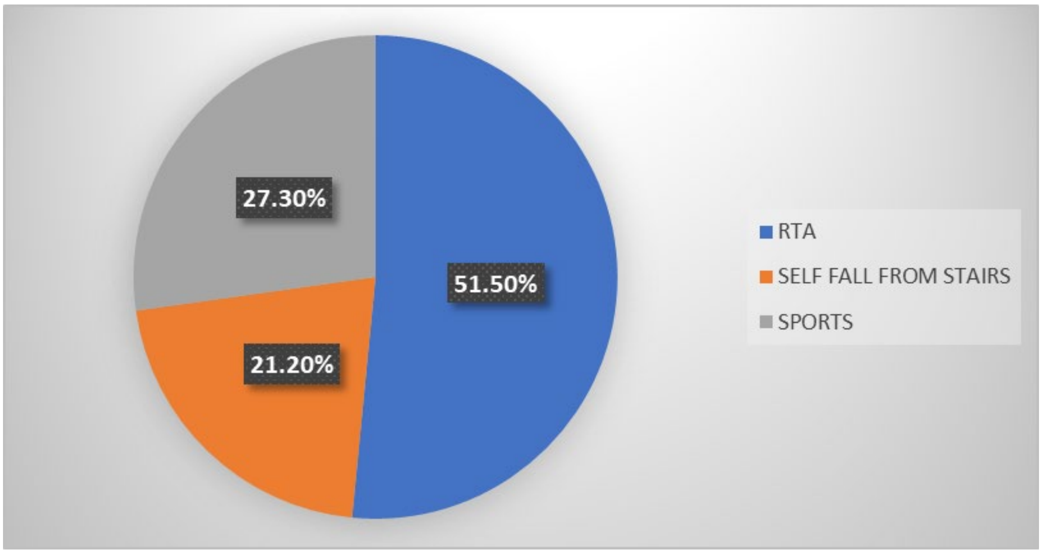


63.6% of the injuries occurred on the right side, while 36.4% occurred on the left side

Mode of injury:

MODE OF INJURY	FREQUENCY	PERCENTAGE
RTA	17	51.5
SELF FALL FROM STAIRS	7	21.2
SPORTS	9	27.3
TOTAL	33	100.0

Table 4. Mode of Injury

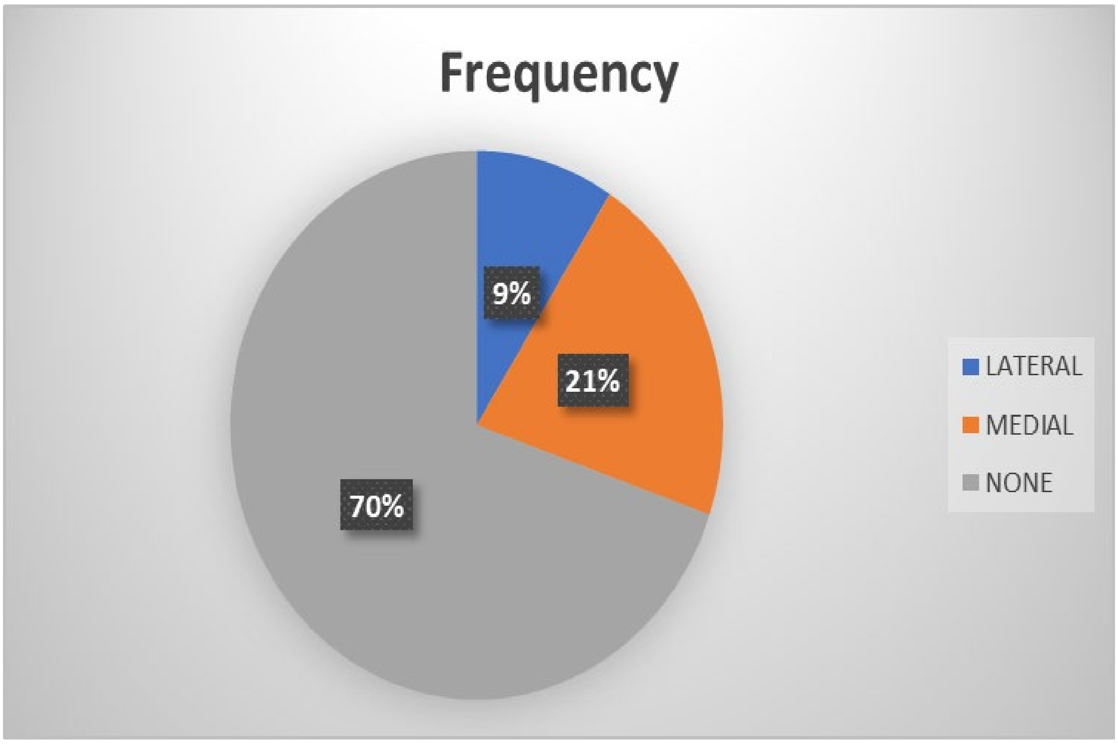


In our study, Road Traffic Accidents (51.5%) were the most common mode of injury, followed by sports-related injuries (27.3%). Additionally, 21.2% of injuries resulted from fall from stairs.

