DISSERTATION ON

OUTCOME ANALYSIS OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT IN ADULTS

Dissertation submitted to

THE TAMILNADU DR. M.G.R. MEDICAL UNIVERSITY

In partial fulfillment of the regulations
for the award of the degree of

MASTER OF SURGERY (M.S)

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APRIL – 2017

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This is to certify that, this dissertation entitled , "**OUTCOME ANALYSIS OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT IN ADULTS ",** is a bonafide record work done by **Dr.Manikandan .P**, and submitted as partial fulfilment for the requirements of M.S. Degree Examination in Orthopaedics, to be held in April 2017.

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This is to certify that this dissertation, titled, **"OUTCOME ANALYSIS OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT IN ADULTS"** is a bonafide work done by **Dr.Manikandan .P**, under my supervision and guidance, during the tenure of his course period between July 2014 – April 2017, under the regulations of, **THE TAMIL NADU DR. M.G.R. MEDICAL UNIVERSITY, CHENNAI.**

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DECLARATION

I, **Dr.Manikandan.P**, do solemnly declare, that this dissertation **"OUTCOME ANALYSIS OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT IN ADULTS"**, is a bonafide record of work done by me, in the Department of Orthopaedics and Traumatology, Thanjavur Medical College, Thanjavur, under the guidance and supervision of my Professor and Head of Department **DR.A.BHARATHY, M.S (ORTHO), D.ORTHO, FRCS (Edin) ,** between August 2014 to August 2016. This dissertation is submitted to the Dr. M.G.R. Medical University, Chennai, in partial fulfilment of the University's regulations, for the award of M.S. Degree (Branch – II) in Orthopaedics, to be held in April 2017.

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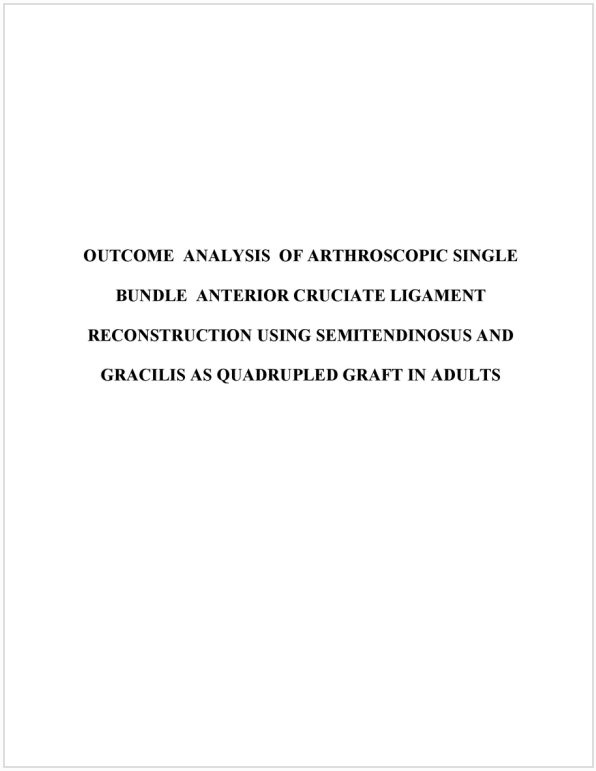
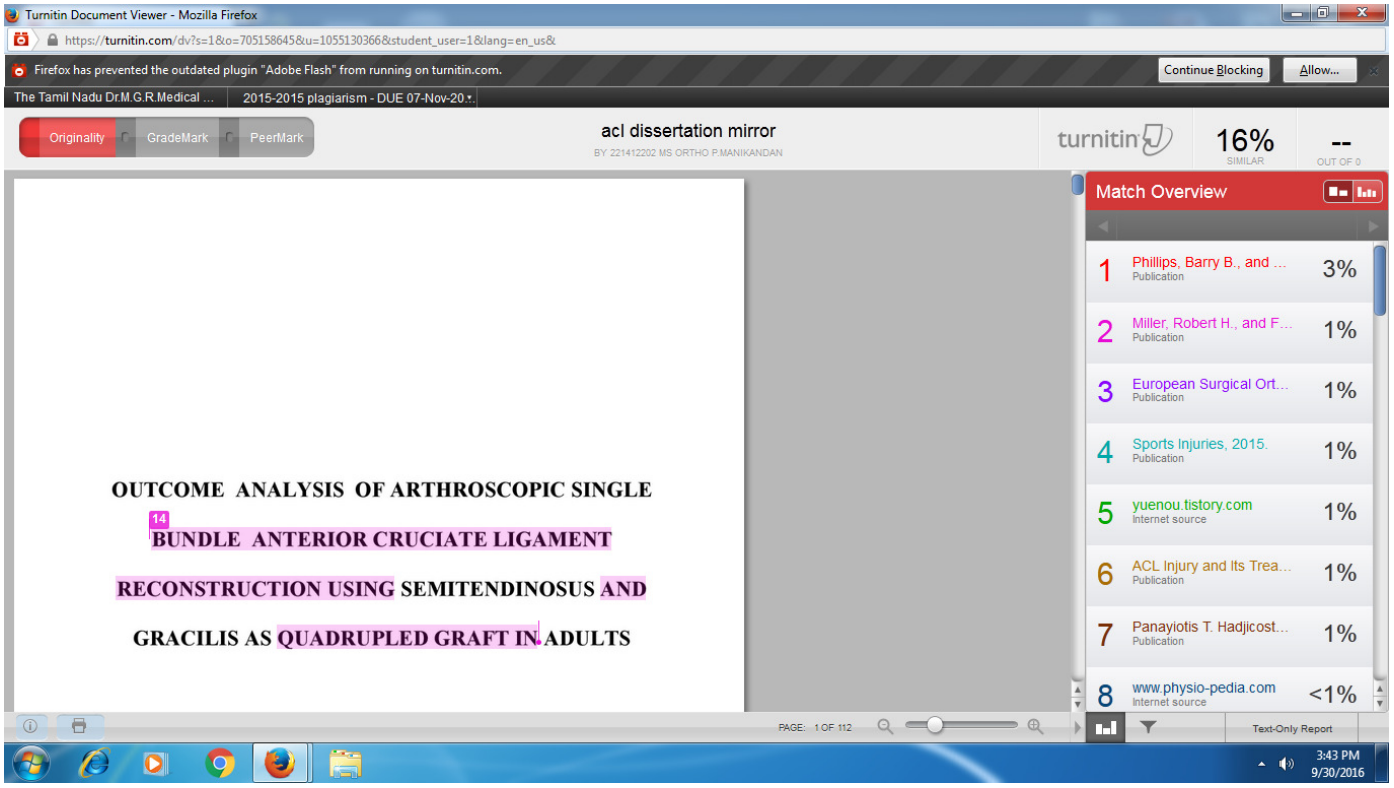


OUTCOME ANALYSIS OF ARTHROSCOPIC SINGLE BUNDLE ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION USING SEMITENDINOSUS AND GRACILIS AS QUADRUPLED GRAFT IN ADULTS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ABSTRACT :

Fifteen adult ACL deficient knees were treated with single bundle hamstring autograft by arthroscopic reconstruction. The femoral anchorage is by endobutton and the tibial tunnel graft fixation is by interference screw. In a follow-up of 6 months to 2 years, it was found that 90% of patients had acceptable results with knee function returning to pre-injury levels.

SYNOPSIS

INTRODUCTION

Seeing is believing. More than the use of images to see indirectly the lesions, direct visualization by arthroscopy revolutionized the management of ligament injuries of the knee. The science of arthroscopy has developed in the past 20 years to an extent that it is now available in most cities even in developing countries. This coupled with the availability of magnetic resonance imaging has revolutionized the manner in which the ligamentous injuries are diagnosed. Reduced daily activities and occasional participation in contact sports like foot ball is a main factor for ACL tear.

Anterior cruciate ligament injury is one of the most common injuries around knee and also poses quite `a lot of controversies in the management. Anterior cruciate ligament has a main role not only in the function but also as a stabilizer of the knee joint. Along with all other ligaments ,capsule, muscles, ACL is a prime stabilizer of the knee preventing the anterior translation of tibia over femur. Also anterior cruciate ligament also restricts valgus and rotational stress to certain degree.

When an individual sustains an ACL injury, they will have recurrent episodes of knee instability, knee pain and decreased knee function. Few patients with less anticipated knee function can be managed non-operatively with intense physiotherapy, bracing and modification of activity.

However with severe symptoms, young active patients may need reconstruction of the injured ligament. Anterior cruciate ligament injury is often associated with meniscal injury. If left alone, it can develop early onset of osteoarthritis.

There is also a gradual decrease in ligament function and activity of individuals with anterior cruciate ligament injured knee. The incidence of associated cartilage damage in acute ACL tears is 15 - 40% whereas it increases to 79% in chronic tears[5]. A stable knee prevents deterioration of existing chondral lesions as well as occurrence of newer lesions.

Arthroscopic reconstruction of torn ACL has become the gold standard in treating ACL tears. The surgical reconstruction of the anterior cruciate ligament with hamstring graft establish knee kinematics. It does not sacrifice other stabilizers of knee. Development of early osteoarthritis , meniscal injuries are delayed and the stability of the joint is restored[7].

Earlier open arthrotomy, extra-articular procedures and intra articular reconstructions were done. But in current understanding of knee biomechanics and with current armamentorium of newer arthroscopic instruments and implants, arthroscopic anterior cruciate ligament reconstruction is needed. Also usage of soft tissue grafts is increasing in number than bone patellar tendon bone graft in recent times.

Unlike open procedures, in arthroscopic reconstruction, there are small key hole incisions, decreased post operative inflammation, almost near absence of post surgical knee stiffness and possibility of early full range of movements post-operatively. However there are also certain controversies regarding the ideal graft, ideal time and technique of reconstruction[8].

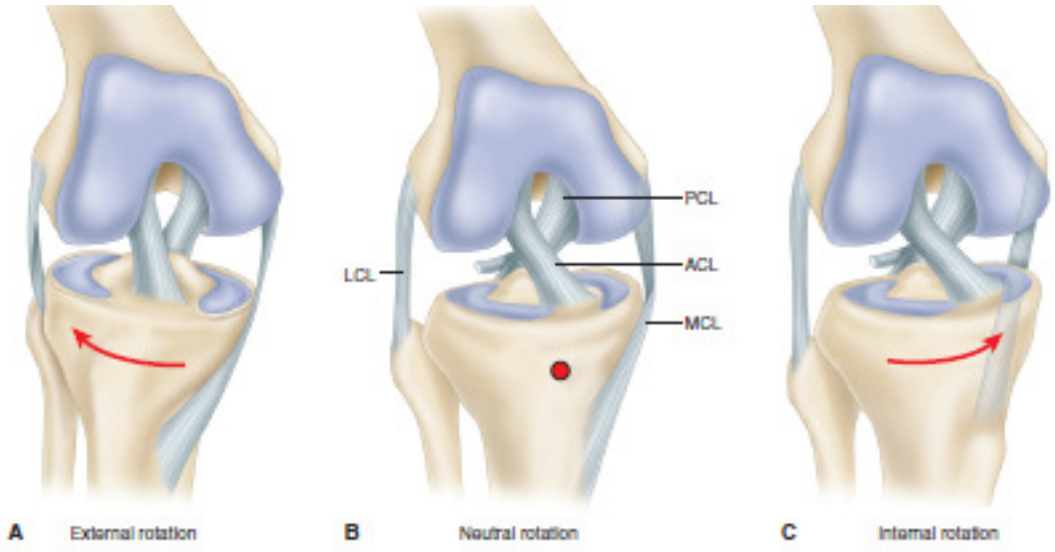

Figure 1 - Anatomy of ACL

AIM OF THE STUDY

To evaluate the functional outcome of arthroscopic single bundle anterior cruciate ligament reconstruction using quadrupled hamstring tendon (gracilis and semitendinosus) autograft with endobutton as femoral fixation device and interference screw as tibial fixation device in ACL deficient knees in adults.

ANATOMY OF KNEE JOINT

Development of knee joint occurs approximately at 4 weeks (5 mm) stage of the embryo;first seen as a concentration of mesenchyme, the 'precartilage stage'. Femoral and tibial components become recognizable only when an area of mesenchyme between these two pre-cartilage representations rarifies. Progress is rapid and by 6 weeks knee joint is discernible. At about 6.5 weeks, ACL then forms as a condensation in the blastema. It appears well before the joint cavitation, at all times it appears extra synovial. The cruciate ligament and semilunar cartilage are derived from the same blastema. It agrees with the theory that these structures(ACL/meniscus) function together[(4)].

GROSS ANATOMY

Anterior cruciate ligament is a strong extra synovial ligament but it is intra articular. It has a multi fascicular structure which runs from anterior part of the tibia posteriorly, upwards and laterally to the medial aspect of lateral femoral condyle. The ligament is 31 to 35 mm in length,1 cm in width and 31.3 mm^2 in cross section.

It has two bundles

1)Anteromedial bundle

2)Posterolateral bundle lying deep to the former

FEMORAL ATTACHMENT

The femoral attachment of ACL is like a segment of a circle, with the straight anterior border and convex posterior border. The anterior cruciate ligament gets attached in the medial aspect of lateral femoral condyle well posteriorly but around 15 mm anterior to the posterior cortex of the lateral femoral condyle[2]. The posterior part of the ligament is separated from the intermuscular septum by the posterior capsule. It runs downwards,forwards and medially from femur to tibia in slight external rotation.

1)Anteromedial bundle of ACL attaches posteriorly and superiorly over the lateral condyle of femur.

2)Posterolateral bundle of ACL attaches anteriorly and inferiorly over the lateral condyle of femur.

On a notch view of the knee joint, the entire femoral attachment of the ACL is lateral to the midline of the intercondylar notch and occupies the superior 66% of the notch. It is from just inferior to the postero superior quadrant of the lateral femoral condyle. The recommended center of the femoral tunnel for ACL reconstruction is between the 10 and 11 o'clock (right knee) or 1 and 2 o'clock (left knee) positions[9].

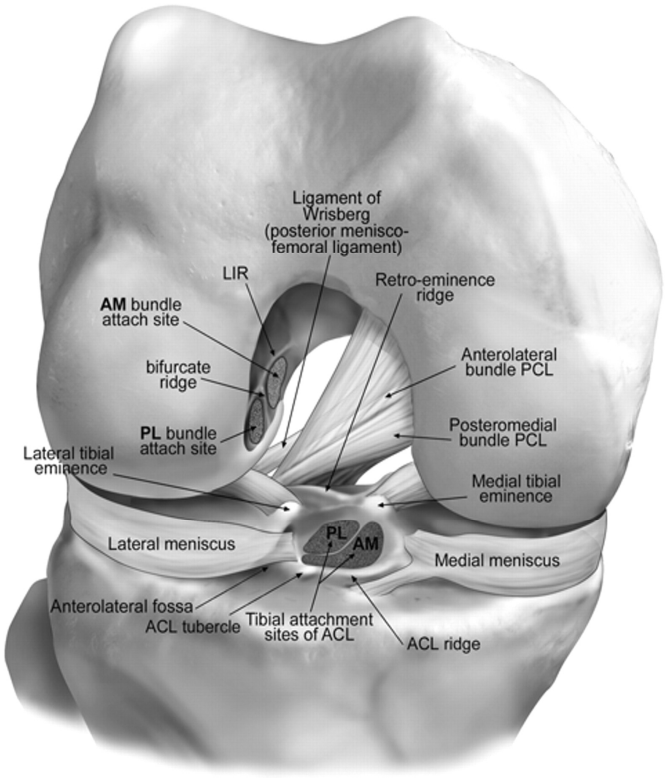

Figure 2.1 – ANATOMY OF ACL – anterior view

TIBIAL ATTACHMENT

Unlike origin of ACL,the tibial attachment is widespread area occupying around 23mm in the anterior tibial plateau ; anterolateral to the anterior tibial spine and medial to the attachment of anterior horn of lateral meniscus.

1)The anteromedial band inserts on the medial surface of the intercondylar eminence.

2)The posterolateral band attaches lateral to the midline of the intercondylar eminence.

The width of ACL averages 11.1 mm , length 31 to 38 mm.ACL consist of longitudinally oriented fascicles, a different portion s of which is taut throughout the range of motion.

The important concepts of the normal ACL are that each fibre has a unique origin and insertion and that all fibres are not parallel and not of the same length and that do not have the same tension at any given instance. The anteromedial bundle becomes taut in flexion and the posterolateral bundle becomes taut in full extension.

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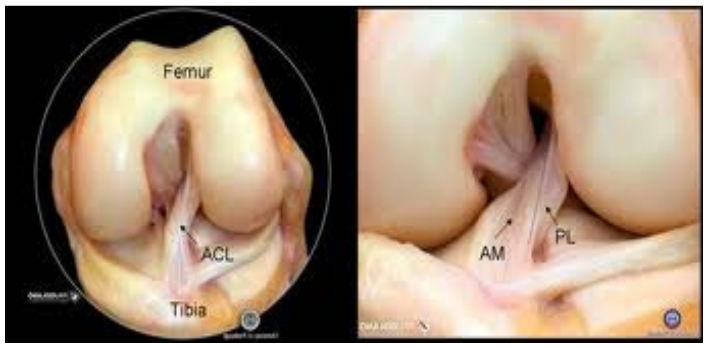


Figure 2.2 - The Two bundles of ACL

When the knee is extended, the PLB becomes tight and AMB is moderately lax. When the knee is flexed, the femoral attachment of the ACL assumes more horizontal orientation, causing the AMB to tighten and PLB to loosen. The insertion area of ACL at its insertion site is 3.5 times greater than the midsubstance cross sectional area[7]. This minimizes the stress of ligament on the bone surface. The ligament bone attachment is an incorporation of collagen fibers of the ligament within the mineralized bone. The transition zone of fibro cartilage mediates change to rigid bone from ligamentous tissue in the course of ACL.

VASCULAR SUPPLY

Ligamentous branch of the middle geniculate artery, which is the principal arterial supply that enters in its upper third through synovial sleeve is the main blood supply of ACL. The lateral and medial inferior genicular arteries also supply the ACL. The synovial membrane that forms an envelope around the ligament is richly endowed by blood vessels. Recently a significant and more important contribution from anterior vessels in the soft tissue and synovium from the region of retropatellar fat pad has been described. There is a less blood supply from femoral attachment and no vascular supply from tibial attachment. In spite of the above sources of blood supply , ACL receives its predominant supply by diffusion from synovial fluid[6].

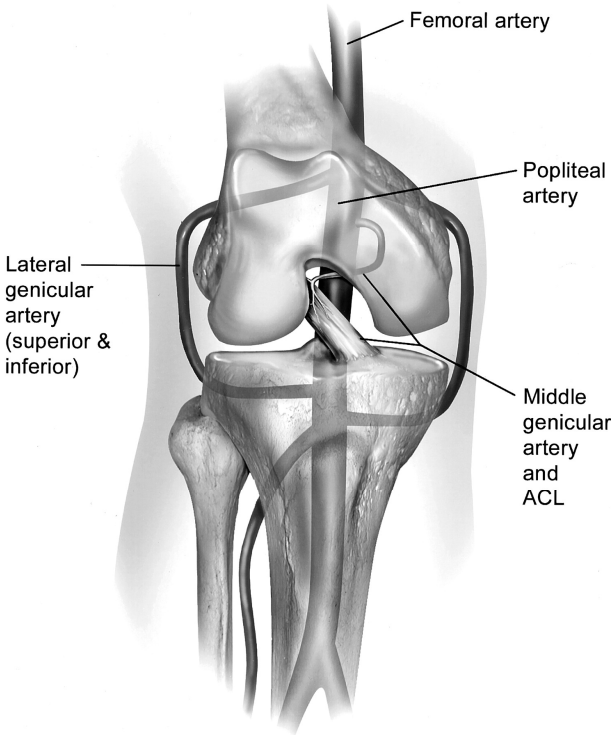


Figure 2.3 - Vascular supply of ACL

NERVE SUPPLY AND NEURAL RECEPTORS

Posterior articular nerve, a branch of posterior tibial nerve innervates the anterior cruciate ligament. Most neural structures have been found in the subsynovial layer and near the insertions of the ACL. Histologic studies have demonstrated nerves of sizes consistent with transmitting pain in the intrafasicular spaces. Mechanoreceptors are also identified in the surface of the ligament mostly near the femoral attachment site.

