"ASSESSMENT OF FUNCTIONAL OUTCOME OF ARTHROSCOPIC ASSISTED ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLED HAMSTRING AUTO-GRAFT"

By

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ABSTRACT

Aims and objectives:

Assessment of functional outcome of arthroscopic assisted anterior cruciate ligament reconstruction using quadrupled hamstring autograft.

Background:

Anterior cruciate ligament reconstruction is the most commonly reconstructed ligaments of the knee. This study attempts to analyse the functional outcome of ACL reconstruction and the parameters utilized commonly to assess the outcomes.

Methods:

This is an analysis of 21 patients who underwent ACL reconstruction in duration between November 2019 to March 2021 on BLDEA’s BM Patil mdical college, hospital and research centre; and were studied. Analysis was made using standard scoring systems like Lysholm and IKDC score by an independent observer.

Results:

The injury was commonly noted in the male gender although the sidedness of the injury did not seem to influence the outcome. The larger percentage of cases was operated less than 6 months from the date of injury. The mean graft diameter was 7.90 mm, with a positive correlation to the thickness of the thigh. The preoperative mean Lysholm score of 59.19 improved to 94.95 after surgery. The mean preoperative IKDC score improved from 46.81 to 81.95. Two patients had infection and one patient had knee reduced range of motion. The timing of surgery and rehabilitation influence the outcome largely.

Conclusion:

Anterior cruciate ligament reconstruction surgery with quadrupled hamstring grafts provides a good outcome to ACL injuries when the surgery is timed well, with sufficient graft thickness and good rehabilitation

Key words:

ACL reconstruction, hamstring graft, quadrupled hamstring, protocol for ACL reconstruction

ABBREVIATION

ACL	ANTERIOR CRUCIATE LIGAMENT
ADT	ANTRIOR DRAWER TEST
AMB	ANTEROMEDIAL BUNDLE
BLBC	BONE LIGAMENT BONE COMPLEX
BPTB	BONE PATELLA TENDON BONE
CM	CENTIMETER
ET	EARLY RETENSIONING
HT	HAMSTRING TENDON
IKDC	INTERNATIONAL KNEE DOCUMENTATION COMMITIE
LB/CM2	POUNDS PER CENTIMETER SQUARE
LCLC	LATERAL COLLATERAL LIGAMENT COMPLEX
LT	LATE RETENSIONING
MRI	MAGNETIC RESONANCE IMAGING
N	NEWTON
N/MM	NEWTON PER MILLIMETER
OA KNEE	OSTEOARTHRITIS OF KNEE
PCL	POSTERIOR CRUCIATE LIAGMENT
PLB	POSTEROLATERAL BUNDLE
POD	POST OPERATIVE DAY
ROM	RANGE OF MOVEMENTS
RTS	RETURN TO SPORTS
SB ACL	SINGLE BUNDLE ANTERIOR CRUCIATE LIGAMENT

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INTRODUCTION

The knee joint is highly common in one of most injured joints in sports, and its prevalence is rising as the world becomes more urbanised. Knee ligaments are frequently injured in sports, particularly ones that involve contact, such as American football. Skiing, ice hockey, gymnastics, and other sports can all cause knee ligaments to rupture due to abrupt stress. Knee ligament ruptures are prevalent in road traffic incidents, particularly those involving motorbikes.

Ligament disruption can even occur devoid of a fall or direct impact when the ligaments are subjected to sudden, severe stress or strain, such as when a runner plants a foot to decelerate or change direction. Four mechanisms have been described as capable of disrupting the ligamentous structures around the knee:

1. Flexion, abduction and internal rotation of the femur on the tibia.
2. Flexion, adduction and external rotation of the femur on the tibia.
3. Hyperextension; and
4. Anteroposterior displacement.

According to the degree of injury Anterior cruciate ligament is torn. Knee instability, discomfort, and a loss in joint function are all symptoms of an ACL injury. Tears of the anterior cruciate ligament are one of the most common knee injuries. (1)

And Anterior-Cruciate-Ligament tear accounts more than 50% of knee injuries. (2). Acute Anterior-Cruciate-Ligament tear, which prevelance range from sixteen to forty six percentage, and in chronic tears, the incidence increases further. (3)

As evidence mounted that primary repair of midsubstance anterior cruciate ligament tears routinely failed, interest turned to reconstructing the ligament.

The grafts commonly used in anterior-cruciate-ligament-reconstruction are bone-patellar tendon-bone graft, peroneus longus graft and hamstring graft.

Among the above-mentioned, hamstring graft has the advantage of advancing soft tissue graft fixation technique and reporting knee pain in bone-patellar tendon-bone graft.

OBJECTIVE OF THE STUDY

“ASSESSMENT OF FUNCTIONAL OUTCOME OF ARTHROSCOPIC ASSISTED ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION, USING QUADRUPLED HAMSTRING AUTO-GRAFT”

REVIEW OF LITERATURE

HISTORICAL REVIEW

The first description of the structure, later known as the anterior-cruciate-ligament (ACL), dates back to ancient Egypt (3000 BC), with Hippocrates (460–370 BC) subsequently reporting a ligament pathology that produced anterior tibial subluxation. (4). Moreover, the first ACL repair was documented in history by Sir Arthur Mayo-Robson (1853–1933), done on 41 years old miner proximally torn anterior-cruciate-ligament was sutured was catgut to femoral insertion. (4)
After following experimental studies, surgical repair was the mainstay for ACL tear in the early 1380s.

In 1917, Ernest William Hey Groves performed the first ACL reconstruction. He used fascia lata from tibial insertion and passed it from proximal to distal through tibial and femoral tunnel. (4)

Zur Verth replaced fascia lata to the torn meniscus and sutured the graft with ligament remnants. (5)

In 1976, Kurt Franke of Berlin reported good long-term functional outcomes following one hundered and thirty cases of ACL reconstructions using a free graft of the central third of the patellar tendon. (5) With excellent long term results, coupled with reliable and reproducible surgical technique, the BPTB was the most popular graft resource, and still it is being used.
As such BPTB graft usage showed few complications in long term studies. They resulted in a patellar fracture, patellar tendon rupture, flexion contracture, patellar tendinitis and anterior knee pain.

1934 by Italian orthopaedic surgeon Riccardo Galeazzi, who described a technique for ACL reconstruction using the semitendinosus tendon. (5)

In 1984, Walter Blauth study showed a good result with 53 patients undergoing ACL reconstruction with quadriceps tendon. But quadriceps tendon didn't gain popularity like BPTB despite studies confirming the excellent mechanical property of the quadriceps tendon until the 21st century. (6)

Allograft reconstruction of the ACL was an attractive proposition as it avoids the need for graft harvest and associated donor site morbidity and prevents weakening of external ligament and tendon structures which contribute to overall joint stability

The Allograft used for reconstruction of the ACL avoids the need for graft harvest and associated donor site morbidity and prevents weakening of external ligament and tendon structures.

In 1986, Konsei Shino and associates became one of the first groups to publish clinical results of 31 patients

who had received allogenic reconstruction of the ACL utilising mainly tibialis anterior and Achilles tendon allografts. (7)

The use of synthetic products for ACL reconstruction was expected to be stronger than soft tissue grafts. The synthetic products could be manufactured according to anatomical variation, leading to better mechanical property and decreasing donor site morbidity. In terms of in vivo, the synthetic graft showed fatigue resistance in nature beyond human ligament endurance.

Stryker produced polyethene terephthalate (i.e., Dacron) ligament replacement device commercially available in the 1980s. The studies showed a higher chance of complications like graft failure and signs of osteoarthritis. The product

was discontinued in 1994.

Various synthetic ACL grafts composed of other materials in the early 1990s was introduced, including GoreTex, PDS, Eulit, and Polyflex. For the expectation of the reliable and durable product. The products result in fatigue failure, graft rupture, chronic synovitis, tunnel widening due to osteolysis, foreign body reaction, and poor incorporation of the synthetic grafts into the host bone.

EMERGENCE OF ARTHROSCOPY

In 1970, Canadian doctor Robert Jackson achieved the most profound advancement in an arthroscopic examination of the knee joint. The first arthroscopic assisted anterior-cruciate-ligament-reconstruction was done by Dr David Dandy in 1980. (8) After several years of debate between open repair or reconstruction of the ACL tear, arthroscopy has become the gold standard. (9)

EVOLUTION OF ARTHROSCOPY

Prior to the invention of arthroscopy, surgeons all around the world prioritised attempts to view closed compartments. In 1806, Bozzini had first effort to visualize the bladder with a device known as the “Lichtletr”(10). Arthroscopy has evolved since the 20th century. The term "arthroscopy" is derived from the Greek work "arthro", which means "joint", and scope, which means "to view" (11).

In the 1912(10), a presentation titled "Endoscopy of closed cavities utilising five millimeter trocar endoscope" was delivered successfully after using cystoscope in knee joint by Danish surgeon – Severin Nordentoft. He utilised an apparatus that looked a lot like Jakobeus's laparoscope. His work was quickly forgotten because his was the only paper on endoscopy.

Takagi, a Japanese surgeon, utilised a cystoscope to examine a cadaver knee in 1918. Due to the instrument's failure, he aided in the development of the arthroscope in 1920. The diameter of the instrument, however, was far too large to be useful.

In 1931(12), Takagi developed a 3.5 mm diameter arthroscope. He also talked about how to use saline solution for knee distention and better vision.

A Swiss surgeon "Eugene Bircher" used the laparoscope to visualise the meniscal lesions of the knee joint. He termed the procedure "arthroendoscopy."

Takagi and Bircher are known as the "Father of Arthroscopy" because of their early contributions to the creation of the procedure.

In 1931, Michael Burman wrote "Arthroscopy or the Direct Visualization of the Joints," a historical study. He also released the first arthroscopic photographs, twenty coloured aquarelles illustrating arthroscopy findings of various joints.

In 1962, he performed the first arthroscopic partial meniscectomy. He is appropriately referred to as the "Father of Modern Arthroscopy."

Dr Lanny Johnson, first invented the arthroscopy motorized shaver in 1976. Dr John Joyce organised the first arthroscopy in 1972(13)

Surgical arthroscopy was evolved arround the year 1970s-with the introduction of optic fiber and the use of monitor, allows surgeon to view the joint on a monitor. 3D visualization during arthroscopy and manual movable optics with 0 to 90 rotation are the future of arthroscopy.

RECENT ARTICLES

In 2004, C. Benjamin Ma, et al., studied to evaluate anterior-cruciate-ligament reconstruction using hamstring graft with bioscrew fixation and distant fixation using Endo-Button and screw-post. Their study stated significant tunnel enlargement was both groups. More enlargement on the femoral componenet. Furthermore, as compared to distant fixation with Endobutton, bioscrew did not result in significant variations in clinical outcome. Furthermore, as compared to distant fixation with Endobutton, bioscrew did not result in significant variations in clinical outcome.
In 2005, Volker Musahl, MD, Anton Plakseychuk, MD, Andrew VanScyoc, Tomoyuki Sasaki(15) studied on femoral Tunnels of Various Types Between the Anatomical Footprint and Isometric Positions, a graft implanted inside the anterior-cruciate-ligament's anatomical footprint restores knee function better than a graft placed in the optimal graft isometric position.

In 2008, Richard B. Meredick, Kennan J. Vance, David Appleby et al. (16) the outcome of single-bundle anterior-cruciate-ligament-reconstruction vs double-bundle anterior-cruciate-ligament-reconstruction was investigated. In individuals treated with double-bundle versus single-bundle reconstruction, there was no statistical difference in the probabilities of obtaining a normal or nearly normal pivot-shift result.

In 2009, Chao Shen, Sheng-Dan Jiang, Lei-Sheng Jiang et al. (17) conducted a meta-analysis of randomised control trials on bio screw vs titanium screw fixation in Anterior-Cruciate-Ligament-Reconstruction. The meta-analysed results of these studies showed no statistically significant difference between bioabsorbable and metallic screw fixation in infection rate. And no significant difference in measurement results of knee joint stability or knee joint function outcome. Knee joint effusion is more prevalent after anterior-cruciate-ligament-reconstruction with bioabsorbable interference screw fixation than metallic interference screw fixation.

In 2010, Alexis Colvin, Charu Sharma, Michael Parides, Jonathan Glashow (18) did a meta-analysis on Best Fixation on femoral side of Hamstring Autografts in anterior-cruciate-ligament-Reconstruction. The study concluded that interference screws for femoral fixation resulted in a trend toward decreased risk of surgical failure. However, there is no difference when post-operative functional outcomes.

In 2012, Hong-Chul Lim, Yong-Cheol Yoon, Joon-Ho Wang, et al. (19) studied and concluded that anatomical single-bundle-Anterior-Cruciate-Ligament-Reconstruction restored the initial stability closer to the native Anterior-Cruciate-Ligament under combined anterior and internal rotational forces when compared to non-anatomical Anterior-Cruciate-Ligament-single-bundle-reconstruction.

In 2015, Hakan Sofu, M.D., Vedat Şahin, M.D., Sarper Gürsu, M.D., Timur Yıldırım, M.D., Ahmet Issın, M.D., Mehmet Ordueri, M.D., (20) a study between June 2005 and November 2010, clinical data of 44 patients operated on were retrospectively analysed on ACL reconstruction with Quadriceps tendon and quadrupled hamstring tendon autograft. Twenty-three patients were in the quadriceps group and 21 patients in the hamstring group. With a mean follow up 37.6 months, the mean laxity of post operative knee was 5.65 mm quadriceps tendon group and 3.67 mm in the hamstring tendon group. Statistically significant differnece was found ($p<0.001$). Quadrupled hamstring tendon autograft is better than quadriceps tendon-patellar bone in arthroscopic anterior-cruciate-ligament-reconstruction surgery.

In 2016, Cristian Tudor Buescu, Adela Hilda Onutu, Dan Osvald Lucaciu, Adrian Todor (21), after single-bundle ACL reconstruction using free quadriceps tendon autograft versus hamstring tendon autograft, pain levels and painkiller usage were compared. A total of fourty eight patients were randomly assigned to one of two groups: free quadriceps tendon autograft (24 patients) or hamstring tendons autograft (24 patients) for anatomic single-bundle ACL reconstruction (24 patients). Supplementary analgesic drug administration was substantially higher in the hamstring graft group, with a median (interquartile range) of 1 (1.3) dose, compared to the quadriceps graft group, with a median (interquartile range) of ¼ 0.5 (0.1.25) (p ¼ 0.009).

A significantly higher number of subjects with a quadriceps graft did not require any supplementary analgesic drug as compared with subjects with the hamstring graft. The free quadriceps tendon autograft for ACL reconstruction leads to less pain and analgesic consumption in the immediate post-operative period than the use of hamstrings autograft.

In 2016, Jeong Ku Ha et al.(22), suggested there is no significant difference in both functional outcome and clinical outcome between single-bundle anterior-cruciate-ligament-reconstruction and double-bundle-anterior-cruciate-ligament-reconstruction in the short term, but the better outcome in follow up. The articles suggested that remnant preservation significantly improved knee stability after Anterior-Cruciate-Ligament-reconstruction. In addition, it was recommended that the degree of initial graft coverage greatly affected post-operative knee stability. Remnant preservation decresed the occurrence rate of cyclops lesions.

The pivot-shift test results were also significantly better in the single bundle (56%) than in the resected group (44%). They concluded that remnant preservation in anatomic double-bundle ACL reconstruction significantly improved post-operative knee stability. However, in the short-term assessment, it had no significant impact on subjective and functional outcomes.

In 2017, Brian T. Samuelsen MD et al. (23) a meta-analysis on 47,613 patients on RCT, prospective cohort studies, and high-quality national registry studies to compare the outcomes of primary ACL reconstruction with bone-patella-tendon-bone autograft or hamstring autograft. In which 7845 were reconstructed with hamstring tendon and 39,768 were reconstructed with BPBT. 2.80% of bone-tendon-bone grafts ruptured compared with 2.84% in the hamstring group, with confidence interval, 0.72-0.96; p = 0.01. In this meta-analysis of short- to mid-term follow-up after primary ACL reconstruction, hamstring autografts failed at a higher rate than bone-tendon-bone autografts. However, failure rates were low in each group, the difference observed was small, and the grafts performed similarly in metrics of graft laxity.

In 2017, Puneet Chamakeri et al.,(24) studied with thirty skeletally mature individuals with a verified anterior-cruciate-ligament tear, with or without concomitant meniscal damage, underwent arthroscopic anterior-cruciate-ligament-restoration using quadrupled semitendinosus autograft with minimum 1 year follow up. Their study showed that the IKDC score was normal in 21 patients (70%), near normal in 7 patients (23.3%) and abnormal in 2 patients (6.6%). 21 patients have excellent grade in lyascholm knee scoring system. Mean pre-op affected leg hop test was 42.36±10.19 and it was improved to 76±19.93 which statistically significant ($p< 0.001$). their result concluded that, the functional outcome of arthroscopic single bundle anatomical ACL reconstruction with quadrupled semitendinosus tendon autograft is excellent to good.

In 2018, Zi-Yang Chia1, Jade N Chee2, Hamid Rahmatullah Bin-Abd-Razak1, Denny TT Lie1 and Paul CC Chang (25) studied ACL reconstruction on 291 patients in which 147 patients were performed double ACL bundle reconstruction, and 76 patients underwent single-bundle ACL reconstruction. After a 2-year follow-up period, there was no significant change in ligament grade, function grade, IKDC grade, or Lysholm knee scoring system means between the three groups. According to the findings, selective bundle reconstruction produces outcomes that are equivalent to D.B. and S.B. reconstruction techniques. For patients with partial tears, it is a viable option.

In 2018, Sandeep Yadav Tirupathi, Divyanshu Goyal, Vidyasagar Jvs (26) studied 96 patients. Forty-eight patients were operated with quadriceps tendon autograft, and 48 patients were operated on with quadrupled hamstring tendon autograft. 2 years of follow up had the following results. At two years follow up in the quadriceps tendon group, the mean IKDC score is 113; in the quadrupled hamstring tendon group, the mean IKDC score is 118 with a p-value > 0.05, showing no statistical significance difference between the quadriceps and hamstring tendon autograft groups following anterior-cruciate ligament reconstruction.

In March 2019 by Bertrand Sonnery-Cottet (27), The study protocol was registered with PROSPERO (International prospective register of systematic review). A total of 780 potential articles were identified. 20 met the inclusion criteria. These studies provide quality evidence to support the efficacy of cryotherapy and physical exercises in managing Arthroscopy reconstruction of an ACL tear. There was low-quality evidence for the effectiveness of neuromuscular electrical stimulation and transcutaneous electrical nerve stimulation, and very low-quality evidence for the efficacy of ultrasound and vibration The efficacy of cryotherapy and physical training in alleviating quadriceps activation failure following ACL damage and repair was found to be of moderate quality in this scoping review. As a result, several therapeutic techniques are indicated in the treatment of AMI.

In 2019 by Mondem, Akshith Bekkam Siddigari, Dileep Kumar Reddy, A. M, Iliyas Basha (28), between September 2016 and August 2018, researchers analyzed at 25 patients with signs and symptoms of ACL tear who were admitted to the government general hospital's OPD and casualty. For ACL injuries, patients had anterior-cruciate-ligament reconstruction with hamstring autograft.

The average IKDC score after surgery is 87.54 percent. Lysholm Knee Score patients had an excellent to good prognosis in 84 percent of cases. Surface infection affected 4% of patients (n=1), extensor latency affected 4% of patients (n=1), and deep infection affected 4% of patients (n=1). Clinical outcomes following anterior-cruciate-ligament-reconstruction using hamstring auto-graft are beneficial for anterior-cruciate-ligament-deficient knees, with least post-operative problems.

In 2020, Lei Yan, Jiao Jiao et al. (29) Identified articles with evidence level I or II studies that compared at least two femoral fixation procedures with hamstring autograft for ACL reconstruction using Medline, EMBASE, and the Cochrane Library. Out of 2536 studies found, 16 clinical trials were chosen for analysis. For the 10 key outcome variables, a Bayesian network meta-analysis revealed no significant differences between the three fixation strategies. The I.S., C.B., and C.P. had the top ProBest in 5, 5 and 0 outcomes and the maximum SUCRA values in 5, 4 and 1 outcomes, respectively, based on the 10 outcome measures. Although the Interference Screw was more likely to perform better than the Cortical Button and Cross Pinning based on the analysis of outcome measures from the included studies, there were no statistical differences in performance between the Cross Pinning, Cortical Button, and Interference Screw femoral fixation methods with hamstring autograft in ACL reconstruction.

In 2020, Matthew W. DeFazio et al. (30) conducted a systemic review in view of comparing Return to sports (RTS) rates among athletes undergoing primary ACL reconstruction using a bone-patellar tendon-bone (BTB) versus Hamstring tendon (H.T.) autograft. Studies were found in the MEDLINE, Embase, and Cochrane Library databases. A total of 2348 athletes were studied in 20 articles. Our cohort's total RTS rate was 73.2 %, with 48.9% recovering to pre-injury levels of performance and a 2.4% re-rupture rate. After primary ACL reconstruction with a BTB autograft, the overall RTS rate was 81.0 %, with 50.0 % of athletes returning to pre-injury performance and a re-rupture rate of 2.2%. The total RTS rate following primary ACL reconstruction with an H.T. autograft was 70.6 %, with 48.5 % of athletes regaining to pre-injury levels of performance and a 2.5% rerupture rate. Study concluded, when compared to H.T. autografts, ACL reconstruction with BTB autografts showed greater overall RTS rates. BTB and H.T. autografts, on the other hand, had identical rates of recovery to pre-injury performance and re-rupture rates.

In 2021, Nam-Hong Choi et al., (31) between June 2016 and January 2018, 101 patients had hamstring ACL reconstruction using the adjustable-loop device for femoral fixation as part of the study. On POD 1, all patients received a follow-up MRI. After the button was flipped and the graft was placed at the tibia, knot tying of the first tightened adjustable loop was performed in the Early re-tensioning group (E.R.). Retensioning and knot tying were done after initial tightening of the adjustable loop and graft fixation on the tibial side in the Late re-tensioning (L.R.) group. The tunnel-graft gap calculated on multiplanar reformatted images of MRI scans was evaluated between the groups, as were clinical outcomes.

The mean S.D. tunnel-graft gap in the E.R. group was 1.5 ± 2.0 mm and 5.4 4.0 mm in the L.R.

group (P.001). E.R. and knot tying demonstrated less tunnel-graft gap than that of L.R. However; there were no differences in clinical and functional outcomes according to the timing of re-tensioning.