Meniscal injury:

SIDE	FREQUENCY	PERCENTAGE
MEDIAL	7	21.2
LATERAL	3	9.1
NONE	23	69.7
TOTAL	33	100.0

Table 5. Meniscal injury

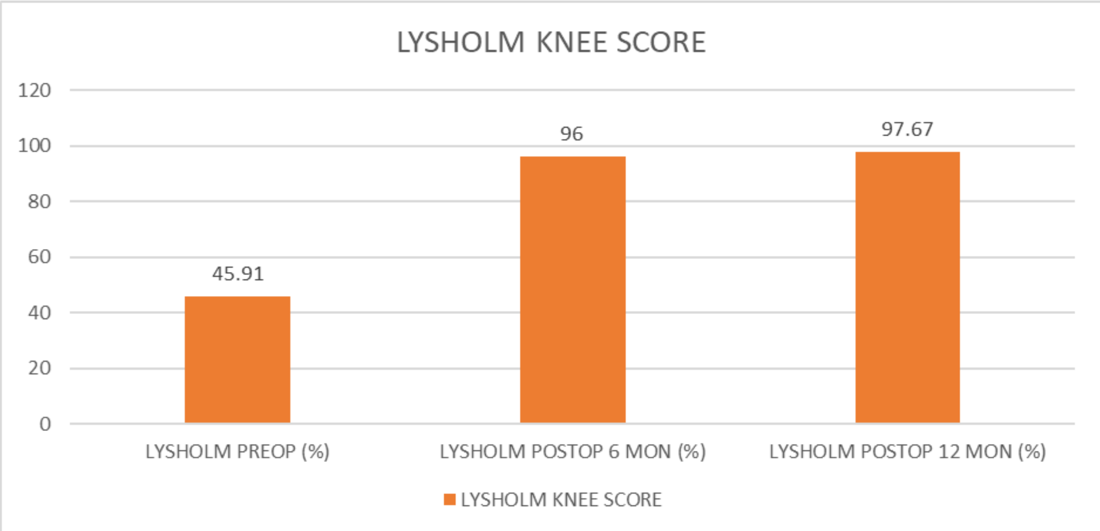


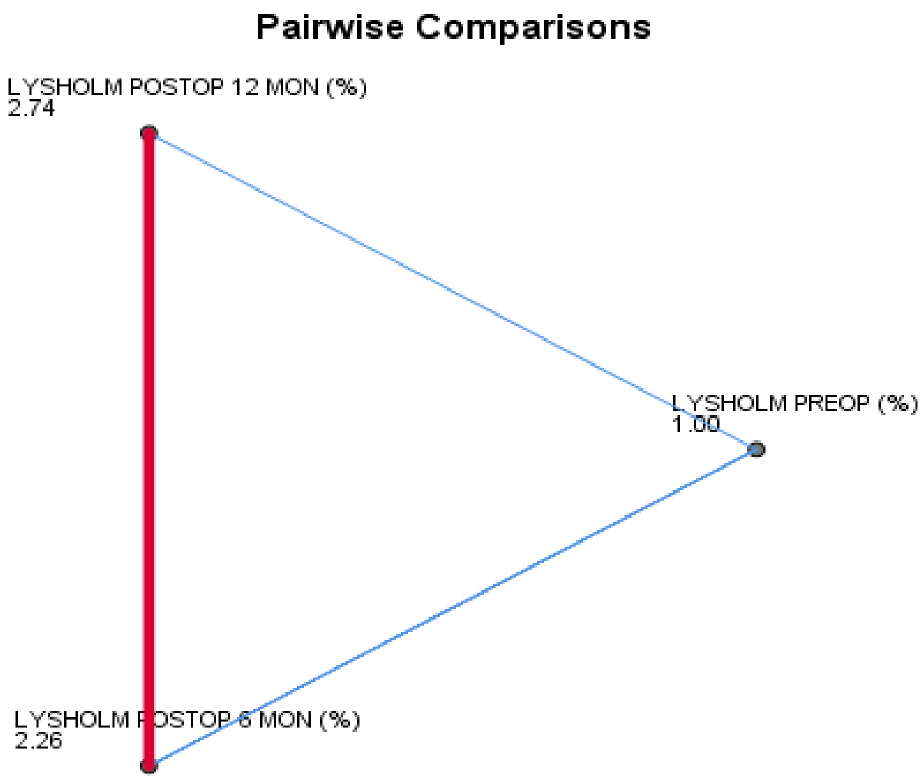
In our study, 10 out of 34 patients (30.3%) had an associated meniscal injury. The medial meniscus was injured more frequently (21.2%) compared to the lateral meniscus (9.1%). The cases that underwent repair involved simple tears and did not necessitate changes in the rehabilitation protocol. Additionally, 23 patients (69.7%) presented with isolated ACL tears.