The receptors found are primarily ruffini receptors and free nerve-endings that function as stretch receptors and nociceptors, respectively. Small nerve fibers that are responsible for pain have also been observed in the substance of ACL and also serve the function of proprioception[9].

HISTOLOGY

The microstructure of the ACL is similar to other soft connective tissues but distinct differences exist in histological and electron microscopic appearances. The ACL is made up of multiple fascicles, which are surrounded by connective tissue called the paratenon. Each fascicle ranges from several micrometers to several millimeters and consists of multiple sub-fasciculi, which are enclosed by an epitenon. The subfasciculi appear to have an undulating course, arranged in various directions.

They consist of groups of sub fascicular units (100 – 250 μm in diameter), which are composed of fibers (1 – 20 μm in diameter) and surrounded by loose connective tissues, the endotenon. Each fiber is made up of collagen fibrils and interlace to form complex networks.Cells and elastic components account for 6% of all ACL tissue. The cell bodies of the fibroblasts appear elongated. Elastic and oxytalan fibers can be found distributed along the individual bundles[12].

The organization of ACL fibrils appears to be unique. Light microscopy and electron microscopy revealed a combination of a helical and planar wave pattern for ACL fibrils. Thus, there is a combination of parallel or twisted, nonlinear networks. The purpose of the wave and nonlinear pattern of the fibrils has been interpreted as **"crimp"** and **"recruitment"**, respectively.

At small loads, fibril "crimp" is straightened out before larger loads affect elongation. With increasing tensile deformation, more of these fibrils become load bearing. During biomechanical testing, this results in a non-linear load-deformation curve with increasing tissue stiffness under increased load. This phenomenon allows the ACL to provide additional protection to the joint rapidly.

FUNCTIONS OF ACL

Anterior cruciate ligament along with other intra articular and extra articular ligaments, functions in maintaining static and dynamic equlibrium of the knee joint and also control and limit the motion .

ACL has two complementary roles:

1. Proprioception
2. Mechanical

From the extensive histologic research and studies which had demonstrated receptors and free nerve endings in ACL there are evidence for proprioceptive function of the anterior cruciate ligament.

The mechanical function of ACL are due to following characteristics.

1. In 90 * knee flexion, the antero-medial band of ACL accounts for the resistance to anterior translation of tibia on the femur.

2. The postero-lateral portion of ACL provides the principal resistance to hyperextension.

3. ACL also provides a check to internal axial rotation and thereby renders adequate rotatory stability of the knee.

4. ACL is a secondary restraint resisting both valgus and varus strains in all degrees of flexion.

5. Tension in the ACL inturn do the fine tuning for the 'screw home' movement thus stabilizing the joint as it approaches terminal extension[(11)].

PRINCIPLES OF ARTHROSCOPY

Good visualization, palpation of the intra-articular structures to arrive at an accurate diagnosis, planning the treatment strategy and work on the target site without damaging the surrounding tissues are the cornerstone of arthroscopy.

Major factors of a good arthroscopy include thorough knowledge of the most widely used approaches, knowing other possible approaches, approach selection according to the disorder to be treated, appropriate equipment usage and strict adherence to surgical principles[14].

EVOLUTION OF ARTHROSCOPY

Along with Joint replacement and internal fixation of fractures,arthroscopic surgery is considered as one of the three greatest improvements in the diagnosis and treatment of orthopaedic patients during the twentieth century. Arthroscopy is the most minimally invasive surgical approach unlike the others.

The word Arthroscopy is derived from Greek language. (arthro-joint and scope - to view) . Small incisions that allow the introduction of an arthroscope or other instruments into a joint are used in arthroscopic surgeries.This surgery was there since the early nineteenth century.

Cystoscope – Arthroscope[18]

Cystoscope was the fore-runner of arthroscope. There are evidences which are traced back to ancient times, Pompeii where they used vaginal speculum and proctoscope to examine the body cavities. The first cystoscope - to study interior of urinary bladder by using lichtleiter(two tubes with a candle) was introduced by philipp bozzini in 1806.

Desormeaux- French physician in 1853, J.Bruck a dentist from England, Max Natze of Germany modified bozzinni's work of cystoscope with various techniques to view inside the bladder until the invention of light bulb by Edison. This invention put forth using light and mirror in a new way to examine anatomical cavities.

Kenji Takagi - Father of arthroscopy, a professor from Japan in 1918 was first who used cystoscope to view the inside of cadaver knee. In 1931, he invented world's the first arthroscope, 3.5 mm in diameter, a model for arthroscopes of present day after he failed in his invention of arthroscope ,7.3 mm which is large in diameter impractical to use in knee.

Eugen bircher, swiss physician in 1921 performed an arthroscopic procedure using abdominal laparascope, using nitrogen an oxygen distension of knee joint also called this techinique as arthroendoscopy. In 1930, he anbandoned his technique instead used contrast media with radiographic images for better visualization of joint. He also shared the title " Father of arthroscopy" along with Kenji Takagi. In 1931, Michael burman published his paper "arthroscopy or the direct visualization of joints" after 20 years of dedicated research.

Masaki Watanabe – a protégé of Takagi from Japan invented no.21 arthroscope instrument in 1959 using electronics and optics, was superior in quality and model for arthroscope production. He is called as " Father of

modern arthroscopy" . He used cold light fibre-optics replacing heat bulb which could shatter in knee for removal of xanthomatous tumor from superior recess of knee in 1955.

On 1962, Watanabe did first arthroscopic partial meniscectomy in the world. In 1970, a boom to surgical arthroscopy happened with the arrival of fiber optics and television technology which leads to an era of therapeutic arthroscopy not only diagnostic. In 1976, Larry Johnson introduced first motorized shaver instrument that leads to more ligament reconstruction procedures in the western world.

The advancement in arthroscopy DOESNOT end here.. Future of arthroscopy is travelling towards the goal of developing three dimensional vision in arthroscopic procedures with manual movable optic with 0 to 90* rotation.

VRATS – virtual reality arthroscopy training simulator are on the way to train budding scopists but rarely used in most of the current training workshops.

REVIEW OF LITERATURE

True nature of anterior cruciate ligament was put forth by Galen in Circa 170 AD[6].

In 1845 Amedee Bonnet described the essential signs of ACL tear as "In patients who have not suffered a fracture,a snapping noise, haemarthosis and loss of function are characteristic of ligamentous injury in the knee"[7].

Stark was the first surgeon to record the description of rupture of the cruciates in 1850. In 1875 George K Noulis wrote on knee sprains and described about the role of ACL[8].He also showed how to test the integrity of the ligament by a test which was similar to the current Lachmans test.

In 1879 Paul F Segond wrote in his research about knee effusions and described an avulsion fracture of anterolateral margin of tibia associated with ACL rupture which now bears his name and is also a pathognomonic sign of ACL tear[9].

A.W.Mayo Robson performed the first cruciate ligament repair in 1895 which he failed to report in literature. Meanwhile in 1900 Brit, W.H.Battle exhibited a ACL repair in clinical society of London[10]. In 1917 Ernest W Hey Groves performed first ACL reconstruction using Iliotibial band transplant, Subsequently in 1918 Alwyn Smith reconstructed using silk substitute.

1936 Willis C Campbell first reported the use of tibia based graft of the medial one third of the patellar tendon, prepatellar retinaculam and a portion of quadriceps tendon . In the same year Bosworth reported extra articular reconstruction using facia lata graft[19].

In 1939 Henry B Macey[20] first described the technique using semitentinosus graft. In 1963 Kenneth G Jones described the idea of central third of patellar tendon with a patellar bone block.

D.L.MacIntosh familiarized extra articular reconstruction using fascia lata by various techniques in 1972.In 1976 Joseph S Torg[22] student of John Lachman described the Lachmans test.

Subsequently ACL reconstruction with free bone patellar tendon bone graft called as Jones procedure was very widely used and became gold standard.

In 1982 AB Lipscomb started using semitendinosus and gracilis soft issue grafts.In 1987 Kurosaka[23] showed that the link in the reconstruction was the fixation site atleast until the graft heals. This led to discovery of various fixation device like cross pins, interference screws, soft tissue washers etc., and the endurance of these devices are studied since then.

In 1988 MJ Freidman[25] pioneered use of four stranded hamstring in arthroscopic assisted technique.In 1992 Tom Roseberg devised Endobutton as fixation device for ACL reconstruction.

Clancy, Ray et al[26] in 1988 compared the conservative treatment of ACL injuries with surgical treatment and found that the surgical treatment was far superior in producing functional results. Barrack in 1990 concluded that young atheletes can only expect unsatisfactory results after conservative treatment of ACL rupture.

Lee in 1988 and Fischer,Fox[27] in 1991 reported the sensitivity of MRI in diagnosing ACL tears and the high sensitivity and specificity of MRI has made it the most important non invasive diagnostic tool in knee injuries.

Howell and Clark recommended more posterior placement of tibial tunnel(2-3mm) to the tibial foot print to avoid impingement.In 1992 Beynnon studied the usefulness of knee braces and recommended the use of knee braces post operatively for six months to protect the graft. In 1991 Shelbourne recommended three weeks delay in reconstruction after injury and reported higher incidence of arthrofibrosis in knees with ACL reconstructed earlier following injury[28].

Though Arthroscopic intra articular reconstruction has become gold standard in ACL reconstruction in this century there is still debate regarding the choice of graft, fixation methods, single or double bundle and trans portal or trans tibial technique.

More recent studies have proved quadrupled Hamstring is superior in strength but time for healing, probable loss of strength during healing and minimal hamstring weakness post operatively are considerations. Though bone

patellar tendon bone graft has theoretical advantage of bone to bone healing the limitation of size and strength of the graft, incidence of quadriceps weakness and anterior knee pain are considerable.

Recent studies have proved endobutton and bone mulch screw have a very high yield load than any other fixation device in view of soft tissue graft fixation. The trans portal technique has been widely used nowadays but the trans tibial technique is easily reproducible and gives comparable functional outcomes though tunnel placement is not more accurate in trans tibial technique.

ACL reconstruction with hamstring autograft has it's advantages of lesser donor site morbidity ,absent anterior knee pain, less occurrence of patella fracture, easy harvesting of graft, reduced loss of extension postoperatively. It also has good biomechanical strength and stiffness near to bone patellaer tendon graft.

With this procedure, the replaced anterior cruciate ligament approximates the functions of normal anterior cruciate ligament while many of the problems of conventional anterior cruciate ligament surgery are avoided.

PORTALS IN ARTHROSCOPY

Adequate illumination, distension of the joint and precise localization of the portals of entry for the arthroscope and accessory instruments are vital in arthroscopy[31]. Without precise placement of the

portals of entry,one cannot see inside the joint or to maneuver instruments within all parts of the joint. Forcing a poorly placed arthroscope or instrument can not only injure joint cartilage but also damage the instrument.

Even before distension, precise portal entry locations are marked with precisely drawing the joint lines, soft tissue and bony landmarks with a skin marking pen. All standard and optional portals are marked as shown in line diagram. The outlines of the patella and patellar tendon are drawn,medial and lateral joint lines are palpated with the finger tip and drawn,the posterior contours of the medial and lateral femoral condyle are marked. The surgeon should recheck these outlines after distension to ensure proper placement of the instruments.

Rehabilitation in patients with three portals took approximately twice the duration than in patients who had two portal because the latter avoided going through the vastus medialis obliqus.The outflow is managed by the arthroscopic shaver in the two portal system.[Stetson and Templin study].

STANDARD PORTALS:

The standard portals for diagnostic arthroscopy are anterolateral, anteromedial, posteromedial and superolateral[32] and are explained below.

ANTEROLATERAL PORTAL:

This portal is located approximately 1cm above the lateral joint line and aooroximately 1 cm lateral to the margin of patellar tendon. Palpation of the inferior pole of the patella helps to ensure that the anterior portal are not placed too high. The portal should be approximately 1cm inferior to the patella. If the portal is placed too near the joint line, the anterior horn of lateral meniscus can be lacerated or otherwise damaged.

ANTEROMEDIAL PORTAL:

This portal is used for additional viewing of the lateral compartment and for insertion of probe for palpation of the medial and lateral compartment structures. It is made 1cm above the medial joint line, 1cm medial to the edge of patellar tendon and just below the tip of patella. Precise placement can be confirmed by using percutaneous spinal needle visualized from the anterolateral portal.

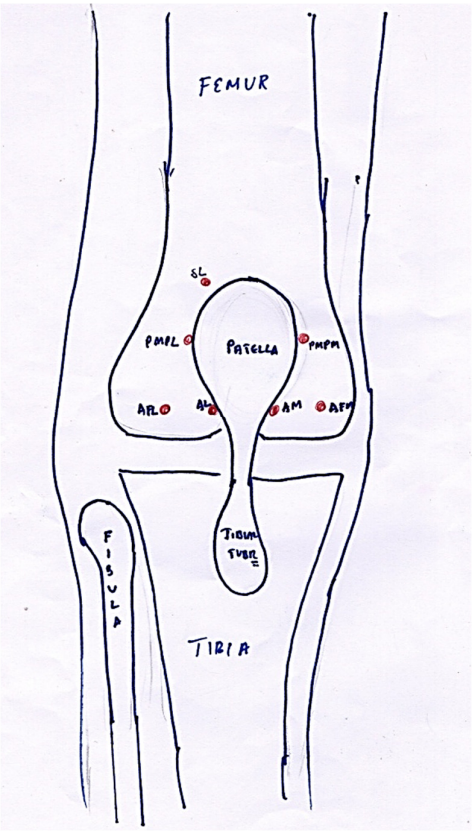
SUPEROLATERAL PORTAL :

This portal is useful diagnostically for viewing the patellofemoral movements dynamically. This portal is located just lateral to quadriceps tendon and about 2.5 cm superior to the superolateral corner of the patella. This can visualize patellar tracking, patellar congruity and lateral overhang of the patella.

POSTEROMEDIAL PORTAL :

The location of the portal should be approximately 1cm above the posteromedial joint line and 1cm posterior to posteromedial margin of the femoral condyle. It is useful for repair or removal of displaced posterior horn of meniscal tears and removal of posterior loose bodies.

PORTALS OF ARTHROSCOPY



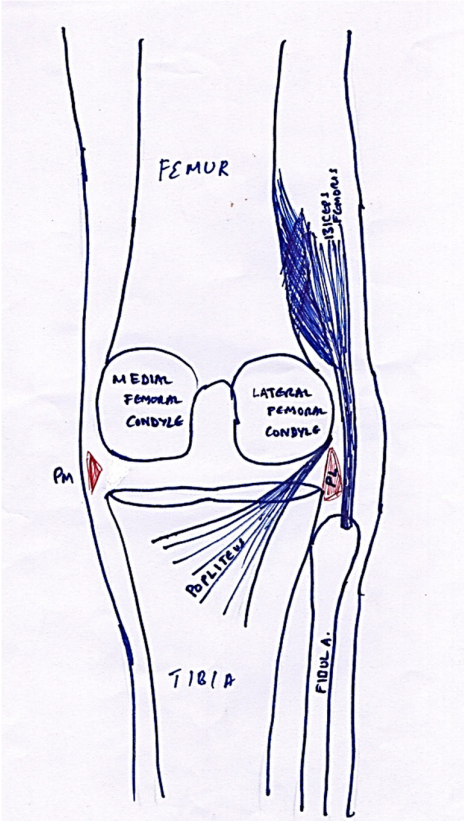


Figure 3.1- Anteriorly placed portals **Figure 3.2 - Posteriorly placed portals**

AM - ANTEROMEDIAL PORTAL

AL - ANTEROLATERAL PORTAL

AFM - ACCESSORY FAR MEDIAL PORTAL

AFL - ACCESSORY FAR LATERAL PORTAL

SL - SUPEROLATERAL PORTAL

PMPM - PROXIMAL MIDPATELLAR MEDIAL PORTAL

PMPL – PROXIMAL MIDPATELLAR LATERAL PORTAL

PL – POSTEROLATERAL PORTAL

OPTIONAL PORTALS :

The optional portals are described in annexure 4.

INSERTION OF SCOPE[33] :

The portal sites should be infiltrated with 4 to 5ml of local anaesthetic agent mixed with epinephrine which reduces bleeding and postoperative pain. More than 4 to 5 ml is not advised as large bolus can distend the fat pads sufficiently to make viewing difficulty. If tourniquet is planned ,infiltration of portals is not needed.

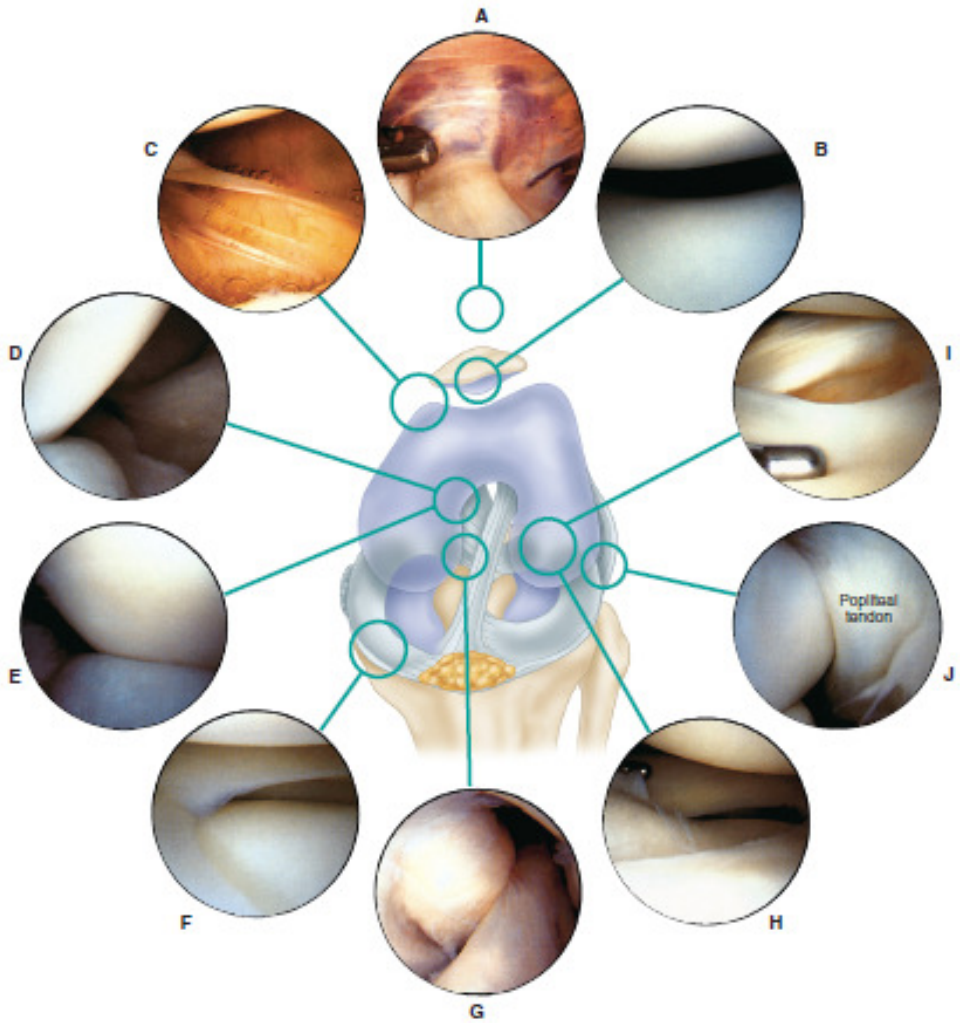


Figure 3.3 – showing different structures of knee as viewed arthroscopically through various portals during diagnostic arthroscopy.

a.Suprapatellar pouch b.patellofemoral articulation

c.Normal medial parapatellar plica d. posteromedial compartment

e. posteromedial viewing of posteromedial compartment

f. medial meniscus and medial compartment

g. cruciate ligament with fatty synovium covering PCL

h. view of lateral meniscus and lateral compartment

i. view of popliteus tendon and lateral meniscus

CLINICAL EVALUATION

An ACL injured patient by far requires a detailed history taking and calm examination. A twisting injury to the knee is usually the most common history. An audible pop during the injury, inability to walk after the injury and swelling of the knee joint over few hours are suggestive of anterior cruciate ligament tear. With the associated heamarthrosis the possibility of ACL tear is around 70%. Pain and sense of giving way of the knee joint while walking are the usual symptoms at the presentation. Non contact injuries are commonly associated with ACL tear while contact injuries are commonly associated with multi ligament injuries[34].