ANATOMY OF ACL

- **EMBRYOLOGY**

At 6.5 weeks of gestation, the ACL appears as mesenchymal conduction in blastoma, well before joint cavitation. While the anterior-cruciate-ligament is positioned intraarticularly, it is encircled by a fold of synovium that derives from the posterior capsular apparatus of the knee joint; consequently, the anterior-cruciate-ligament remains extra synovial throughout its duration. (32)

- **GROSS ANATOMY**

The anterior-cruciate-ligament is a type of cruciate ligament that runs across the front of the knee joint. The cruciate ligaments are also known as the cranial cruciate ligament in the quadruped stifle joint because of its anatomical position. (33).

The ACL is a thick connective tissue band-like structure. The femoral attachment is on the posterior part of the medial aspect of the lateral femoral condyle. The insertion bundle breadth is about between 11 and 24 mm in diameter.

In fig. 1, the ACL is seen in the femoral intercondylar notch in a front view of a left knee. The length of ACL ranges from twenty-two to forty one millimeter, averaging about thirty two millimeter and the average width is ten millimeter. Which ranges from seven to twelve millimeter. The cross-sectional area varies in size and shape from the femur to the tibia. (As seen in fig. 1)

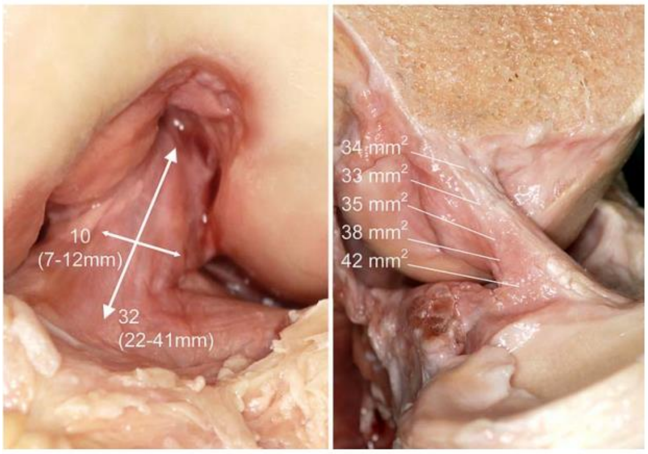


Fig 1: Gross anatomy of ACL

The posterior side of the medial surface of the lateral femoral condyle attaches to the ACL, which inserts into the large space in the middle of the tibial plateau. Within the knee joint, the ACL runs in an oblique direction, from lateral and posterior at its origin from femur to medial and anterior towards its tibial insertion. As the synovium surrounds the anterior-cruciate-ligament, it is an intra-synovial intra-articular structure.

The ACL fibres fan out as they approach their tibial attachment. They attach anterior and lateral aspect of the medial tibial spine to the fossa. This fossa is a wide, depressed area measuring ranges from eight to twelve millimeter i.e., average approximately eleven millimeter wide. In AP direction, ACL measures ranging from fourteen to twenty-one millimeter in diameter which averages approximately about seventeen millimeters. Before the ACL reaches tibial attachment, some of fibres run anteriorly underneath the transverse intermeniscal ligament. Some extensions of anterior-cruciate-ligament fibres to the anterior or posterior horn of the lateral meniscus of the knee joint. The tibial attachment is somewhat broader and stronger than the femoral attachment.

Girigis suggested the ACL is divided into two parts, the anteromedial bundle (AMB), and the posterolateral bundle (PLB).

The AMB bundle is situated at the most anterior and proximal end in femoral end. Moreover, insert at the anteromedial end of the tibial attachment. And as anatomical position of the ACL, the PLB fibres on the other hand, originate from the posterodistal aspect of the femoral attachment, and inserts into posterolateral aspect of the tibial attachment. They are posterolateral with respect to AMB bundle.(34) (fig 2). During knee flexion, there is a actual lateral rotation of the ligament as a whole around its longitudinal axis, and the AMB begins to spiral around by itself with the rest of the ligament. The position of the Anterior-Cruciate-Ligament's bone attachments causes this relative displacement of one bundle over another.

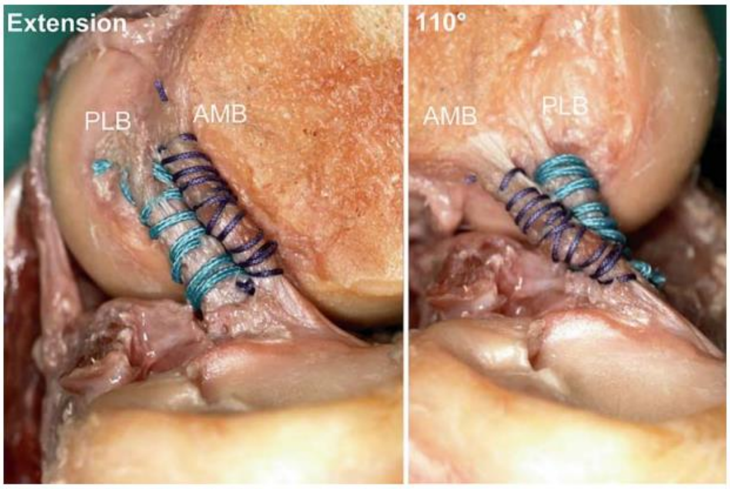


FIG 2: Bundle of ACL

The two bundles are not isometric in flexion and extension movements of knee joint, but they exhibit distinct patterns of change in length of ligament. In flexion, the AMB lengthens and tightens, whereas the PLB shortens and becomes slack, according to Mollis et al(35).

- **MICRO ANATOMY**

Microscopically, the ACL is distinguished in three zones.

1. The less solid proximal part is extremely cellular, with a round and ovoid cell rich in fusiform fibroblasts, glycoproteins such as fibronectin, laminin, and collagen type II.

2. A high density of collagen fibres, a particular zone of cartilage and fibrocartilage, elastic, and oxytalan fibres make up the middle part, which contains fusiform and spindle-shaped fibroblasts. This middle part, also known as the fusiform zone, is characterised by fusiform and spindle-shaped fibroblasts. High collagen density, poor cellularity, and elongated spindle-shaped fibroblasts are found in the ACL's mid-substance.
3. The distal part, which is the highly solid, is rich in chondroblasts and ovoid fibroblasts (Fig. 5b) and with a low density of collagen bundles.

The site of the femoral and tibial attachment of anterior-cruciate-ligament has the structure of chondral apophyseal enthesis (36)

- 1st layer - insertion of the mineralised fibrocartilage into the subchondral zone
- 2 nd layer - mineralised cartilage zone
- 3 rd layer - non-mineralised cartilage zone
- 4 th layer - ligament fibres

The 6% of ACL is composed of a matrix and consists of four different systems.

1. Collagen
2. Glycosaminoglicans
3. Glycoconjugates
4. Elastic components

- **STRUCTURAL AND MECHANICAL PROPERTY**

Mechanical qualities are the properties of the ligament or replacement graft without its insertion sites, whereas structural properties are the properties of the ligament or replacement graft with its insertion site and fixation devices(36). When a femur ACL tibia complex is tensile tested, the load-elongation curve that results represents the FATC's structural qualities (Fig. 3A). The graph curve is determined by the qualities of the ligament substance, the complicated geometry, and the ligament's bone insertion point. The linear stiffness, ultimate load, ultimate deformation, and energy absorbed at failure are all essential structural parameters.(37)

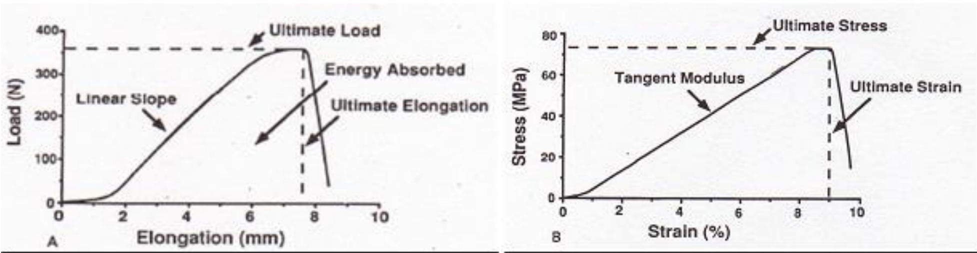


FIG.3 : Structural properties of a bone-ligament-bone complex
Load elongation curve

FIG.3B Mechanical properties of ligament substance
Stress-strain curves

The stress-strain curve could be used to determine the "mechanical properties" of the ligament substance (Fig. 3B). Energy density can also be calculated by using stress-strain curve values for modulus, ultimate stress, and strain.

The natural ACL's structural and mechanical qualities have been demonstrated to deteriorate with ageing. FATC had a mean ultimate load of 2,160 (157 N) in specimens aged 22–35 years. The area beneath the curve may be used to compute the energy absorbed at failure, and for specimens aging 22-35, the energy absorbed at failure was found to be 11.6 (1.7) Nm.(38)

The biomechanical analysis of a quadrupled hamstring graft revealed a mean load and stiffness of 2,422 (± 538) N and 238 N/mm. (39)

- **BLOOD SUPPLY**

Diffusion from the surrounding synovial fluid is the primary source of nutrition for ACL. The ligament branch of the superior middle genicular artery, branch of popliteal, which enters through the synovial sleeve's proximal part, provides blood flow. The blood flow to the synovial membrane around ACL is abundant. The femoral attachment site receives less blood, and the tibial insertion site receives nearly no blood.

- **NERVE SUPPLY**

The nerve supply to the Anterior-Cruciate-Ligament originates from the posterior articular nerve branch of the posterior tibial nerve. Although the majority of fibres appear to have a vasomotor function, some fibres may serve a proprioceptive or sensory function. The receptors present in Anterior-cruciate-ligament are the Ruffini receptors (stretch receptors) and free nerve endings.

FUNCTION OF ACL

The primary function of ACL is mechanical stability to the knee joint. It helps maintain the knee's static and dynamic equilibrium with other structures around the knee joint.

The ACL has two other complementary roles

- Mechanical function
- Proprioception of joint

The fact that nerve terminals in the ACL may be seen histologically indicates that the ACL has proprioception function.

The mechanical functions of ACL have the subsequent characteristic

- Resistance against the anterior translation of the tibia on the femur in 90 degrees of knee flexion by the anteromedial bundle of ACL.

  - Avoids the hyperextension of the knee joint by the posterolateral bundle of the ACL
- The Anterior-cruciate-liagement gives rotational stability to the knee joint by acting as a check to internal axial rotation.
- The Anterior-Cruciate-Liagement acts as secondary restraint against valgus and varus stresses in all degrees of knee flexion
- As the joint reaches in full extension, tension in the Anterior-cruciate-ligament does fine-tuning in the screw home mechanism, thus stabilising the joint.

BIOMECHANICS OF KNEE JOINT

The knee joint is the largest and very complex joint. It is an articulation among the distal femur, proximal tibia and patella, surrounded by a soft tissue envelope of capsule, ligaments, tendons and muscles. The specific anatomical features and interactions of these structures determine the stability and movements of the knee joint.

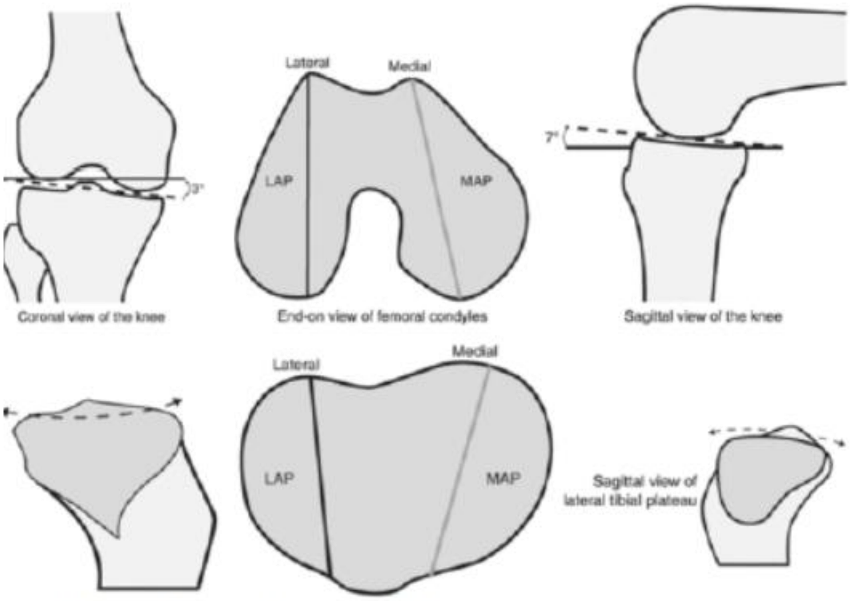


FIG 4: Biomechanics of knee joint

- **TIBIOFEMORAL JOINT**

In comparison to the lateral tibial plateau, the medial tibial plateau is bigger. It also features a concave depression, whereas the convex surface of the lateral tibial plateau. Both plateaux have a posterior inclination of roughly 7°, while the menisci keep the joint surface tilt to 3°. In addition, the plateaux have a 3° varus tilt, which means the joint surface is slanted medially. On the femoral side, the medial condyle is bigger, more curved, and extends more distally than the lateral condyle. The relative mobility of each compartment is determined by the imbalance between the medial and lateral compartments of the knee. As seen in fig 4, the concave medial tibial plateau provides more constraint, whereas the convex lateral tibial plateau provides less constraint to their respective femoral condyles.

- **BIOMECHANICS WITH RESPECT TO CRUCIATE LIGAMENTS**

The anterior-cruciate-ligament is major restraints on tibia anterior translation, whereas posterior-cruciate-ligament restraints on tibial posterior translation. The cruciate ligaments work in an exceptional configuration known as the 'four-bar linkage mechanism' (FBL). The cruciate ligaments form two crossed bars in this figure, while the bones functionally form the other two bars. The cruciate ligaments can swivel about their insertion places as the knee joint flexes and stretches. The length of the four bars does not change throughout joint motion, but the angle between them does. Furthermore, the four-bar linkage (FBL) hinge's (FBL) centre of rotation lies at the cruciate ligaments' crossover point, which varies with knee position.

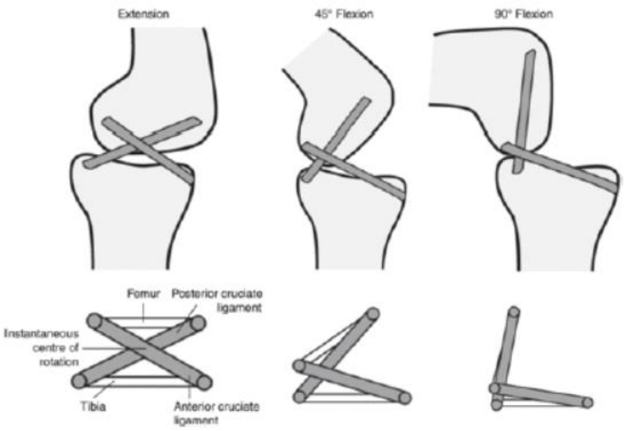


Fig 5 The cruciate ligaments function as a four-bar linkage hinge o stabilise the joint whilst permitting motion

The cruciate ligaments are not stiff and alter length, allowing the joint to rotate internally and externally. As a result, the ligaments are described as a 'modified' four-bar connection mechanism (as opposed to rigid). Figure 5 depicts a modified four-bar linkage.

When the knee is in 90^0 of flexion and neutral rotation, the anterior-cruciate-ligament is the principal restriction to anterior tibial translation, accounting for roughly eighty five percentage of the resistance to the Anterior Drawer Test (ADT). The anteromedial band is tight in flexion, providing the principal constraint, according to selective sectioning of the anterior-cruciate-ligament. The bulky posterolateral section of this ligament, on the other hand, is tight in extension. The main source of resistance to hyperextension is the posterolateral bundle. At 30 to 40 degrees of knee flexion, the anterior-cruciate-ligament has the least amount of stress. At full extension, the anterior-cruciate-ligament also acts as a supplementary to tibial rotation stability and varus-valgus angulation stability. The anatomical anterior-cruciate-ligament has been demonstrated to carry loads across the whole ROM of the knee. The ultimate load was 1725 ± 269 N, the stiffness was 182 ± 33 N/mm, and the energy absorbed to failure was 12.8 ± 2.2 N-m, according to complete biomechanical research. The ultimate load was determined to be 2160 ± 157 N in younger specimens, with a rigidity of 242 ± 28 N/mm.

MECHANISM OF INJURY

The mode of injury is either Direct (contact) or indirect (non-contact).

Deceleration with a valgus and twisting action is the most prevalent non-contact mode of injury.

Deceleration, internal/external rotation, and hyperextension were the most prevalent modes of injury in isolated ACL injuries, which occur when landing from a jump or making an abrupt change in direction while jogging.

Women have predominance in a non-contact mode of injury due to the following reasons.

- Women have a smaller intercondylar notch
- Females have a greater Q angle than males
- Neuromuscular risk factors
- Females has Lesser strength and smaller size ACL
- Hormonal factors may cause laxity of ligaments

Varus and valgus stability is provided by structures in medial and lateral aspect around the knee joint, like collateral ligaments, whereas anteroposterior and rotatory support is provided by the anterio-cruciate-ligament, posterior-cruciate-ligament and capsule-ligamentous structures. The primary and secondary stabilisers change depending on the location of the knee.

When the above is combined with rotation, the medial meniscus becomes trapped between the articulating surfaces of the tibial and femoral condyles, resulting in the classic O' Donoghue triad.

CLASSIFICATION OF ACL INJURY

According to the American Medical Association handbook, a sprain is defined as an injury limited to ligaments. The sprains are classified into 3 distinct degrees of severity. (40)

The severity of the ligament injury and whether or not there is stability of joint are used to grade the sprain. When the injured ligament can no longer provide adequate support, the joint becomes unstable.

- A 1st degree of sprain of a ligament is defined as 'a ligament tear involving a small number of fibres with localised discomfort but no instability'.
- A 2nd degree of sprain is a 'With mild-to-moderate instability, more ligamentous fibres are disrupted, resulting in increased function loss and joint response like inflammation or synovitis.'.
- A 3rd degree of sprain, as a 'complete disruption of the ligament with resultant marked instability'.

The third - degree sprain can be further graded by the degree of instability demonstrated during stress testing.

- Grade – instability 1 +, the joint surfaces separate about 5 mm or less
- Grade – instability 2 +, the joint is separated 5 to 10 mm
- Grade – instability 3 +, the joint is separated 10 mm or more

The treatment of first - degree sprains is symptomatic only;

- The first - degree sprain within a few days, one ought to be able to continue athletic activities.
- The second - degree sprains with a knee brace locked in extension, individuals with mild local injury and joint response and no evidence of instability can be managed conservatively.
- Third - degree sprains with Unless there is a specific contraindication, complete ligament disruption may necessitate surgical repair.

NATURAL HISTORY

Various study shows that after an Anterior-cruciate-liagament injury, abrupt resuming in sports activity or episodes of instability may lead to meniscal injury and osteochondral injury that will lead to arthritis. In the first year following undergoing reconstruction and returning to sports activities, the incidence of a second anterior-cruciat-ligament tear is 15 times higher than in previously undamaged ACL patients.

Meniscal injuries occur fifty to Seventy percent of the time with acute ACL tears, with the lateral meniscus being the most frequently affected. Because of the anomalous loading and shear forces, late meniscal degeneration is very common in Anterior-cruciate-ligament torn knees. Because of its strong relationship to the capsule, the medial meniscus is frequently affected in chronic ACL injuries.

After the first anterior-cruciate-ligament injury osteochondral alteration occurs in twenty to thirty percent of patients. In individuals with acute and chronic anterior-cruciate-ligament injuries, MRI is a sensitive method for diagnosing bone lesions. These osteochondral anomalies could be osteoarthritis precursors.

CLINICAL EVALUATION

The clinical evaluation of an Anterior-Cruciate-Ligament injured patient starts with detailed clinical history. Deceleration injury or jumping action are the natural history for non contact injury. The patient presents with hearing or feeling a popping soung in the knee at the time of injury. And patients gives history of significant fall i.e., patient cannot get up immediately after fall. The patient is unable to resume his normal activities right away, and walking after a fall is a laborious task. Haemarthrosis develops afterwards. In these circumstances, the likelihood of an anterior-cruciate-ligament damage is over seventy percentage. It is easier to perform a physical examination before haemarthrosis occurs.

Pain and giving way of the knee joint among common complaints at the time of presentation. ACL rupture are more common in non-contact accidents, whereas multiple ligament injuries are more common in contact injuries. Clicks are indicative of related meniscal injury when there are complaints of locking episodes. Knowledge of the patient's occupation and personal needs aids in the individualization of patient care.

PHYSICAL EXAMINATION

After the patient’s consent is taken in verbal form, the physical examination is begun. This includes an inspection of the knee joint from the front side and back. Followed by Palpation, measurements, and movements of the knee joint. Then there are testing for the cruciate ligaments, collateral ligaments, and menisci. This aids in accurate diagnosis and management planning. The following are some of the many tests used to diagnose an anterior-cruciate-ligament injury.

1. **Anterior Drawer test:**

In the supine position, the hip is flexed 45 degrees and the knee is flexed 90 degrees. To stabilise the foot, the examiner sits on the dorsal aspect of foot. Placing the hands over the posterior part of the knee confirms that the hamstring muscles are relaxed. The thumbs are retained on both sides of the tibial tuberosity. After that, the proximal tibia is gently dragged anteriorly. The degree of tibia translation on the femur is noted. Thirty degrees of external rotation and Thirty degrees internal rotations are performed in the same way.

A displacement of 6-8 mm more than that of the contralateral knee indicates Anerior-Cruciate-Liagment injury.

FIG 6: Anterior drawer test

2. **Lachman test**

In a painful, acutely damaged knee, the anterior drawer test is impossible to perform since ninety degrees of flexion is not possible. The Lachman test could be used in this situation. The patient is supine, with the limb flexed at a fifteen-degree angle. The proximal section of the tibia is pulled forward to translate it anteriorly, while the femur is stabilised with one hand.

The thumb should be on the anteromedial joint edge when holding the proximal tibia in the hand. The anterior translation of the tibia with a soft end point is suggestive of anterior-cruciate-ligament injury. In acute anterior-cruciate-ligament injury the Lachman test is more sensitive than the ADT.

FIG 7 Lachman's test

3. Slocum Anterior Rotatory Drawer test

The anterior drawer test is performed with the knee rotated fifteen degrees internally, neutrally, and thirty degrees externally. The anterior drawer test reveals anteromedial rotatory instability if it is positive in neutral rotation, increases in thirty degrees of external tibial rotation, and decreases in fifteen degrees of internal rotation.

4. Pivot shift test

This is an indirect test for an ACL injury that elicits the subluxation that occurs when the ACL isn't functioning. Callway and McIntosh described the conventional pivot shift. The patient is positioned supine, and the examiner lifts the lower limb of the patient from the table by holding the foot, and twisting into internal rotation. The knee falls into extention in a completely relaxed limb..