Lysholm score:

LYSHOLM SCORE	MEAN	STD. DEVIATION	MINIMUM	MAXIMUM	FRIEDMAN TEST	P-VALUE
LYSHOLM PREOP (%)	45.91	5.779	38	54	61.270	0.001
LYSHOLM POSTOP 6 MON (%)	96.00	3.518	86	100		
LYSHOLM POSTOP 12 MON (%)	97.67	3.159	86	100		

Table 6. Lysholm score comparison



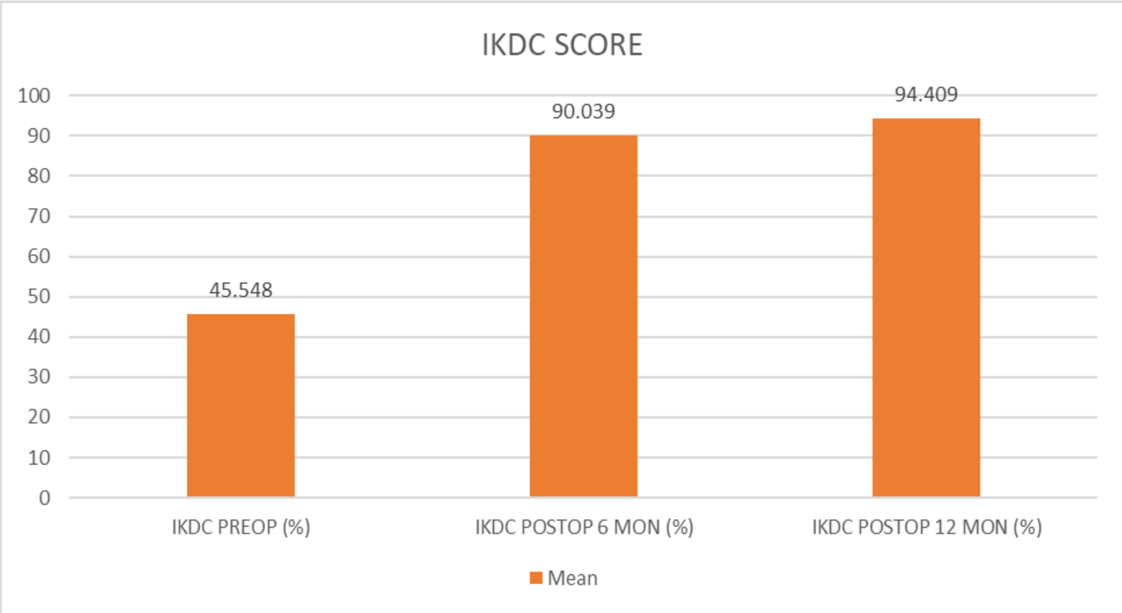


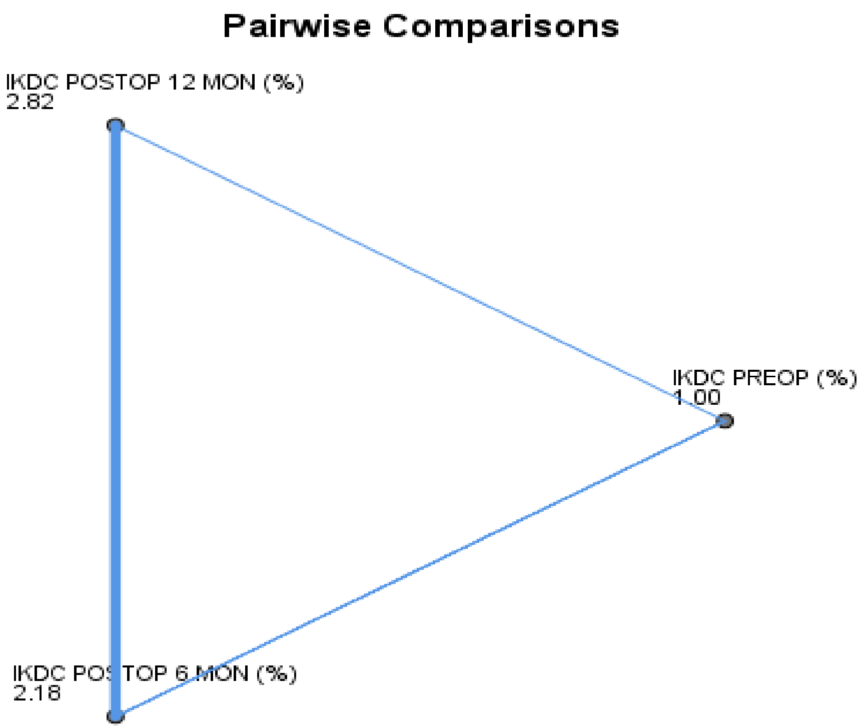
A significant difference is seen in Lysholm scores six months and 12 months postoperatively.

IKDC score:

IKDC	MEAN	STD. DEVIATION	MINIMUM	MAXIMUM	FRIEDMAN TEST	P-VALUE
IKDC PREOP (%)	45.5485	6.97182	37.90	60.90	61.800	0.001
IKDC POSTOP 6 MON (%)	90.0394	6.06027	77.20	96.60		
IKDC POSTOP 12 MON (%)	94.4091	3.66976	80.00	96.60		

Table 7. IKDC score comparison





IKDC scores showed significant differences at 6 and 12 months postoperatively.

Thirty cases went back to pre-injury activity level, and three patients out of 33 still had restriction of full movements, restricting them from squatting and sitting cross-legged. Twenty-one patients returned to sports activity, and the rest, 12, had mild knee pain and difficulty in cutting, accelerating, and stopping from running.