With valgus violence and internal rotation injury the medial structures and collaterals are initially disrupted and with continued violence ACL is torn. In varus violence the lateral structures are disrupted first followed by the cruciate ligament. In hyperextension injuries ACL is torn first and with continued violence posterior capsule and posterior cruciate ligament is torn. History of locking episodes, click and clunk are suggestive of associated meniscal injury. History of the patient's socioeconomic status, occupational and personal requirements of the patient are important in individualizing patient treatment.

PHYSICAL EXAMINATION

General examination of the patient with inspection, palpation, measurements and movements of the knee joint are done. This is followed by various test. The tests for cruciate ligaments, collateral ligaments and meniscus are done. The diagnosis is done followed by planning of treatment.

The common tests performed are Anterior drawer test,Lachmann's test, Slocum test, Pivot shift test, Mcmurrays test for meniscus, Valgus and varus stress test for collateral ligaments and Jerk test or reverse pivot shift test.

ANTERIOR DRAWER TEST [35]

This test is done with patient supine. The hip is flexed to 45 degrees and knee joint flexed to 90 degrees, foot is stabilized by examiner sitting on the dorsum of the foot, hamstrings made to relax by placing the fingers of both the hands behind the knee and the proximal tibia is gently pulled forward. Any movement of tibia over femur is noted and compared with the opposite knee.

Pull of 6-8 mm more than the opposite knee with a mushy end point indicates anterior cruciate ligament tear.

False positivity can occur in conditions like inherited ligament laxity, posterior cruciate ligament tear. False negativity can occur in obese patients, hamstring spasm, heamarthrosis and mechanical block.

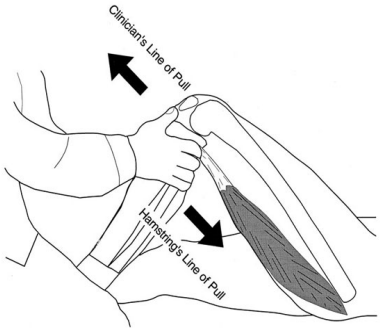


Figure 4.1 - Anterior drawer test

LACHMANS TEST[36]

When patients presents with heamarthrosis knee cannot be flexed to 90 degrees and anterior drawer test is difficult to do. In those situations Lachmans test is useful. Also Lachmans test is more sensitive than anterior drawer test in testing anterior cruciate ligament integrity

This test is done with patient supine and relaxed. The side affected is placed towards the examiner or examiner stands by the affected side. Patient is asked to relax and the limb is externally rotated to relax the limb. Distal part of the thigh is grasped with one hand and proximal leg is grasped with the other so that the thumb of the hand holding the leg is in the medial joint line.

Holding the limb in this position a firm pressure is applied in an attempt to move the proximal tibia anteriorly and posteriorly. The anterior translation of the tibia can be palpated with the thumb of the hand holding the leg. Any anterior translation of the tibia with a mushy end point signifies ACL tear.

Figure 4.2 - Lachmans test

SLOCUM TEST

Slocums modification of the anterior drawer test is performing the anterior drawer test in neutral, 30 degree external rotation and 15 degree internal rotation. Accentuated anterior translation in external rotation indicates anteromedial instability and increased anterior translation in internal rotation indicates anterolateral instability[36].

PIVOT SHIFT TEST[37]

The foot is lifted with the knee extended and internally rotated. Valgus stress applied to the lateral side of the leg in the region of the fibular neck with the opposite hand and when the knee is slowly flexed while valgus and internal rotation being maintained the anteriorly subluxated knee relocates at around 30 degrees of flexion. This test is difficult to do with muscle spasm and it can be demonstrated easily with the patient anaesthetised.

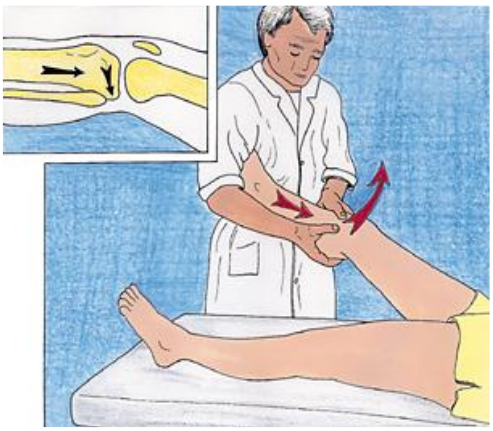


Figure 4.3 - Pivot shift test

RADIOGRAPHIC EVALUATION

Radiographs which include anteroposterior and lateral views of the knee needed to look for fractures, degenerative changes and malalignment. Plain films can demonstrate haziness in Hoffa's fat, a joint effusion, and may reveal subtle fractures of the posterior tibial plateau, impaction of the lateral sulcus, or an avulsion of the lateral tibial rim called as Segonds fracture. Tibial attachment avulsions are more commonly detected on plain radiograph and are seen more commonly in younger patients. Stress view s(lateral view) are taken to demonstrate the ACL injury radiographically while Anterior drawer sign is elicited. An anterior translation of more than 5 mm is significant to call it abnormal. A difference of more than 3 mm with the contralateral knee is significant[32].

MAGNETIC RESONANCE IMAGING

Magnetic resonance imaging offers direct, noninvasive visualization of the ACL and other soft tissue structures, improving the preoperative assessment of internal derangement. The accuracy of MR imaging for evaluation of ACL pathology is high. Using direct signs, sensitivities are as high as 92% to 94% and specificities are as high as 95% to 100%[34].

The patient is placed supine with the knee within the extremity coil, avoiding excessive extension or flexion. Sagittal images are the most useful for evaluation of ACL fiber orientation and the femoral and tibial attachments. If the ligament is not adequately visualized on routine sagittal views, then additional sequences may be supplemented with thin cuts through the intercondylar notch and oblique images plotted parallel to ACL on coronal or axial views. Images in the coronal plane are useful for evaluation of the collateral ligaments and for assessing the signal characteristics of the ACL within the intercondylar notch in equivocal cases. On coronal views, the ACL appears coursing posterior superolateral to anterior inferomedial.

Axial views are useful for assessing the ACL and posterior cruciate ligament (PCL) in the notch, bone contusions, para-articular fluid collections, and the joint capsule. T1-weighted images delineate bony anatomy but not adequate for evaluation of edema. Inversion recovery and / or T2-weighted images with fat suppression are sensitive for visualization of marrow edema

and fractures. Either fast spin-echo or conventional spin-echo imaging can be used to assess the ACL. On sagittal views, the normal ACL (with knee in extension) should have a taut, straight anterior margin, with low signal intensity of its fibers on all pulse sequences and fiber striation visible at its attachments.Propeller or fanlike configuration[29].

Figure 4.4 : MRI showing normal ACL

INJURED ACL IN MRI

Direct MR imaging signs of acute ACL tear include poor or non visualization of the ACL on sagittal images, an amorphous edematous mass with focally increased signal on T2-weighted images, irregular contour with wavy redundant fibers, or interruption of fibers with tears seen at midsubstance or at the tibial or femoral attachments.

Figure 4.5 : MRI showing injured torn ACL

MATERIALS AND METHODOLOGY

Between August 2014 to August 2016, a prospective study was conducted in Thanjavur Medical College,Thanjavur.

All young and middle aged patients presenting with unilateral knee complaints and history of trauma to the knee in the orthopaedics emergency and out patient department in Thanjavur medical college,Thanjavur were evaluated by a thorough general and local clinical examination of the knee. In a relaxed patient and in supine position, the uninjured knee was examined first to establish reference values after which the affected knee was examined.

The following specific tests were performed for diagnosing anterior cruciate ligament deficiency:

1) Lachmann test in 20 * flexion

2) Anterior drawer test in 90 * flexion

3) Lateral pivot shift maneuver

Injuries to the associated structures were assessed by performing the following clinical tests:-

1) Valgus / Varus stress test (for collateral ligaments)

2) McMurray's test / Apley grinding test (for menisci)

3) Posterior drawer test (for posterior cruciate ligament)

4) Reverse pivot shift maneuver (for Posterolateral complex)

Routine radiographs of both knees in standing position in antero-posterior view and lateral view of the affected knee were taken. MRI of the knee was done in all ACL torn cases for confirmation.

Inclusion criteria:

The following patients were included

1) Clinical /MRI evidence of symptomatic individuals with anterior cruciate ligament deficiency.

2) Radiological evidence of skeletal maturity patient between 20-40 years of age.

3) A normal contralateral knee for comparison and rehabilitation.

4) Associated with medial or lateral meniscus tear that may or may not require repair

Exclusion criteria:

The following patients were not included in the study.

1) Asmptomatic individuals
2) Patients with the systemic diseases compromising their pre-anaesthetic fitness
3) Associated with PCL tear
4) Patients with osteoarthritic knee.
5) Patients with associated fracture of the tibial plateau.
6) Patients with local skin infections.

INSTRUMENTATION AND THE IMAGES

Many specialized instruments are required for arthroscopic anterior cruciate ligament reconstruction. They are elaboratively explained in annexure .

METHODS

PRE-OPERATIVE WORK UP

Patients with ACL tear proven clinically and radiologically are admitted in Department of Orthopaedics and Traumatology. Routine investigations like heamoglobin, total and differential counts, platelet count, ESR, blood sugar, renal parameters, chest X-ray, ECG were taken and anesthetist assessment for regional and general anesthesia was done. Static and dynamic quadriceps exercise was taught to patients while awaiting surgery.

PRE -OPERATIVE REHABILITATION

1. All Patients in this study were given education on joint protection and likely outcomes of rehabilitation
2. Patients were educated to avoid deep squatting and low chairs prior to surgery.
3. All patients were instructed and taught on post-operative exercises.
4. Pre-operative strength and ROM of knee joint were measured and documented.

CONSENT

All patients in this study group were explained about the injury,diagnosis,conservative management,operative procedure,complications of non operative treatment and operative treatment,peroerative and postoperative complications,donor site morbidity,injury to surrounding structures,infection,compartment syndrome,extravasation of fluid,anaesthesia risks,postop knee pain,restriction of range of motion.

Consent for surgery was obtained for all patients who are under this study. All consent were obtained prior to surgery. Patients and their attenders were well explained about advantages and disadvantages of procedure. Risk benefit ratio was explained.

Some patients in this study group were obtained high risk consent considering cardiac and pulmonary problems, need for postop ventilatory support. After obtaining consent patient were shifted inside operation theatre for surgery.

EXAMINATION UNDER ANAESTHESIA AND PATIENT POSITIONING

All patients are operated under spinal anesthesia. In supine position under anesthesia anterior drawer test, posterior drawer test, Lachmans test, pivot shift test are done. With patient supine knees are flexed to 90 degrees and a removable side support is placed in the side of the table to support the ipsilateral thigh, a foot stopper is placed beneath the foot after flexing the knee to 90 degrees. In all the cases a pneumatic tourniquet is used which is placed in the upper thigh after soft padding. The limb is shaved around the knee joint and prepared with betadine scrub. Limb is draped exposing the knee joint lower thigh and upper leg after painting the limb with betadine. In all cases, a prophylactic preoperative antibiotic usually 1 g ceftriaxone is given before inflating the tourniquet and limb is held upright for 3 minutes to exanginuate the limb before inflating the tourniquet.

Figure 5.1 : Patient positioning with foot rest

Figure 5.2: Exsanguination of limb.

TECHNIQUE OF ARTHROSCOPIC ACL RECONSTRUCTION

Arthroscopoic anterior cruciate ligament reconstruction techniques are explained in detail in annexure - 5.

POST OPERATIVE MANAGEMENT

Immobilisation in knee brace and limb elevation immediate post operatively. Intravenous antibiotics were given post-operatively for 3 days. Drainage tube was removed on 2nd post operative day. Wound was inspected on 2th, 5th, 7th post operative day. The Sutures were removed on 12th postoperative day. Gradual physical rehabilitation was started from day 1. Post-operatively, patients were followed up at 3, 6weeks and 3, 6 months.

POST OPERATIVE REHABILITATION[39]

The general post operative protocol for anterior cruciate ligament reconstruction is followed and progression of the rehabilitation is individualized for each patient. Emphasis on arthrofibrosis, joint contracture and joint laxity has been made.

***Goals*:** Full range of motion (ROM), normal gait pattern, stability of the knee joint, pain free movement.

On the 1st Postoperative day, the knee was rested in extension in long knee brace and static quadriceps exercise,ankle and foot movement were advised and limb kept elevated.

In the 1 st 2 Weeks , full knee extension to 90 degrees knee flexion Strong quadriceps setting and straight leg raising exercise without extention lag. The Emphasis is given to gain normal gait pattern. Passive, active, and active – assisted range of motion for knee flexion.Partial weight – bearing (50% to 75%) with walker or weight-bearing to tolerance with knee immobilizer with a walker.

At 2nd – 4th weeks, full extension to 120* flexion;Full weight bearing without crutches; Progress SLR with weights(resisted) is advised; Walking is continued with emphasis on normal gait.

At 4th – 10 thWeeks, progress to full range of movements by 6 weeks;Progress closed chain exercises; Progress all the exercises

At 12th -14 thWeeks, full range knee extension exercises initiated with light weight and high repetition. At this stage, jogging program is initiated.

At 16th –18 thweeks, isokinetic strength test for quadriceps and hamstrings is done; Agility training and sport-specific training is also done.

In addition to the above, co- contraction test, Cariaco test[41] and shuttle run test was advised and used as a evaluation tool for all patients from 2 weeks for patients with pure ACL, 4 weeks for patients with ACL and associated meniscal / chondral injuries and later at 2 months,3 months,6 months and 1 year.

All knees were examined immediately after the procedure at operating room; and at 6 weeks,3 months,6 months and at 1 year

Ability to bear weight (graded as full, partial, or impossible) was assessed preoperatively and at 6 weeks,3 months,6 months and at 1 year

Difficulty with squatting (assessed as no problem flexing the knees greater than or equal to 90 degrees, ability to flex the knees greater than or equal to 90 degrees with slight difficulty, unable to flex the knees greater than or equal to 90 degrees, or unable to squat) will be assessed at the post-operatively at 6 weeks,3 months,6 months and at 1 year and compared with pre- operative findings.

Presence or absence of anterior knee pain was documented at 6 weeks,3 months,6 months and at 1 year.

CASE ILLUSTRATION

CASE 1

A 38 years old male Mr.SML presented in our OPD with complaints of pain and instability of his right knee for three months duration. He had a fall from a two wheeler while riding as a pillion rider and sustained injury to his right knee. He had difficulty in walking following fall without any open injuries of the limb. While trying to walk, he felt pain and instability of his right knee. He had native bone setters's treatment for this for about 2 months in the form of massaging and plaster.

He did not have any no comorbid illness or significant past history and a family history. He came to our opd 3 months after the injury.On examination of his right knee, significant quadriceps muscle wasting of medial joint line tenderness . Relevant clinical tests like Lachmann's test, aAnterior drawer test,Slocum test,Lateral pivot shift test were positive. Radiographs of knee were taken and it didn't reveal anything. Diagnosis of ACL tear confirmed with MRI right knee.

These patients were subjected to all protocols in this study. Arthroscopic ACL reconstruction with hamstring graft(20 mm soft silk endobutton CL as femoral fixation device and 9mm x 20 mm titanium interference screw as tibial fixation device). He was rehabilitated with all exercises and evaluated at regular periods as per protocol.Patient had full

range of painless knee movements with no swelling in knee at 6 months. Patient was allowed to recreational sports at 6 months.

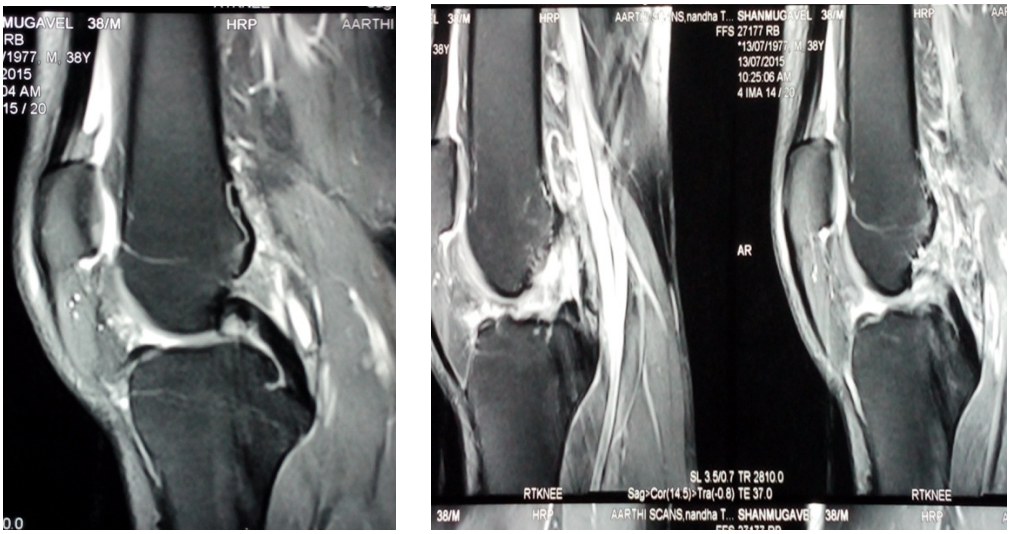


Figure 1A : Sagittal images of MRI right knee showing torn ACL with intact PCL

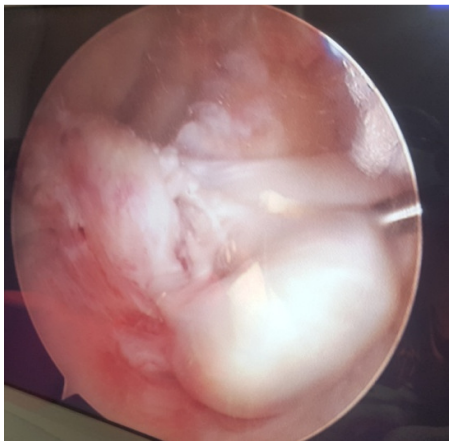


Figure 1B :

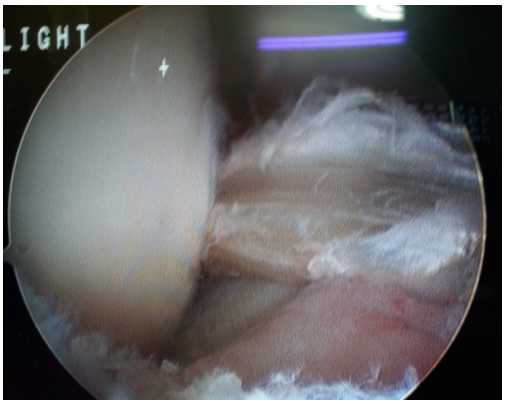


Figure 1C :

Figure 1 B: Torn ACL as shown by probe arthroscopically

Figure 1C : Torn ACL reconstructed with hamstring autograft

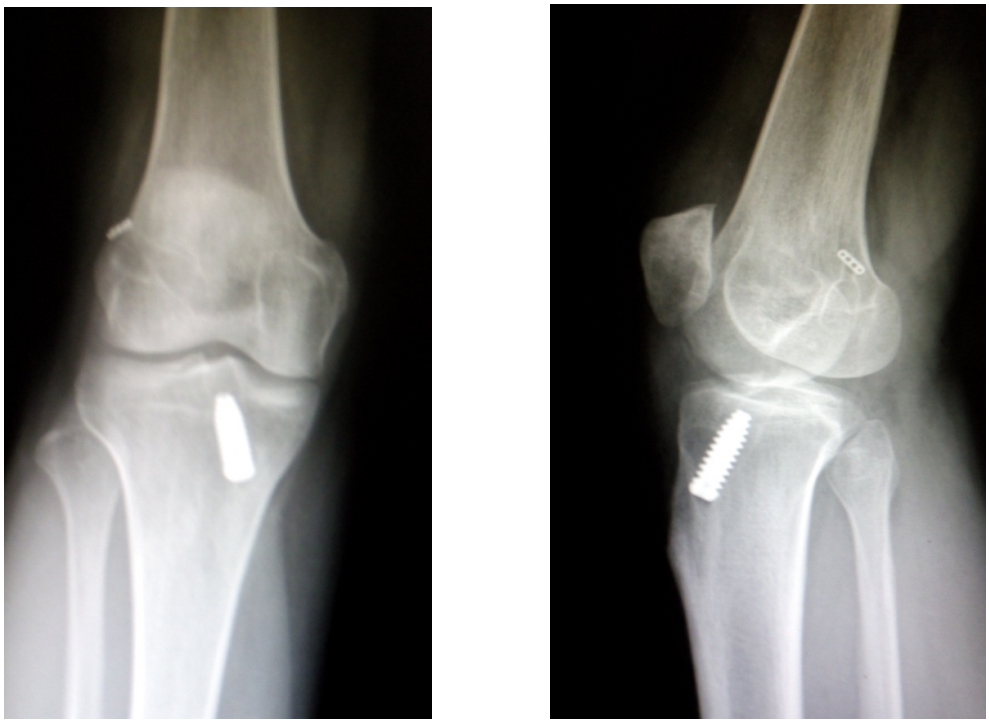


Figure 1D: Postop x –ray of Right knee (AP and lateral view) showing endobutton and interference screw after ACL reconstruction.