If the anterior-cruciate-ligament is damaged, gravity causes the femur to fall posteriorly, resulting in anterior tibia subluxation. Valgus force is given to the knee joint in flexion. With a quick jump or movement, the anteriorly subluxated tibia reduces into normal position in twenty to thirty degrees of knee flexion.

5. Lever sign/ lelli's sign(41)

The patient is placed supine, and the knee joint is in extension. The examiner stands at the patient's effected side and place a closed fist under the proximal third of the calf. Moreover, causes the knee to flex slightly. With his other hand, he applies a moderate downward force to the distal third of the thigh. Now the patient's leg acts as a lever over a fulcrum—the clinician's fist. Leading to two downward forces on the patient's leg must be considered: the force of the clinician's hand on the quadriceps and the force of gravity on the foot and lower leg. In normal ACL, downward force is applied to thigh, more than offset the force of gravity, the knee extends, and the heel rises off. With ACL complete or partial tear, the ability to offset the force of gravity on the lower leg is compromised, and then the tibial plateau slides anteriorly to the femoral condyles.

FIG 8: LEVER SIGN

6. **Jerk test**

Hughston developed a test that is the polar opposite of the pivot shift test. The patient is supine, with the knee flexed at ninety degrees and the tibia rotated internally. Valgus stress is applied with the other hand, and the knee is gradually stretched. If the tibia subluxes anteriorly with a rapid shock at around thirty degrees of knee flexion, the test is positive.

7. **Slocum's method**

On the examination table, the patient is in a lateral decubitus posture, with the pelvis tilted Thirty degrees posterior and the knee fully extended, with the medial side of the foot firmly rooted on the table. After that, the examiner bends the knee into flexion gradually. The test is considered positive when the knee flexion is reduced by twenty-five to forty-five degrees. Slocum's method offers the advantage of detecting lower degrees of instability while also being less unpleasant.

8. **Flexion rotation drawer test**

It's a modified version of the placid pivot shift test. The examiner's both hands are clasped around the patient's ankle. At the ankle, the valgus, internal rotation, and flexion are all applied indirectly. This procedure is gentler on the patient and less dangerous.

Following tests are elicited on patients to diagnose associated injuries.

9. **Valgus stress test**

On a flat examining table, the patient is in recumbent position and relaxed. By gently gripping the patient's lower limb at the ankle, the examiner lifts it off the examining table. The patient's legs should be completely relaxed, allowing the knee to fully extendIf the patient has problem relaxing, the testing can be conducted by abducting the leg till the knee hits the table's edge, leaving only the patient's thigh supported by the table. The examiner applies a little inward force at the knee and a reciprocating outward force at the ankle. The force will then be released. The examiner checks and feels for a separation of the femur and tibia on the medial side of the knee in response to the valgus stress..

FIG 9: VALGUS TEST

When the knee is fully extended, there is almost no gap between the medial tibia and the femur. When the valgus tension is applied, the femur and tibia separate and clunk back together in the abnormal condition. If valgus stability is normal in full extension, the examiner flexes the knee around ten to fifteen degree and repeats the test for medial collateral ligament.

10. Varus stress test

The varus stress test is used to diagnose injury to the lateral-collateral-ligament-complex. The patient is knee is relaxed and kept in extension in a supine over examination table. The examiner holds the patient's lower limb at the ankle and lifts it off the table. At the knee joint, the examiner gives an outward force, and at the ankle, the examiner applies a inward force. When the knee is in extention, there is almost no gap between the lateral tibia and the femur in a normal sound knee. When the lateral-ligamentous-complex are damaged, femur and tibia appear to separate abnormally over the knee joint, when stress is applied. Rarely clunk is felt, or patient may elicite pain.

FIG 10: VARUS TEST

There could be physiological condition causing more laxity in varus stress. For that instance opposite side of knee joint is examined and careful history is necessity. If there is increased varus laxity in the fully extended knee joint, it indicates a more extensive injury affecting the posterolateral ligament complex with anterior-cruciate-ligament or posterior-cruciate-ligament injury.

11. The McMurray's Test

The knee joint is held in flexion completely while patient is lying down on the examination table. The examiner holds the patient's hindfoot and externally rotates the foot while applying a outward knee joint force to assess the medial meniscus. The medial meniscus is compressed during this maneure. And further examiner extendes knee joint passively. McMurray test is called positive if the patient localizes the pain in medial joint line and/or the examiner feels a click in this location. The true McMurray click is only infrequently felt, although joint line pain is commonly elicited in the absence of such a click and often indicates a meniscus tear.

FIG 11: McMURRAY'S

The examiner repeats the same manoeuvre and applies the hindfoot in internal rotation and inward force to the hyper-flexed knee joint to test for a lateral meniscus tear. For lateral meniscus tear, patient implies pain in lateral knee joint line. And the knee joint is passively extended. A click is hardly ever felt with the lateral McMurray test.

12. Apley's Grind Test

The Apley test is divided into two sections. The patient is evaluated while lying prone with his knee joint is flexed to ninety degrees. The examiner places his hand on the patient's foot. The examiner stabilises the patient's thigh exerting downward pressure and pulling the patient's foot and leg upward to distract the patient's knee during the distraction section of the test. This component of the exam is unpleasant when ligaments are disturbed. External and internal rotation manoeuvres of the patient's foot are performed by the examiner. Push down on the patient's foot to compress the knee while alternate externally and internally pivoting the foot for the compression test. When pain is localised to the medial joint line, a medial meniscus tear is suspected, whereas pain is localised to the lateral joint line, a lateral meniscus tear is assumed.

RADIOGRAPHIC EVALUATION

The Anterp-Posterior view and lateral view of Xray of the knee joint are required to rule out fractures or degenerative changes. Avulsion fractures of the tibial spine or lateral tibial rim also called as segond's fracture may be visible on xray. These are more common in patients who are skeletally immature. While the anterior drawer test is one, stress lateral radiographs can be utilised to show ACL injury radiographically. A translocation of more than 5mm anteriorly is considered abnormal. When compared to the contralateral knee, a discrepancy of greater than 3cm is likewise regarded significant. On X-rays, the deep lateral femoral notch sign (prominent lateral condylopatellar groove) that arises as a result of pivot-shift damage can also be detected. When compared to the contralateral knee, a discrepancy of greater than 3cm is likewise regarded significant. On X-rays, the deep lateral femoral notch sign (prominent lateral condylopatellar groove) that arises as a result of pivot-shift damage can also be detected.

- **MRI**

The MRI aids the pre-operative assessment of the patient by providing non-invasive imaging of the anterior-cruciate-ligament and associated soft tissue components in the knee joint. A T2 weighted series in two to three orthogonal planes is part of the imaging technique for anterior-cruciate-ligament. In a sagittal view, the normal anterior-cruciate-ligament appears as a solid or striated band. The anterior-cruciate-ligament is usually straight; however, minor convex inferior sagging can be noticed. The anterior-cruciate-ligament has a rather higher signal intensity than posterior-cruciate-ligament.

The AMB and PLB of the anterior-cruciate ligament can be seen in MRI in ninety four percent of the total no .of patients in 3-tesla field strength, according to Adriaensen ME et al.(42).

The middle part of the anterior-cruciate-ligament is the most prevalent site of anterior-cruciate-ligament tears. Injuries to the proximal region of the anterior-cruciate-ligament near the origin account for seven to twenty percent of all anterior-cruciate-ligament tears. Injury frequency is roughly three to ten percent distally at the tibial attachment site.

Primary signs of an ACL injury are:

- The ACL is not visible in its regular location.
- Interruption of focus.
- Non-linearity / angulation
- Distal ACL axis is flattened, and proximal anterior-cruciate-ligament visibility is low (Abnormal ACL axis).
- On a sagittal view, the anterior-cruciate-ligament more horizontal than the Blumensaat line.

(Fig12: Non visualization as a primary sign of ACL tear)

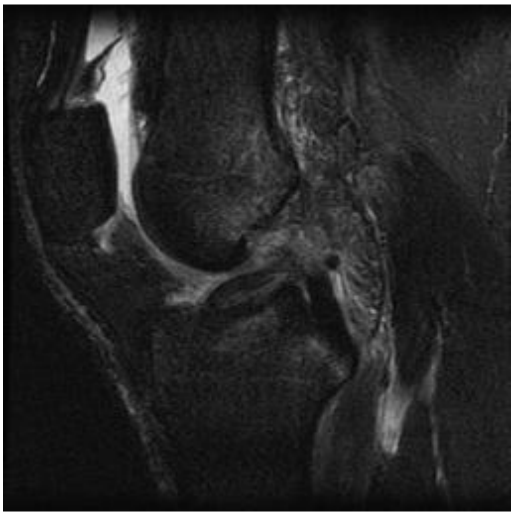


Fig13: Flattened axis of the distal ACL with poor visualization of proximal ACL as a primary sign of ACL tear

Fig14: Angulation / non linearity as a primary sign of a ACL tear

Secondary signs:

Secondary signs are those that indicate an ACL injury in addition to the abnormalities of the ACL itself.

- Countercoup medial bone bruise of the tibia
- A tangential line is drawn to the along the posterior margin of the tibia, it passes through the posterior horn of the lateral meniscus. (uncovered meniscus sign). And in normal knee, this tangent line will pass posterior to the meniscus.
- Pivot shift bone bruises in tibia and femur
- Redundant Posterior-Cruciate-Ligament
- Anterior translation of the tibia on sagittal MRI
- Osteochondral fracture of the lateral femoral condyle
- Vertically oriented lateral collateral ligament
- Fractures like,
    - arcuate fracture in fibula head.
    - Segond fracture- avulsion fracture lateral tibial plateau
    - Tibial spine fracture (bumper fracture)

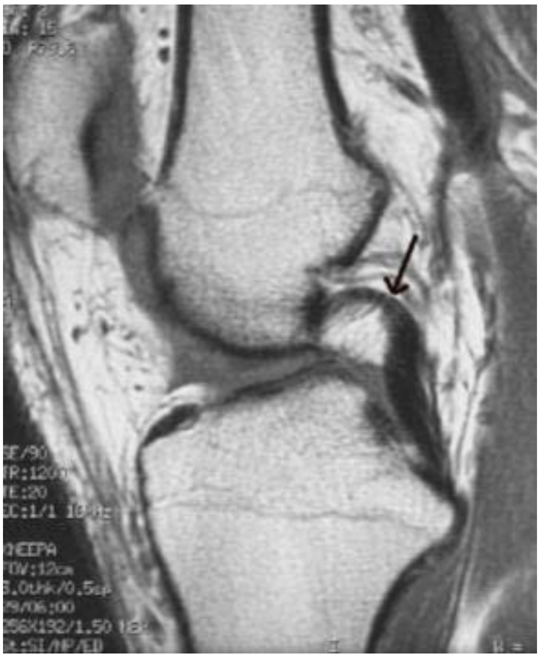


Fig15: PCL redundancy as secondary sign of ACL tear

Fig16: Segond fracture in a patient with Anterior Cruciate Ligament tear

Partial ACL tears:

Partial anterior-cruciate-ligaments tear accounts for ten to forty-three percentage of total anterior-cruciate-ligamentinjuries. Injuries involving less than twenty-five percent of the anterior-cruciate-ligament when seen arthroscopically have a fair prognosis, but tears involving fifty percentage to seventy-five percentage of the anterior-cruciate-ligament have a high risk of progressing to total tears.

(43)

Chronic anterior-cruciate-ligaments tears:

With bone bruises and oedema in the knee joint, chronic anterior-cruciate-ligaments insufficiency are identical to those of acute anterior-cruciate-ligaments tears. It's possible an empty notch sign is seen, which means the MRI solely shows fat.

The anterior-cruciate-ligaments is missing in the lateral intercondylar notch. The sensitivity and specificity of MRI for detecting anterior-cruciate-ligaments injuries using direct symptoms range from ninety-two to ninety-four percentage and ninety-five to hundred percentage, respectively.(44)

MATERIAL AND METHODS

The material for the present study was obtained from the patients admitted in BLDEA S' Shri B.M.Patil Medical college hospital and research Center, Department of Orthopedics with diagnosis of anterior-cruciate-ligament tear from November 2019 to March 2021
A minimum of 21 cases were taken, and the patients were fully informed about the study. Each patient gave their informed consent.

With anticipated Mean of Pre-op and Post-op IKDC score 29.26 and 58.70 with common SD ±4.459 the sampling size is 21 patients with the power of 80% with 5% level of significance with 5% expected effect size

By using the formula

$$n = \frac{z^2 p(1-p)}{d^2}$$

Z= z statistic at 5% level of significance

d is margin of error

p is anticipated prevalence rate (50%)

STATISTICAL ANALYSIS

Data will be represented using Mean SD

A significant difference of baseline and postoperative data will be compared using Paired test/ Wilcoxon sin rank.

METHOD OF COLLECTION OF DATA

- By history
- By clinical examination of knee joint
- By MRI of knee joint
- By follow up at intervals of 6 weeks, 3months, and 6months

INCLUSION CRITERIA

1. Patients aged between 18 to 45 years
2. Clinical /MRI evidence of symptomatic individuals with ACL tear.
3. ACL tear associated with medial or lateral meniscus tears not amenable for repair.

EXCLUSION CRITERIA

1. Associated with multi ligamentous injury

2. Patients with associated fracture of tibial plateau

3. Tibial Avulsion

4. Patient with osteoarthritic knee

5. Revision surgeries

6. Associated sepsis or local skin infection

7. Patients with systemic diseases which compromising their pre-anaesthetic fitness

INVESTIGATIONS

- X-ray Knee joint Antero-Posterior and Lateral view.
- MRI of knee joint – sagittal, coronal, transverse plain
- CBC.
- BT, CT.
- Urine – routine.
- RBS,
- Blood urea level and Serum creatinine level.
- HIV, HCV and HbsAg.
- Blood grouping and Rh- typing.
- ECG.
- Chest X-ray- Postero-anterior view.
- Other specific investigations whichever needed.

PREOPERATIVE PREPARATION

After receiving signed and informed risk consent about the nature and complications of the surgery, the patients were scheduled for surgery. The operative site (knee joint) was shaved and prepared with betadine scrub a day prior to the surgery.

Xylocaine test dose & tetanus toxoid injections were given preoperatively.

All patients were started on antibiotics prophylactically. A third-generation Cephalosporin was administered via IV route prior to induction of anesthesia, and continued at 12 hourly intervals for 3-5 days, and switched over to oral form till the 12th day post-operatively, i.e. until suture removal.

INSTRUMENTS

Arthroscopic anterior-cruciate-ligament-reconstruction necessitates a large number of specialised devices. An arthroscopic tower and system is made up of the following components. (as shown in photograph 1)

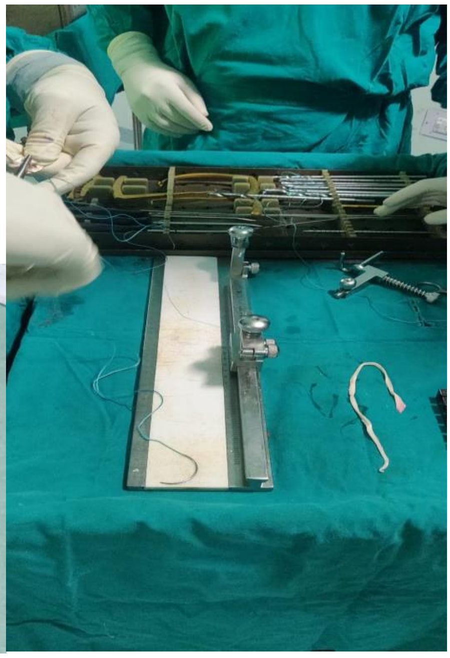
- Television monitor
- Arthroscope
- Camera
- Light source with fiber optic light source cable
- Shaver system and handpiece

PHOTOGRAPH 1:
Arthroscopy tower

Surgery instruments used: ACL reconstruction set include (seen in photograph 2 – 4)

- Trocar, cannula, ACL probe
- 4mm/5mm shaver burr
- Cannulated headed reamers (5 to 10 mm)
- Beadth guide pin
- Depth gauge
- Sizing master board
- 2.4 mm drill tip guide pins
- Meniscus punch
- Tibial aiming guide
- Femoral entry point aimer (6mm / 7mm offset)

PHOTOGRAPH 2: ACL instrument set.



PHOTOGRAPH 3: ACL instrument set

PHOTOGRAPH 4: Graft master

Implants:

The various fixation options available for soft tissue grafts can be classified into direct methods and indirect methods. The commonly used direct fixation devices are,

Direct graft fixation:

- Washers
- Interference screws
    - Titanium
    - Biodegradable

- Staples
- Crosspins

For nndirect fixation devices used in anterior-cruciate-ligament-reconstruction are:

- Suture post
- Polyester tape/titanium button

In our study, we used a titanium and biodegradable interference screw.

Interference screws:

Interference screws are graft-holding devices which use direct fixation between the graft and the bone tunnel. The titanium interference screw and the bioabsorbable interference screw are two commercially available.

The advantages of interference screws are

- Low cost
- Intraarticular device

The disadvantages interference screws are

- The graft may relocate while advancing the screw
- Risk of injury to the graft.
- Screw laceration of the passing suture may occur.
- Chance of a blowout of the posterior cortex.
- Difficulty in locating the screw in revision surgery, if the screw misplaced into the tunnel.
- Graft advancement if more tension is applied while inserting device.
- Screw may be misplaced in the posterolateral recess during insertion.

Biodegradable screws:

These have a equal fixation strength when compared to that titanium screws.

Both screws provides equal functional outcome.(45)

Polyetheretherketone (PEEK) is popular for radiolucent, elastic modulus and vast biocompatibility.(46)

The advantages of bioscrews are

- No implant removal
- Better biocompatibility

The disadvantages of bioscrews are

- Visco plastic deformation – fixation strength is lost
- Extra-articular migrations of PEEK interference screw from the tibial tunnel (46)
- Foreign body reaction

Grafts:

The most common type of graft used is autograft; however, allografts and synthetics are also available. The quadrupled hamstring tendon graft and the bone-patellar tendon-bone graft are the two most popular graft options nowadays.

The bone-patellar tendon-bone graft is typically an 8–11 mm wide graft obtained from the middle third of the patellar tendon and the neighboring patella and tibial bone blocks. The high ultimate tensile stress (about 2300 N), rigidity (approximately 620 N/mm), and the possibility of firm attachment with its attached bone ends are all appealing properties of this graft. Both ends of a quadruple-stranded semitendinosus graft or a quadruple-stranded semitendinosus-gracilis graft are folded in half and combined. The ultimate tensile load of our quadrupled hamstring autograft has been reported to be as high as 4108 N.

This quadruple-stranded graft also functions as a multiple-bundle replacement graft, which may be more functional than the two-bundle anterior-cruciate-ligament. The lack of strict bone anchoring and concern about tendon healing within the osseous tunnels are both disadvantages of this soft-tissue graft.

Graft placement:

- Tibial insertion

The graft should be placed towards the posterolateral bundle position in the posterior section of the anterior-cruciate-ligament tibial insertion site best to replicate the function of the intact anterior-cruciate-ligament. With knee extension, this site also reduces graft impingement against the roof of the intercondylar notch, which can occur with anterior insertion.

- Femoral insertion

Lower the femoral tunnel on the lateral wall toward 10 or 2 o'clock or even lower, which more exactly replicates the anterior-cruciate-ligament's femoral attachment site and provides rotational stability.

Portals in arthroscopy:

Adequate illumination, proper positioning and joint distension are needed for portals entry of the arthroscope. Accessory instruments are essential in arthroscopy. In arthroscopy, additional instruments are required. Because incorrect portal location makes it difficult to access the joint and manoeuvre the instruments within it, appropriate portal placement is essential. If an instrument is driven through an incorrectly situated portal, it may cause harm to the joint and damage to the instruments. It's a good idea to mark the portal access points.

The outlines of the bone and soft tissue landmarks are made –

The patella, The patellar tendon, and medial and lateral joint line of knee.

The marking of portals and landmarks helps to correct the placement of portals.

William B Stetson, Kevin Templin (47) studied and implied that two portal scopy has better rehabilitation than 3 portal surgery. Also stated that, it was due to violation of vstas medialis obliqus while 3 portals was used.

Standard portals:

The standard portals include,

- Antero-lateral portal
- Antero-medial portal
- Supero-lateral portal
- Postero-medial portal

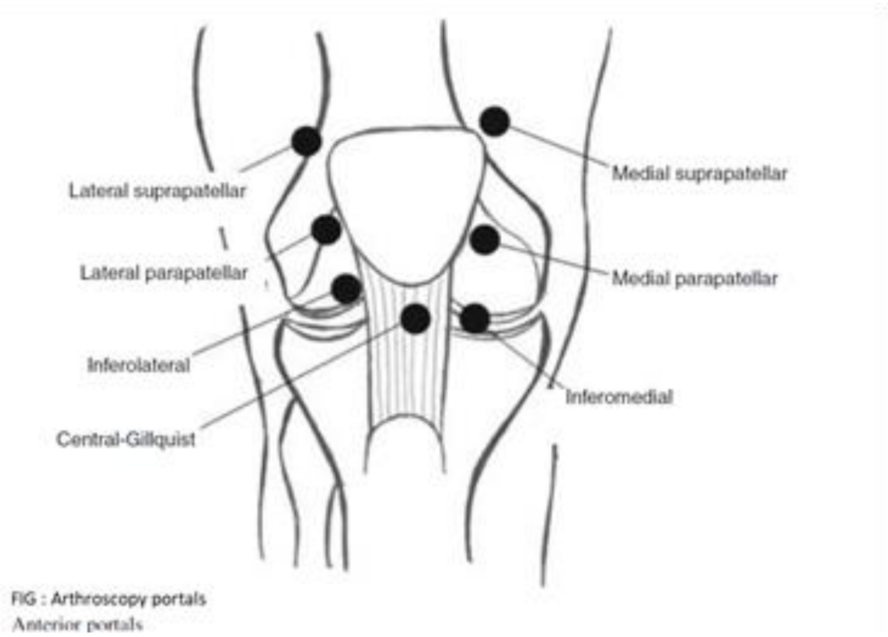


FIG 17: Arthroscopic portals

Anterolateral portal:

Anterolateral portal is the most common type of portal used by surgeons. Except for visualization of the posterior-cruciate-ligament and the front part of the lateral meniscus, almost all the structures within the knee joint can be seen through the antero-lateral portal. Incision was made over one centimeter superior to the lateral joint line of knee and one centimeter lateral to the lateral border of patellar tendon. The portal is one centimeter distal to the inferior pole of the patella. If the portal is formed too close to the joint line, the anterior horn of the lateral meniscus may be injured while insertion of instruments. If the portal is made close to the patellar tendon, the scope may penetrate the fat pad resulting in difficult viewing the joint and manoeuvring of arthroscope.