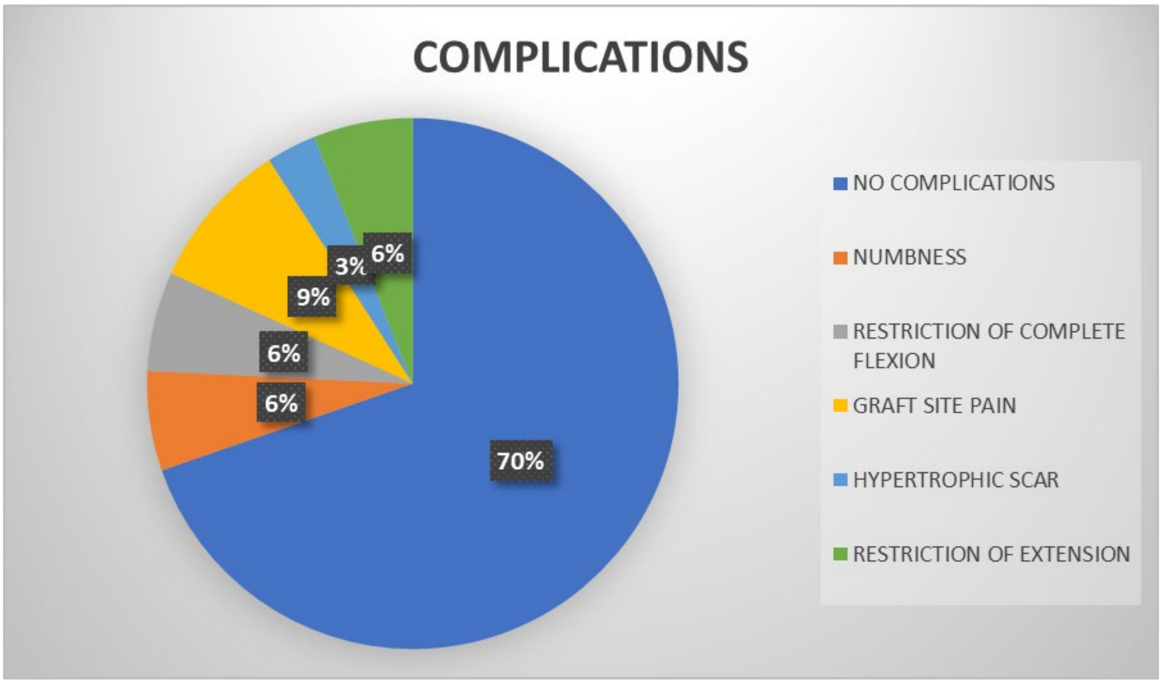
POSTOPERATIVE REHABILITATION

Phase	Duration	Activities
1	0-14 Days	• Quadriceps strengthening (static, dynamic) • Straight leg raises • Patellar mobilization (superior-inferior) • Ankle pumps • Gradual increase in range of motion (up to 90°) • Partial weight-bearing with crutches
2	2-10 Weeks	• Gradual increase in range of motion (up to 120°) • Discontinuation of crutches • Progressive quadriceps strengthening • Therapist-assisted extension (90-40°) • Introduction of lunges
3	3-4 Months	• Knee extension exercises (high reps/low weight) • Isokinetic quadriceps exercises • Slow and controlled drills for lateral sports
4	4-5 Months	• Jogging and jump rope exercises (if no effusion, full ROM, and stable knee)
5	5-8 Months	• Sports-specific drills (cutting, figure-of-eight) • Agility testing
6	> 8 Months	• Full return to sports (contingent on achieving 0-130° ROM, 90% hamstring strength, and 85% quadriceps strength) • Completion of sports-specific agility training • Continuation of exercises (3 times/week)

Table 8. Postoperative protocol

COMPLICATIONS

- Four patients showed poor compliance with post-operative rehabilitation, and progressive, aggressive physiotherapy showed complete improvement to pre-op levels.
- Two patients who had preoperative restriction of complete flexion by 20 degrees had restricted terminal flexion of 10 degrees at the 6 month follow up, and 2 patients had 10 degrees of restriction of extension, which gradually showed improvement with physiotherapy.
- Two patients reported numbness over the anteromedial aspect of the leg.
- Three patients complained of graft site pain in subsequent follow-ups.
- One patient had developed a hypertrophic scar at the graft harvest site and complained of unsatisfactory cosmetic appearance.
- None of the cases experienced implant or fixation failure necessitating removal or revision by the end of one year.
- No patient reported to have instability symptoms.
- None of the cases had a superficial or deep infection.



DISCUSSION

Only a few studies are available that have utilized quadrupled semitendinosus grafts with adjustable loop Endo buttons on the femoral and suture discs on the tibial side. Thirty-three patients with confirmed ACL tears underwent arthroscopic ACL reconstruction with quadrupled semitendinosus autograft and were prospectively followed up for minimum of 12 months. A similar prospective study by Chidanand KJC et al. [70] in 2015 was followed up for two years. Another study was done by Vinod Jagtap et al.[29] in 2017, where patients were followed up for up to 2 years.

There are various choices of fixation; one of the most widely used are endo buttons and interference screws. Suspensory fixation offers superior arthrometric stability with fewer graft ruptures. With an adjustable loop endo button, we can put the desired 1.5-2 cm graft inside the femoral tunnel, which is not possible with fixed loop devices. Aperture fixation may compromise graft integrity, cause soft tissue graft slippage, damage, and compromised primary graft stability, possibly leading to early failure,[71,89] especially on the tibial side.[28]