Figure 1E : Post op images showing painless full range of motion at 3 month follow up

CASE 2

Mr. PAB, 33 years old, driver by occupation who used to play kabadi for recreation activities presented to our outpatient department with complaints of pain,instability left knee for past 4 months. He had accidental injury to left knee while playing kabadi 4 months back, valgus type of force to involved knee. He was non- ambulatory with severe pain and sweeling. He took native treatment in the form of oil massage and bandage. He was diagnosed to have complete ACL tear left knee with radial tear of medial meniscus after complete evaluation by history,clinical examination.and MRI of left knee.

Routine investigatory work up was done for assessment of surgery. He was evaluated for generalized ligamentous laxity. Detailed consent was obtained for surgery. Patient underwent arthroscopic partial meniscectomy of medial meniscus and ACL reconstruction using hamstring autograft (semitendinosus/ gracilis graft) of thickness 9.5 mm x length 13 cm. Reaming of femoral and tibial tunnel with 9.5 mm flower tip reamer. Graft was passed from tibial to femoral side after connecting with 20 soft silk Endobutton , graft was passed successfully and confirmed by flipping of endobutton on the femoral side, graft was tensioned inside the tunnel with cycling 25 – 30 times.

Fixation of graft at tibial side with 20 mm length x 10 mm thickness titanium interference screw. Graft inside the joint was checked for proper position, impingement during full extension. All dissected tissues were closed in layers after achieving hemostasis with drain kept in situ. Tight compressive bandage with long knee brace was applied with knee in full extension. Rehabilitation protocol was continued as routine from day 1.

Patient was taken AP and lateral view of left knee joint on day 2, position of the endobutton and interference screw was checked. On day 12, patient had huge swelling after he went for CPM for about 100 degrees. He had painful swelling during flexion which disappears on extension. On clinical examination, it was diagnosed as lateral subluxation of patella; he was withdrawn from rehabilitation protocol with advice not to flex knee vigorously.

Surgery was suggested for his problem. He deferred the surgery for lateral subluxation of patella despite explained about the consequence.

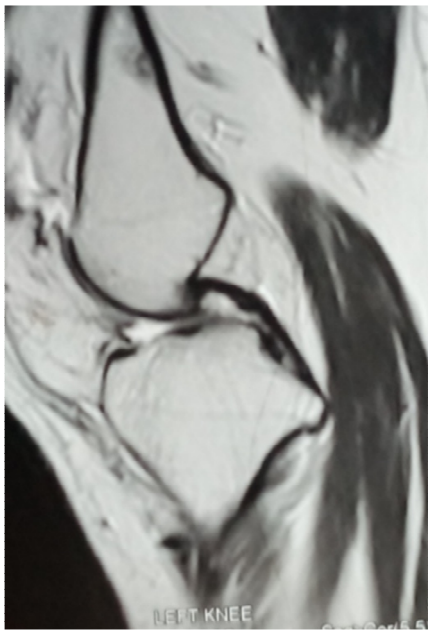


Figure 2A : Sagittal section of MRI - left knee showing deficient ACL

Figure 2A : Gracilis tendon hooked up by right angled forceps before harvesting

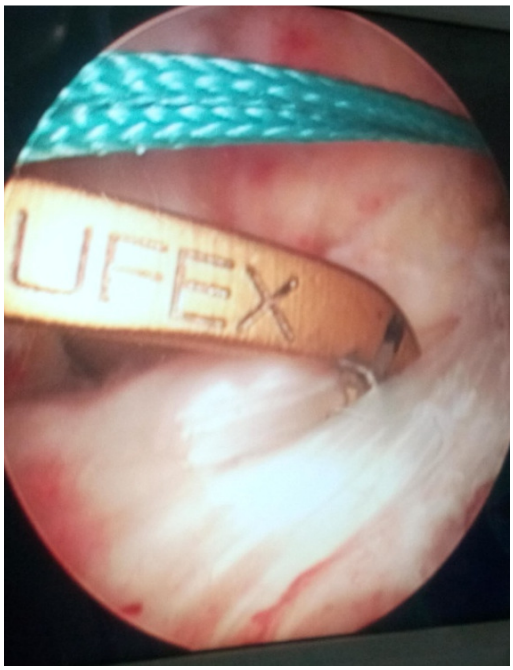


Figure 2C : showing tibial aimer for proper postion of tibial tunnel over remanant of torn ACL at tibia

Figure 2D : showing fixation of quadrupled hamstring graft in tibia tunnel with interference screw with the knee in full extension.

Figure E: Immobilization of knee with long knee brace during 2nd post operative day 2

Figure 2F : showing healed wound at graft harvested site with minimal knee swelling postoperatively.

CASE 3:

29 years old gentleman, Mr.Ktk who was referred from another hospital with diagnosis of post traumatic complete ACL tear right side 2 months old. There was no comorbid illness. He came with all radiological work up (x-ray AP and lateral/ MRI) of right knee. He had accidental injury to his right knee while trying to turn suddenly with his right foot planted on ground after parking his two wheeler.

He consulted nearby clinic for his ailment there he was advised rest, analgesics and immobilization for about 4 weeks since he had moderate effusion of injured knee. He was advised to review after 1 month. MRI of injured knee showed complete tear of ACL right side with normal findings of other surrounding structures. He agreed for surgery after explaining about pros and cons of arthroscopic reconstruction.

Intra-operatively ACL was found to be avulsed from femoral attachment with positive empty lateral wall sign as shown in figure. Graft harvesting was difficult in this case as more bands were present both in semitendinosus and gracilis. This graft was the smallest graft in our study. Single bundle arthroscopic ACL reconstruction procedure was done for this patient with 20 size soft silk endobutton and 25 mm x 9 mm interference screw.

Patient had severe pain at operated site from postoperative day 6 with no discharge from operated site. Infection was suspected in this case since patient had mild fever and was on broad spectrum antibiotics. ESR, CRP, TC, DC

were taken postoperatively. All investigations were within normal limits. All these complaints settled 1 week from day 6 with knee flexion of about 80 degree in continuous passive motion. Patient was discharged on 14 th day after suture removal.

No significant complaint after discharge . He came for routine follow up at 6 weeks, 3 months, 6 months and 1 year. At the end of 6 months, he had full range of painless knee movements with good quadriceps and hamstring power. He was advised to lead normal routine recreational sports activities. There was no screw breakdown, graft failure, instability after surgery during follow up period of 16 months .

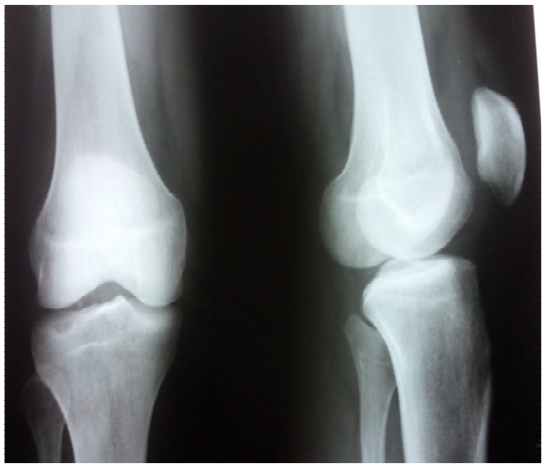


Figure 3A :showing pre operative (anteroposterior and lateral view) xray of right knee

Figure 3B : showing arthroscopic image of torn ACL from femoral attachment site (empty lateral wall sign)

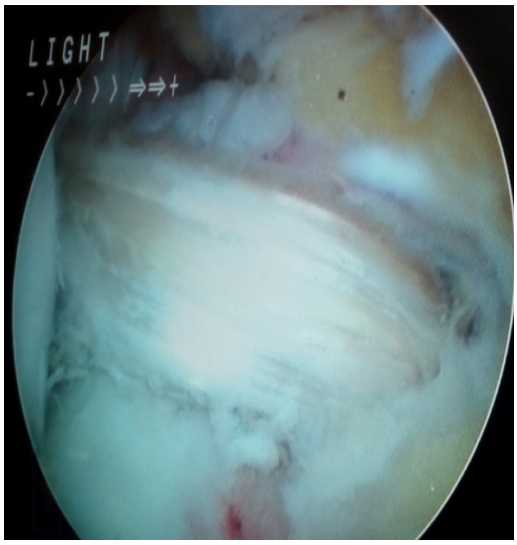


Figure 3C : Arthroscopic image of reconstructed quadrupled hamstring graft after ACL reconstruction

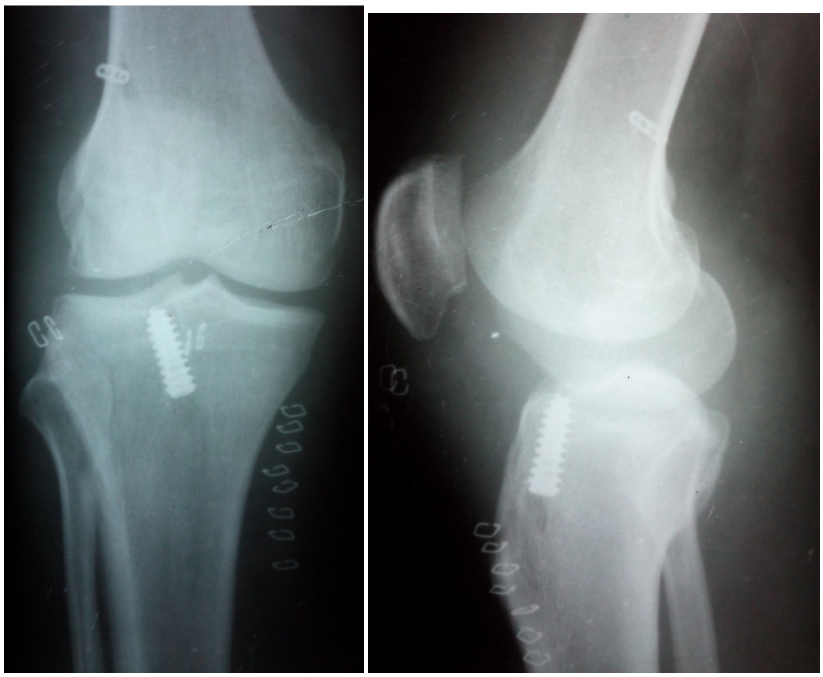


Figure 3D : Post operative xray (both AP and Lateral view) of right knee showing Endobutton and interference screw and position of tibial tunnel after ACL reconstruction.

CASE 4:

20 years old Mr.ARK, college student sustained injury to his right knee while playing kabadi during sports meet. Valgus type of force to his right knee following which he developed pain and severe swelling, immobilization and rest for period of 1 months. He felt instability of his injured limb,admitted in our hospital for evaluation.

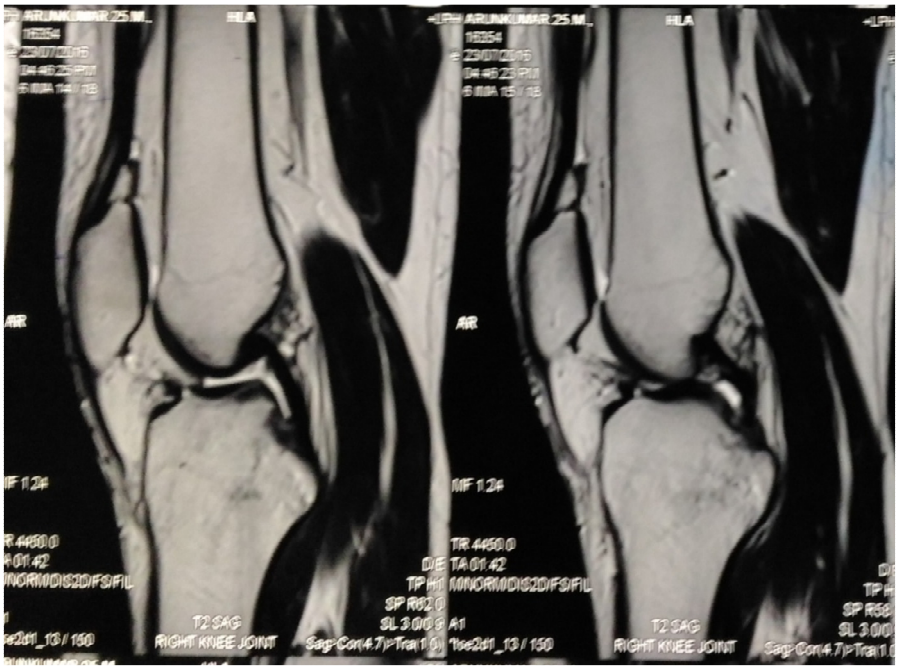
On clinical examination, there was muscle wasting. Valgus stress test in both extension and 20 degree flexion of knee were positive. Lachman's and anterior drawer test were positive along with lateral pivot shift.

An MRI showed complete ACL tear from femoral attachment with grade 2 strain of medial collateral ligament with normal other structures. After obtaining consent, we proceeded for surgery. In our study, longest graft(32cm) was harvested in this patient. Arthroscopic reconstruction procedure ended in 90 minutes in this case with ease. Postoperative period was uneventful with standard rehabilitation protocol.

Post-operatively knee flexion of 120 degree was achieved within 2 weeks in this patient. On day 14, suture removed and discharged with discharging advice. During follow up,he showed excellent results compared to pre trauma level as documented by IKDC and Lysholm scores.

He returned to his day to day routine activities, recreational sports at 6 months follow-up without any complaint. Co- contraction test, cariaco test and shuttle run test was tested for this patient to assess rotatory stability postoperatively. He finished all these above test in minimal standard time.

Figures 4A : positive Anterior drawer test and Lachmann's test preoperatively



Figures 4B : MRI of right knee (sagittal section) showing torn ACL with hyperbuckling of PCL

Figure 4C: Graft preparation

Figure 4D:Hamstring graft after reconstruction

Figures 4 E : Painless full range of knee movement without extensor lag during 4 months follow up

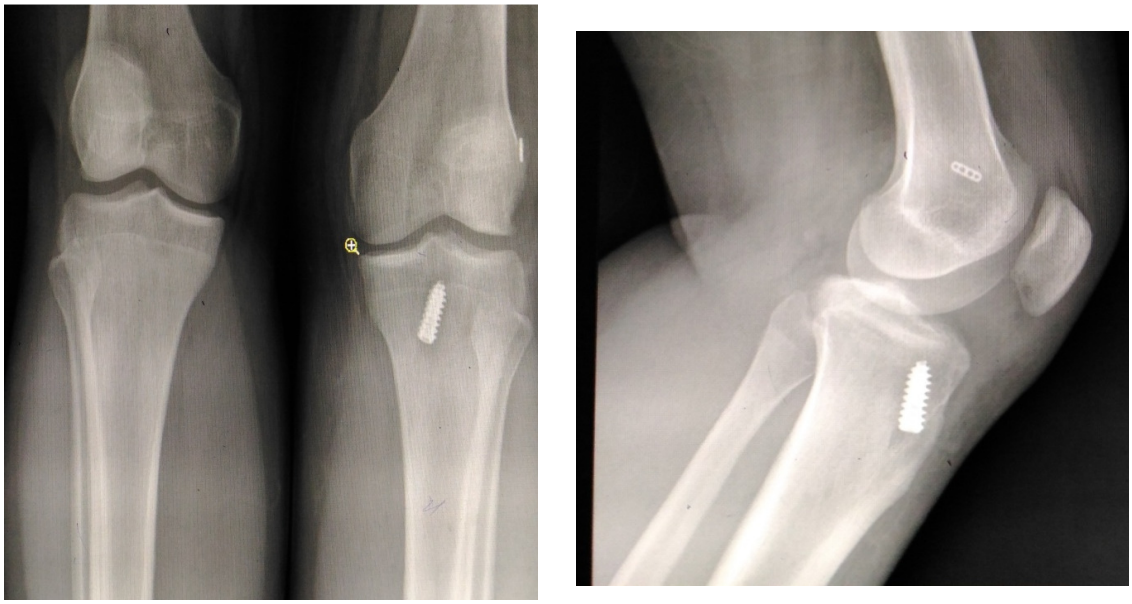


Figure 4F : Post op xray of right knee during 4 month follow up showing proper positionig of endobutton and interference screw without loosening or pullout.

CASE 5:

21 years old gentleman, Mr. SRK, college student who had a accidental fall 1 year ago while getting downstairs referred from another hospital with the complaints of pain, knee instability and locking episodes left knee for about 10 months. At the age of 2 years, he had fire accident of his right foot but he can do his routine activities without any difficulty with full weight bearing on his right knee.

He had no signs of any generalized ligamentous laxity. He had no other systemic illness. He was well explained about the surgery after confirmation of ACL tear by MRI left knee. MRI left knee showed bucket handle tear of medial meniscus. Pre-operative rehabilitation protocol was taught and carried out effectively.

Mr.SRK underwent ACL reconstruction arthroscopically with partial medial meniscectomy of his left knee. Operated Knee was immobilized with long knee brace immediately. Post operative rehabilitation was carried out as per protocol. Post op period was uneventful. Stitches were removed on post-op day 14.

He had painless full range of knee movements at 5 weeks follow up. Patient was advised to reduce weight as he is obese with BMI – 32. During follow up, he lost around 5 kg of his body weight by his modification of his life style and food habits. He is in regular follow up with good to excellent results.

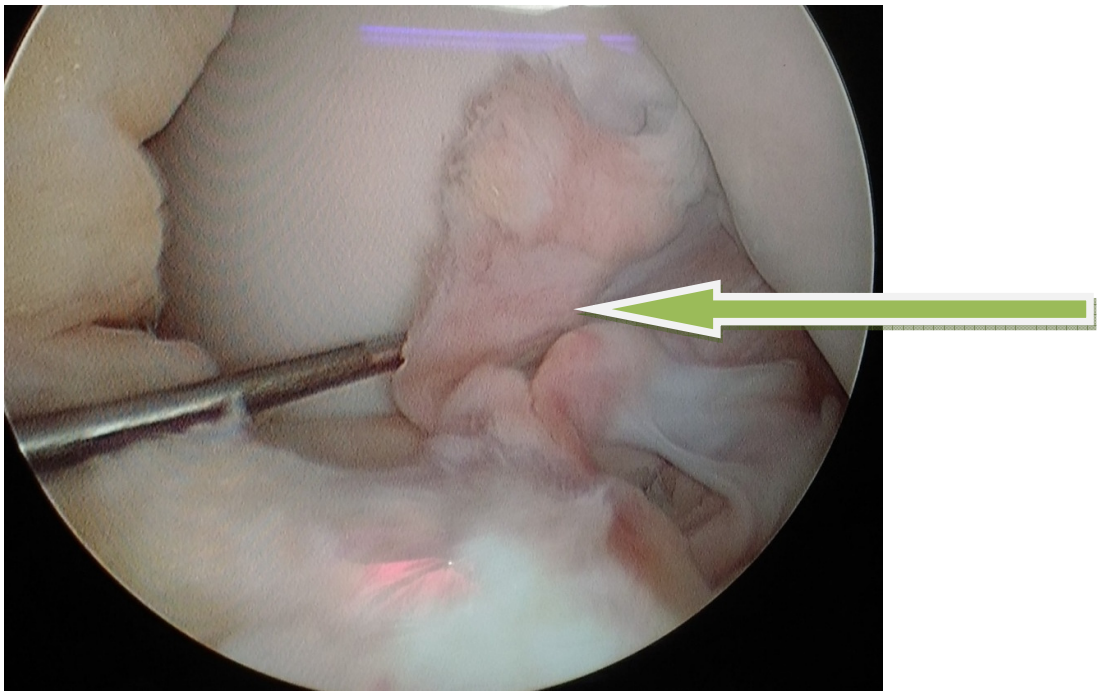


Figure 5A - Arrow showing arthroscopic view of torn ACL with bucket handle tear of medial meniscus

Figure 5B - Measurement of the thickness of quadrupled hamstring graft with sizer before creation of femoral and tibial tunnel for easier graft passage .