Antero-medial portal:

The antero-medial portal is employed extensively for improved lateral compartment visualisation and probe manipulation of the medial compartment components. The incision is made one centimeter superior to the medial joint line, one centimeter medial to medial border of patellar tendon. The portal can be used for percutaneously inserting a spinal needle that can be seen through the anterolateral portal. AM portal should be one centimeter inferior to lower pole of patella.

Posteromedial portal:

The postero-medial portal is located in a small triangular area formed by the femoral condyle and tibia's postero-medial margins. Before the joint is distended, this landmark is palpated with the ninty degrees of knee flexion. A thirty degree angled arthroscope introduced through this portal, can visualise the structures in the postero-medial compartment. This portal should be placed one centimeter superior to the posteromedial joint line and posterior to the femoral condyle's posteromedial border.This part is mainly used for dealing with pathologies of the posterior horn of the menisci and posterior loose bodies that cannot be approached through the anterior portals.

Superolateral portal:

The use of superolateral port is to visualize the patella femoral joint. When the knee is moved from extension to flexion, the superolateral portal is utilized generally to visualise the dynamics of the patellofemoral joint, such as patellar tracking and patellar congruity. This portal located one inch above the patella's superolateral border and one inch lateral to the quadriceps tendon.

Screw placement:

- **The Bernard and Hertel grid:**(48)

Bernard and Hurtle Grid is a transparency sheet. Superimpose this sheet over a fluoroscopy photo intraoperatively in the lateral position to estimate the position of the guidewire by calculating the involved percentage of boxes (fig 18). On the femur side, a target of 27.7% proximal to distal and 37.5 % anterior to posterior, and 45 % front to back and medial to lateral on the tibial side. The Bernard and Hurtle Grid, which was created to achieve accuracy in tunnel placement without violating anatomy and at no additional cost, can be utilised everywhere in the world

FIG 18: BERNARD AND HERTEL GRID

FIG 19: PLACEMENT OF SCREW

Lines representing deep/shallow and high/low**. (fig 19)**

In the A.P. view, for ACL reconstructions done through the trans-tibial technique, the tibial tunnel should be less than 72° from a line along the proximal tibial articular surface. More vertical tunnel placement may lead to graft impingement. (fig 20, 21)

FIG 20: Xray Knee AP view

FIG21: Xray lateral view

EXAMINATION OF PATIENT UNDER ANAESTHESIA AND PATIENT POSITIONING

All patients in our study were operated under spinal anesthesia or epidural anaesthesia with muscle relaxation, and in a supine positioning. And these examinations were redone under anesthesia, i.e., anterior drawer test, posterior drawer test, Lachman test and pivot shift test. These tests are redone due to good muscle relaxation.

A tourniquet is applied, which is positioned in the high upper thigh with soft padding. Under all aspectic precaution, the operative site is scrubbed, including the ankle joint up to the tourniquet. In all the cases, prophylactic antibiotic, usually Inj ceftriaxone + clavulanic acid 1.5 gm with Inj amikacin 500 mg IV is given preoperatively before inflating the tourniquet. The limb is exsanguinated the limb before inflation of the tourniquet.

SURGICAL TECHIQUE

In brief: One tibial tunnel and one femoral tunnel were used in the quadrupled hamstring anterior-cruciate-ligament-reconstruction, with their attachments corresponding to the anatomical anterior-cruciate-ligament tibial and femoral, respectively. The anteromedial portal was used to make the femoral tunnel and tibial tunnel is made via tendon graft donor site, resulting in an anatomic femoral tunnel location. A bioscrew / titanium interference screw was used to secure the transplant on the tibial and femoral sides.

Diagnostic arthroscopy:

Incision made using 11 no. BP blade for anteromedial portal. Then the scope is introduced, and the knee joint is examined in a sequential manner of the following as shown in fig 22:

1. Suprapatellar pouch with view of undersurface of knee joint
2. Tangential view of patellofemoral articulation
3. Normal medial parapatellar plica
4. Posteromedial compartment is seen by passing arthroscope through intercondylar notch
5. Medial meniscus and lateral meniscus
6. Cruciate ligaments with fatty synovium which covers PCL
7. Posterior horn of lateral meniscus and popliteal tendon through hiatus

After diagnostic arthroscopy, all the intraoperative findings are noted and dealt with the pathological findings such as meniscus repair, partial meniscectomy or total meniscectomy for meniscal tear.

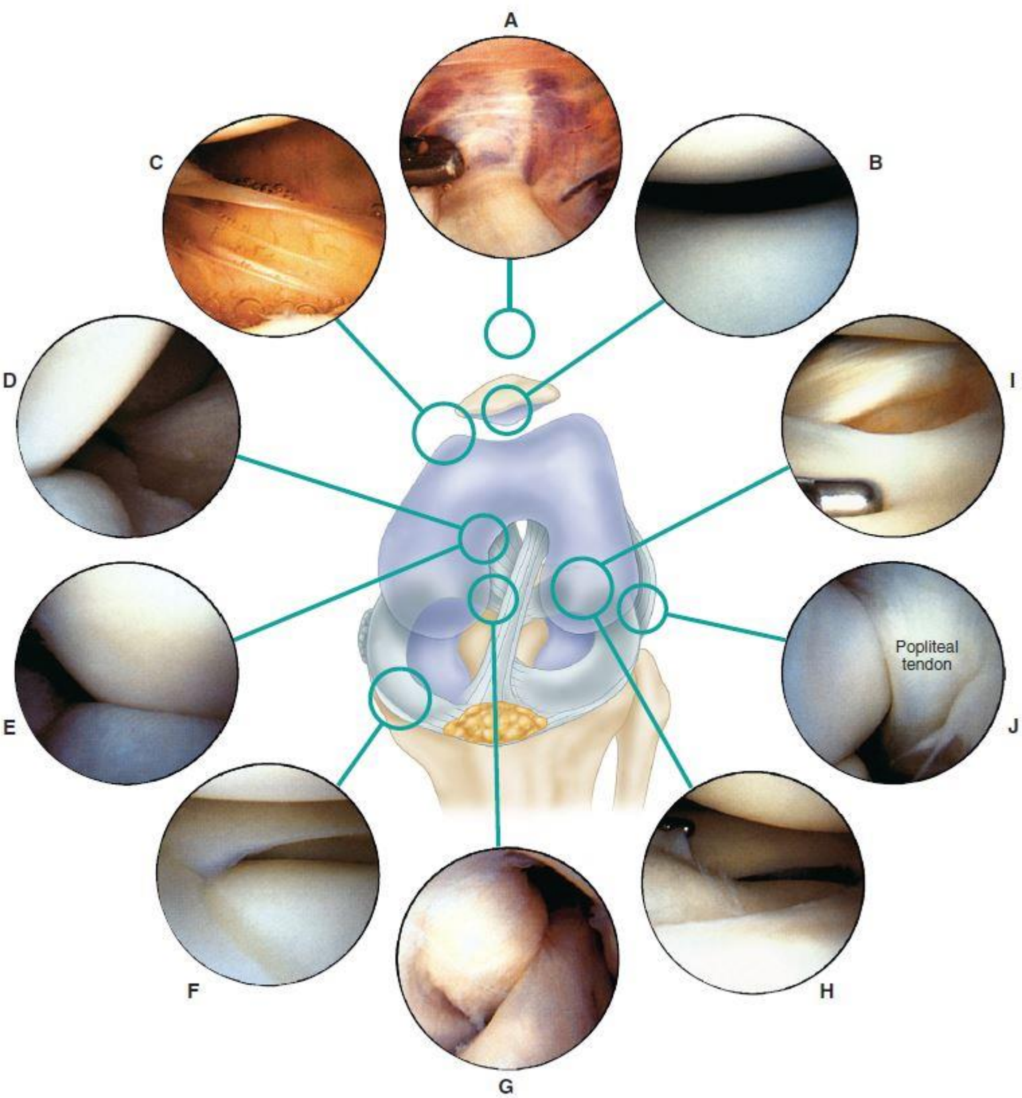


Fig. 22

A. Suprapatellar pouch

B. Patellofemoral joint

C. Normal medial parapatellar plica

D. Posteromedial compartment

E. Posteromedial compartment through posteromedial approach

F. Medial meniscus and medial compartment

G. Cruciate ligaments

H. Lateral meniscus and lateral compartment

I. Posterior horn of lateral meniscus and popliteal tendon through hiatus

J. Postero-lateral view of knee joint with arthroscope in anterolateral portal showing popliteal tendon insertion into femur in popliteal hiatus.

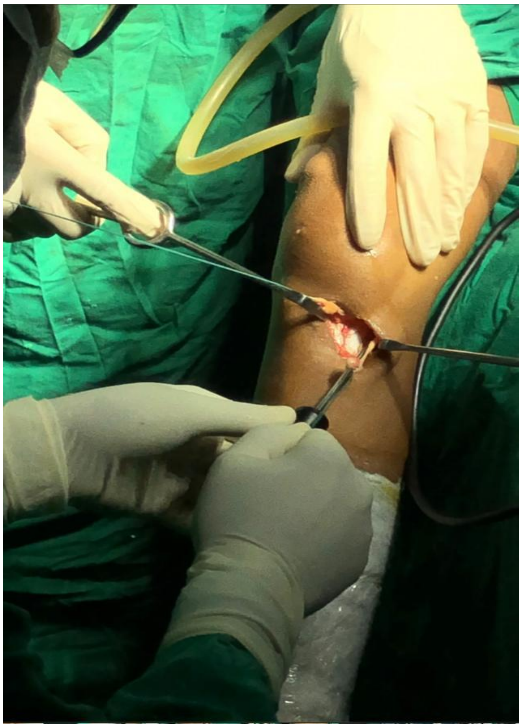
Hamstring graft harvest and graft preparation:

One centimeter medial to the tibial tuberosity and five centimeter below the medial joint line, a three centimeter oblique skin incision was made. The oblique incision is favored because it exposes more of the pes anserinus and reduces the risk of harm to the saphenous nerve's infrapatellar branch. The graft harvest and tibial tunnel drilling will both be done over the same incision.

Fingers are used to identify the superior boundary of the pes anserinus. The fascia is incised, and the upper border is raised. Fingers running from above to below can feel the tendons. The semitendinosus tendon lies beneath all other structures. The sartorius fascia and additional bands are split along the course of the tendons; after the hamstring tendons have been identified; the Gracilis and subsequently the Semitendinosus are hooked out using right-angled artery forceps. To aid with traction, the tendon ends were knotted in a double loop knot. Both the tendons are tagged.

PHOTOGRAPH 5: Intra op picture showing Graft harvest technique

The knee was put in ninety degrees of flexion while continuous traction was administered through the threads, and proximal dissection of the tendons was done using blunt dissection with fingers till the musculotendinous junction, eliminating adhesions and accessory bands. Scissors are frequently used to cut the major band, which are interconnected to the medial head of the gastrocnemius muscle. It has been confirmed that there should be no dimpling posteriorly across the gastrocnemius as the tendon is pulled distally.



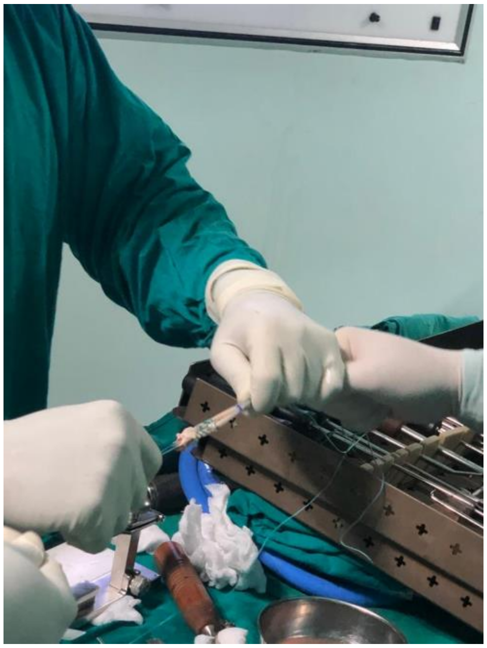
PHOTOGRAPH 6: Intra op picture showing Graft harvest technique. Using tendon stripper for hamstring graft.

Gracilis and semitendinosus harvest one by one. Scissors are used to release the tendon's distal end. Then, in line with the tendon, a tendon stripper is advanced over it, applying firm, steady, and mild pressure even while applying traction by gripping the threads. If resistance is encountered while advancement of tendon stripper, then, the stripper is withdrawn, adhesions are incised with scissors. The semitendinosus is mostly tendon and gracilis is muscular. The Graftmaster board is then used to place the harvested graft. The graft is kept moist by supplying saline to tendon graft. With the use of blunt end of the blade, any remaining muscle fibers are cut from the tendons.

To achieve uniform size, the tendon ends are trimmed. To form Quadrupled tendons the graft is looped. Both ends of the tendon were suture together with ethibond 2-0 for around three to four centimeters. The graft sizer is then used to measure the quadruple graft diameter. The tunnel's diameter is much like the smallest size sleeve through which the quadrupled graft passed with the minimum amount of resistance. The length of the graft to be inserted inside the femoral tunnel is marked with sterile marker. Tibial and femoral side of graft is noted. Aids to proper graft placement while being seen arthroscopically.

PHOTOGRAPH 7: Intra op picture showing Graft in gtaftmaster board.

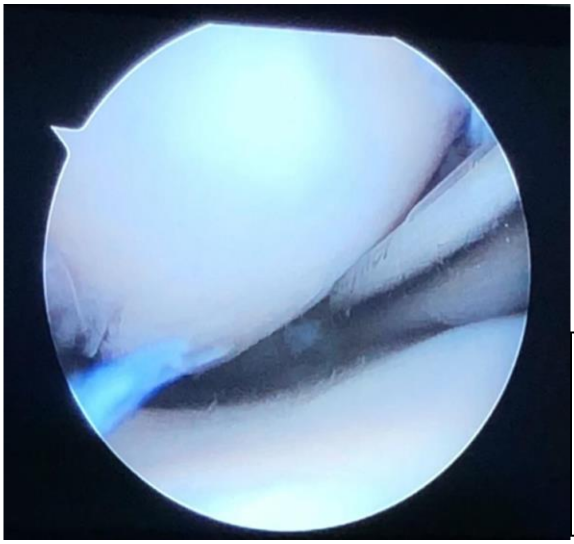
The quadrupled graft is attached to the graftmaster board's posts, and adequate tension is applied.



PHOTOGRAPH 8: Intra op picture showing quadrapuled Graft preparation.

Intraarticular preparation:

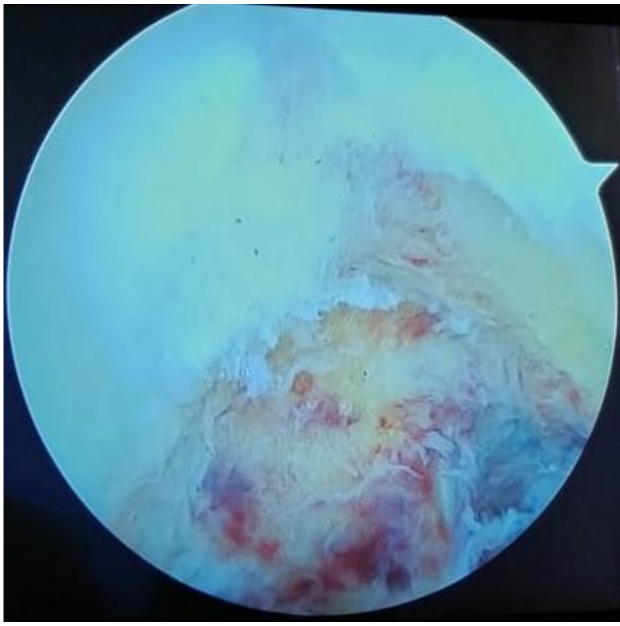
The joint cavity was visualised after arthroscope was inserted through the antero-lateral portal. The joint is debrided with help of shaver introduced through the anteromedial portal. Ligamentum plicae, fat pads, synovium hypervascular structures and synovial reflections that obstructs the view. Femoral attachment footprint of the anterior-cruciate-ligament and medial surface of the lateral femoral condyle is thorough assessed. It's vital to avoid injuring the posterior-cruciate-ligament during joint debridement.



PHOTOGRAPH 9: Intra op arthroscopy picture showing ACL tear, and debridment of joint with shaver.

Notch preparation and notchplasty:

The torn anterior-cruciate-ligament may appear as a remnant scarred to the posterior-cruciate-ligament or the roof of the intercondylar notch. Eventually the remnant may found attached on the medial surface of the lateral condyle, referred to as an empty lateral wall sign. The remaining anterior-cruciate-ligament tissues are removed, and remains on the tibial and femoral attachment site are preserved. The femoral anterior-cruciate-ligament remnant will serve as a reference for placing guide pins in the femoral tunnel preparation, while the tibial anterior-cruciate-ligament remnants may serve as the graft's neurologically active envelope, allowing for proprioceptive function after anterior-cruciate-ligament reconstruction.



PHOTOGRAPH 10: Femoral foot print is prepared after notchplasty is done.

The shaping and enlargement of the intercondylar notch to form a inverted "U" shape of the femur is called notchplasty. The goal of notchplasty is to get widen the medial surface of the lateral femoral condyle and avoiding graft impingement. It's especially critical when osteophytes intrude on the notch due to chronic anterior-cruciate-ligament insufficiency.

The technique of notchplasty:

Starting two-three centimeter anteriorly on the articular surface of the intercondylar notch two to three centimeter superior to the edge, the notch is usually deepened by twenty to thirty millimeter. The notch should be deepened in an anterolateral orientation. To avoid graft impingement in full knee extension, the anterior ceiling of the notch should be deepened. The notch plasty anteromedial wall is avoided until there is the presence of osteophytes.

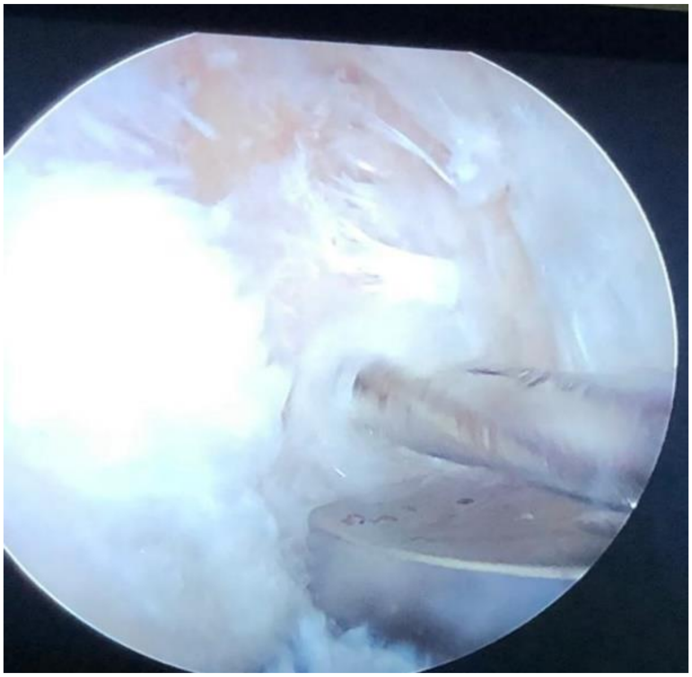
To avoid lateralisation of the femoral graft attachment site, avoid excessive lateral notchplasty.

Femoral tunnel preparation

In ninety degrees of knee flexion, the Anterior-Cruciate-Ligament footprint is situated over the medial surface of the lateral femoral condyle. The entry point of femoral tunnel is femoral footprint. The entry point is then drilled with help of a guide wire in full knee flexion using the femoral offset aimer device which is inserted through the antero-medial portal.

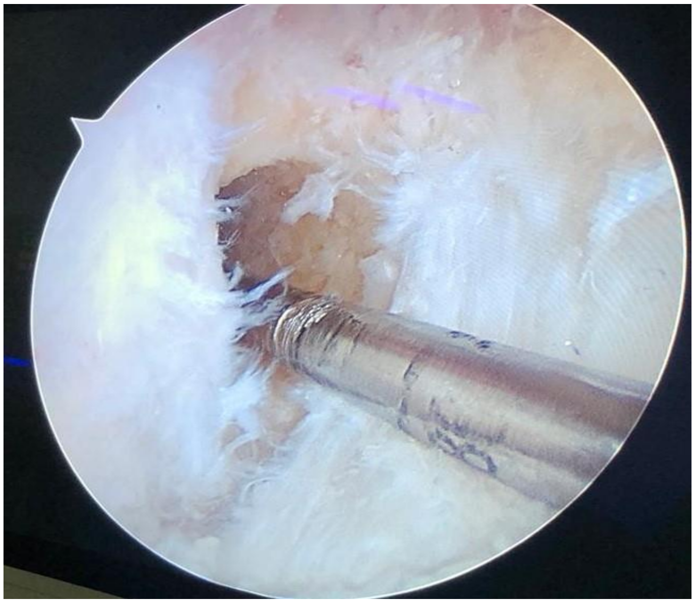
PHOTOGRAPH 11: Intra op picture showing placement for femoral tunnel.

Drilling continues till the guide wire tip comes on the lateral aspect of the distal femur at the level of the femur epicondyle just below the skin. Skin incision was made over introduced guide tip about half of centimeter.



PHOTOGRAPH 12: Intra op scopy picture showing drill for Femoral tunnel placement.

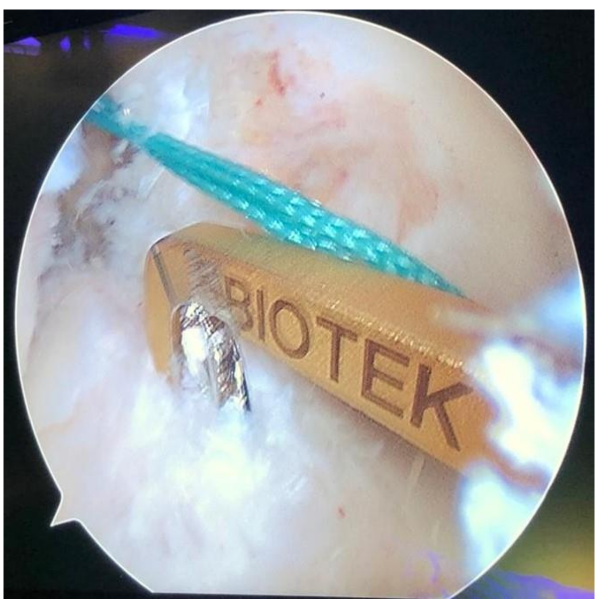
The femoral tunnel was then constructed by drilling both the cortex of distal femur, using a 4.5 mm cannulated drill bit. A depth gauge was then used to measure the tunnel's length. The diameter size which was obtained for graft diameter, equal size of diameter was reamed. Serial reaming was done. And according to length of harvested graft, reaming was stopped prior reaching to other cortex. After the femoral tunnel was established, a beadth pin with ethibond no 5 tied to its end was passed into it to aid in the easy transit of the prepared graft.