All patients in our study underwent arthroscopic ACL reconstruction with quadrupled semitendinosus autograft fixed with an adjustable loop endo button on the femur and suture disc on the tibial side. According to a study done by Vernon J Cooley et al.[53], excellent clinical results are obtained with quadrupled semitendinosus tendon autograft for ACL reconstruction. None of the patients had re-injury and continued with their pre injury activities[53]. About 85% of patients fell into normal to near normal in their study, compared to 84.8% in our study. Adjustable loop Endo button does not directly fix into the graft and has the potential to stretch during cyclic loading, which can lead to increased anterior joint laxity [27, 15]. This can be overcome with graft tension readjustment and intraoperative tightening [77] to remove excess laxity to improve graft placement and maximize the bone-graft interface[4]. After 1 year postoperatively, eight of the patients in our study had grade I laxity and one patient had grade II laxity. The suspensory nature of the fixation of the graft makes it prone to stretch during cyclic loading, which can lead to tunnel widening and inhibit tendon-bone healing [53]. Anteroposterior movement of the graft occurring inside the tunnel is described as the "windscreen wiper" effect. Wolfgang Nebelung et al.[51] concluded that hamstring tendon autograft, when fixed with an endo button, can lead to bone tunnel enlargement and osteolytic reaction. In our study, no tunnel widening was noted.

The titanium suture disc has MRI compatibility and also performing revision surgery becomes easier when compared with metal screws. In a study by D.D.M Spicer et al.[52], areas of sensory change over the front of the knee were identifiable in 50% of patients, and 86% of these demonstrated sensory changes in the distribution of infra-genicular branch of saphenous nerve [52]. 2 patients (6%) in our study reported having numbness over their anteromedial leg.

In our study, according to the IKDC scale, 96.7% of patients had a normal postoperative recovery, and 3.3% of patients had an abnormal recovery. according to lysholm knee score, 90.9% of patients showed excellent results, 6% of patients with good and 3% of patients got fair results. These findings can be compared with the study done by Chidanand et al., where 93.3% of patients showed normal postoperative recovery, 6.6% of patients were abnormal and related to knee stiffness in IKDC scores and 93.3% of patients according to lysholm knee scores showed excellent to good results and 6.7% with fair result. In another study done by Vinod Jagtap et al. where 90% of patients had normal postoperative recovery, and 10% of patients had an abnormal recovery, according to IKDC scores, 90% of patients showed excellent to good scores, and 10% showed fair results.

CONCLUSION

- In conclusion, we found patients undergoing anatomic single bundle anterior cruciate ligament reconstruction with semitendinosus quadrupled autograft with adjustable loop endo button on femur and suture disc on tibia gives good functional outcomes at the end of 1 year follow-up.
- This method predictably reproduces graft tunnel healing and maintaining its strength till healing is complete.
- More then 95% of our cases had excellent to good outcome.
- There are no specific complications related to our study.

Limitations of this study are:

- Sample size was small
- Follow-up duration was short; longer follow-up is required to properly assess such procedures
- Assessment was done by subjective scores only.

2000 IKDC SUBJECTIVE KNEE EVALUATION FORM

Name: ____________ ____________ **Date:** ____________
First Last

Physician: ____________ **Date of Injury:** ____________

SYMPTOMS*:

*Grade symptoms at the highest activity level at which you think you could function without significant symptoms, even if you are not actually performing activities at this level.

1.What is the highest level of activity that you can perform without significant knee pain?

- ◯ Very strenuous activities like jumping or pivoting as in basketball or soccer
- ◯ Strenuous activities like heavy physical work, skiing or tennis
- ◯ Moderate activities like moderate physical work, running or jogging
- ◯ Light activities like walking, housework or yard work
- ◯ Unable to perform any of the above activities due to knee pain

2.During the past 4 weeks, or since your injury, how often have you had pain?

	0	1	2	3	4	5	6	7	8	9	10	
Never	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Constant

3.If you have pain, how severe is it?

	0	1	2	3	4	5	6	7	8	9	10	
No pain	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	Worst pain imaginable

4.During the past 4 weeks, or since your injury, how stiff or swollen was your knee?

- ◯ Not at all
- ◯ Mildly
- ◯ Moderately
- ◯ Very
- ◯ Extremely

5.What is the highest level of activity you can perform without significant swelling in your knee?

- ◯ Very strenuous activities like jumping or pivoting as in basketball or soccer
- ◯ Strenuous activities like heavy physical work, skiing or tennis
- ◯ Moderate activities like moderate physical work, running or jogging
- ◯ Light activities like walking, housework or yard work
- ◯ Unable to perform any of the above activities due to knee swelling

6.During the past 4 weeks, or since your injury, did your knee lock or catch?

◯ Yes ◯ No

7.What is the highest level of activity you can perform without significant giving way in your knee?

- ◯ Very strenuous activities like jumping or pivoting as in basketball or soccer
- ◯ Strenuous activities like heavy physical work, skiing or tennis
- ◯ Moderate activities like moderate physical work, running or jogging
- ◯ Light activities like walking, housework or yard work
- ◯ Unable to perform any of the above activities due to giving way of the knee

SPORTS ACTIVITIES:

8.What is the highest level of activity you can participate in on a regular basis?