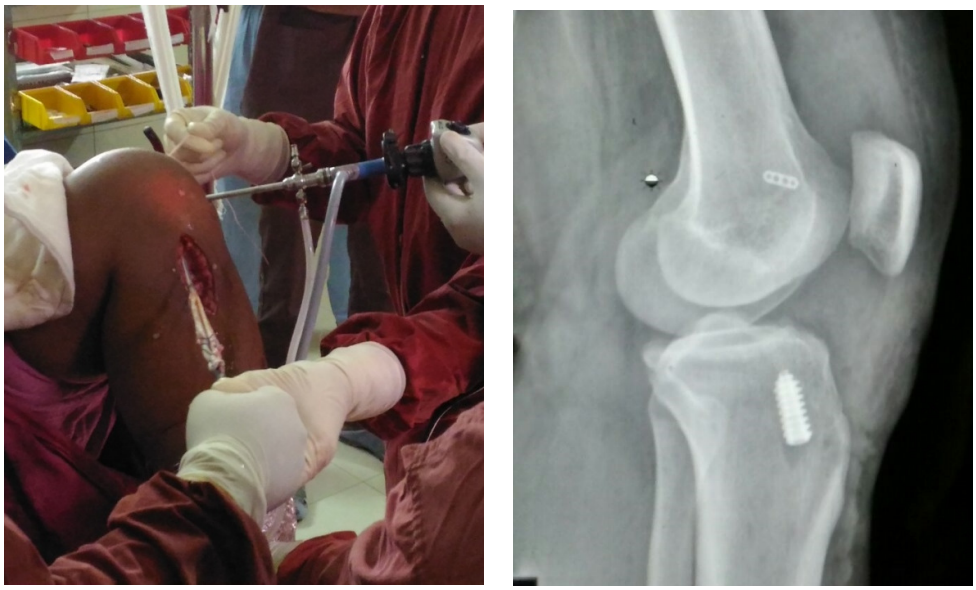


Figure 5C - showing graft passage intrapoeratively through tibial tunnel and immediate postop lateral view of ACL reconstructed knee showing tunnel position .

Figure 5D - Arrow showing healed healthy wound at graft harvested site during 3 months followup

Figure 5 E - showing full range of movement compared with contralateral knee

CASE 6:

32 years old male, Mr.DVN, mason by occupation presented to our Out Patient department with the complaints of pain and instability of the right knee for the past 6 months. He had fall from two wheeler while riding it and sustained injury to right knee. After fall when he was trying to walk, he had severe pain and some sort of giving away in his injured knee. He consulted nearby clinic for his ailment. They treated him with analgesics, limb immobilization and elevation, strict bed rest for 2 weeks. He did not follow up after 2 weeks. He was routinely doing his day to today activities for about 4 months after injury with mild pain and occasional instability episodes.

Two months before admission, he had fall again while getting downstairs with severe pain. He consulted our department. He had no comorbid illness. He was subjected to relevant clinical tests. All test were positive. He was advised MRI right knee to confirm ACL tear. MRI right knee shows complete tear of ACL. Mr.DVN was well explained about the pros and cons of arthroscopic reconstruction. After obtaining consent, he underwent arthroscopic ACL reconstruction with hamstring autograft.

He had serous discharge on and off from graft harvested site with elevated ESR post operatively. He was managed with systemic antibiotics and strict post op rehabilitation. He was discharged on 16^{th} day after surgery. His operated right knee was examined arthroscopically at 4^{th} week postoperatively to look for proper positioning of graft and ligamentization.

He had well revascularized reconstructed graft with no impingement and no adhesions. He was discharged on 2nd postop day with sterile wound dressing and antibiotic coverage. He had no significant complaints postoperatively. He was subjected to cariaco test, co-contraction test, shuttle run test from 5th week. He is in regular follow up with good results.

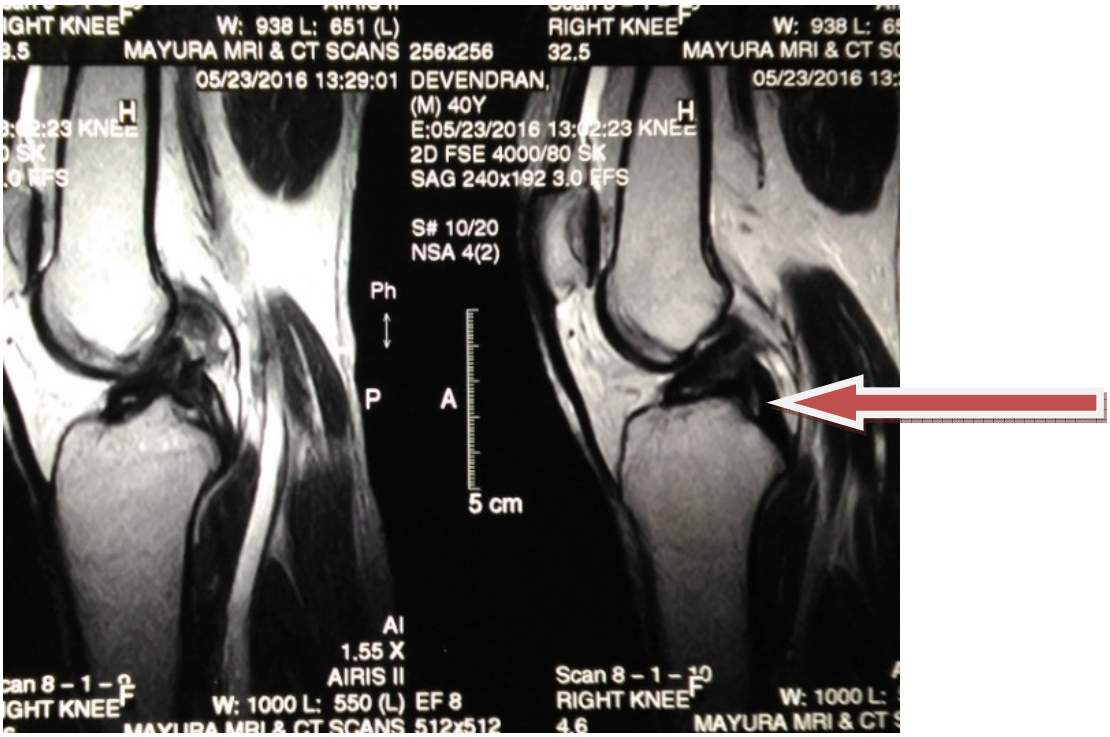


Figure 6A-Arrow showing torn ACL in sagittal section of MRI of right knee

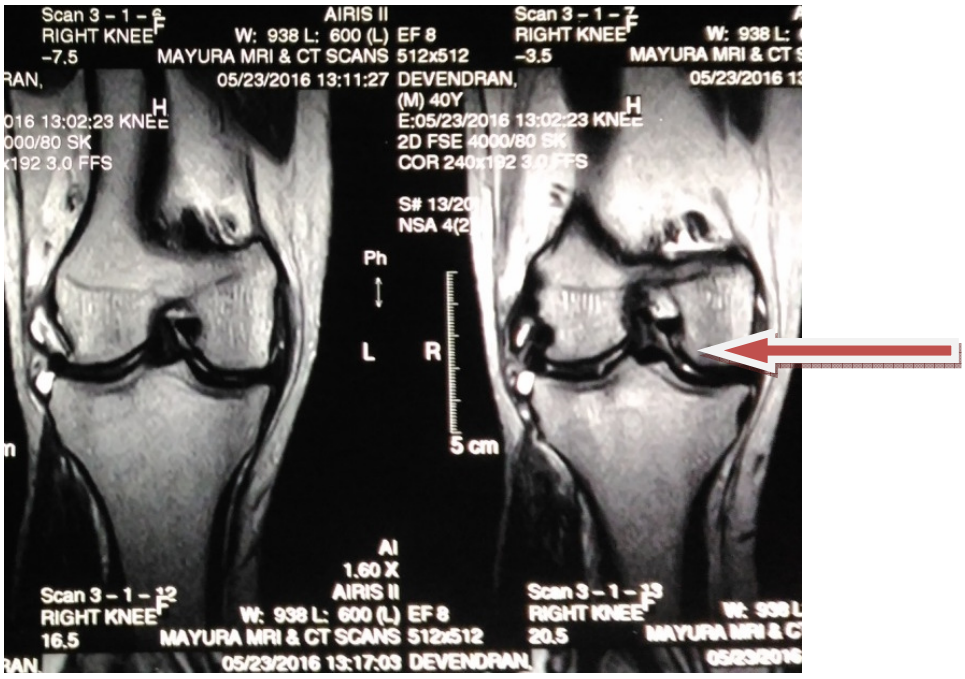


Figure 6B - coronal section of MRI right knee showing torn ACL

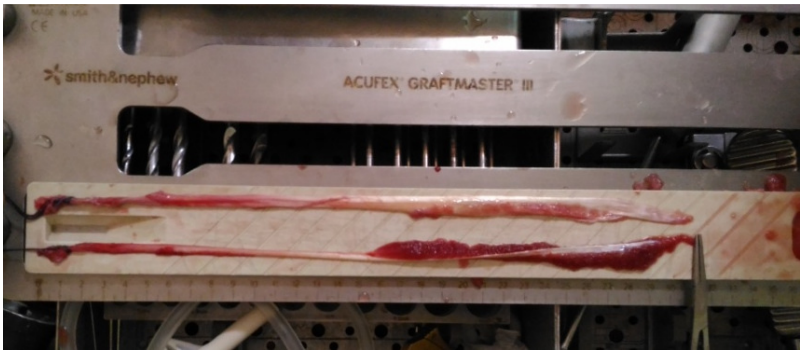
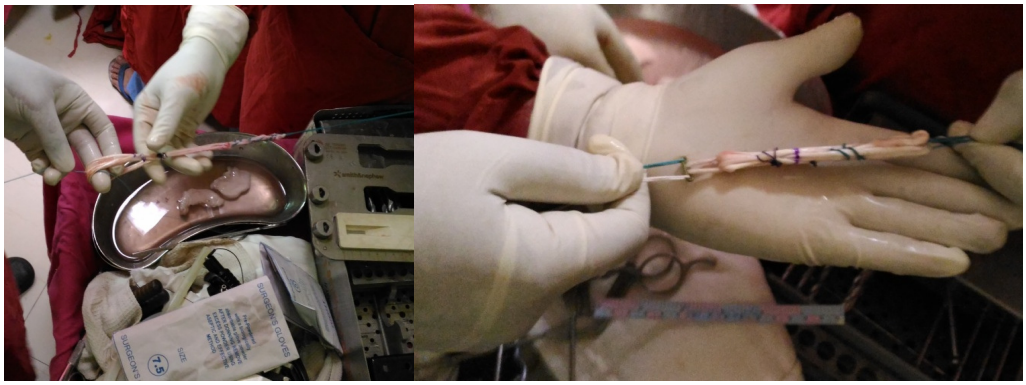


Figure 6C - Measurement of harvested graft before quadrupling .

The length of the graft was 33 cm . This is the longest graft in our study .



Distant view **closer view**

Figure 6D - Preparatioin of quadrupled graft with endobutton CL before passing through tunnels from tibial to femoral side.

Figure 6 E - Post op xray images of right knee (both AP and Lat) immediate postop after ACL reconstruction.

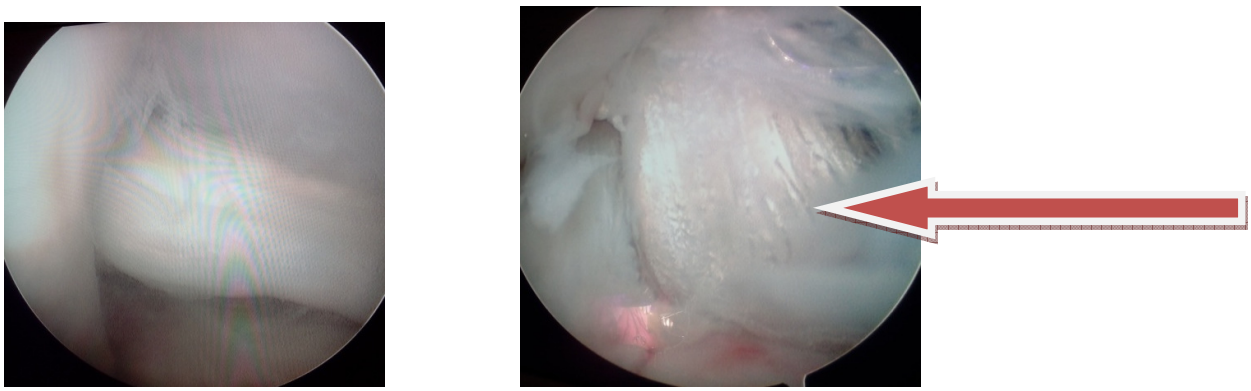


Figure 6F - Post operative first look arthroscopic images of hamstring graft in ACL reconstructed knee during 4 weeks followup showing signs of ligamentization of graft.

PROBLEMS WE FACED PER-OPERATIVELY IN ACL CASE

1.Haemorragic and hazy unclear operative field

2.Instrumental and camera system failures

3.Thin hamstring graft

4. short hamstring graft

5. premature amputation of graft

6.Multiple bands in the graft

7.Graft laceration during passage

8.Problems related to graft passage

9.Broken guide wire

10.Tourniquet failure

COMPLICATIONS:

We came across various complications postoperatively:

We had 9 patients with minor complications which are described below

1. Four patients had paraesthesia and numbnesss present over the anteromedial part of proximal leg which recovered to normal sensation 6 to 8 months after surgery.

2. Three patients had pain at operated site which resolved by itself following broad spectrum antibiotics, NSAIDS and opiod analgesics.

3. Two patients in our study had stitch abscess (superficial infection) at graft harvested site on postop day 7 which settled with antibiotics and sterile dressing.

We dealt with 3 patients who had major complications which are described below

1. One patient had continuous seropurulent discharge from graft harvested site with low grade fever with elevated ESR which failed with empirical therapy. He was suspected to have septric arthritis hence arthroscopic lavage was done to remove the septic foci inside the joint. Intra-operatively there was no pus . Wound debridement at graft harvested site was done. No significant complaints postoperatively.Patient returned to near normal function with loss of terminal 15 degree of knee flexion at 3rd month follow - up.

2. Another patient frequently complained of pain, loss of full extension post-operatively during follow-up. His MRI showed Cyclops lesion in ACL graft at tibial attachment site. He was advised excision of the lesion. He wished to have surgery after few months despite explained about the consequences of this lesion.

3. On 7th Post operative day ,patient had pain and severe swelling of the operated knee following knee flexion. Lateral subluxation of the patella was the finding,patient disagreed the surgery and was lost during the follow up.

EVALUATION:

All patients were subjected to post operative anteroposterior and lateral radiographs to determine the tunnel placement and position of endobutton in femur and interference screw in the tibia. Patients are followed at 3 weeks, 6 weeks, 3months, 6 months and once in 6 months there after for assessing functional outcomes.

The International Knee Documentation 2000 Score (IKDC) and Lysholm & Gillquist Knee Scoring Scale[42] were used for evaluation of patients.

The **IKDC 2000 Score[44]** is a single page form consisting of three sections for documentation, qualification and evaluation. The documentation section records the patient's personal details and the history of injury. The qualification is the major part in the IKDC form and it consists of eight parameters for evaluation like – effusion, range of joint movement,functions of ligament,findings in knee compartments, pathology at graft harvested site,findings in radiography and functional testing. The three problem areas viz. effusions, joint motion range and examination of ligament are evaluated for qualification of groups.

The final outcomes are documented as A, B, C & D. 'A' being - Normal' functional outcome and 'B' as 'Nearly Normal' functional outcome. 'C' being 'Abnormal' & 'D' are 'Severely Abnormal' functional out-comes.

The Lysholm & Gillquist Knee Scoring Scale consisting of eight parameters for evaluation. The parameters evaluated were– 1.limping, 2.Aided walking,3.episodes of knee locking,4. knee instability, 5.knee pain,6.knee swelling,7.climbing of stairs and 8.squatting. The individual parameters were allotted specific scores depending on the patient's functional ability. The maximum possible knee score was 100 points. Based on the outcome scores they were divided into Excellent, Good, Fair and Poor.

Excellent - 94 – 100 points

Good - 83 – 93 points

Fair - 64 – 82 points

Poor - 63 or less points

RESULTS

20 cases of arthroscopic ACL reconstruction were regularly observed for a period of 4 months upto 2 years in Thanjavur medical college, Thanjavur (from August 2014 to August 2016). The mean follow up period was 10.5 months.

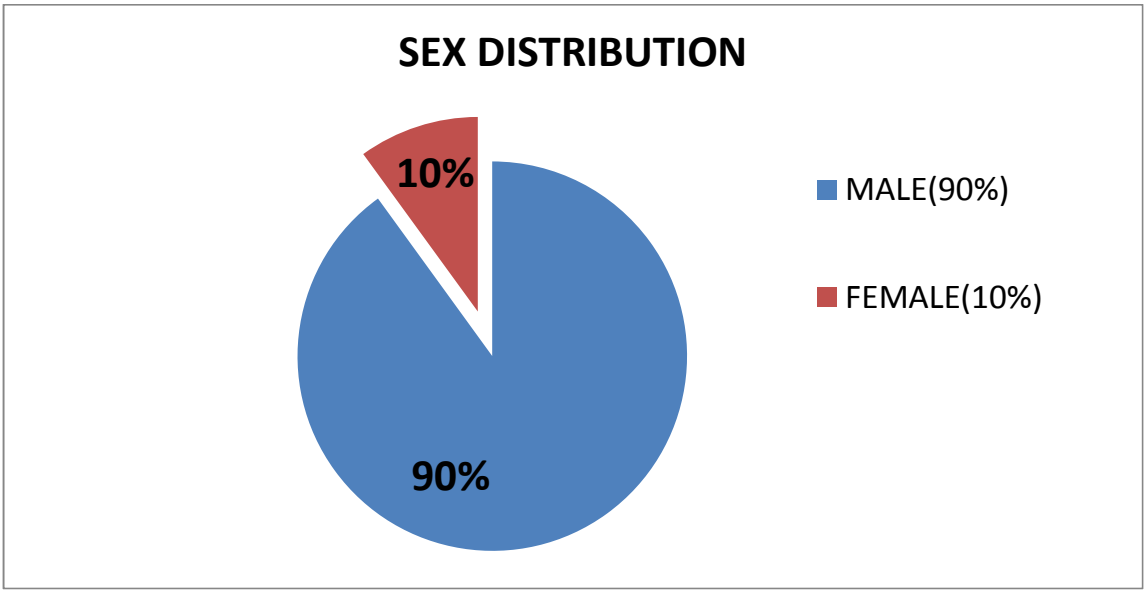
AGE DISTRIBUTION:

TABLE NO 7-1

AGE (years)	PATIENTS	PERCENTAGE
20-25	9	45%
26-30	4	20%
31-35	5	25%
36-40	2	10%
TOTAL	20	100%

SEX DISTRIBUTION:

PIE CHART 1:



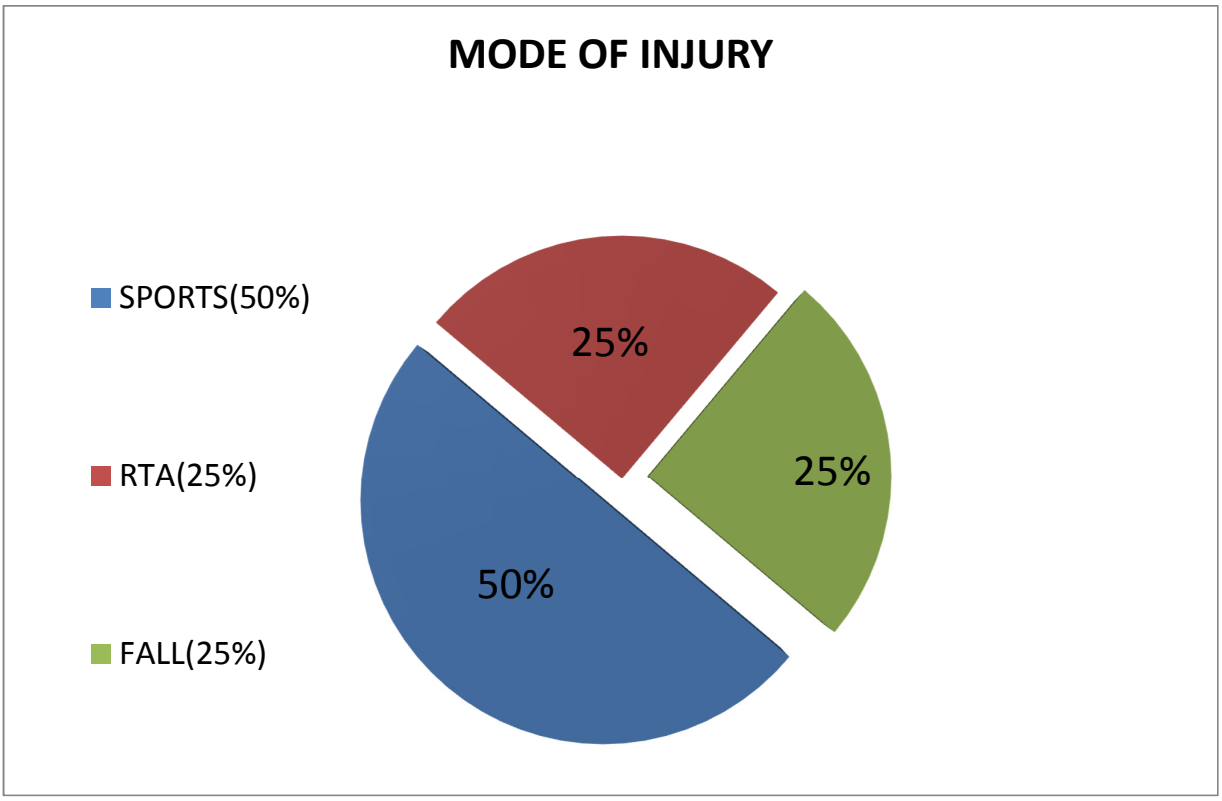
SIDE INVOLVED

TABLE 7- 2:

SIDE	PATIENTS	PERCENTAGE
RIGHT	13	65%
LEFT	7	35%
TOTAL	20	100%

MODE OF INJURY:

PIE CHART 2 :



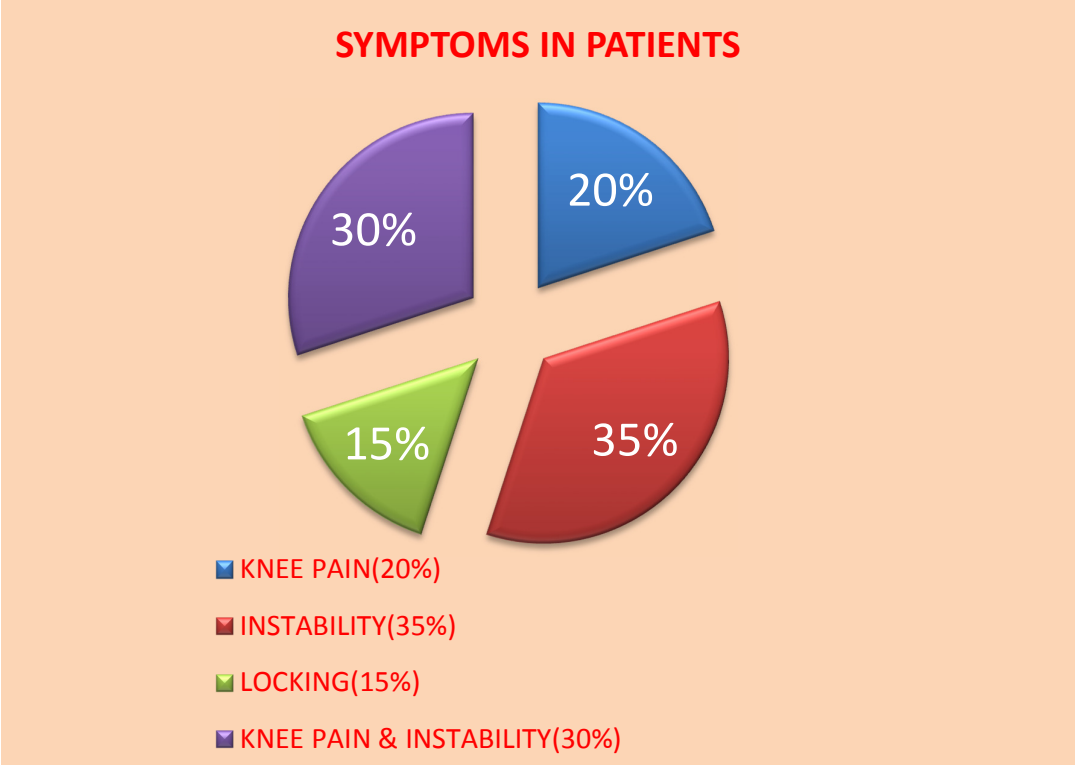
DURATION OF INJURY:

TABLE 7-3:

DURATION	PATIENTS	PERCENTAGE
Upto 3 months	9	45%
Upto 6 months	6	30%
Upto 9 months	3	15%
Upto 1 year	2	10%
TOTAL	20	100%

SYMPTOMS AT PRESENTATION:

PIE CHART 3:



PRE- OPERATIVE TREATMENT:

(ASPIRATION / KNEE IMMOBILIZATION)

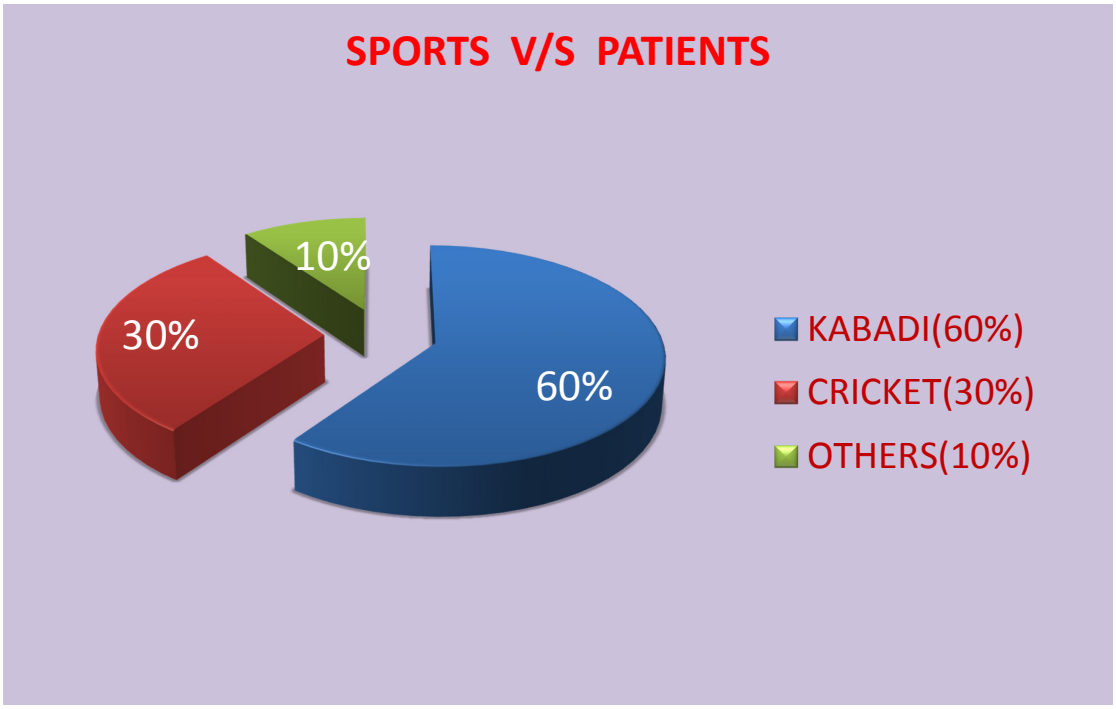
TABLE 7- 4:

	PATIENTS	PERCENTAGE
YES	9	45%
NO	11	55%
TOTAL	20	100%

SPORTS CAUSING ACL TEAR :

In my part of the country, Kabadi is the most common cause of ACL tears.

PIE CHART 4:



ASSOCIATED MENISCAL INJURIES:

TABLE 7- 5:

S.NO	ASSOCIATED INJURIES	NO. OF CASES	PERCENTAGE
1	ISOLATED ACL TEAR	7	35%
2	MEDIAL MENISCAL TEAR	5	25%
3	LATERAL MENISCAL TEAR	3	15%
4	MEDIAL & LATERAL MENISCAL TEAR	2	10%
5	MILD CHONDRAL CHANGES	3	15%

OVERALL RESULTS (LYSHOLM KNEE SCORE) :

TABLE 7- 6:

S.NO	RESULTS	NO. OF CASES	PERCENTAGE
1	EXCELLENT	10	50%
2	GOOD	6	30%
3	FAIR	2	10%
4	POOR	2	10%

RANGE OF MOTION :

TABLE 7 - 7:

S.NO	RANGE OF MOTION	NO.OF PATIENTS	PERCENTAGE
1	0-120 DEGREE FLEXION & ABOVE	15	45%
2	LOSS OF (>15*) TERMINAL FLEXION	4	20%
3	LOSS OF (>5*) TERMINAL EXTENSION	1	5%

EVALUATION OF RESULTS:

GOOD TO EXCELLENT RESULTS

In our study 16 patients had good to excellent excellent results and the patients had no limp, were able to walk without support, there was no locking, except for a few with mild instability during athletics or heavy exertion. There was no pain or swelling of the knee joints. There was no difficulty in climbing stairs or squatting.

FAIR RESULTS

2 of our patients in our study had fair results with the following clinical findings.There was slight limping, occasional locking, with mild instability during daily activities. There was anterior pain and swelling on exertion. squatting and stair climbing were slightly impaired.

POOR RESULTS

2 patients had poor results, with mild pain during weight bearing. The patient walked with support, and felt the knee giving way in daily activities. There was constant swelling and pain of anterior knee joint. Squatting and climbing stairs was painful.

DISCUSSION:

Incidence of anterior cruciate ligament reconstruction had increased significantly in the past decade owing to the increased number of road traffic accidents and more involvement in sports activities. Arthroscopic ACL reconstruction have become gold standard[4] and open reconstruction have become almost obsolete nowadays.

The arthroscopic procedure has the advantage of reduced morbidity, reduced incidence of patellofemoral adhesions, decreased anterior knee pain following reconstruction. Arthroscopic also has a techinal advantage of better visualisation of intraarticular structures and helps in accurate placement of tunnels.

Cyril b Frank et al[34] reported that arthroscopic reconstruction have better functional outcome in short term but the outcomes were similar to open procedures in long term.But ***Hamid Barzegar*** [35] reported arthroscopic reconstruction is superior to a mini arthrotomy procedures in time taken to return to preinjury working level. There are only few studies comparing arthroscopic procedure with a open procedure as arthroscopy offers minimally invasive and more cosmetic surgery and have overshadowed open procedures.

The arthroscopic reconstruction have been standardized. But there are controversies regarding graft choice, graft fixation methods and technique of reconstruction like single bundle or double bundle and trans tibial or trans

portal are still in debate. In the past decade ACL has been widely studied and various scientific articles have been published on ACL reconstruction techniques and outcomes.The goal of reconstruction is to provide a normal stable joint with painless full function and to prevent the complications following ACL tear like meniscal injury and early onset of secondary osteoarthritis.

Our study is to evaluate the functional outcome of arthroscopic single bundle ACL reconstruction with quadrupled Hamstring graft with transportal technique using endobutton as femoral fixation device and titanium interference screw as tibial fixation device.

In our study sports injuries ,fall and road traffic accidents predominated as the cause of injury accounting for 50%,25% and 25%% respectively. Sports injuries accounted for 50% similar to all international studies.

D W Lewis[36] reported 58% meniscal injury associated ACL tear at presentation. Medial meniscus was involved more than the lateral meniscus in his study and he also proposed meniscal repair or resection did not alter the outcome and chondral lesions are a better predictor of funtional outcome.

Stephen Lyman[39] reported more than 50 % meniscal procedures with ACL reconstructions in 2009.

In our study 45% of patients had meniscal injury at presentation and medial meniscus injury predominated lateral meniscus injury like other

studies. None of our patients had significant chondral damage at diagnostic arthroscopy.

The graft choice was of great debate in the recent years. The graft options include bone patellar tendon bone graft, Hamstring graft, Quadriceps tendon graft, allograft, and synthetic grafts[41]. Bone patellar tendon bone graft has been gold standard until recent past as many studies supported patellar tendon graft for its strength and direct bone to bone healing providing early stability.

But recent development and advancement in soft tissue fixation devices studies have found that hamstring grafts are superior in strength and avoiding extensor mechanism disruption.

A Harvey [42]in 2005 published histological analysis of soft tissue graft healing by indirect integration producing Sharpey fibres between the graft and bone and achieves adequate pullout strength by 12 weeks in animal studies**.** ***Aune et al*** compared the outcomes of patellar tendon and hamstring grafts and reported significantly improved outcome and improved quadriceps function at 6 months follow up but the outcomes equalised with time[43].

Though the outcomes equalised the donor site morbidity was less with hamstring graft**.** ***Michael Wagner[44]*** recommended hamstring graft even in high level atheletes. ***David D Greenberg*** proposed allografts has a good alternative of graft but it carries the risk of disease transmission[44].

In our study we used Quadrupled Hamstring graft in all patients which had greatest ultimate load to failure 4140N.***Thomas D Rosenberg***[46] reported patellar chondrosis and anterior knee pain with bone patellar tendon bone graft.

The fixation of the graft[49] has been proved to be the site of failure rather than the graft itself irrespective of the type of graft especially in the early rehabilitation phase when the graft integration has not taken place and the fixation is of little significance after 8 to 12 weeks when graft has integrated with the bone as proposed by ***Dawn T Gulick.***

Various graft fixation devices has been developed in the recent past for soft tissue graft fixation which resulted in the increased reliability on the soft tissue grafts and its use***. Steiner et al***[51]proposed strong fixation as the key to success in soft tissue grafts.

Petterikousa based on in his biomechanical study comparing various fixation devices published that the Bone mulch screw is superior to any other device in providing stiffer fixation of soft tissue grafts and endobutton second only to bone mulch screw[52]. We didn't use bone mulch screw in our study because of it's cost and availability.

Studies have proved that interference screws to be inferior to the endobutton and the bone mulch screw. One another concern was the laceration that interference screw can cause to the soft tissue graft. But despite the concerns, interference screw fixation of soft tissue grafts have shown

comparable results with that of interference screw fixation of bone patellar tendon bone grafts.

Robert G Marx reported two cases of failure with femoral cross pins. ***Chae Gwan Kong*** showed endobutton to be superior than cross pins in femoral fixation, Whereas ***Young Ho oh*** showed that a hybrid fixation with a endobutton and a bio screw in femoral tunnel provided adequate stability and stiffness[54]. ***Andreas Weiler*** published his results of bioabsorbable round contoured screw to be better than the regular titanium interfernce screws[55].

We used endobuttons as femoral fixation device and titanium interference screw as tibial fixation device. Though there are concerns about the bungee effect of the graft while using endobutton causing movement of graft in the tunnel, tunnel widening and interference to graft incorporation, a recent study had reported tunnel widening was more with interference screw than the endobutton and attributed tunnel widening to biological factors rather than mechanical factors of the fixation device.

In our study there was no pull outs or graft fixation site failures and in our patients endobutton was able to withstand the post operative rehabilitation.

We used transportal single bundle reconstruction with quadrupled hamstring graft placing the femoral tunnel between 10: 30 and 11'o clock position in the right knee and between 1'o clock and 1: 30 position in the left knee. This is very close to the position as proposed by ***John Paul's*** placement of graft at 10 30 position and 1 30 position in single bundle

reconstruction reconstructs portions of anteromedial and posterolateral bundles[47].

Masayoshi Yagi showed that anatomic reconstruction allowed better rotatory stability than non-anatomic placements of graft. ***Asheesh Bedi*** showed that trans portal placement of tunnel achieved more lateral placement than the trans tibial drilling and trans tibial approach to achieve lateral tunnel placements resulted in over reaming of tibia[57].

Double bundle reconstructions have gained attraction and the studies have shown double bundle reconstruction to be superior in providing stability in high demand ACL torn patients. ***Adachi, Ochi and Uchio[58]*** showed no significant advantage of double bundle reconstruction than anatomic single bundle reconstruction in factors of stability and proprioception in general population.

Our patients had 82% good to excellent results,16% fair results and 2% poor results were documented. ***Lewis et al*** reported 81% good results in his review article which showed 19% patients had positive pivot shift post operatively. In our study 33% patients presented with less than 5 degree extensor lag, 16% had minimal anteroposterior laxity[60]. Overall patient satisfaction was good in 18 patients.

Riley J Williams [58] reported 8% extensor lag and 11% positive lachmans and positive pivot shift. He reported 2% infection which required

arthroscopic joint lavage, similar 2% in our study which required arthroscopic joint lavage and joint debridement similar to his study.

John C Austin [61]showed fixing of graft in 30 degree flexion cause loss of extension and he recommended fixation of graft in extension. Lewis et al reported 50% patients had arthritic changes in long term follow up. Since our study was a short term follow up we could not comment about the arthritic changes post operatively.

Fox et [53] al reported 3 to 17% incidence of anterior knee pain, compared to 13% in our study, Apostolopoulos reported 10% of anterior knee pain.

Kurt Spindler [54] stated regular exercise can lead to better outcomes in ACL deficient individuals. Our patients are put on home based physiotherapy programe insisting on knee flexion and quadriceps strengthening and mean flexion achieved was 135 degree.

J A Grant [55] concluded that home based physiotherapy is cost effective and not significantly inferior to supervised programmes. This several factors influence the functional outcome in arthroscopic ACL reconstruction. Factors like graft choice, graft fixation, tunnel placement and graft tensioning play a vital role in altering the final outcomes.

This prospective study was conducted in Thanjavur medical college, Thanjavur to clinically evaluate the results of arthroscopic single bundle anterior cruciate ligament reconstruction. This study group comprises of 21 patients with one patient lost for follow up. 20 patients were followed up

with minimum of 1 year follow up. There were 18 males and 2 females in this study. Among the causes for injury, sports(kabadi) stands first followed by vehicular accidents and accidental fall while doing daily activities.

All cases were above two months old at the time of presentation to our OPD . Patients who were young and middle aged, active, motivated patients with interest towards recreational sports or who were involved in vigorous activities, unwilling to change their active life style with normal contra- lateral knee were selected for study. Patients with associated meniscus injury in the ipsilateral knee were also included but the patients with associated ligamentuos injury(i.e., PCL , MCL) and tibial plateau fracture were excluded from our study.

All patients who were selected under this study were clinically evaluated after taking proper thorough history, standard clinical examination. They were evaluated for knee stability test and by Lysholm knee score preoperatively and postoperatively and follow up at 6 weeks, 3 months, 6 months and 1 year and necessary documentation were made[62]. All patient strictly followed rehabilitation protocol. Most of the patients in our study were sport related injury (50%). Patients (60%) presented with complains of giving way with guarded walking during normal activity, 75% of the patients presented with effusion and 50% patients presented with joint line tenderness.. The following conclusions were drawn after results, analysis and discussion.

One of the most common ligament injuries of knee in younger age group is Anterior cruciate ligament injuries.

In our study, there was male prepondernece.

Recreational sports injuries like kabadi are the commonest cause for anterior cruciate ligament injuries in our study.

Associated meniscal and chondral lesions increase with duration of the injury.

The excellent treatment options for ACL deficient knee is arthroscopic reconstruction with hamstring autograft (semitendinosus/ gracilis).

Functional outcome of ACL reconstructed patients is mainly determined by position of tibial tunnel.