PHOTOGRAPH 13: Intra op scopy picture showing guide wire placed along femoral tunnel.

Tibial tunnel preparation

The tibial guide is used for construction of the tibial tunnel. With the knee in ninety degrees of flexion, the tip of the tibial guide wire is inserted two to three millimetres anterior to the anterior horn of the lateral meniscus with help of tibial jig. The jig was set to 45 degrees. The tip of guide wire is positioned just medial to the anterior-cruciate-ligament tibial attachment area.

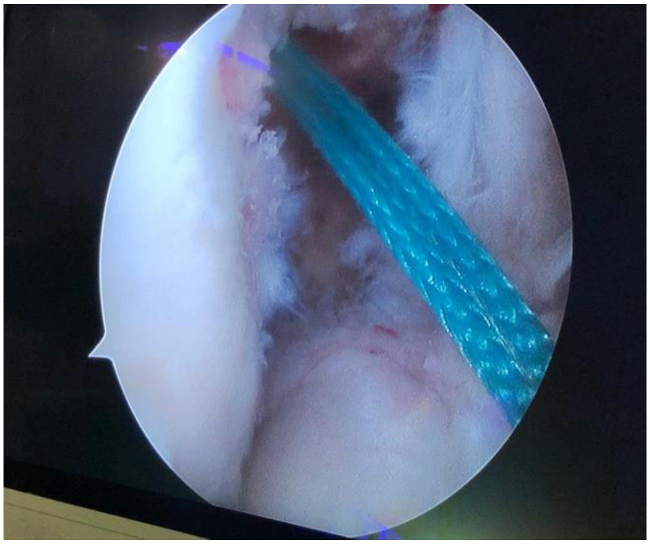


PHOTOGRAPH 14: Intra op scopy picture for tibial tunnel preparation.

The tibial tunnel is contructed by reaming through the guide pin with a cannulated drill bit of the same diameter as the graft. For enhanced proprioception, the edges of the tunnel are shaved to make it smooth with a shaver, leaving the remnants at the anterior-cruciate-ligament tibial attachment point.

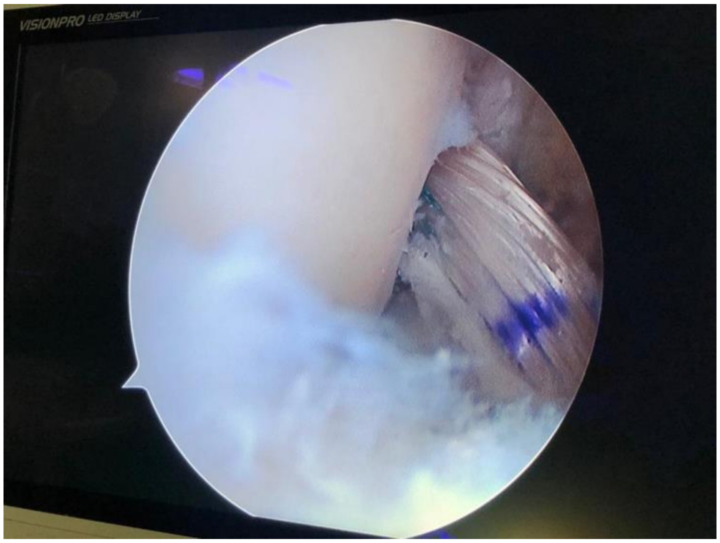
Passage and fixation of the graft

A passing suture is inserted into the femoral tunnel's extraarticular opening. The suture is recovered inside the joint and then sent via the tibial tunnel to the outside. The tendon component of the graft's traction sutures is passed through a loop of the passing suture.

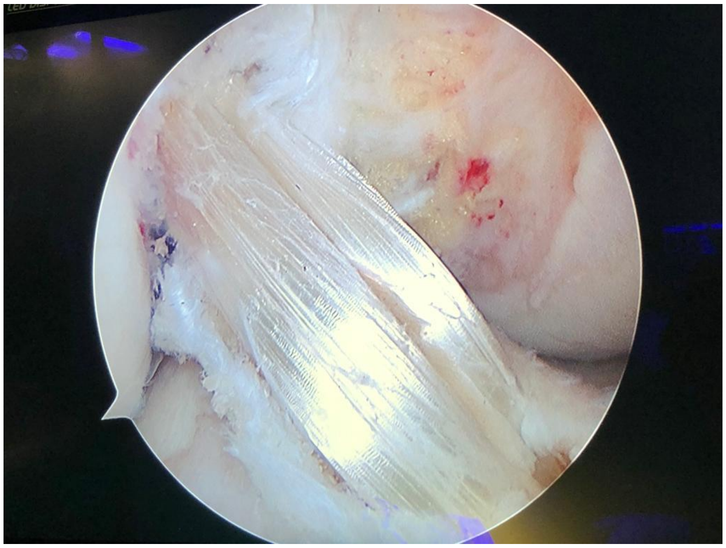


PHOTOGRAPH 15: Intra op scopy picture for ethibond is passed through femoral tunnel and passed out through tibial tunnel.

The graft is subsequently injected from the tibial tunnel to the femoral tunnel retrogradely. The scope is used to track the graft's progress. From the outside - in technique, interference screws are used to secure the graft to the femur and tibia. Fixation of the femur is done first.

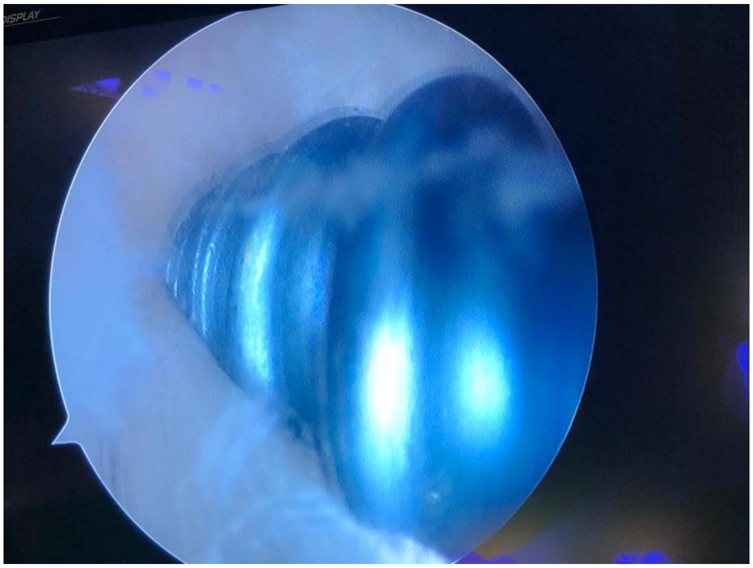


PHOTOGRAPH 16: Intra op scopy picture showing graft is marked at femoral side.



PHOTOGRAPH 17: Intra op scopy picture showing graft passed throught femoral tunnel.

The scope is inserted in the anteromedial portal, and the portals are inverted. In the tunnel, a screw guide wire is inserted. In the tunnel, the graft is placed posteriorly. The screw is implanted through an arthroscopy procedure. The graft is held firmly, with sutures tied in the distal portion of the graft. It is essential to make sure the graft does not get pushed inside the joint. We used a screw of the same size or 1 mm less than the tunnel. Once the femoral side is secured, the graft undergoes cyclic loading. For the tibial fixation, the screw guide wire is placed anterior to the graft in the tibial tunnel; we use a Kocher forceps to lock the K-wire in this position.



PHOTOGRAPH 18: Intra op scopy picture showing titanium interference screw is passed throght femoral tunnel.

The graft is fixed at 10–15° of knee flexion, with about 10° of external rotation and the assistant inducing a posterior drawer. The surgeon keeps the graft under tension and then inserts the selected screw. The screw is advanced until it is flushed with the joint.

Wound closure:

The tourniquet is released before closing, and hemostasis is confirmed. The portal and tunnel incisions are closed with nonabsorbable suture. The graft site requires particular attention. As already mentioned, tendon edges are approximated with 2-0 Vicryl in a simple interrupted pattern. The parapatellar periosteum is then closed; subcutaneous and dermal tissues are closed with 2-0 vicrly and 2-0 ethilon respectively.

Surgical wound dressing was done, and a long knee brace was applied; the patient shifted to recovery room.

POST OPERATIVE PROTOCOL

General guidelines:

• During primary re-vascularisation and graft fixation, i.e. around 8–12 weeks, special attention given to graft protection.

• Defer in the ROM and weight-bearing precautions stated in the meniscal repair/transplant protocol for ACL reconstruction performed with meniscal repair or transplant.

• Change in the time limits for using a brace and crutches.

• Stretching/strengthening of the hamstrings were done with caution because to donor site morbidity.

General progression of daily activity protocol:

•No bathing or showering (only sponge bath) until the sutures are removed. The brace will be taken off while bathing or showering.

•Brace in full extension - sleep with the brace locked in extension for 1 week.

•Driving: Start after 2-4 weeks for bikes and cars.

•Post-op brace locked in full extension) for 1 week to ambulate & sleep

- ➢ 1-3 weeks- unlock brace upto 90^0 as quad control allows
- ➢ 3-4 weeks- Wean the patient from the brace if he or she has demonstrated strong quad control and normal gait mechanics.
- ➢ Use of crutches/brace for ambulation for 4 weeks with adequate quad function
- ➢ Weight bearing starts from 1 week Partial Weight Bearing with crutches and brace

• Return to work based on physical work load.

REHABILITATION PROGRESSION (49)

Phase I: immediate post operative (0 to 4 weeks)

Goals:

- With the use of a brace and appropriate physiotherapy, protect graft and graft fixation.
- Immobilisation's effects minimised.
- Inflammation and edoema is to be controlled.
- Active and passive extension range of motion achived. Excessive hyperextension of more than 10 degrees should be avoided.
- Educate the patient about the rehabilitation process.
- Only flex to 90 degrees to protect the graft attachment.
- On level surfaces, reestablish a normal gait.

Brace:

- 0 to 1-week post-op brace is locked in full extension for sleep and ambulation
- 1 to 3-week post-op unlock brace up to 90 degree
- 3 to 4 weeks post-op ambulation without brace when a patient showed reasonable quadricep control
- 3 to 8 weeks post-op brace for uneven surface ambulation

Weight-bearing:

- Post-op 0 to 1 week: partial weight-bearing
- Post-op 1 to 4 weeks: progress to full weight bearing with a normal gait
- 3 to 8 weeks post-op brace for uneven surface ambulation

Exercise:

- Active assisted isometric quad exercise for 0 to 1-week post-op and delay quad strengthening for 12 weeks post-op
- 1 to 4-week post-op straight leg rise in all plane in full extension
- One week post-op Heel side up to 90 degree
- Gentle hamstring muscle stretching
- If available, aquatic treatment for normalising gait, weight bearing strengthening, and deep-water aqua jogging for a range of motion and edoema after sutures are removed.

Phase II: Post-op 4 to 12 weeks

Advanced to phase II if a patient shows the following criteria

1. 0 to 90 degree Range of movements
2. SLR without an extension lag
3. Good quadricep control
4. Normal gait
5. Minimum swelling and inflammation

Goal:

- Stairclimbing
- Full flexion
- Protect graft
- Hamstring and quadricep muscles strengthening

Exercise:

- Continue range of motion and flexibility exercises as needed by the patient.
- Start with CKC quad strengthening exercises such as wall sits, step-ups, mini-squats, Leg Press 90 -30 degrees, and lunges and continue as tolerated.

- At week 12 post-op, continue to develop hips, hamstrings, and calf muscles while gradually adding resistance to open chain hamstring workouts.
- Stretching hamstrings, Gastroc/Soleus, and calves.
- Stairmaster
- Stationary Biking
- At 10-12 weeks, single leg balance/proprioception training on an unweighted treadmill.

Phase III: Post-op 12 to 20 weeks

Criteria to advance to Phase III include:

- No patellofemoral pain
- Minimum of 120 degrees of flexion
- Sufficient strength and proprioception to initiate running
- Minimal swelling/inflammation
- No patellofemoral pain
- Minimum of 120 degrees of flexion
- Sufficient strength and proprioception to initiate running
- Minimal swelling/inflammation

Goals:

- Complete range of movements
- Improve strength and proprioception to prepare for sport activities
- Overstressing graft is avoided
- Increase hamstring muscle strengthening
- Patellofemoral joint is protected
- Running mechanism is normalised

Exercise:

- Continue with flexibility and range of motion exercises as needed by the patient.
- Start with mid-range speeds (120^0/sec-240^0/sec) in isokinetic (with anti-shear device).
- At around 16 weeks, the patient should be able to progress to full weight-bearing running.
- Begin with a 90^0-30^0 open kinetic chain leg extension, then move to eccentrics as tolerated.
- If desired, begin swimming.
- At 14-16 weeks, recommend an isokinetic test with an anti-shear device to advise ongoing strengthening.
- Strengthening of the hips, quads, hamstrings, and calf
- Stairmaster, elliptical, and bike cardio/endurance training
- Proprioceptive activities should be advanced

Phase IV: Post-op upto 6th month:

Criteria for advancement to Phase IV:

- No significant swelling/inflammation
- Full, pain-free ROM
- No evidence of patellofemoral joint irritation
- Strength approximately 70% of uninvolved lower extremity per isokinetic evaluation
- Sufficient strength and proprioception to initiate agility activities
- Normal running gait

Goals:

- basics and sport-specific agility drills.
- Single hop or three hop tests 85% of the contralateral limb
- Reach upto 85% of quadriceps strength

Exercise:

- Initiate sport-specific drills as appropriate for a patient
- Maintain and advance the flexibility and strengthening programme in accordance with individual needs and limitations.
- Agility progression includes, but is not limited to:
  - Agility ladder drills
  - Crossovers
  - Figure 8 running
  - Shuttle running
  - Side steps
  - One leg and two legs jumping
  - Cutting
  - Acceleration/deceleration/springs
- Initiate plyometric program as appropriate for patient's athletic goals
- Continue progression of running distance based on patient needs

Phase V: After post-op 6 months

Criteria for phase V:

- No patellofemoral joint complains
- Complete ROM, strength, proprioception, and endurance to safely return to work or athletics.

Goals:

- Safe return to sports activity and work
- Maintenance of strength
- Patient education regarding limitation and possibilities

Exercise:

- Maintenance programme for strength, endurance

CLINICAL EVALUATION

At regular intervals follow up at an outpatient level at 6 weeks, 3 months, and 6 months for clinical examination and radiological evaluation was done. If possible, further follow up was done. At every visit, patient was assessed clinically regarding pain, limp, stability of knee joint, swelling.

Clinical assessment:

All patients were clinically assessed by using **INTERNATIONAL KNEE DOCUMENTATION COMMITTEE (IKDC QUESTIONNAIRE)** and **LYSHOLM AND GILLQUIST KNEE SCORING SYSTEM**

INTERNATIONAL KNEE DOCUMENTATION COMMITTEE (IKDC QUESTIONNAIRE)

The answers to each item is assessed using an ordinal approach, with 0 representing the lowest degree of function and 1 representing the highest level of symptoms. For example, item 1 is scored by giving a 0 to the response "Unable to undertake any of the following activities due to knee pain" and a 4 to the response "Very rigorous sports such jumping or pivoting as in basketball or soccer."

The IKDC Subjective Knee Evaluation is scored by adding the individual item scores and then converting the total to a scale ranging from 0 to 100. To achieve the current form of the IKDC, simply sum up the scores of individual item and divide by the constant number 87 which is maximum possible score.

IKDC SCORE = [SUM OF ITEMS / 87] X 100

The higher score represent higher level of functions and lower level of symptoms, and the converted score is interpreted as a reflection of function. A score of 100 indicates that there are no restrictions on daily activities or athletic activities, as well as the lack of symptoms.

A: 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 (+4)
   - ☐ Strenuous activities like heavy physical work, skiing, or tennis (+3)
   - ☐ Moderate activities like moderate physical work, running, or jogging (+2)
   - ☐ Light activities like walking, housework, or yard work (+1)
   - ☐ Unable to perform any of the above activities due to knee pain (+0)

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?

No| Pain|	0 ☐	1 ☐	2 ☐	3 ☐	4 ☐	5 ☐	6 ☐	7 ☐	8 ☐	9 ☐	10 ☐	|Worst pain |imaginable

4. During the past 4 weeks, or since your injury, how stiff or swollen was your knee?
   - ☐ Not at all (+4)
   - ☐ Mildly (+3)
   - ☐ Moderately (+2)
   - ☐ Very (+1)
   - ☐ Extremely (+0)

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 (+4)
   - ☐ Strenuous activities like heavy physical work, skiing, or tennis (+3)
   - ☐ Moderate activities like moderate physical work, running, or jogging (+2)
   - ☐ Light activities like walking, housework, or yard work (+1)
   - ☐ Unable to perform any of the above activities due to knee pain (+0)

6. During the past 4 weeks, or since your injury, did your knee lock or catch?
   ☐ Yes (+0) ☐ No (+1)

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 (+4)
   - ☐ Strenuous activities like heavy physical work, skiing, or tennis (+3)
   - ☐ Moderate activities like moderate physical work, running, or jogging (+2)
   - ☐ Light activities like walking, housework, or yard work (+1)
   - ☐ Unable to perform any of the above activities due to knee pain (+0)

B: Sports Activities

1. 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 (+4)
   - ☐ Strenuous activities like heavy physical work, skiing, or tennis (+3)
   - ☐ Moderate activities like moderate physical work, running, or jogging (+2)
   - ☐ Light activities like walking, housework, or yard work (+1)
   - ☐ Unable to perform any of the above activities due to knee pain (+0)

2. 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	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
B. Go down stairs	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
C. Kneel on the front of your knee	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
D. Squat	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
E. Sit with your knee bent	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
F. Rise from a chair	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
G. Run straight ahead	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
H. Jump and land on your involved leg	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)
I. Stop and start quickly	☐ (+4)	☐ (+3)	☐ (+2)	☐ (+1)	☐ (+0)

C: Function

3. 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:

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

Current function of your knee:

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

LYSHOLM AND GILLQUIST KNEE SCORE

The Lysholm Knee Scoring Scale was designed to be used for evaluating outcomes of knee ligament surgery, particularly for symptoms related to instability, and was first published in 1982 in The American Journal of Sports Medicine before being revised in 1985 in Clinical Orthopaedics and Related Research.

The Lyshom Knee Scoring Scale is a patient-reported instrument including subscales for pain, instability, limping, stair climbing, locking, swelling, squatting, and support requirements. Scores range from 0 (worst disability) to 100 (less disability).

Depending on the patient's functional ability, particular ratings were assigned to each criterion. The maximum score for a knee was 100. Scores are divided as Excellent, Good, Fair, and Poor based on the outcome scores.

- Excellent grade for score between– 95 – 100
- Good grade for score between – 84 – 94
- Fair grade for score between – 65 – 83
- Poor grade for score between– 64 or less

<u>Lysholm Knee Scoring Scale</u>

Patient Name: ______________________________

Date: _______________________________________

Limp

☐ I have no limp when I walk	+5
☐ I have a slight or periodical limp when I walk	+3
☐ I have a severe and constant limp when I walk	+0

Support

☐ I do not use a cane or crutches	+5
☐ I use a cane or crutches with some weight--bearing	+2
☐ Putting weight on my hurt leg is impossible	+0

Locking

☐ I have no locking and no catching sensation in my knee	+15
☐ I have catching sensation but no locking sensation in my knee	+10
☐ My knee locks occasionally	+6
☐ My knee locks frequently	+2
☐ My knee feels locked at this moment	+0

Instability

☐ My knee never gives way	+25
☐ My knee rarely gives way, only during athletics or other vigorous activities	+20
☐ My knee frequently gives way during athletics or other vigorous activities; in turn I am unable to participate in these activities	+15
☐ My knee occasionally gives way in daily activities	+10
☐ My knee often gives way in daily activities	+5
☐ My knee gives way every step I take	+0

Pain

☐ I have no pain in my knee	+25
☐ I have intermittent or slight pain in my knee during vigorous activities	+20
☐ I have marked pain in my knee during vigorous activities	+15
☐ I have marked pain in my knee during or after walking more than 1 mile	+10
☐ I have marked pain in my knee during or after walking less than 1 mile	+5
☐ I have constant pain in my knee	+0

Swelling

☐ I have no swelling in my knee	+10
☐ I have swelling in my knee only after vigorous activities	+6
☐ I have swelling in my knee after ordinary activities	+2
☐ I have swelling constantly in my knee	+0

Stair--climbing

☐ I have no problems climbing stairs	+10
☐ I have slight problems climbing stairs	+6
☐ I can climb stairs only one at a time	+2
☐ Climbing stairs is impossible for me	+0

Squatting

☐ I have no problems squatting	+5
☐ I have slight problems squatting	+4
☐ I cannot squat beyond a 90° bend in my knee	+2
☐ Squatting is impossible because of my knee	+0

Scoring Guide:

Lysholm Knee Score: Summation of points

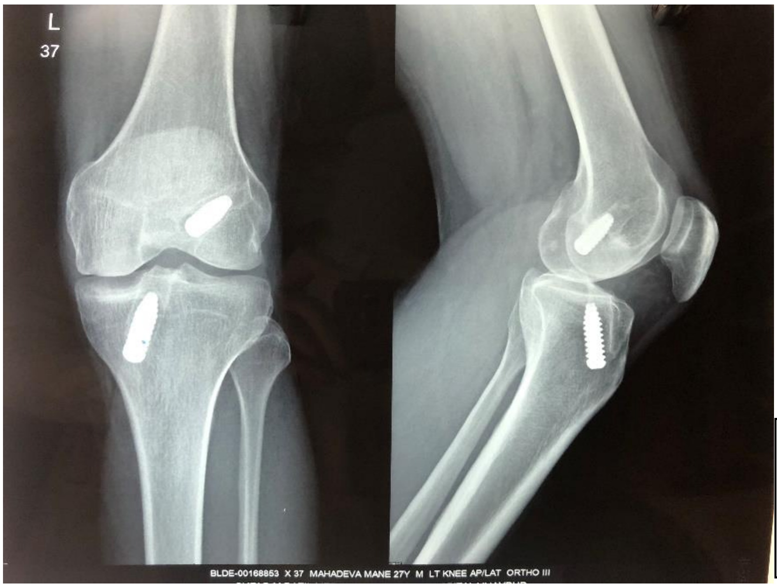
Lysholm Knee Score:_______Points

CLINICAL PICTURES

- **CASE 1:**

PHOTOGRAPH 19: Pre-op MRI

Showing ACL tear



PHOTOGRAPH 20: Post-op xray

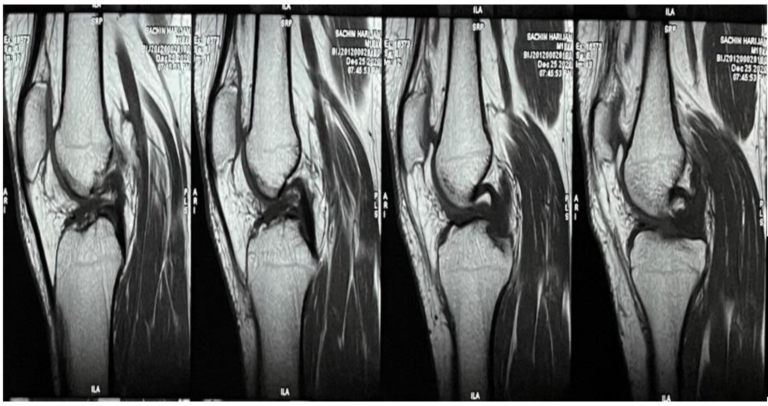
Showing titanium screw

PHOTOGRAPH 21: Post-op

6 months

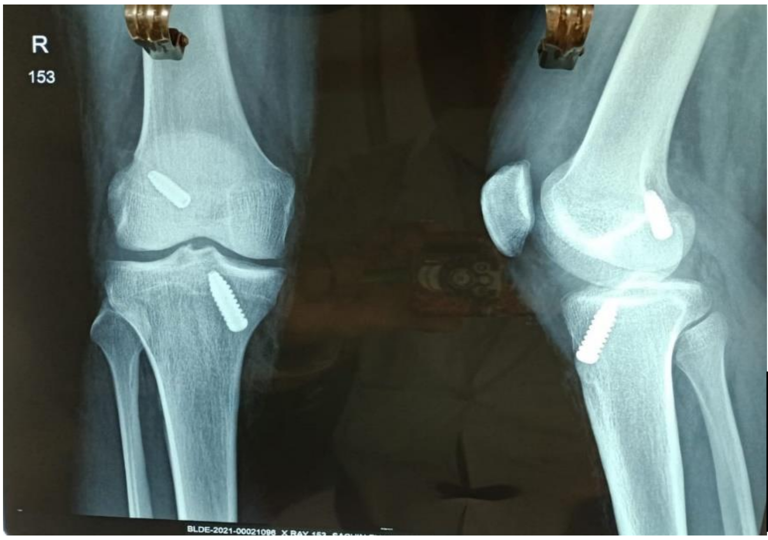
clinical pictures

- **CASE 2:**



PHOTOGRAPH 22: Pre-op MRI

Showing ACL tear



PHOTOGRAPH 23: Post-op xray

Showing titanium screw

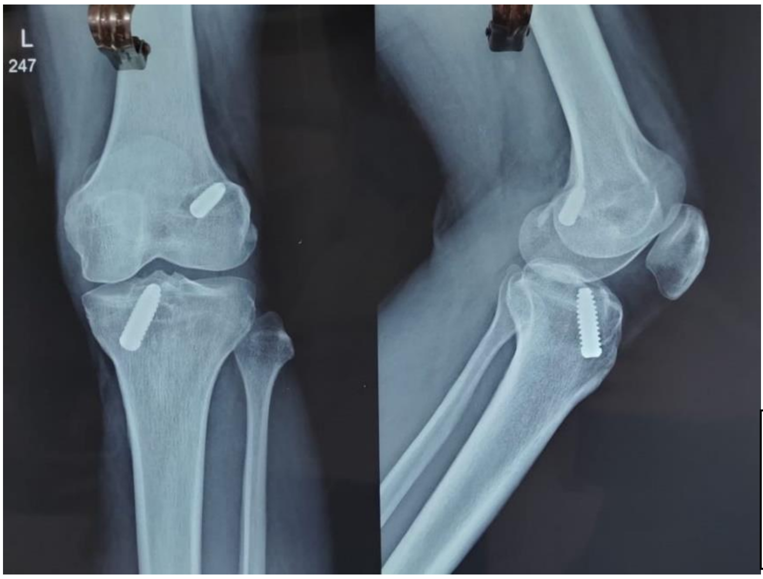
PHOTOGRAPH 24: Post-op

6 months

clinical pictures

- **CASE 3:**

PHOTOGRAPH 25: Pre-op MRI: Showing ACL tear



PHOTOGRAPH 26: Post-op xray

Showing titanium screw

PHOTOGRAPH 27: Post-op

6 months

clinical pictures

RESULTS

21 cases underwent of arthroscopic assisted anterior-cruciate-ligament-reconstruction were followed up at regular interval for an average period of 11.10 months in BLDE’A B.M Patil medical college, hospital and research centre, Vijayapura.

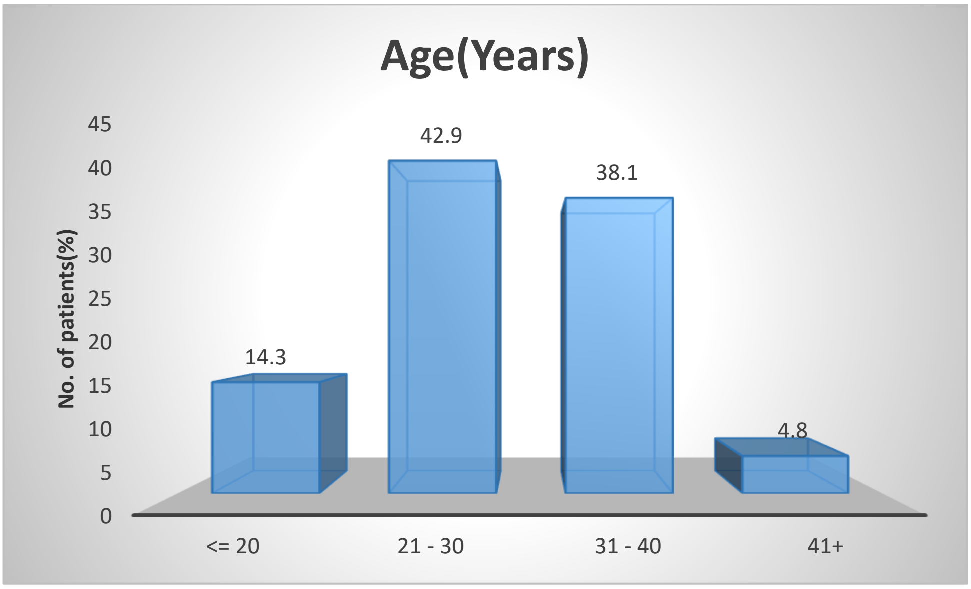
Age:

Most of the patients i.e., 42.9% were belong to the 21 to 30 years of age group, followed by 38.1% of patient belong to 31 to 40 years of age group. Mean age of the patient in current study was 30.38.

Table 1: **Age Distribution** (Years)

Age (Years)	No. of patients	Percentage
<= 20	3	14.3
21 - 30	9	42.9
31 - 40	8	38.1
41+	1	4.8
Total	21	100.0

Graph 1: Age distribution



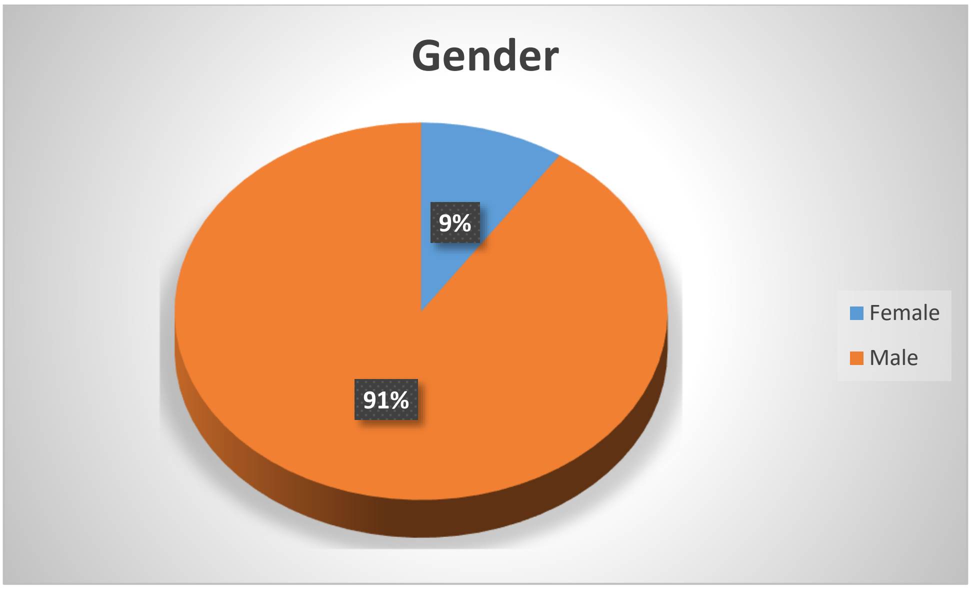
Sex:

Among total studied patient, 19 of patients (90.5%) were male and 2 (9.5%) were female.

Table 2 : **Gender Distribution**

Gender	No. of patients	Percentage
Female	2	9.5
Male	19	90.5
Total	21	100.0

Graph 2 : Gender distribution



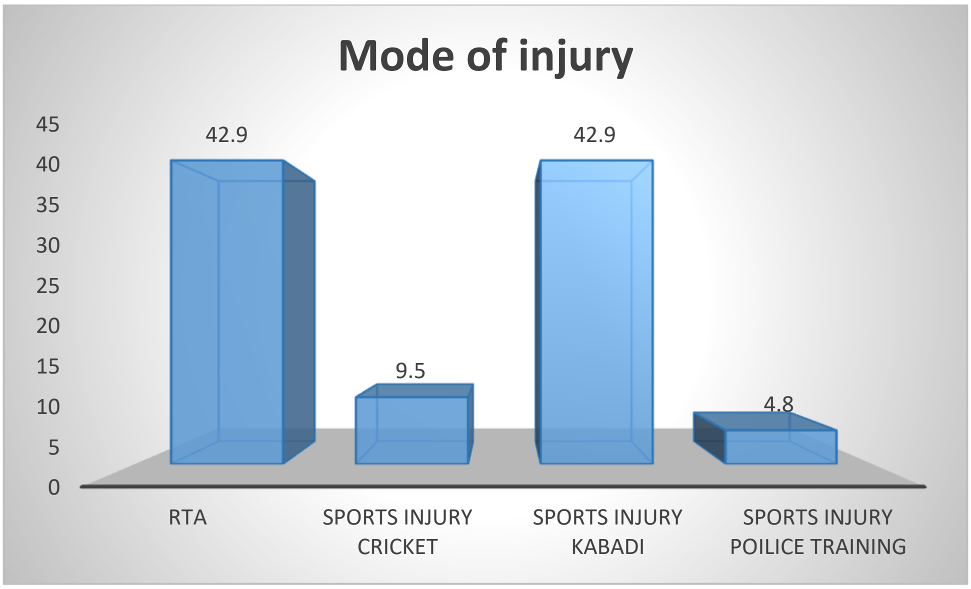
Mode of injury:

In our study, we the most common mode of injury was due to Sports injury (57.1%), followed by RTA (42.9%).

Table 3 : **Distribution of Mode of injury**

MODE OF INJURY	No. of patients	Percentage
RTA	9	42.9
SPORTS INJURY CRICKET	2	9.5
SPORTS INJURY KABADI	9	42.9
SPORTS INJURY POILICE TRAINING	1	4.8
Total	21	100.0

Graph 3 : Distribution of Mode of injury



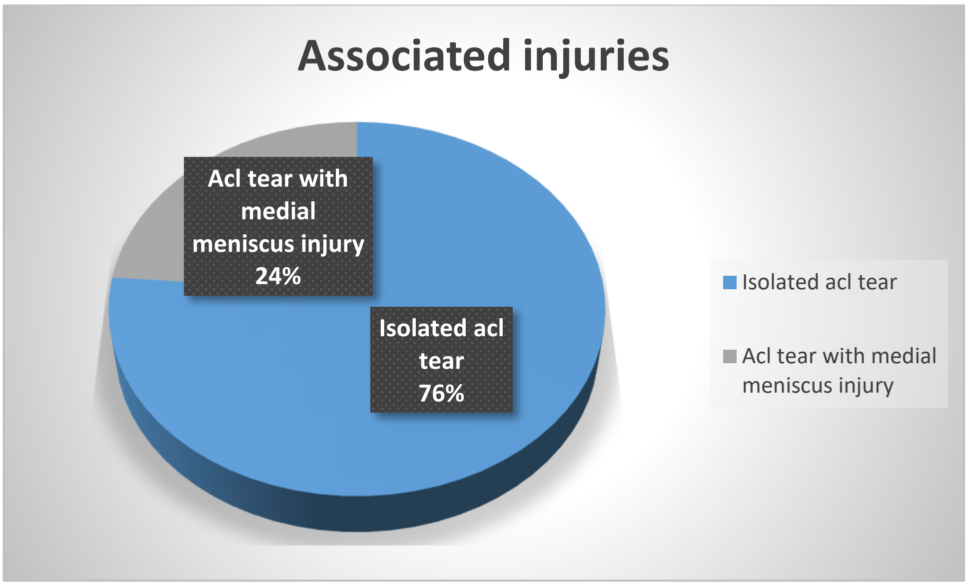
Associated injuries:

In current study, associated meniscal injury was seen in 23.8 % of patients. Isolated ACL tear was present in 16 patients (76.2%).

Table 4 : **Associated injuries**

Diagnosis	No. Of patinets	Percentage
Isolated acl tear	16	76.2
Acl tear with meniscus injury	5	23.8
Total	21	100.0

Graph 4 : Associated injuries



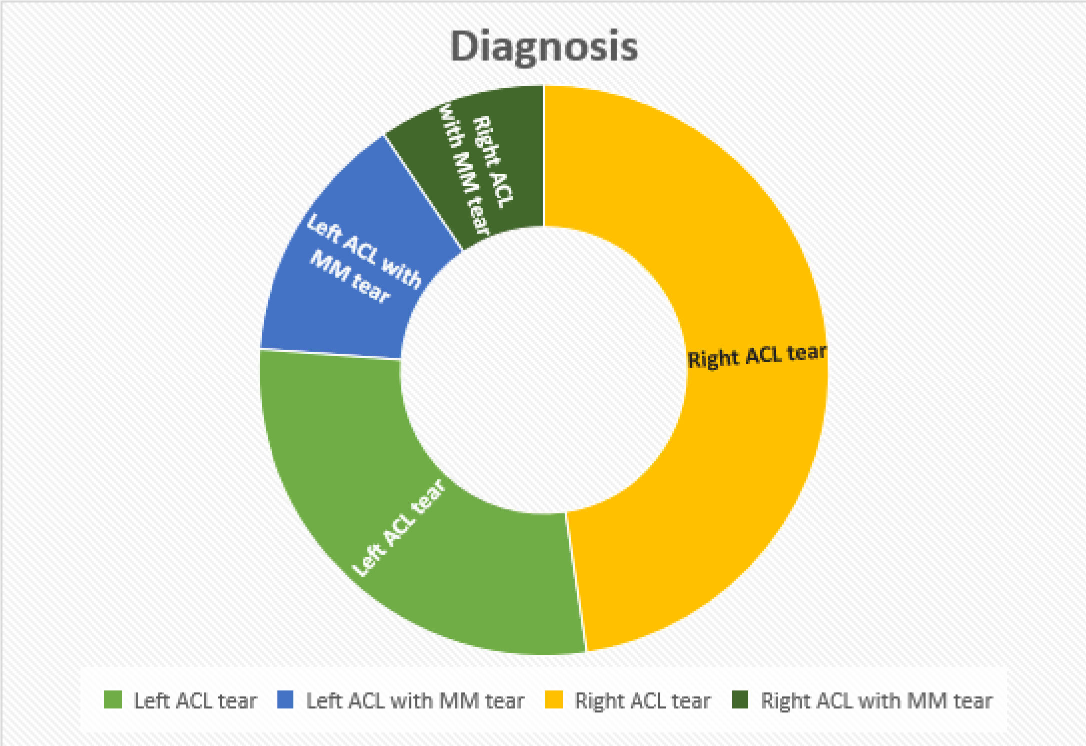
Diagnosis:

In current study, the right ACL tear was common (57.1%) than the left ACL tear (42.7%).

Table 5 : **Diagnosis**

Diagnosis	No. of patients	percentage
Left ACL tear	6	28.6
Left ACL with MM tear	3	14.3
Right ACL tear	10	47.6
Right ACL with MM tear	2	9.5
Total	21	100.0

Graph 5 : Diagnosis



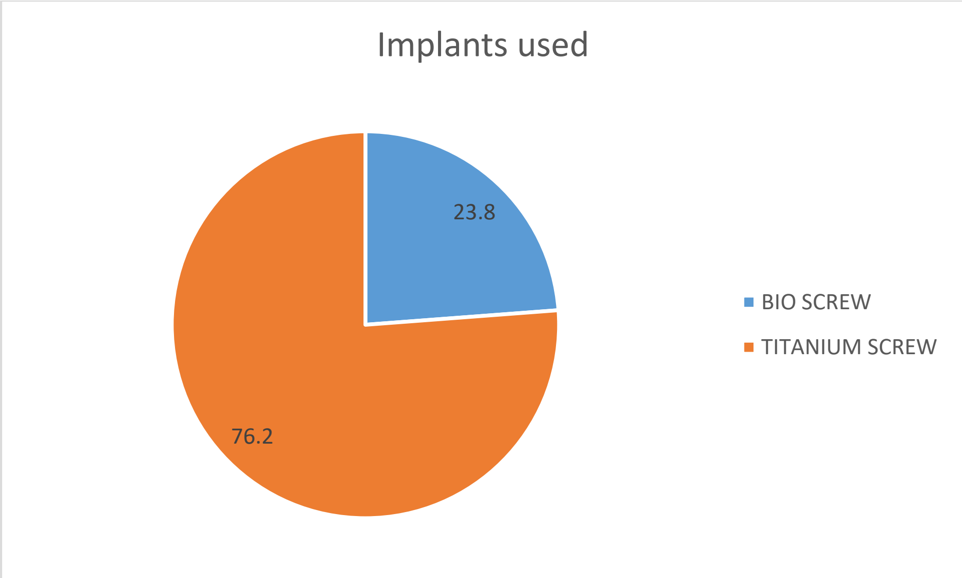
Implants distribution:

In our study, an interference screw was used, out of which titanium screw was used in 16 patients (76.2%), and bio screw in 5 patients (23.8%).

Table 6 : **Implants distribution**

IMPLANTS USED	NO. OF PATIWNTS	PERCENTAGE
BIO SCREW	5	23.8
TITANIUM SCREW	16	76.2
TOTAL	21	100

Graph 6 : Implants distribution



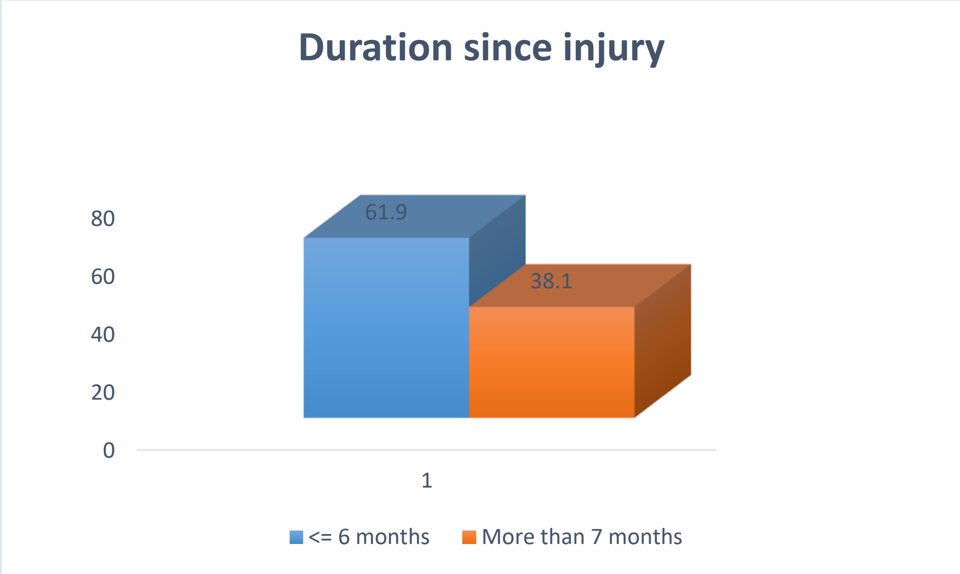
Duration since injury:

In our study, 61.9% of the patients presented within 6 months after injury.

Table 7 : **Distribution of duration since injury**

In months	No. of patients	Percentage
<= 6 months	13	61.9
More than 7 months	8	38.1
Total	21	100.0

Graph 7 : Distribution of duration since injury



The pre-op function of the knee:

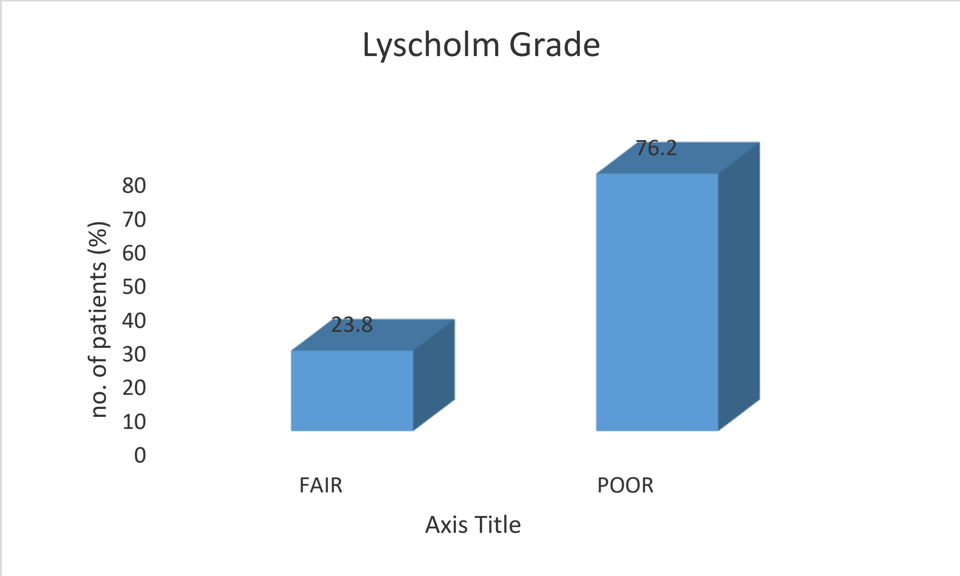
Lyscholm knee score:

On presentation, 5 patients (23.8%) had a fair functional grade. And in 16 patients (76.2%) had a poor functional grade.