- ◯ Very strenuous activities like jumping or pivoting as in basketball or soccer
- ◯ Strenuous activities like heavy physical work, skiing or tennis
- ◯ Moderate activities like moderate physical work, running or jogging
- ◯ Light activities like walking, housework or yard work
- ◯ Unable to perform any of the above activities due to knee

9.How does your knee affect your ability to:

		Not difficult at all	Minimally difficult	Moderately Difficult	Extremely difficult	Unable to do
a.	Go up stairs	◯	◯	◯	◯	◯
b.	Go down stairs	◯	◯	◯	◯	◯
c.	Kneel on the front of your knee	◯	◯	◯	◯	◯
d.	Squat	◯	◯	◯	◯	◯
e.	Sit with your knee bent	◯	◯	◯	◯	◯
f.	Rise from a chair	◯	◯	◯	◯	◯
g.	Run straight ahead	◯	◯	◯	◯	◯
h.	Jump and land on your involved leg	◯	◯	◯	◯	◯
i.	Stop and start quickly	◯	◯	◯	◯	◯

FUNCTION:

10. How would you rate the function of your knee on a scale of 0 to 10 with 10 being normal, excellent function and 0 being the inability to perform any of your usual daily activities which may include sports?

FUNCTION PRIOR TO YOUR KNEE INJURY:

	0	1	2	3	4	5	6	7	8	9	10	
Couldn't perform daily activities	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	No limitation in daily activities

CURRENT FUNCTION OF YOUR KNEE:

	0	1	2	3	4	5	6	7	8	9	10	
Cannot perform daily activities	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	◯	No limitation in daily activities

IKDC EVALUATION FORM

Parameter	Finding	Score	Parameter	Finding	Score
Limp	None	5	Pain	None	25
	Slight or periodic	3		Inconstant and slight during strenuous activities	20
	Severe and constant	0		Marked during or after walking >2 km	10
Support	None	5		Marked during or after walking <2 km	5
	Stick or crutch needed	2		Constant	0
	Weight bearing impossible	0	Swelling	None	10
Locking	None	15		After strenuous activities	6
	None, but catching sensation present	10		After ordinary activities	3
	Occasional	6		Constant	0
	Frequent	2	Squatting	No problem	5
	At examination	0		Slight problem	4
Stairs	No problem	10		Not beyond 90 degrees of knee flexion	2
	Slight problem	6		Impossible	0
	One step at a time	3			
	Impossible	0			
Instability	Never	25			
	Rarely during athletic activities	20			
	Frequently during athletic activities	15			
	Occasionally during daily activities	10			
	Often during daily activities	5			
	Every step	0			

LYSHOLM KNEE SCORING SCALE

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ANNEXURE –I

SCHEME OF CASE TAKING:

CASE NO. :

FOLLOW UP NO. :

NAME :

AGE/SEX :

IP NO :

DATE OF ADMISSION :

DATE OF SURGERY :

DATE OF DISCHARGE :

OCCUPATION :

RESIDENCE :

Presenting complaints with duration :

History of presenting complaints :

Family History :

Personal History :

Past History :

Vitals

PR:

RR:

BP:

TEMP:

Systemic Examination:

Respiratory system -

Cardiovascular system -

Per abdomen -

Central nervous system -

Local examination:

Right/ Left Leg

Gait:

Inspection:

a) Attitude

b) Abnormal swelling

c) Skin condition

d) Compound injury, if any

Palpation:

a) Swelling
b) Local tenderness
c) Bony irregularity
d) Abnormal movement
e) Crepitus/ grating of fragments
f) Absence of transmitted movements
g) Wound

Movements:	Active	Passive
Flexion		
Extension		

Clinical tests:

Anterior drawer test

Posterior drawer test

Lachman's test

McMurray's test

Varus test

Valgus test

Investigations: MRI of the affected knee

Intra Operative details:

Post Operative:

- Rehabilitation protocol as per the guidelines
- Functional outcome evaluation with:
    1. IKDC scores
    2. Lysholm score

ANNEXURE –II

INFORMED CONSENT FORM FOR PARTICIPATION IN DISSERTATION / RESEARCH

I, the undersigned, _______________, S/O D/O W/O ________________, aged ____years, ordinarily resident of ____________ do hereby state/declare that **DR. NITESH SINGH RATHORE** of Shri. B. M. Patil Medical College Hospital & Research Centre has examined me thoroughly on ______________ at ______________ (place) and it has been explained to me in my own language that I am suffering from ________________ disease (condition) and this disease/condition mimic following diseases. Further**, Dr. NITESH SINGH RATHORE** informed me that he/she is conducting dissertation/research titled **" FUNCTIONAL OUTCOME OF ARTHROSCOPIC SINGLE BUNDLE ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING SEMI TENDINOSUS QUADRUPLED GRAFT FIXED WITH ADJUSTABLE LOOP ON FEMUR AND SUTURE DISC ON TIBIA: A PROSPECTIVE CLINICAL STUDY"** under the guidance of **Dr. SANDEEP NAIK** requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative, and follow-up observations will be utilized for the study as reference data.

The doctor has also informed me that during the conduct of this procedure, adverse results might encounter. Most of them are treatable but are not anticipated; hence there is a chance of aggravation of my condition. In rare circumstances, it may prove fatal despite the expected diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study will help in the evaluation of the results of the study, which is a useful reference for the treatment of other similar cases in the near future, and also, I may be benefited from getting relieved from suffering or a cure of the disease I am suffering.

The Doctor has also informed me that information given by me, observations made/ photographs/ video graphs taken upon me by the investigator will be kept secret and not assessed by a person other than my legal hirer or me except for academic purposes.