The final outcome in anterior cruciate ligament reconstructed patients is dependent of associated meniscal and chondral injuries in our study.

Postoperatively results are excellent in pure ACL tear alone whereas fair to good results in individuals with ACL tear and associated menisci injuries.

ACL single bundle reconstruction aims to reconstruct the deficient torn ACL following trauma and vehicular accidents as close to near anatomical position as possible thus theoretically provides stability and knee kinematics close to the anatomical ACL[(63)].

Quadrupled hamstring graft provides both anterior and rotatory stability to knee post operatively almost similar results to pre trauma level.

. This prospective subjective study suggest that most of patients undergoing single bundle ACL reconstruction were satisfied with results and almost achieved the functional status like uninjured contralateral knee.

Most of our patients in this study were satisfied with these results .This may imply that this is good technique for young and sport patients involving pivoting most of times in their life time but more quantitative and long term studies are required.

ACL single bundle reconstruction with hamstring autograft is preferred over other techniques since it has advantages of less donor site morbidity, early recovery time, less damage to surrounding bony and soft tissue structures.

Limitations in our study are small duration study and small sample size.

Our study was subjective study based on the Lysholm and Gillquist score, IKDC -2000 score and was not objective based, as KT 1000[65] is required to quantify our results. The procedure needs long learning curve and the surgery should be performed by experienced arthroscopic surgeon.Follow up studies of long duration are required to know long term outcomes of this procedure .

SUMMARY:

The summary of our prospective study is as follows:

- Post- operative knee assessment scores are compared with pre-operative knee assessment scores, it shows a definite improvement in knee function post-operatively.
- For young active adults, single bundle reconstruction by arthroscopic methods gives acceptable results.
- The problems which are faced post-operatively can be again settled arthroscopically.
- Still long term follow-up of these cases is a must to analyse if there is degeneration that happened in the time between injury and ligament reconstruction .

MASTER CHART

S. NO	NAME	AGE	SEX	SIDE	MODE OF INJURY	TIME SINCE INJURY (months)	PRE OP Rx	MENISCAL INJURY	SURG- ERY	FOLLOW UP (months)	IKDC		LYSHOLM SCORE	
											PREOP	POST OP	PRE OP	POST OP
1	Smv	38	M	R	RTA	4	yes	No	ACLR+S	15	C	A	F	E
2	Pb	23	M	L	Sports	3	No	Yes	ACLR+S+PM M	12	C	B	F	G
3	Kt	29	M	R	Sports	2	yes	No	ACLR+S	13	B	A	G	E
4	Vrl	40	M	L	Fall	6	No	Yes	ACLR+S+PM M	16	C	B	F	G
5	Pru	33	M	R	Sports	5	No	Yes	ACLR+S	18	D	B	F	G
6	Mad	24	M	R	RTA	9	yes	N0	ACLR+ S	16	C	A	F	E
7	Rjn	24	M	L	Sports	4	yes	Yes	ACLR+S+PLM	14	C	B	F	G
8	Cad	33	M	R	Fall	6	No	Yes	ACLR+S	15	C	B	F	G
9	Mgn	24	M	R	RTA	3	yes	Yes	ACLR+S+PM M	12	D	B	F	G
10	Auk	25	M	L	Sports	4	No	No	ACLR+S	9	C	A	F	E

11	Srk	20	M	R	Fall	3	yes	Yes	ACLR+S+PMM	10	C	B	F	G
12	Dvn	34	M	R	Sports	5	No	No	ACLR+S	11	B	A	G	E
13	Cin	22	M	R	Sports	2	yes	No	ACLR+S	10	B	A	G	G
14	Skr	25	M	R	Sports	3	No	No	ACLR+S	10	B	A	G	E
15	Dlk	35	F	L	Fall	8	No	Yes	ACLR+S+PLM	14	C	B	F	G
16	vnp	20	F	L	Sports	7	yes	No	ACLR+S	6	B	A	G	E
17	mui	34	M	R	RTA	12	yes	yes	ACLR+S	4	C	B	F	G
18	Rmd	26	M	R	Fall	3	No	No	ACLR+S	3	B	A	G	E
19	Srn	27	M	L	RTA	2	No	No	ACLR+S	5	C	A	F	E
20	Ruc	22	M	R	Sports	10	No	No	ACLR+S	8	C	A	F	E

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ABBREVIATIONS

M - Male

F : Female

R : Right

L : Left

RTA : Road Traffic Accident

MMT : Medial Meniscal. Tear

MM : Medial Meniscus

LMT : Lateral Meniscal Tear

RECON : Reconstruction

PMM : Partial Medial Meniscectomy

PLM : Partial Lateral Meniscectomy

CMM : Complete Medial Meniscectomy

CLM : Complete Lateral Meniscectomy.

ANNEXURE - 1

PROFORMA

1. Name:
2. Age:
3. Sex:
4. Occupation:
5. Address:
6. I.P No:
7. Presenting H/o: Side: L/R

   Knee pain Yes / No

   Instability Yes / No

   Swelling Yes /No

   Locking Yes/No
8. H/o Trauma: Yes / No (If yes – Type of trauma: fall/ RTA / others / Sports).
9. Duration between injury and surgery:
10. Associated medical problems:
11. Clinical Examination Finding:

    Ant Drawers –

    Post Drawers-

    Lachmans-

    Effusion-

McMurrays-

Pivot shift-

12. Investigation X-Ray / MRI details:

13. Associated injuries:

14. Type of anesthesia – General / Spinal:

15. Meniscectomy: done / not done

16. Suture removal done on --post-op day

17. Whether brace support used / not used: if used for how many days.

18. Assessment:

- 1st pod

- 1st week

- 2nd week

- 6th week

- 3 months

- 6 months

- 1 year

- 1 & 1/2year

30. Complications:

- Knee effusion yes / no
- Surgical site infection yes / no
- Septic arthritis yes / no
- Fever yes / no

- Implant failure yes / no
- Graft failure yes / no
- Knee stiffness yes / no
- Wound gaping yes / no
- Others

ANNEXURE - 2

BIOMECHANICS OF KNEE JOINT

The cruciate ligaments form the pivot and nucleus of the knee joint kinematics. On internal rotation the cruciates twist around each other and in external rotation they unwind. The anterior cruciate ligament exerts visco elastic properties like any other ligaments with its ultimate strength of 1725+/-269 N( ).

The range of mobility is enhanced by the orientation of fibers. Since the femoral origin of the cruciate ligaments lie on a line, which forms an angle of 40 degrees with the long axis of femur, it produces normal mobility of 50-145 degrees.

The anteromedial fibers of anterior cruciate ligaments are tense principally in flexion while the posterolateral fibers are in increasing tension as the knee is extended. The reciprocal relationship of this bundle constitutes a twist within the anatomy of this single ligament and provides for stability throughout the entire arc of knee motion assisting the rolling and gliding movement of the femoral condyle over the tibial plateau in the sagittal plane.

Anterior cruciate ligament also assist in the screw home movement of the femoral condyle in the terminal extension. In ACL tear, the femur rolls up onto the meniscus and its posterior horn on flexion and skids back. This causes meniscus symptoms and further tears( ).

STABIILIZERS OF KNEE JOINT

The stabilizers of knee joint are classified as

1) Static stabilizers

- Capsule and capsular ligaments
- Extracapsular ligaments

2) Dynamic stabilizers

- Musculotendious units and their aponeurosis Gravity and propriocepic receptors of the joint are the other important stabilizers of the joint.

HUGHSTON AND SLOCUM'S DESCRIPTION OF STABILIZERS

TABLE – 1:

SIDE	STATIC STABILIZERS	DYNAMIC STABILIZERS
MEDIAL Anterior 1/3 rd Middle 1/3 rd Posterior 1/3 rd	Capsule + ligamentum patella Capsule + tibial collateral ligament Capsule (posterior oblique ligament)	Pes anserinus muscles – gracilis,Sartorius,semitendinosus, Medial gastrocnemius muscle
LATERAL Anterior 1/3 rd Middle 1/3 rd Posterior 1/3 rd	Capsule Capsule(lateral capsular ligament) + Iliotibial tract Arcuate complex(collateral ligament + arcuate ligament + popliteus tendon)	Biceps Popliteus Lateral gastrocnemius muscle

MECHANISM OF INJURY

Knee joint is inherently unstable without the strong capsulo ligamentous structures supporting the joint in extension and flexion. Varus and valgus stability is provided by the medial and lateral structures along with cruciates. The cruciate ligaments provide anteroposterior and rotatory stability along with other capsuloligamentous sructures. Depending on the position of the knee some acts as primary stabiliser and some as secondary stabiliser. Most ligamentous injuries occur with flexed knee when the capsule and ligaments are relaxed and femur is allowed to rotate on the tibia.

The commonest mechanism of injury is a non contact deceleration with a valgus and twisting movement. In isolated ACL injury the mechanism of injury was mostly deceleration, internal or external rotation and hyperextension as with landing from a jump or sudden turning of direction while running.

Valgus movements do not cause a serious injury until medial collateral ligament is intact, but once it is injured the ACL ruptures as the valgus thrust continues. When this is associated with a rotational component the medial meniscus is torn caught between the articulating condyles causing the classical unhappy triad of O'Donoghue.

Figure 2. 4 - Mechanism of injury of ACL

Regarding rotatory violence, on continued extension of the knee from flexion the femur rotates medially on tibia or tibia rotates externally to lock the knee which is called as screw home mechanism. On sudden block to screw home mechanism the ACL goes for stress and ruptures. Also a direct posterior thrust on femur on fixed tibia as in dash board injury can cause avulsion injury of ACL especially in young individuals.

Various intrinsic and extrinsic factors are identified contributing to the anterior cruciate ligament tear. The intrinsic factors include factors which cannot be changed like the size of the ligament, notch width, and physiological alignment of the joint and physiological laxity, hormonal influences, inherited skills and coordination. The extrinsic factors are those that can be modified like strength, conditioning and motivation. Many factors like coordination, proprioception, position sense and balance require both intrinsic and extrinsic factors. The most important factor contributing to ACL tear is the dynamic movement pattern rather than the static anatomic measurements.

NATURAL HISTORY( )

The course that a anterior cruciate ligament deficient knee follows or the natural history of anterior cruciate ligament tear is varied and there are many controversies regarding this, as all ACL tears are not reported, not all ACL injuries are symptomatic, and due to varied patient requirements and extent of injury. But it is very well documented that a ACL deficient athlete with a unstable knee will acquire a meniscal tear and arthrosis if he continues to involve in high demand activities in spite of repeated episodes of instability.

It has been reported that around 50 to 70% of ACL injuries are associated with meniscus injury. Lateral meniscus is more commonly injured in a acute setting whereas medial meniscus is more commonly injured in chronic tears. Studies reveal that around 58 to 61 % of ACL injuries will require a meniscal surgery within 5 years. The incidence of chondral damage is reported to be twice in the chronic ACL tears than the acute tears.

Most patients are comfortable with their daily activities and have limitations only in vigorous sports. Only a few patients are purely asymptomatic. The persons with high pre injury activities like children, athletes are the persons most affected. It is the challenge to the surgeon and his responsibility to evaluate, understand and predict how an ACL injury will affect different individuals based on their requirement. The events following the anterior cruciate ligament injury is described as ACL cascade.

ACL CASCADE

ACL INJURY

↓

JOINT SUBLUXATION

↓

MENISCAL TEAR

↓

JOINT ARTHROSIS

ANNEXURE – 3

OPTIONAL PORTALS

POSTEROLATERAL PORTAL :

It is about 2cm above the posterolateral joint line at the posterior edge of iliotibial band and anterior edge of biceps femoris tendon. It is useful for assisting the repair of lateral meniscal tears.

PROXIMAL MIDPATELLAR MEDIAL AND LATERAL PORTALS :

These portals are located just off the medial and lateral edges of midpatella at the broadest portion of the patella. They are very helpful in viewing of anterior compartment structures,the lateral meniscocapsular structures and popliteus tunnel to minimize crowding of accessory instruments.

ACCESSORY FAR MEDIAL AND LATERAL PORTALS :

These inferior optional portals often are used for triangulation of accessory instruments into the knee during operative arthroscopic procedures. They are located approximately 2.5 cm medial or lateral to the standard anteromedial and anterolateral portals.

CENTRAL TRANSPATELLAR TENDON[GILLQUIST PORTAL]:

It is located approximately 1cm inferior to the lower pole of the patella in the midline of the joint through the patellar tendon. Adjustments should be made based on patellar locations. This is helpful in ACL reconstruction procedures after graft harvest has been completed avoiding tendon damage

ANNEXURE – 4

INSTRUMENTATION AND THE IMAGES

Many specialized instruments are required for arthroscopic anterior cruciate ligament reconstruction. They are elaboratively explained in annexure .An arthroscopic system which consist of

1) Television monitor
2) Camera
3) Light source and fibre optic light source cable
4) Arthroscope (30 degree)
5) Shaver system and hand piece
6) Tourniquet set (Pneumatic)

Equipments needed for surgery

- 2.4mm drill tip guide pins
- Trocar, canula, ACL probe
- Meniscus punch
- 4mm/5mm shaver burr
- Tibial aiming guide
- cannulated headed reamers(size 5 mm to 10 mm)
- femoral entry point aimer (6 mm / 7mm offset)
- extra lomg 2.4 mm guide pin with suture eye (beath type guide pin)
- 4.5 mm cannulated reamer for passage of endobutton

- depth gauge

- sizing master board

- cannulated interference screws of all sizes

- endobutton of all sizes

IMPLANTS

The fixation options for soft tissue grafts in femur can be direct devices like interference screws and washers. The indirect devices like endobutton, femoral cross pins, suture discs and anchors are also available. Fixation options in tibia are interference screws, staples, screw and washer(Washerloc).We used endobutton for femoral fixation and titanium interference screws in the tibia.

ENDOBUTTON

Endobutton ensures most of the graft in the tunnel. It has 4 holes of which central two holes are used to create the loop for quadrupling the graft.The peripheral two holes are for passing wires which are used to flip the endobutton. Endo button was stronger than round contoured interference screw and bio screw in withstanding cyclical loads and has a greater advantage of not lacerating the soft tissue graft.

Figure : Endobutton

INTERFERENCE SCREW

Interference screws are direct fixation devices which hold the graft to bone having inserted between the graft and the bone tunnel. These are made of either stainless steel or titanium. Round contoured interference screws, bio absorbable interference screws, titanium interference screws are available. We used titanium interference screws. They provide juxta articular fixation, increasing the stability of the knee joint than the other implants which suspend the graft or fix the graft at the surface of the joint.

Figure : Interference screw

ANNEXURE – 5

ARTHROSCOPIC ACL RECONSTRUCTION

TECHNIQUE

The technique used was based on the creation of one femoral and one tibial tunnel with centres corresponds with centre of ACL femoral and tibial attachment sites. Femoral tunnel was prepared by using anteromedial portals independently in this technique thereby ensuring anatomical native femoral footprint of ACL graft.

Harvested graft was fixed on the femoral side with one endobutton continuous loop and on the tibial side with one interference screw.

DIAGNOSTIC ARTHROSCOPY BEFORE GRAFT HARVESTATION:

Before harvesting graft, the knee was examined with an arthroscope. With the knee flexed at about 90 degrees, an anterolateral portal (viewing portal) was made using no. 11 blade at the level of patellar inferior pole just lateral to patellar tendon. The scope was introduced and knee was examined systematically in the *'W'* sequence, starting from the suprapatellar pouch, undersurface of the patella, the patellofemoral joint, medial gutter, medial meniscus,undersurface of patella, intercondylar notch, lateral meniscus and lateral gutter.

The normal and defective parts were examined. Once all the pathologies were recorded, a second anteromedial portal (working portal) was made at the patella inferior pole , just medial to patellar tendon. All associated pathologies were dealt appropriately like (i) partial menisectomy done for a meniscal tear that was unstable to probing, (ii) chondral defect shaved and (iii) loose bodies removed.

Figure 5.3 : Arthroscope inserted in arterolateral portal

Figure 5.4 : Distension of knee joint with normal saline

HAMSTRING GRAFT HARVESTATION

A 3 to 4 cm oblique incision is placed over the anteromedial aspect of tibia (4cm distal and 3 cm medial to medial joint line and tibial tubercle respectively) exactly over the pes anserinus which is identified by palpating the semitendinosus and gracilis tendon by running the fingers from above downwards in the anteromedial aspect of the upper tibia. The tendons slip under the finger like the bumps of speed breakers, the lowest one being semitendinosus.Skin subcutaneous tissue is incised along the incision and blunt dissection is done to expose the sartorius fascia which is lifted up with a forceps and cut with a number 11 scalpel taking care not to injure the infrapatellar branch of the saphenous nerve.

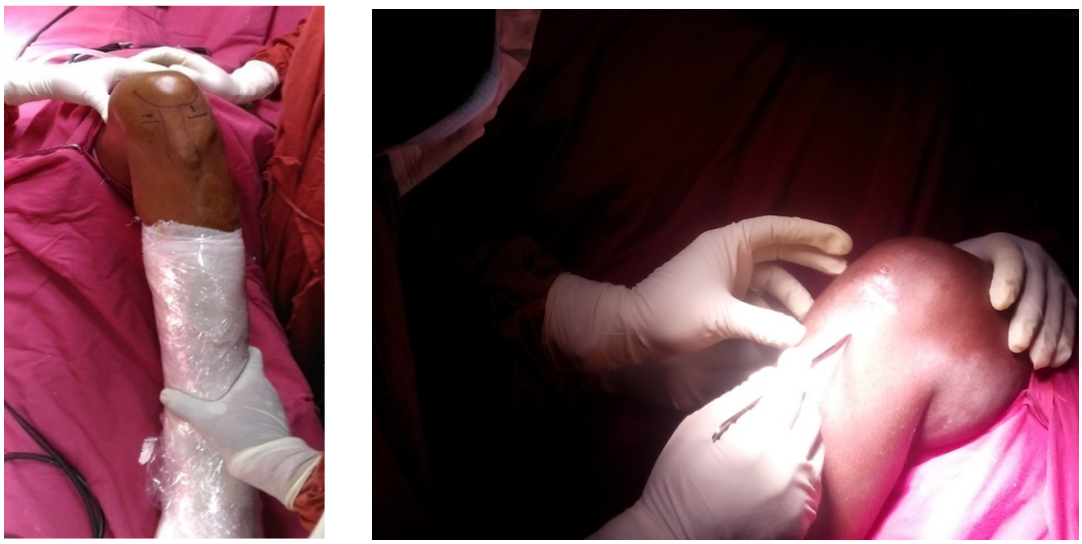

Figure 5.5 : surface marking before incision

Once the hamstring tendon were identified, the sartorius fascia was carefully incised along the course of and in between the gracilis and semitendinosus tendon, taking care to preserve the integrity of fascia and deeper layer comprising medial collateral ligament. Using a right angled artery forceps first the gracilis and then the semitendinosus tendon were hooked and delivered into the wound. Dissection was carried out distally to point where they became a conjoint structure and then amputated there to maximize their length. To give traction,each tendon at its distal end was tied with double looped knot.

After placing the knee in 90 – 100 degrees of flexed position, the tendon were dissected proximally by using blunt fingers towards their musculotendinous junction to release adhesion and accessory bands, while constant traction was applied through the threads. Special consideration was given to the consistent fibrous band approximately 8-10 cm proximal to tendon insertion, which was released using Mayo's scissors. Once the tendon were free, traction was given and the taut tendon was simultaneously felt in popliteal fossa from outside to confirm it's distal position.

Then a closed-end stripper was passed over the tendon one by one and advanced carefully in line with it giving firm, steady but gentle pressure and simultaneously applying counter- traction using the previously placed suture. If any resistance was felt persistently, the stripper was removed and any additional fibrous bands were identified and removed. The stripper was then

reinserted and tendon harvested. Gracilis usually had a more muscular appearance after harvesting. After harvesting the graft was placed on *graft master board*. They were stripped of their residual muscle fibers proximally using the blunt end of scalpel blade.

Figure 5.6 : The donor site showing the harvesting of Semitendinous.