Table 8 **: Pre op function of knee**

Lyscholm grade	No. of patients	Percentage
FAIR	5	23.8
POOR	16	76.2
Total	21	100.0

Graph 8 : Pre op function of knee



Post-op function of the knee:

Lyscholm knee score:

11 patients (52.4%) had excellent functional outcomes, while 9 patients (42%.9) had a good functional outcome. The remaining 1 patient (4.8%) had a fair functional outcome according to Lysholm knee scoring system.

Table 9 : **Post op Function of knee**

Lyscholm grade	No. of patients	Percentage
EXCELLENT	11	52.4
FAIR	1	4.8
GOOD	9	42.9
Total	21	100.0

Graph 9 : Post op Function of knee

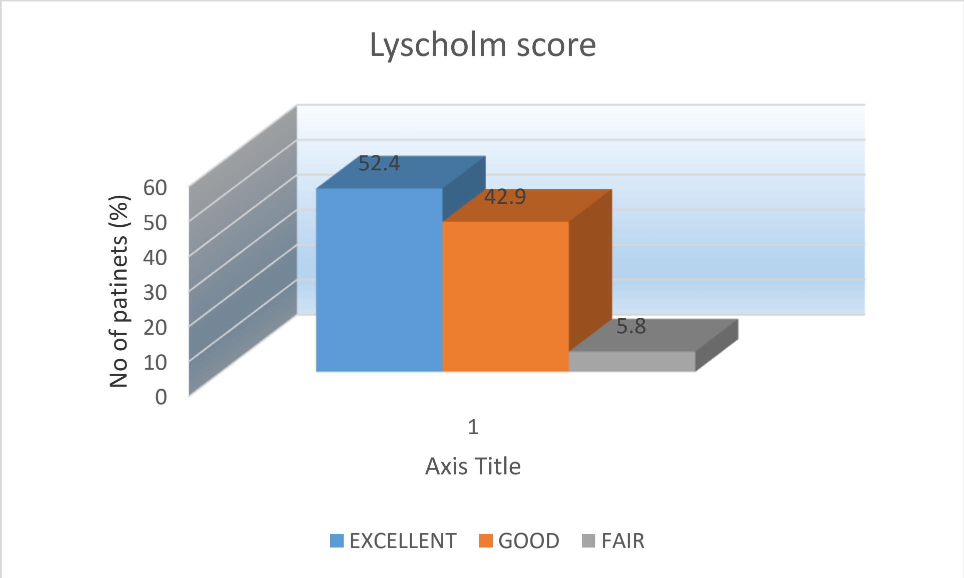
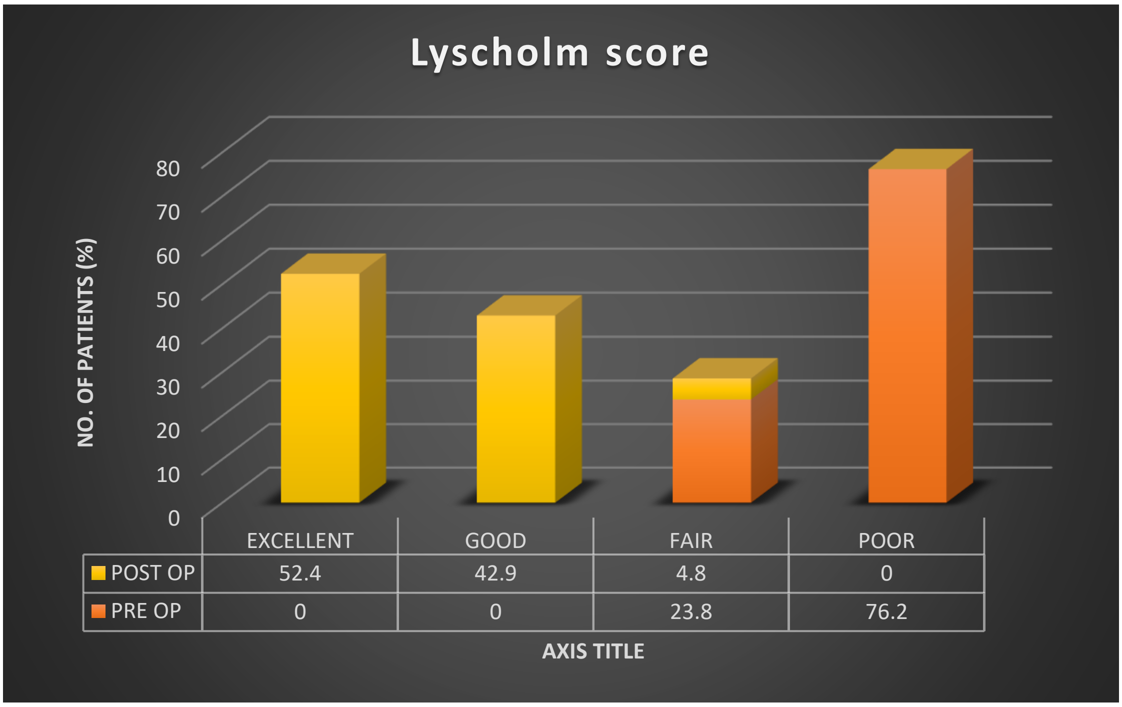


Table 10 : **Comparison of lyscholm grades**

Lyscholm grade	PRE OP		POST OP	
	No. of patients	Percentage	No. of patients	Percentage
EXCELLENT	0	0	11	52.4
GOOD	0	0	9	42.9
FAIR	5	23.8	1	4.8
POOR	16	76.2	0	0

Graph 10 : Comparison of lyscholm grades



Graft diameter:

The diameter of quadrupled hamstring graft used in our study was 7 mm in 5 patients (23.8%), 8 mm in 14 patients (66.7%), 9 mm in 2 patients (9.5%).

Table 11 : **Graft diameter**

Graft Diameter (mm)	No. of patients	Percentage
7	5	23.8
8	14	66.7
9	2	9.5
Total	21	100.0

Graph 11 : Graft diameter

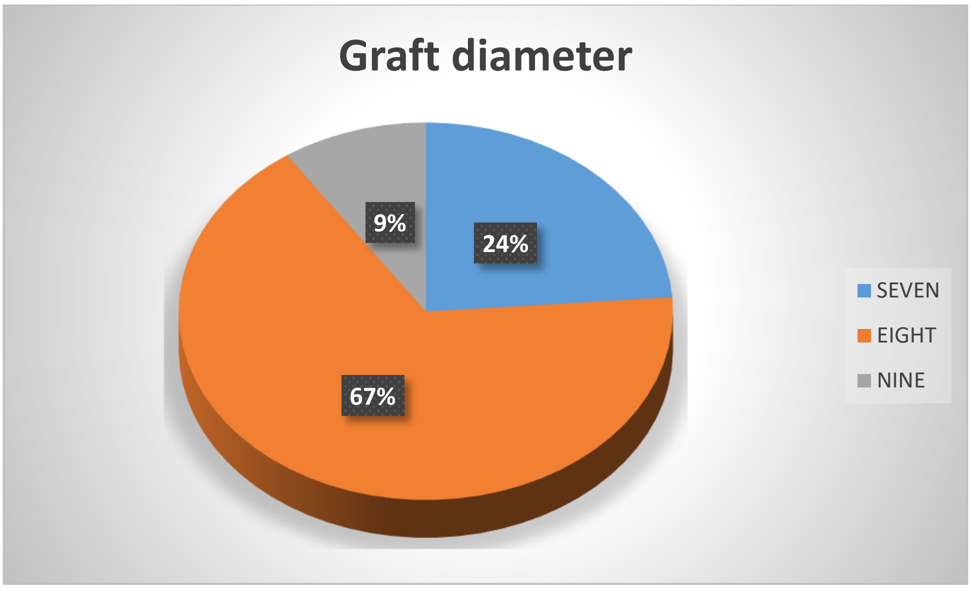
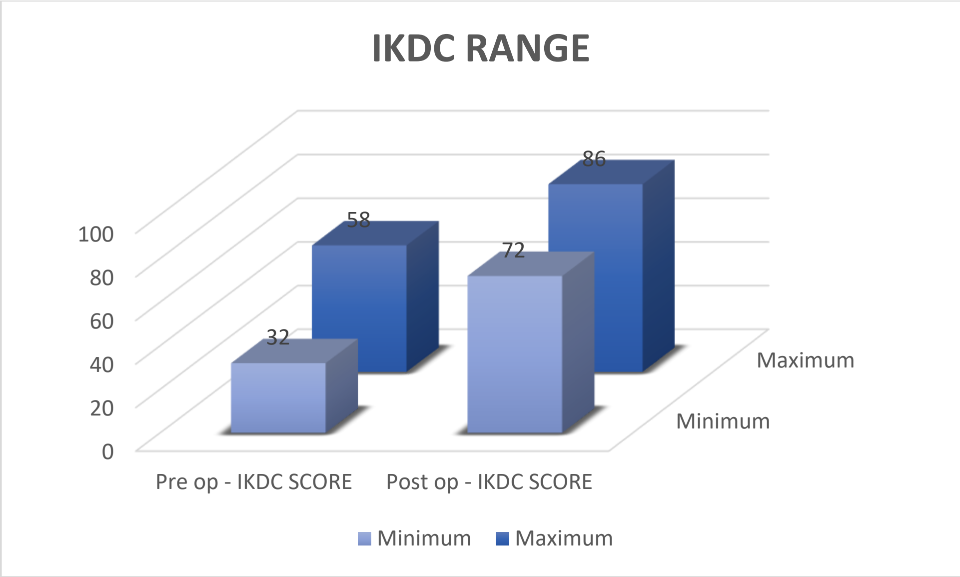


Table 12:

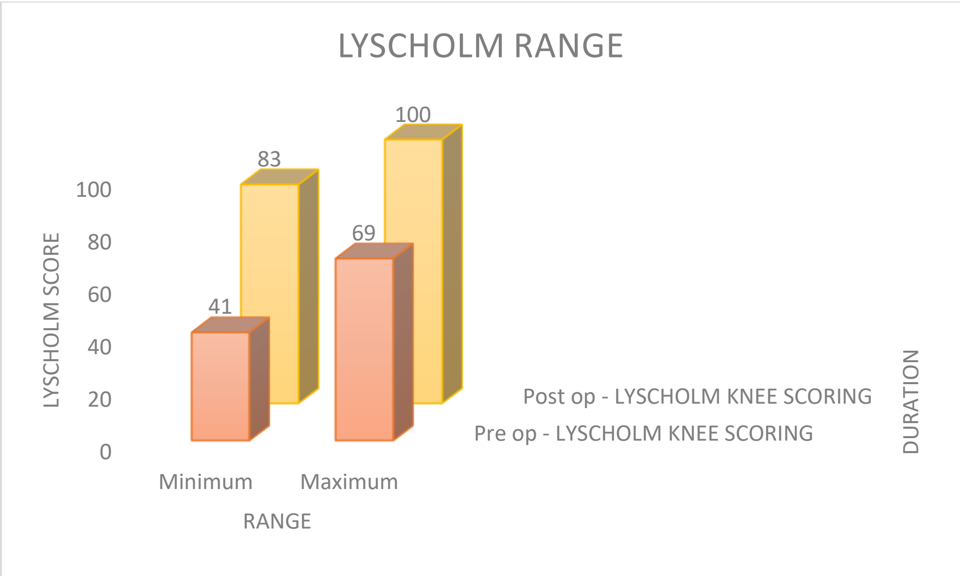
Descriptive Statistics				
	Minimum	Maximum	Mean	Std. Deviation
Age	20	45	30.38	7.235
Time of injury (in months)	2	96	12.52	20.064
Pre op - IKDC SCORE	32	58	46.81	7.139
Pre op - LYSCHOLM KNEE SCORING	41	69	59.19	7.047
Post op - IKDC SCORE	72	86	81.95	3.653
Post op - LYSCHOLM KNEE SCORING	83	100	94.95	4.727

Total follow up duration (months)	6	19	11.10	3.961

Graph 12 : IKDC score range



Graph 13 : LYSCHOLM score range



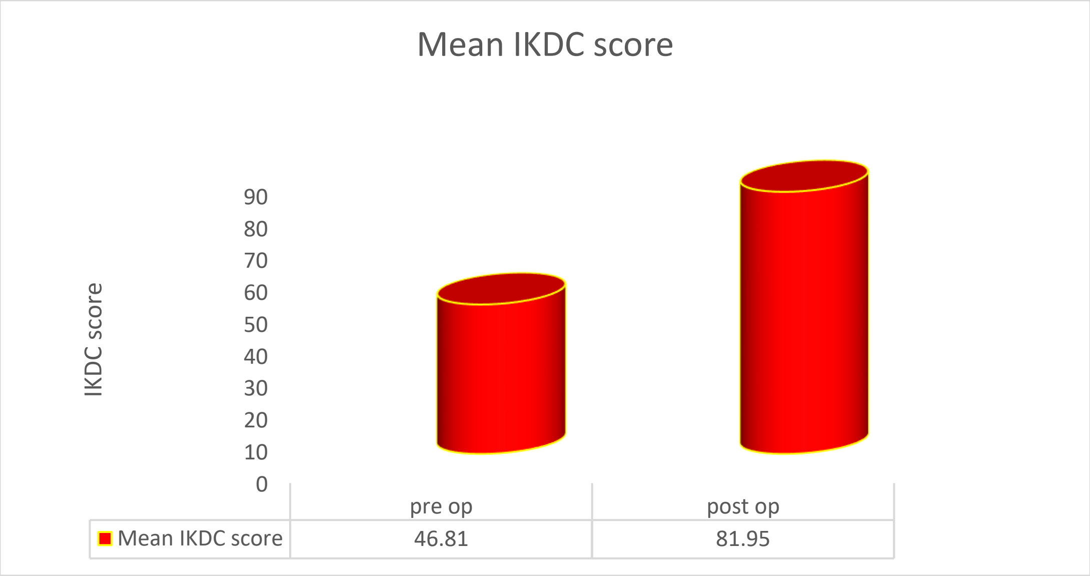
Functional outcome:

The mean pre-op International Knee Documentation Committee (IKDC Questionnaire) subjective score was 46.81±7.139, while the mean post-op IKDC scroe was 81.95±3.653. There was a significant improvement in the post-op IKDC score compared with the pre-op score ($p<0.0001$). The mean pre-op Lyscholm knee scoring was 59.19±7.047, while the mean post-op Lyscholm knee scoring was 94.95±4.727. There was a significant improvement in post-op lyscholm knee scoring compared with pre-op score ($p<0.0001$).

Table 13 : **Functional outcome**

Comparison between	Pre		Post		Paire t test	P value
	Mean	±SD	Mean	±SD		
IKDC SCORE (OUT OF 87)	46.81	7.139	81.95	3.653	16.143	0.0001*
LYSCHOLM KNEE SCORING SCORE	59.19	7.047	94.95	4.727	-15.683	0.0001*

Graph 14 : Mean IKDC score



Graph 15 : Mean Lyscholm score

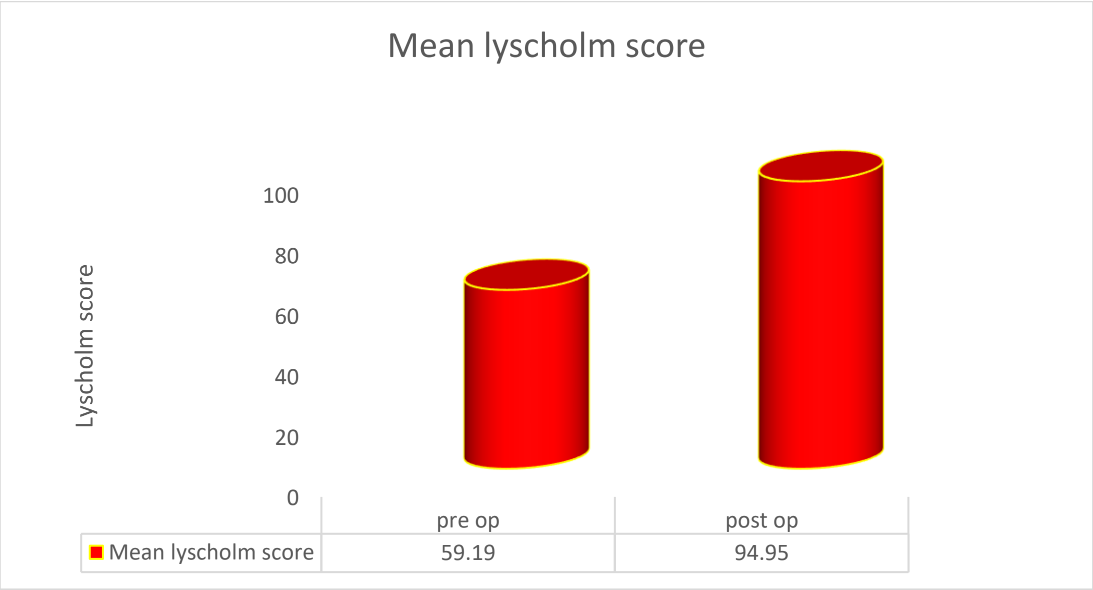


Table 14 : **Comparison between Time since injury and post-op average IKDC score**

Time since injury	Average of post op IKDC score
1 year	80.75
2 months	85.5
2 years	74
3 months	84
4 months	84.5
6 months	83.125
8 months	81
8 years	80

Graph 16 : Comparison between Time since injury and post-op average IKDC score

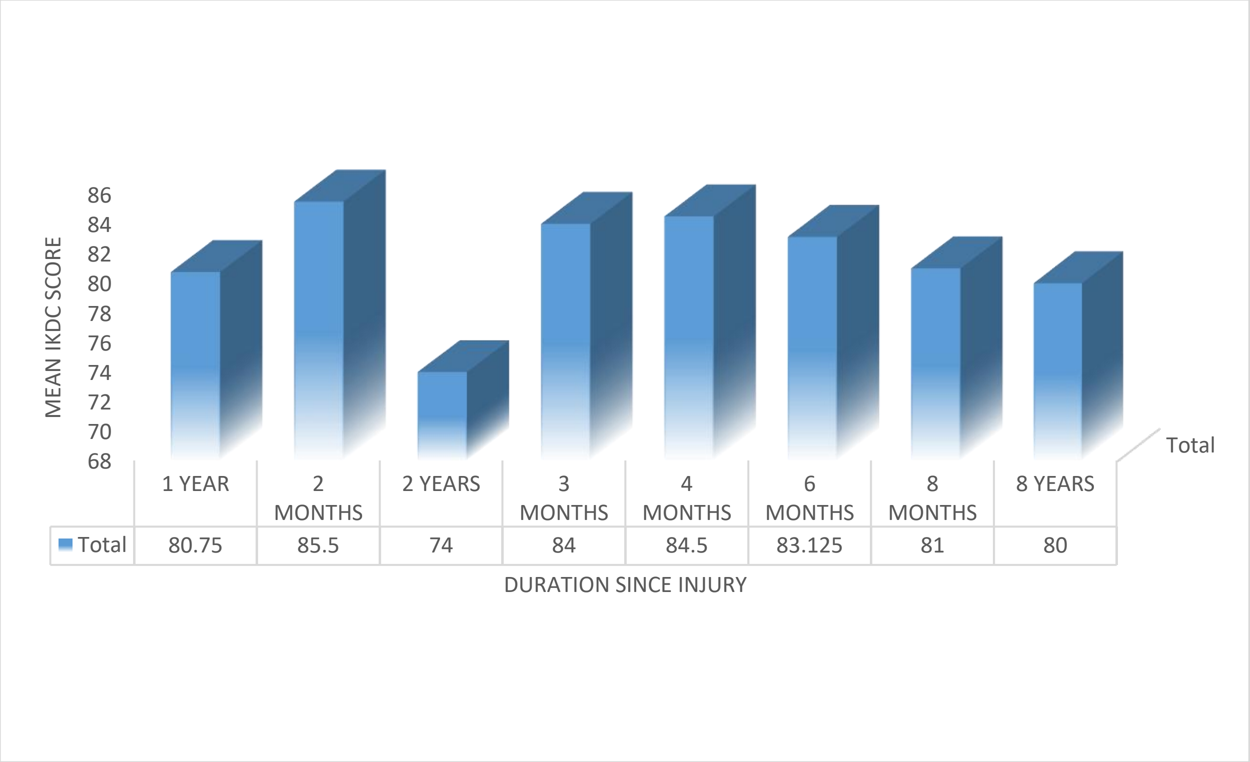


Table 15 : **Comparison between graft diameter and post-op average IKDC score**

Graft diameter (mm)	Average IKDC score
7	78.33
8	82.72
9	85.25

Graph 17 : Comparison between graft diameter and post-op average IKDC score

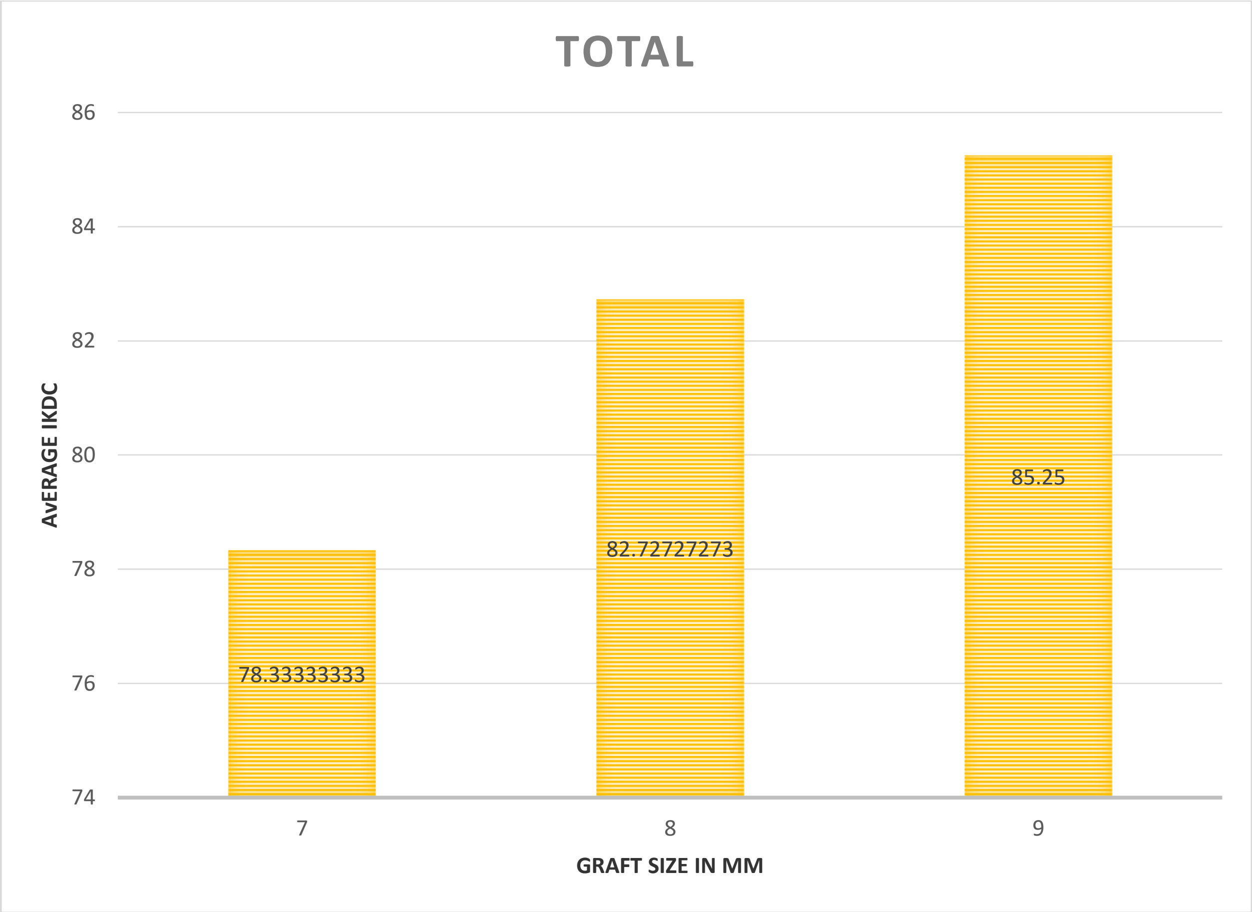


Table 16 : **Complications distribution**

Complications	6 weeks		3 months		6 months	
	No. of patients	Percentage	No. of patients	Percentage	No. of patients	Percentage
Discharge from wound	3	14.3	0	0	0	0
Knee stiffness	0	0	1	4.8	0	0
nil	18	85.7	20	95.2	21	100.0
total	21	100.0	21	100.0	21	100.0