The Doctor informed me that though my participation is purely voluntary, based on the information given by me, I can ask for any clarification during the course of treatment/study related to diagnosis, the procedure of treatment, the result of treatment, or prognosis. I've been informed that I can withdraw from my participation in this study at any time if I want, or the investigator can terminate me from the study at any time from the study but not the procedure of treatment and follow-up unless I request to be discharged.

After understanding the nature of dissertation or research, diagnosis made, mode of treatment, I the undersigned Shri/Smt ____ under my full conscious state of mind agree to participate in the said research/dissertation.

Signature of the patient:

Signature of doctor:

Witness: 1.

2.

Date:

Place:

ANNEXURE -III

Azadi Ka Amrit Mahotsav

BLDE

(DEEMED TO BE UNIVERSITY)

Declared as Deemed to be University u/s 3 of UGC Act, 1956

Accredited with 'A' Grade by NAAC (Cycle-2)

The Constituent College

SHRI B. M. PATIL MEDICAL COLLEGE, HOSPITAL & RESEARCH CENTRE, VIJAYAPURA

BLDE (DU)/IEC/ 728/2022-23 30/8/2022

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The Ethical Committee of this University met on **Friday, 26th August, 2022 at 3.30 p.m. in the Department of Pharmacology** scrutinizes the Synopsis of Post Graduate Student of BLDE (DU)'s Shri B.M.Patil Medical College Hospital & Research Centre from ethical clearance point of view. After scrutiny, the following original/ corrected and revised version synopsis of the thesis/ research projects has been accorded ethical clearance.

TITLE: "Functional Outcome Of Arthroscopic Single Bundle Anterior Cruciate Ligament Reconstructon Using Semi Tendinosus Quadrupled Graft Fixed With Adjustable Loop On Femur And Suture Disc On Tibia: A Prospective Clinical Study".

NAME OF THE STUDENT/PRINCIPAL INVESTIGATOR: DR NITESH SINGH RATHORE

NAME OF THE GUIDE Dr.Sandeep Naik, Dept. of Orthopedics. .

Dr. Santoshkumar Jeevangi
Chairperson
IEC, BLDE (DU),
VIJAYAPURA

Chairman,
Institutional Ethical Committee,
BLDE (Deemed to be University)
Vijayapura

Dr.Akram A. Naikwadi
Member Secretary
IEC, BLDE (DU),
VIJAYAPURA

MEMBER SECRETARY
Institutional Ethics Committee
BLDE (Deemed to be University)
Vijayapura-586103. Karnataka

Following documents were placed before Ethical Committee for Scrutinization.

- Copy of Synopsis/Research Projects
- Copy of inform consent form
- Any other relevant document

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MASTER CHART

SERIAL NO	NAME	AGE	SEX	PATIENT ID	SIDE OF INJURY	MODE OF INJURY	INJURY TO SURGERY TIME (MONTHS)	GRAFT USED	MENISCAL INJURY	LYSHOLM PREOP (%)	LYSHOLM POSTOP 6 WEEKS (%)	LYSHOLM POSTOP 3 MON (%)	LYSHOLM POSTOP 6 MON (%)	LYSHOLM POSTOP 12 MON (%)	IKDC PREOP (%)	IKDC POSTOP 6 WEEKS (%)	IKDC POSTOP 3 MON (%)	IKDC POSTOP 6 MON (%)	IKDC POSTOP 12 MON (%)
1	DEVENDRAPPA	26	M	278497	LEFT	RTA	2	SEMITENDINOSUS	MEDIAL	54	80	94	100	100	41.4	59.8	74.7	85.1	95.4
2	DEVANNA	25	M	283335	RIGHT	SPORTS	1	SEMITENDINOSUS	LATERAL	47	84	95	99	99	44.8	59.8	86.2	96.6	96.6
3	MALLIKARJUN	22	M	291952	LEFT	RTA	6	SEMITENDINOSUS	LATERAL	42	80	90	94	100	41	61.9	66.7	85.2	95.2
4	NAGAVVA	45	F	320068	RIGHT	SELF FALL FROM STAIRS	2	SEMITENDINOSUS	MEDIAL	38	84	90	95	100	45	61.9	66.7	85.1	95.4
5	RAMESH	31	M	223842	LEFT	RTA	3	SEMITENDINOSUS	MEDIAL	54	80	94	100	100	60.9	64	79	91	96
6	VISHAL	19	M	358952	RIGHT	SPORTS	3	SEMITENDINOSUS	LATERAL	47	64	86	95	99	44.8	66.7	86.2	96.6	96.6
7	SANDESH	20	M	361838	LEFT	SPORTS	2	SEMITENDINOSUS	MEDIAL	38	61	81	86	86	47.1	61.9	74.7	85.1	91
8	PRAKASH	38	M	396002	LEFT	RTA	3	SEMITENDINOSUS	NONE	42	69	94	95	95	41.4	65.5	80	95.6	96.6
9	ANNAPURNA	35	F	289043	RIGHT	RTA	2	SEMITENDINOSUS	NONE	42	85	95	100	100	38.9	59.8	86.2	95.4	96.6
10	KASHIRAM	37	M	15528	RIGHT	RTA	9	SEMITENDINOSUS	MEDIAL	51	80	90	94	95	41.1	66.7	85.1	95.4	95.4
11	AKASH	18	M	73785	RIGHT	SPORTS	1	SEMITENDINOSUS	NONE	51	84	95	94	95	41.1	60.8	66.7	77.2	85.2
12	VIKAS	26	M	103951	RIGHT	SELF FALL FROM STAIRS	3	SEMITENDINOSUS	NONE	47	85	90	95	95	44.8	59.8	86.1	91	96.6
13	SANDEEP	23	M	112584	RIGHT	RTA	0.5	SEMITENDINOSUS	NONE	38	66	86	95	99	42	60.9	74.7	89.7	90.7
14	ASHOK	26	M	134121	RIGHT	RTA	1	SEMITENDINOSUS	NONE	42	84	94	100	100	60.9	64	85.1	95.4	96.6
15	SANJEEV	38	M	89600	LEFT	SELF FALL FROM STAIRS	24	SEMITENDINOSUS	NONE	47	85	95	100	100	37.9	61.9	77.2	86.2	95.4
16	VENKATESH	20	M	201488	RIGHT	SPORTS	6	SEMITENDINOSUS	MEDIAL	54	80	90	95	100	60.9	64	79	80	95.4
17	SUNITA	38	F	216843	LEFT	RTA	2	SEMITENDINOSUS	NONE	49	80	86	94	95	38.9	60.9	85.1	96.6	96.6
18	RAJSHEKHAR	25	M	185474	LEFT	SPORTS	0.5	SEMITENDINOSUS	NONE	42	64	86	90	94	45	60.9	66.7	78.2	90.7
19	GOURAPPA	27	M	230657	RIGHT	RTA	1.5	SEMITENDINOSUS	NONE	38	80	95	100	100	41	59.8	85.1	96.6	96.6
20	MAHADEV	24	M	276651	RIGHT	SELF FALL FROM STAIRS	6	SEMITENDINOSUS	NONE	51	84	90	100	100	38.9	60.8	86.1	90.7	95.6