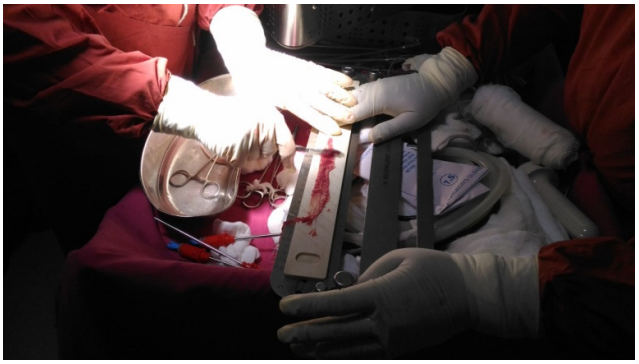

Figure 5.7 : Graft preparation after harvesting

The tendon end were carefully trimmed to uniform size,verified, measured and made of equal lengths. They were placed together and using a number 5 Ethibond suture a running baseball stitch was placed in both tendons in a *Chinese finger trap configuration*. About 3-4 cm of both ends of tendons were stitched together. The tendons were looped (using an umbilical tape around the stitched tendons) and passed through various holes in the graft sizer. The diameter of reamer chosen for subsequently making the tunnels was equivalent to smallest sizing sleeve that passed over the four stranded graft with minimal friction.

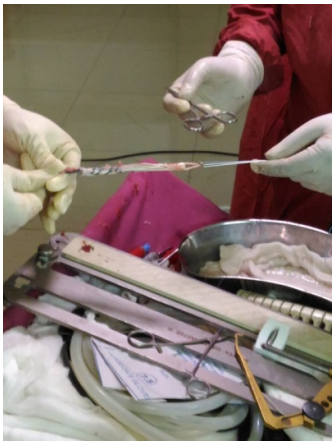

Figure 5.8: Quadrupled graft

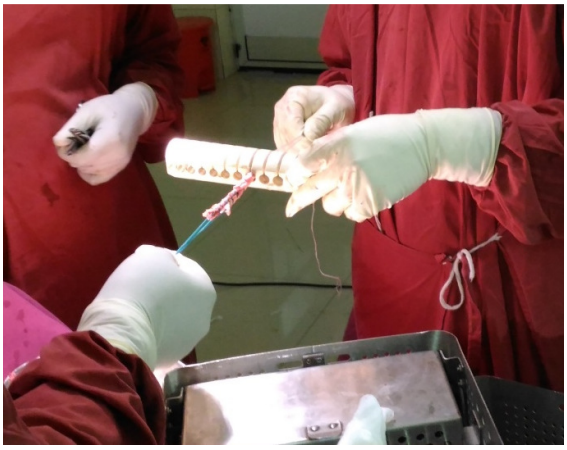

Figure 5.9 :Sizing the graft after quadrupling

Circular marks were made 3cm distal to loop proximal end for ensuring exact placement of graft inside the femoral tunnel while viewing through arthroscope. The loop of the quadrupled tendons was then tied to the graft master posts and a pressure of about 15 pounds was applied for 10-15 minutes for *pre-stressing the graft.*

ARTHROSCOPIC RECONSTRUCTION AFTER GRAFT HARVESTATION

INTRAARTICULAR PREPARATION

(Anterolateral portal for inserting scope and anteromedial portal for inserting instruments)

The arthroscope is introduced through the anterolateral portal and the 4mm or 5mm shaver blade is inserted through the anteromedial portal and the joint is debrided of the ligamentum plicae, some pad of fat and some synovial reflections which hinder a through visualization of the medial surface of lateral femoral condyle, the over the top position and the tibial foot print of the anterior cruciate ligament.The medial surface of the lateral femoral condyle is shaved of the native ACL remanents and the over the top position is identified without misinterpreting the students ridge. Then the ACL foot print in the tibia

is prepared. Throughout this joint debridement undue care is taken to avoid injury to the native posterior cruciate ligament.

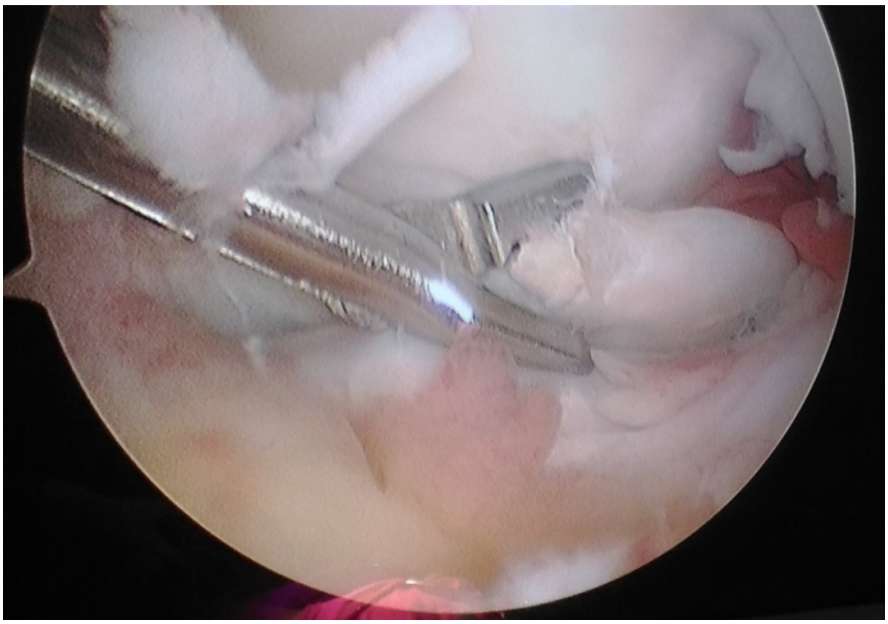

Figure 5.10 – Partial Medial Meniscectomy using meniscal punch

NOTCH PREPARATION AND NOTCHPLASTY

After this, attention was focused to the intercondylar notch. A torn anterior cruciate ligament was usually visualized as a tibial stump scarred to the posterior cruciate ligament or the intercondylar roof (vertical strut sign) or failing to extend to its normal femoral attachment (empty lateral wall sign). The remaining anterior cruciate ligament tissue was removed using the basket forceps and a 4mm or 5mm aggressive plus resector. All soft tissues from the notch lateral wall were removed. Synovium overlying the lateral aspect of posterior cruciate ligament can be shaved off to visualize the "over the top" position. A portion of the tibial stump of anterior cruciate ligament was

retained as it is believed to have proprioceptive properties and promotes revascularization.

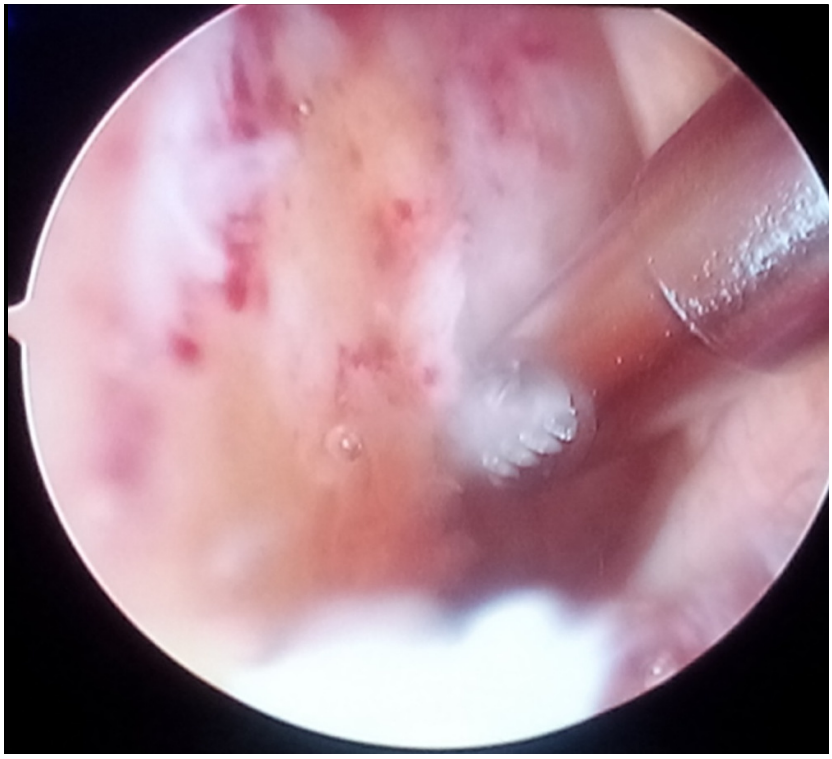

Figure 5. 11 : Notchplasty using burr

Appropriate shaping and enlargement of the intercondylar notch of femur is called notchplasty.The main aims of notchplasty are to obtain adequate exposure of the lateral wall of the notch from front to back and to avoid impingement or abrasion of the graft against the roof or lateral wall of the notch in chronic ACL insufficiency marked osteophytic encroachment into the intercondylar notch often narrow this already confined space. Intraarticular ligament substitution often increases the content of the notch.So even without

osteophytic encroachment, notchplasty is an important part of ACL reconstruction.

TECHNIQUE OF NOTCHPLASTY:

Notch is deepened by 2-3mm.Deepening should begin anteriorly on the articular surface of intercondylar notch 2 to 3mm above its margin and should be beveled posteriorly.Major deepening should be anterolateral.

Widening of notch by 2-3mm by removing the inner wall of the lateral femoral condyle.Again widening should start anteriorly and beveled posteriorly.Anteromedial side of notch is not removed unless osteophytes are present.Widening of the notch all the way to its posterior outlet removes the shelf for femoral insertion of ACL and makes the achievement of isometry more difficult.

FEMORAL TUNNEL PREPARATION

After confirming origin of ACL,well visualization of medial surface of lateral condyle was carried out in 90 degree of knee flexion. With the help of 6mm or 7 mm femoral offset aimer, guide wire was drilled from entry point. After drilling to 3mm,knee was flexed upto 120 degree, drilling was continued until guide wire tip visualized on lateral aspect of distal thigh.once confirmed guide wire was exactly in middle of anteroposterior cortex of distal femur.

Femoral tunnel was created with 4.5 mm drill bit,drilling both near and far cortex and tunnel length was measured with depth gauge. Femoral side of

the prepared graft was measured with sizer, with that diameter drill bit, femoral tunnel was reamed without reaming 15 to 20 mm of lateral Cortex of the femoral tunnel based upon the length of the graft. Once tunnel prepared, beath pin with Ethibond at its end was passed into femoral tunnel for easier passage of prepared graft.

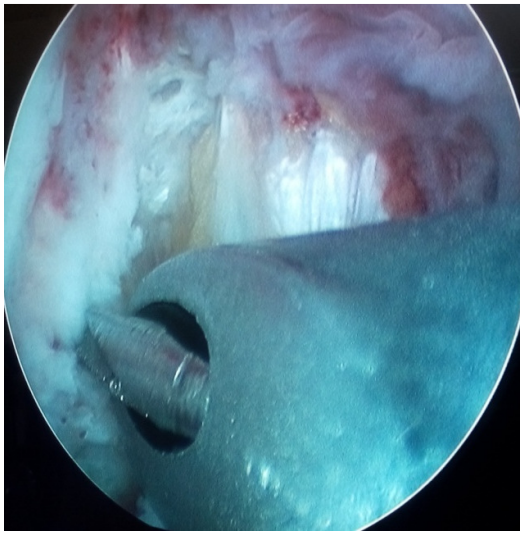

Figure 5.12 : Femoral aimer with 2.5 mm drill bit for femoral tunneling

Figure 5.13 - Femoral tunnel after reaming

TIBIAL TUNNEL PREPARATION

The tibial tunnel is made using the 'Tibial Guide'.The angle of the guide is usually adjusted with the calculation ‘N + 7’ where N stands for the length(in mm) of the quadrupled hamstring tendon. The tibial guide pin was drilled and brought at 7mm anterior to intact PCL or remnant of ACL almost 24 to 26 mm posterior to anterior margin of proximal tibia.The tibial tunnel is reamed using cannulated drills over this guide pin upto the measured width of the hamstring tendon. Care is taken not to form a vertical tunnel. The tunnel intra articular edges are smoothened using the automated shaver leaving remanant of ACL for better proprioception.

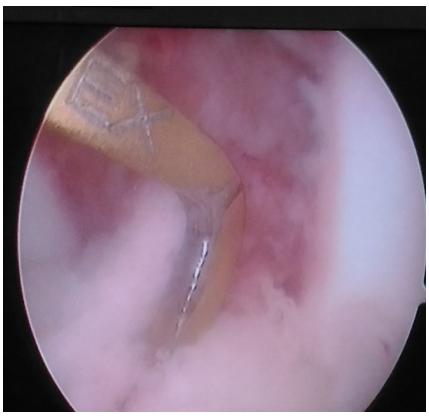

Figure 5.14 - Tibial elbow aimer

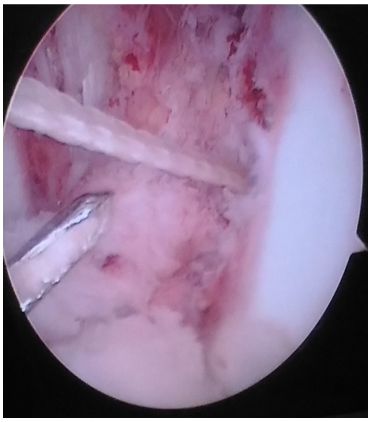

Figure 5.15 : Tibial Tunnel drilled with drill bit(2.4mm)

GRAFT PREPARATION, PASSAGE AND FIXATION[31]

After graft preparation,based on the length of the graft, it is quadrupled, loop part of the graft is connected to endobutton with looped silk(length of the silk based upon graft length and unreamed femoral tunnel length). Ethibond sutures which were already inside the joint was pulled out through tibial tunnel and connected to white and blue threads of ethibond. With the help of these ethibond sutures,both the threads were pulled through tibial tunnel and brought via femoral tunnel followed by pulling the graft from tibial to femoral tunnel. By alternative pulling of both the threads,graft was passed and position was confirmed by sudden absence of resistance and flipping of endobutton.

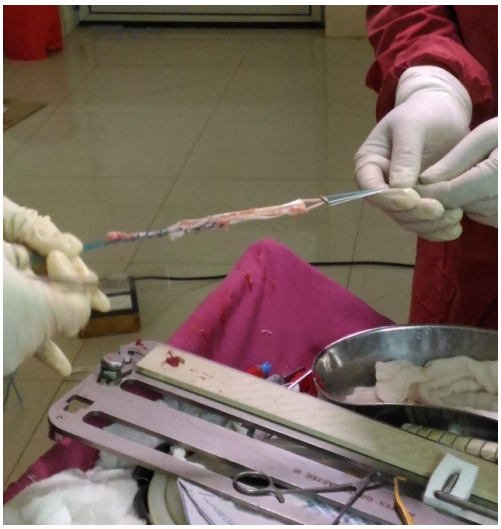

Figure 5.16 : Prepared quadrupled graft

Figure 5.17 : Graft passage

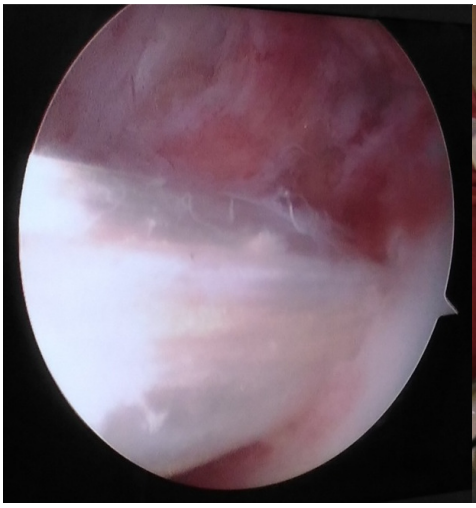

Figure 5.18 **Figure 5.19 :**

Figure 5.18 : Hamstring graft after passage

Figure 5.19 : flipping of endobutton (in the place of native ACL) for confirmation of position of graft

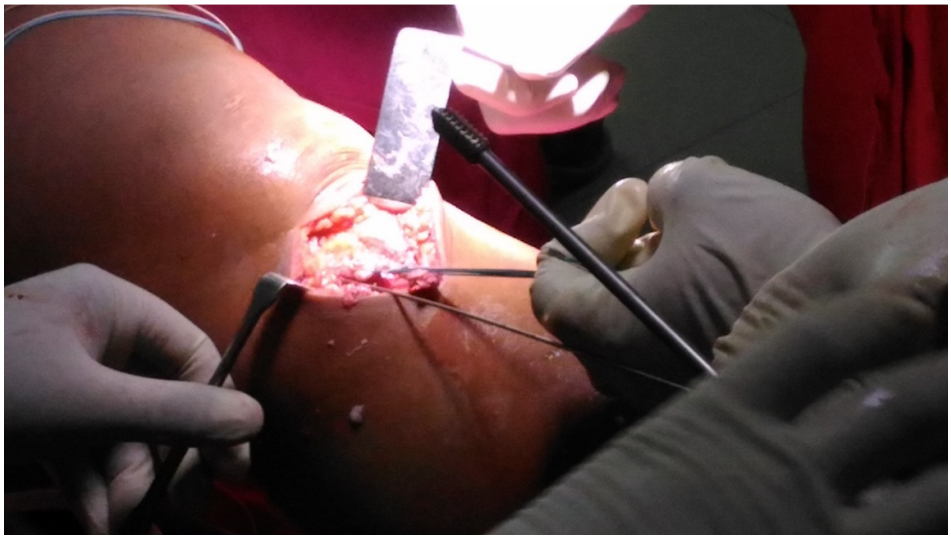

Figure 5.20 : Fixation of graft on the tibial side with interference screw

Once graft positioned, tensional loading of the graft was applied by 20-30 cycling maneuver by repeated flexion and extension of knee with the graft kept in constant pull from tibial side. Once satisfactory cyclical loading was achieved, reconstructed graft was visualized by viewing portal and looked for any graft impingement,graft laceration and proper alignment of graft. Graft on tibial entry site was fixed with titanium interference screw of appropriate length. Intra-articular placement of screw also visualized with arthroscope. Remaining part of the graft outside the tunnel was sutured with fascia.

WOUND CLOSURE

All dissected tissue closed in layers after drain kept in situ. Compressive bandage was applied. Limb immobilized in hyperextension with long knee brace

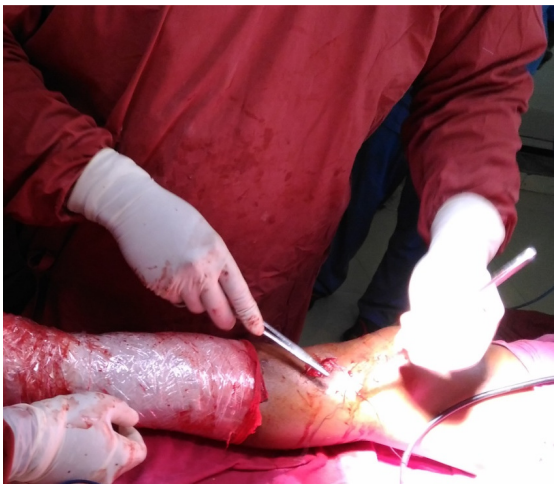

Figure 5.20 : closure of wound

ANNEXURE - 6

LYSHOM AND GILLQUIST KNEE SCORING SCALE

Limping (5 points)
Never = 5
Mild or periodically = 3
Strong and continuous = 0

Support (5 points)
No support = 5
Walking stick or crutches = 2
Impossible = 0

Restraining (15 points)
No restraining or restraining feeling = 15
Has the feeling, but no restraining = 10
Occasional restraining = 6
Frequent = 2
Joint restrained at examination = 0

Instability (25 points)
Never miss a step = 25
Seldom, during athletic activities or other strong-effort exercises = 20
Frequently during athletic activities or other strong-effort exercises (or unable to participate) = 15
Occasionally in daily activities = 10
Frequently in daily activities = 5
At each step = 0

Pain (25 points)
No pain = 25
Intermittent or mild during strong-effort exercises = 20
Marked during strong-effort exercises = 15
Marked during or after walking more than 2 Km = 10
Marked during or after walking less than 2 Km = 5
Continuous = 0

Swelling (10 points)
No swelling = 10
Upon strong-effort exercises = 6
Upon usual exercises = 2
Continuous = 0

Climbing stairs (10 points)
No problem = 10
Slightly damaged = 6
One step at a time = 2
Impossible = 0

Squatting (5 points)
No problem = 5
Slightly damaged = 4
Not exceeding 90 degrees = 2
Impossible = 0

Total score: _____