Dissertation on

ASSESSMENT OF THE FUNCTIONAL OUTCOME OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT USING HAMSTRING TENDON AUTOGRAFT

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CERTIFICATE

This is to certify that this dissertation titled **"ASSESSMENT OF THE FUNCTIONAL OUTCOME OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT USING HAMSTRING TENDON AUTOGRAFT"** is a bonafide record of work done by **DR. S. R. VENKATESWARAN**, during the period of his post graduate study from July 2014 to June 2016 under guidance and supervision in Stanley Medical College and Government Stanley Hospital, Chennai-600001, in partial fulfilment of the requirement for **M.S.ORTHOPAEDIC SURGERY** degree Examination of The Tamilnadu Dr. M. G. R Medical University to be held in April 2017.

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DECLARATION

I declare that the dissertation entitled **"ASSESSMENT OF THE FUNCTIONAL OUTCOME OF ARTHROSCOPIC RECONSTRUCTION OF ANTERIOR CRUCIATE LIGAMENT USING HAMSTRING TENDON AUTOGRAFT"** submitted by me for the degree of M. S. ORTHOPAEDICS is the record work carried out by me during the period of **July 2014 to July 2016** under the guidance of **Prof. Dr. M. ANTONY VIMAL RAJ M. S. Ortho,** Professor of Orthopaedics, Department of Orthopaedics, Stanley Medical college & Govt Stanley Hospital, Chennai. This dissertation is submitted to the Tamilnadu Dr. M. G. R. Medical University, Chennai in partial fulfilment of the University regulations for the award of degree of M.S.ORTHOPAEDICS (BRANCH - II) examination to be held in April 2017.

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CONTENTS

LIST OF ABBREVIATIONS

ACL	**-**	**Anterior Cruciate Ligament**
PCL	**-**	**Posterior Cruciate Ligament**
RTA	**-**	**Road Traffic Accident**
OA	**-**	**Osteoarthritis**

INTRODUCTION

Knee injuries are increasing and becoming more common due to the exponential rise in road traffic accidents and sports related activities by common people. In current scenario, knee injuries take the Orthopaedician to a plethora of diagnostic and management challenges which is not resolved even by modern understanding and technical improvements in science.

Anterior cruciate ligament is one amongst the most common injured structure around knee. Being one of the prime stabilizers of the knee, the major role of Anterior cruciate ligament is to resist anterior translation of the tibia on the femur. ACL also contributes to stabilize the knee against varus and valgus stress, excessive hyperextension and proprioception.

As ACL doesn't heal with repair, reconstruction is the only possibility. Anterior cruciate ligament reconstruction is done to improve stability of the knee joint, to prevent later meniscal tear and to delay the onset of early osteoarthritis. Graft tissue selection, graft placement, methods of graft fixation, variations in the rehabilitation protocol, post reconstruction functional bracing, and criteria for return to routine activities remains controversial. As the open ACL reconstruction has prolonged rehabilitation and more complications, arthroscopic assisted ACL reconstruction is a boon for such injuries where precision and rehabilitation is quick.

Since early return to daily routine with full range of movements and minimal donor site morbidities is feasible following arthroscopic reconstruction of ACL, it is considered more superior to the extraarticular and intraarticular reconstruction by open arthrotomy.

AIM

To assess the functional outcome of Arthroscopic Reconstruction of Anterior Cruciate Ligament using hamstring tendon autograft.

REVIEW OF LITERATURE

The cruciate ligaments have been known since 3000 BC and their anatomy was described in the Smith Papyrus.

In 170 AD Claudius Galen [1], described the true nature of the ACL. He described the cruciate ligaments as genu cruciata [2, 3].

In 1836, the Weber brothers from Germany recognised an abnormal translation of tibia after transection of the ACL and elucidated the tension pattern of the different bundles of the ACL [1].

In 1845, Amade Bonnet published a paper regarding the mechanism of ligamentous injury of the knee [1].

Rupture of the ACL was first documented by Stark in 1850 [3].

In 1879, Paul Segond described an avulsion injury of the anterolateral tibial plateau which was most commonly associated with ACL rupture.

In 1900, Mayo - Robson performed the first ACL repair [4].

The significance of the anterior cruciate ligament was recognised by Fick in 1911 [5].

In 1916 Jones [6] had illustrated that the repair of the ACL is not sufficient.

In 1917, Hey Groves used fascia lata to reconstruct the ACL, by partially removing the fascia lata from its insertion and redirecting it in to the tibial tunnel [7, 8, 9]. He also reported that tension within the ACL varies with flexion and extension of the knee [9].

In 1934 Riccardo Galeazzi used semitendinosus tendon for ACL reconstruction and was the first to bring out the use of hamstring graft in ACL reconstruction [10, 11].

In 1935, Campbell used medial one- third of the patellar tendon, along with the prepatellar retinaculum and quadriceps tendon for the reconstruction of ACL [12].

In 1944, Abbott grouped ligamentous injury of the knee together as "internal derangements of the knee" [13].

In 1950, Lindemann and Augustine reported the use of semitendinosus tendon to stabilize ACL deficient knees [14, 15].

In 1963 Jones proposed a new technique using patellar tendon which was considered simpler and more "nearly physiological" for the reconstruction of ACL [16].

Brückner acknowledged the same technique in 1966, using the patellar tendon with a bone block [17].

By 1969, Franke pioneered the use of bone patellar tendon bone graft which consisted of a portion of the patellar tendon with bone blocks from patella and proximal tibia at either ends [18].