COMPLICATIONS:

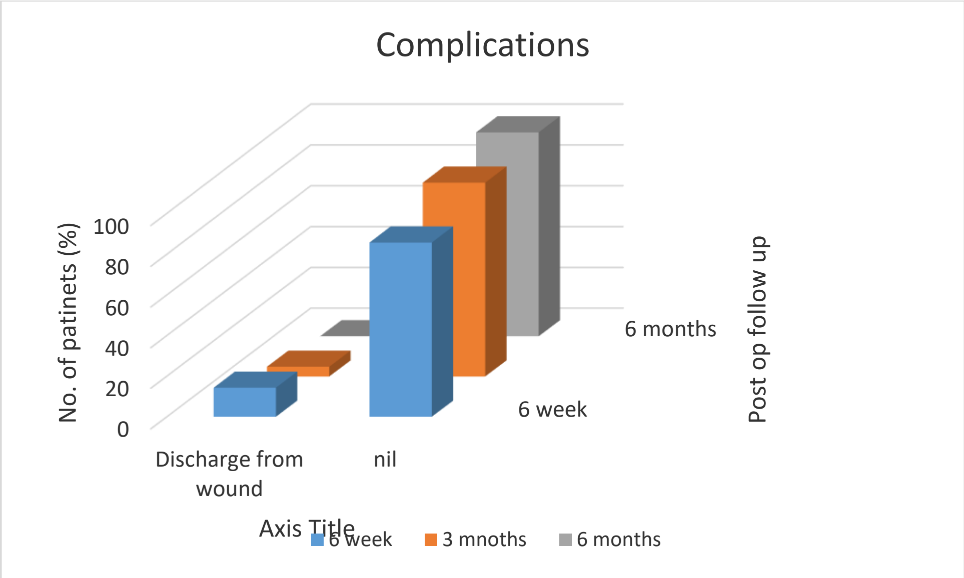
In our study, 3 patients, i.e., 14.3%, had surgical site infection. In which:

-2 patients out of 3 had a superficial surgical site infection at the donor site, which was managed by intravenous antibiotics.

-The third patient developed a deep surgical site infection over donor site with wound gaping. This patient was a known case of diabetes. The patient underwent wound debridement procedure, had diabetic control management. The infection was settle with broad-spectrum antibiotics. Sutures were removed after post-suture 12 days.

In current study, one patient developed restricted range of movements ranging from 5 to 50 degrees in follow up of post-op 3 months. We had lost follow up of that patient until post-op 3 months due to COVID-19 Pandemic. After the patient was admitted and had aggressive post-op physiotherapy protocol under supervision, the functional outcome was improved. This patient had the least IKDC and lyscholm score in post-op 6 months 72 and 83 respectively.

Graph 18 : Complications distribution


Complications
No. of patinets (%)
100
80
60
40
20
0
Discharge from wound
nil
Axis Title
6 week
6 months
Post op follow up
6 week
3 mnoths
6 months

DISCUSSION

The study comprises twenty-one patients who underwent arthroscopy assisted ACL reconstruction using quadrupled hamstring autograft in BLDEA's BM Patil medical college, hospital and research centre, vijayapura for one year and six months. All patients were operated on for the reconstruction using an interference screw on the femoral and tibial side.

The number of anterior-cruciate-ligament-reconstructions has increased as a result of the increased occurrence of sports activity and urbanization. Arthroscopic reconstruction of an injured anterior-cruciate-ligament has become the gold standard, and it is one of the most popular arthroscopic procedures. As a result, it has been thoroughly investigated, and the outcomes of anterior-cruciate-ligament-reconstruction have received a lot of attention.

In current study, the most common group of mode of injury was due to Sports injury (57.1%), followed by RTA (42.9%). In current study, Kabaddi is the common sport activity that leads to anterior-cruciate-ligament tear.

Male predominance was found in current study. 19 out of 21 patients were males i.e, 90.5 % and 2 (9.5%) were females. Most of the patients, i.e., 42.9%, were 21 to 30 years of age. The mean age of the patient studied was 30.38 years. In current study, the associated meniscal injury with anterior-cruciate-ligament injury was seen in 23.8 % of patients. Isolated ACL tear was present in 16 patients (76.2%).

In current study, 61.9% of the patients presented within six months after injury. The Right knee has predominance with 12 (57.1%) of patients and the left knee in 9 (42.7%) patients. Brown et al. (50) studied the incidence of the sidedness of limb injury and sex incidence and stated that although their study pointed out that females are more prone to this injury, the incidence is yet, more in males due to increased exposure to work in a strenuous environment. They also hypothesised that limb sidedness do not influence either during injury or the recovery period. Our study did not find any significance in the sidedness of the gender to the recovery during rehabilitation.

According David Logerstedt et al., (51), the incidence of meniscal injuries at the time of anterior-cruciate-ligament-reconstruction was reported to be 58 percent, with the medial meniscus being the most usually affected. They also came to the conclusion that meniscal repair or resection had no effect on the end result.The medial meniscus injury is more common than seen in the study. anterior-cruciate-ligament-reconstruction with meniscus repair or meniscectomy were excluded from our study.

In our study, Patients in which no surgical intervention was needed for medial meniscus were taken in this study. There was associated meniscal injury in 23.8 % of patients. Isolated anterior-cruciate-ligament tear was present in 16 patients (76.2%). And also according to David Logerstedt et al.,(51) who stated that the presence of meniscal injury does not alter the functional outcome after anterior-cruciate-ligament-reconstruction.

There is no clear demonstration on the timing of surgery, although much has been studied so far in the literature. Most authors have opined on waiting for at least three weeks before anterior-cruciate-ligament-reconstruction from the time of injury. (52)(53)

Riley et al. 2004(54), D Chaudhary et al. 2005(55), Mahir et al. 2006(56), Jomha et al. 1999(57) and Ashok Kumar et al.2016(58). These studies were used to compare the results. Mean age of surgery, graft used, no of patinets studied, gender distribution, and mean follow up interval were studies.

Table 17:

Study	Mean age at surgery	Graft Used	Gender	No. of Patients	Mean Follow up Interval (months)
Railey et al.	33 Years	Quadrupled hamstring graft	59% Male	85	24
D Choudhary et al.	26 Years	Ipsilateral autogenous BPTB	73% Male	59	84
Mahir et al.	24 Years	Quadrupled hamstring graft	100% Male	62	18
Jomha et al.	27 Years	Ipsilateral autogenous BPTB	93% Male	100	12
Ashok Kumar et al.	27 years	Ipsilateral autogenous BPTB four stranded hamstring graft	97.1%	34	14
present study	30.38 years	Quadrupled hamstring graft	91%	21	11.10

Table 18:

Study	Average Lyscholm
Railey et al. 2004	95
D Choudhary et al. 2005	92
Mahir et al. 2005	93.5
Jomha 1999	94
Ashok Kumar et al.2016	90
Present study	94.95

The mean pre-op International Knee Documentation Committee (IKDC Questionnaire) subjective score was 46.81±7.139, while the mean post-op IKDC scroe was 81.95±3.653. There was a significant improvement in the post-op IKDC score compared with the pre-op score ($p<0.0001$). In following table: 19, the pre-op and post-op IKDC score has been compared with several studies. The article are by kumar et al.(58), Prasad et al.(59), and Aparajit et al.(60). These articles had significant improvements after ACL reconstruction.

Table 19:

Study	Pre-op IKDC score	Post-op IKDC score
kumar et al.	45.63	80.38
Prasad et al.	42.45	84.33
Aparjit et al.	50.50	86.30
Present study	46.81	81.95

The post-operative IKDC score in this study was comparable with the scores from other studies from the above data.

International Knee Documentation Committee (IKDC Questionnaire) subjective score was in this current study improved from a mean pre-operative score of 46.81±7.139 to a mean post-operative score of 81.95±3.653 with a p-value <0.001. Although the IKDC system is less subjective than most other scoring systems, it may give a less favourable result than other evaluating systems.(61)

Williams et al.,(62) in their study of 2500 cases of arthroscopic anterior-cruciate-ligament-reconstruction, reported an infection rate of 0.3%. In our study, 2 patients had a superficial surgical site infection at the donor site, which was managed by intravenous antibiotics.
And 1 patient developed a deep infection of the donor site with gaping of the wound. This patient was a known case of diabetes. The patient underwent wound debridement, diabetic control management and was given intravenous antibiotics.

Treme et al.(63) opined that a graft diameter of <7 mm would have a higher risk of failure. The average diameter of the graft in our study was 7.90 mm. The graft used in the current study with a diameter of 9 mm average functional outcome was maximum, i.e., 58.25. Compared to 7- and 8-mm diameter.

CONCLUSION

Anterior-cruciate-ligament-reconstruction with quadruple hamstring auto-graft is time tested technique. Adequate graft with appropriate thickness is a prerequisite for the success of surgery. Timing of surgery, precision in technique and adequate rehabilitation are the variables which influence strongly the outcome of surgery. Lysholm scores and IKDC scores are useful parameters to access the outcome of surgery

Summary of this study

- In young active individual, ACL reconstruction with quadrupled hamstring auto-graft produces good functional results.
- Fixation of the hamstring graft with a titanium and biodegradable interference screw results in an excellent functional outcome.
- For anterior-cruciate-ligament deficient knees, arthroscopic assisted anterior-cruciate-ligament-reconstruction with quadrupled hamstring auto-graft is an appropriate therapy choice.

Limitation of current study

- Sample size
- Small period of time - Longer-term follow-up studies are needed to establish the long-term outcome of this operation..

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ANNEXURES-I ETHICAL

B.L.D.E. (DEEMED TO BE UNIVERSITY)

(Declared vide notification No. F.9-37/2007-U.3 (A) Dated. 29-2-2008 of the MHRD, Government of India under Section 3 of the UGC Act, 1956)

The Constituent College

SHRI. B. M. PATIL MEDICAL COLLEGE, HOSPITAL AND RESEARCH CENTRE

INSTITUTIONAL ETHICAL CLEARANCE CERTIFICATE

The ethical committee of this college met on 13-11-2019 at 3-15 pm to scrutinize the synopsis of Postgraduate students of this college from Ethical Clearance point of view. After scrutiny the following original/corrected and revised version synopsis of the Thesis has been accorded Ethical Clearance

Title: Assessment of functional outcome of anterior cruciate ligament reconstruction using quadruple hamstring autograft

Name of PG student: Dr. Sagar Mengaji, Department of Orthopaedics

Name of Guide/Co-investigator : Dr. Ashok Nayak Professor & HOD Department of Orthopaedics

DR RAGHVENDRA KULKARNI
CHAIRMAN

Institutional Ethical Committee
BLDEU's Shri B.M. Patil
Medical College,BIJAPUR-586103

Following documents were placed before Ethical Committee for Scrutinization

1. Copy of Synopsis / Research project
2. Copy of informed consent form
3. Any other relevant documents.

ANNEXURES-II

INFORMED CONSENT 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. Kulkarni Onkar Satish of Shri. B. M. Patil Medical College Hospital and 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. Further Dr. Sagar mengaji informed me that he/she is conducting dissertation/research titled "ASSESSMENT OF FUNCTIONAL OUTCOME OF ARTHROSCOPIC ASSISTED ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING QUADRUPLED HAMSTRING AUTOGRAFT" under the guidance of Dr. ASHOK NAYAK, requesting my participation in the study. Apart from routine treatment procedure, the pre-operative, operative, post-operative and followup observations will be utilized for the study as reference data.

Doctor has also informed me that during conduct of this procedure like adverse results may be encountered. Among the above complications most of them are treatable but are not anticipated hence there is chance of aggravation of my condition and in rare circumstances it may prove fatal in spite of anticipated diagnosis and best treatment made available. Further Doctor has informed me that my participation in this study help in evaluation of the results of the study which is useful reference to treatment of other similar cases in near future, and also I may be benefited in getting relieved of suffering or 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 the person other than me or my legal hirer except for academic purposes.

The Doctor did inform me that though my participation is purely voluntary, based on information given by me, I can ask any clarification during the course of treatment / study related to diagnosis, procedure of treatment, result of treatment or prognosis. At the same time I have 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 followup 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 patient:

Signature of doctor:

Witness: 1.

2.

Date:

Place

ANNEXURES-III

PROFORMA

CASE NO:

NAME:

AGE/SEX:

I P 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 :

General Physical Examination

Pallor: present/absent

Icterus: present/absent

Clubbing: present/absent

Generalized lymphadenopathy: present/absent

Built: poor/moderate/well

Nourishment: poor/moderate/well

Vitals

PR: RR:

BP: TEMP:

Other Systemic Examination:

Local examination:

Inspection:

a) Attitude/ deformity

b) Abnormal swelling -Effusion

- Site

- Size

- Extent

d) Skin

Palpation:

Special test:	right	left
Lachman test:		
Anterior drawer test:		
Posterior drawer test:		
Lilly’s test:		
McMurray test:		
Varus stress test:		
Valgus stress test:		

Movements:	Active	Passive
Knee Joint:		
Flexion		
Extension		

Radiological Evaluation

X-ray knee AP and Lateral: MRI knee:

GRADE:

Associated injuries:

Posterior cruciate ligament

Medial meniscus

Lateral meniscus

Medial Collateral ligament

Lateral collateral ligament

Provisional Diagnosis:

Follow Up:

Range of movement :

Laxity :

Anterior Knee pain :

Radiological evaluation:

IKDC knee score:

Lysholm knee score:

MASTER CHART

SERIAL NO	IPD	NAME	AGE	SEX	MODE OF INJURY	IMPLANTS USED	TIME OF INJURY	DIAGNOSIS
1	11702	KASTURI HARIJAN	35	F	RTA	BIO SCREW	6 MONTHS	RIGHT ACL TEAR
2	11279	DAVAL MALIK	36	M	SPORTS INJURY KABADI	TITANIUM SCREW	8 MONTHS	RIGHT ACL TEAR
3	18627	VISHNAIR ANHALGI	21	M	SPORTS INJURY CRICKET	TITANIUM SCREW	6 MONTHS	LEFT ACL TEAR WITH MEDIAL MENISCUS INJURY
4	19863	SHIVANAND METRI	21	M	SPORTS INJURY KABADI	BIO SCREW	2 MONTHS	LEFT ACL TEAR
5	24644	SUSHILKUMAR BANSODE	27	M	SPORTS INJURY CRICKET	TITANIUM SCREW	1 YEAR	LEFT ACL TEAR WITH MEDIAL MENISCUS INJURY
6	31006	ANIL BICHAGATTI	30	M	SPORTS INJURY KABADI	TITANIUM SCREW	3 MONTHS	RIGHT ACL TEAR
7	30681	HANUMANTH KANAPUR	28	M	RTA	TITANIUM SCREW	6 MONTHS	RIGHT ACL TEAR WITH MEDIAL MENISCUS INJURY
8	37082	MAHADEV MANE	20	M	SPORTS INJURY POILICE TRAINING	TITANIUM SCREW	4 MONTHS	Left ACL TEAR
9	39628	PRADEEP SHRIKANTH	32	M	SPORTS INJURY KABADI	TITANIUM SCREW	6 MONTHS	RIGHT ACL TEAR
10	41110	RAMAPPA KONDIKAR	45	M	RTA	TITANIUM SCREW	2 YEARS	RIGHT ACL TEAR
11	42793	RAMESH	34	M	RTA	TITANIUM SCREW	1 YEAR	LEFT ACL TEAR
12	5503	WASIM MISTRI	30	M	RTA	TITANIUM SCREW	2 MONTHS	LEFT ACL TEAR
13	3223	ANAND WALIKAR	40	M	RTA	TITANIUM SCREW	6 MONTHS	RIGHT ACL TEAR
14	14800	GIRIJABAI BAGALI	30	F	RTA	TITANIUM SCREW	4 MONTHS	RIGHT ACL TEAR
15	30289	IRANNA SAROOR	34	M	SPORTS INJURY KABADI	TITANIUM SCREW	6 MONTHS	RIGHT ACL TEAR WITH MEDIAL MENISCUS INJURY
16	47291	SATISH KOTYAL	20	M	SPORTS INJURY KABADI	TITANIUM SCREW	1 YEAR	RIGHT ACL TEAR
17	112724	SACHIN PUJARI	20	M	SPORTS INJURY KABADI	TITANIUM SCREW	1 YEAR	RIGHT ACL TEAR
18	114412	ANIL NATIKAR	37	M	SPORTS INJURY KABADI	BIO SCREW	6 MONTHS	Left ACL TEAR
19	20669	MAHANTESH MALAGOND	30	M	RTA	BIO SCREW	2 YEARS	LEFT ACL TEAR WITH MEDIAL MENISCUS INJURY
20	107004	SIDDALINGA KODAKOL	28	M	SPORTS INJURY KABADI	BIO SCREW	6 MONTHS	RIGHT ACL TEAR
21	96910	PRAVEEN TELI	40	M	RTA	TITANIUM SCREW	8 YEARS	LEFT ACL TEAR

	IKDC SCORE		LYSCHOLM KNEE SCORING		POST OP 6 WEEKS	POST OP 3 MONTHS
PROCEDURE	IKDC SCORE OUT OF 87	PERCENTAGE	SCORE	GRADE	ASSOCIATED COMPLAINS	ASSOCIATED COMPLAINS
ACL RECONSTRUCTION	39	44.80%	55	POOR	NIL	NIL
ACL RECONSTRUCTION	48	55.20%	61	POOR	NIL	NIL
ACL RECONSTRUCTION	45	51.70%	59	POOR	DISCHARGE FROM WOUND	NIL
ACL RECONSTRUCTION	39	44.80%	51	POOR	NIL	NIL
ACL RECONSTRUCTION	52	59.80%	64	POOR	NIL	NIL
ACL RECONSTRUCTION	41	47.10%	53	POOR	NIL	NIL
ACL RECONSTRUCTION	40	46%	55	POOR	NIL	NIL
ACL RECONSTRUCTION	44	50.60%	53	POOR	NIL	NIL
ACL RECONSTRUCTION	58	66.70%	61	POOR	NIL	NIL
ACL RECONSTRUCTION	53	60.90%	66	FAIR	NIL	NIL
ACL RECONSTRUCTION	53	60.90%	64	POOR	NIL	NIL
ACL RECONSTRUCTION	32	36.80%	41	POOR	NIL	NIL
ACL RECONSTRUCTION	54	62.10%	66	FAIR	NIL	NIL
ACL RECONSTRUCTION	46	52.90%	58	POOR	DISCHARGE FROM WOUND	NIL
ACL RECONSTRUCTION	42	48.30%	50	POOR	NIL	NIL
ACL RECONSTRUCTION	38	43.70%	58	POOR	NIL	NIL
ACL RECONSTRUCTION	55	63.20%	62	POOR	NIL	NIL
ACL RECONSTRUCTION	47	54%	67	FAIR	NIL	NIL
ACL RECONSTRUCTION	56	64.40%	69	FAIR	DISCHARGE FROM WOUND	KNEE STIFFNESS
ACL RECONSTRUCTION	47	54%	62	POOR	NIL	NIL
ACL RECONSTRUCTION	54	62.10%	68	FAIR	NIL	NIL

POST OP 6 MONTHS						
IKDC SCORE OUT OF 87	IKDC PERCENTAGE	LYSCHOLM SCORE	LYSCHOLM GRADE	ASSOCIATED COMPLAINS	TOTAL FOLLOW UP DURATION	Graft diameter
83	95.40%	100	EXCELLENT	NIL	10	8
81	93.10%	95	EXCELLENT	NIL	18	8
80	92.00%	94	GOOD	NIL	6	7
85	97.70%	100	EXCELLENT	NIL	18	9
80	92.00%	94	GOOD	NIL	16	7
84	96.60%	93	GOOD	NIL	11	8
83	95.40%	95	GOOD	NIL	10	8
86	98.90%	100	EXCELLENT	NIL	19	9
84	96.60%	90	GOOD	NIL	8	8
76	87.40%	86	GOOD	NIL	10	8
79	90.80%	92	GOOD	NIL	12	7
86	98.90%	100	EXCELLENT	NIL	14	8
81	93.10%	94	GOOD	NIL	10	7
83	95.40%	96	EXCELLENT	NIL	6	8
84	96.60%	98	EXCELLENT	NIL	9	9
86	98.90%	100	EXCELLENT	NIL	9	8
78	89.70%	91	GOOD	NIL	7	7
86	98.90%	100	EXCELLENT	NIL	7	9
72	82.80%	83	FAIR	NIL	9	7
84	96.60%	96	EXCELLENT	NIL	14	8
80	92.00%	97	EXCELLENT	NIL	10	8