21	**APPASAB**	**40**	**M**	**246784**	**LEFT**	**RTA**	**2**	**SEMITENDINOSUS**	**NONE**	**42**	**64**	**86**	**95**	**95**	**60.9**	**64**	**85.1**	**91**	**96**
22	**VIKAS**	**27**	**M**	**256078**	**RIGHT**	**RTA**	**1.5**	**SEMITENDINOSUS**	**NONE**	**47**	**84**	**90**	**94**	**95**	**44.8**	**65.5**	**80**	**96**	**96**
23	**SABEERA**	**35**	**M**	**22541**	**LEFT**	**RTA**	**12**	**SEMITENDINOSUS**	**NONE**	**38**	**66**	**86**	**94**	**95**	**44.8**	**59.8**	**86.2**	**96.6**	**96.6**
24	**SHIVKUMAR**	**27**	**M**	**278740**	**RIGHT**	**SPORTS**	**6**	**SEMITENDINOSUS**	**NONE**	**42**	**80**	**90**	**95**	**99**	**42**	**60.9**	**85.1**	**90.7**	**90.7**
25	**RUSHIKESH**	**24**	**M**	**279459**	**RIGHT**	**SPORTS**	**0.5**	**SEMITENDINOSUS**	**NONE**	**54**	**85**	**95**	**100**	**100**	**41.4**	**66.7**	**86.2**	**95.6**	**95.6**
26	**VIRUPAKSHYA**	**32**	**M**	**291039**	**RIGHT**	**SELF FALL FROM STAIRS**	**18**	**SEMITENDINOSUS**	**NONE**	**54**	**80**	**94**	**95**	**100**	**44.8**	**59.8**	**85.1**	**95.6**	**95.6**
27	**SHIVANAND**	**30**	**M**	**310467**	**RIGHT**	**RTA**	**3**	**SEMITENDINOSUS**	**NONE**	**47**	**84**	**94**	**100**	**100**	**44.8**	**61.9**	**66.7**	**78.2**	**80**
28	**MANJUNATH**	**41**	**M**	**313297**	**RIGHT**	**RTA**	**6**	**SEMITENDINOSUS**	**NONE**	**38**	**61**	**86**	**90**	**94**	**45**	**61.9**	**80**	**85.1**	**95.6**
29	**GOVIND**	**19**	**M**	**340498**	**LEFT**	**SPORTS**	**1**	**SEMITENDINOSUS**	**NONE**	**49**	**80**	**94**	**100**	**100**	**41.1**	**65.5**	**80**	**86.2**	**95.6**
30	**PURSHOTTAM**	**21**	**M**	**48202**	**RIGHT**	**SELF FALL FROM STAIRS**	**1.5**	**SEMITENDINOSUS**	**NONE**	**38**	**80**	**86**	**94**	**99**	**45**	**60.9**	**85.1**	**86.2**	**96.6**
31	**SRINIVAS**	**23**	**M**	**380376**	**RIGHT**	**RTA**	**9**	**SEMITENDINOSUS**	**NONE**	**47**	**85**	**90**	**100**	**100**	**44.8**	**60.9**	**85.1**	**91**	**96.6**
32	**GOVIND**	**45**	**M**	**11408**	**LEFT**	**RTA**	**6**	**SEMITENDINOSUS**	**NONE**	**54**	**88**	**95**	**95**	**95**	**45**	**65.5**	**85.1**	**95.4**	**95.4**
33	**SHASHANK**	**18**	**M**	**23415**	**RIGHT**	**SELF FALL FROM STAIRS**	**0.5**	**SEMITENDINOSUS**	**MEDIAL**	**51**	**69**	**86**	**95**	**99**	**60.9**	**64**	**80**	**91**	**91**

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