In 1972, D. L. Mac Intosh practiced extraarticular reconstruction of ACL by various techniques.

In 1974, McMaster et al. reconstructed ACL using the gracilis tendon [19].

In 1976 Joseph S Torg, student of John Lachman described the Lachman's test.

In 1987, Kurosaka described that the weakest link in the reconstruction was the fixation site atleast until the graft heals [20].

In 1988, M J friedman [21] pioneered arthroscopic assisted four stranded hamstring graft technique.

Lee in 1988, Fischer and Fox in 1991 the high sensitivity and specificity of MRI in diagnosing ACL tears.

By the 1990s, Jones procedure which used free bone patellar tendon bone graft harvested from the central one-third of the patella became the “Gold Standard” of treatment [16].

In 1991, Shelbourne [22] advised three weeks delay in reconstruction after injury to avoid Arthrofibrosis.

In 1992, Tom Roseberg [23] devised endobutton as fixation device for ACL reconstruction.

Though arthroscopic intraarticular reconstruction has become the gold standard in this century, there are still controversies regarding the choice of graft, fixation implants, single or double bundle reconstruction and either through trans portal or through trans tibial technique.

More recent studies have proven that the hamstring tendon as a graft is more superior to bone patellar tendon bone graft [24]. Though the hamstring tendon graft has minimal harvest site morbidities, the time for healing and hamstring weakness post operatively are still its considerations. Though bone patellar tendon bone graft offers advantage of direct bone to bone healing, post operative stiffness, anterior knee pain and prolonged rehabilitation have placed it inferior to hamstring tendon graft.

Regarding fixation of the soft tissue graft, endobutton and bone mulch screw have been proven to have a very high yield load than any other fixation device [25].

ANATOMY

EMBRYOLOGY [26]

The knee originates from vascular femoral and tibial mesenchyme in the fourth week of gestation between the blastoma of femur and tibia. The Anterior cruciate ligament appears early by 6.5 weeks. It begins ventrally and gradually invaginates with the formation of the intercondylar space. By 9 weeks, the cruciate ligaments contain numerous immature fibroblasts with scanty cytoplasm and fusiform nuclei. After 20th week, the ACL does not change in form. During these stages two main bundles are detectable, but the bundles are more parallel in comparison to the bundle orientation in an adult ACL. ACL is surrounded by a fold of synovium, resembling the mesentry which originates from the posterior capsule.

GROSS ANATOMY

The Anterior cruciate ligament is an intraarticular ligament but extra synovial. It runs from the femur to the tibia in anteromedial direction. The ACL consists of two bundles, the Anteromedial and the Posterolateral bundles, which are named based on their tibial insertion [27].The length of ACL varies from 22 to 41 mm and width of ACL

Figure 1: Bundles of ACL

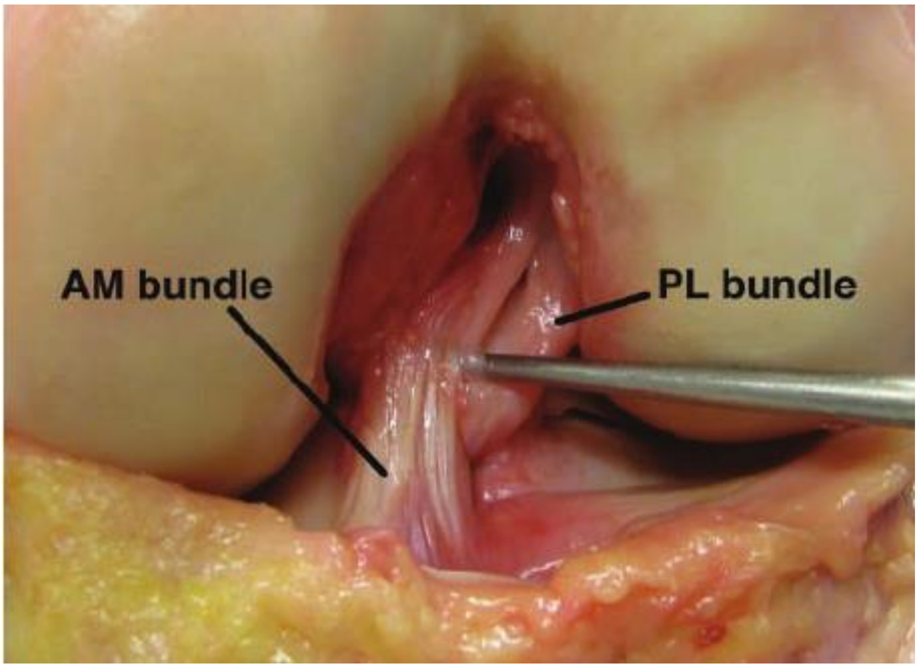
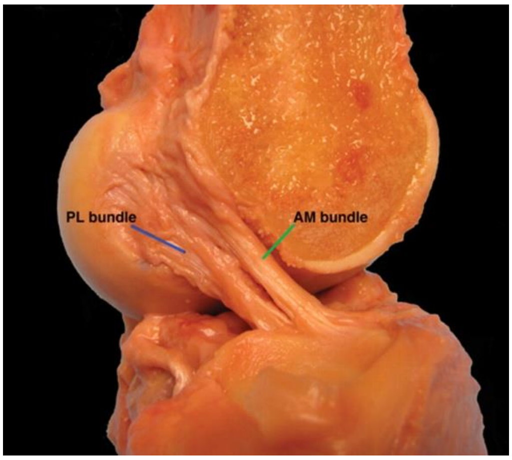
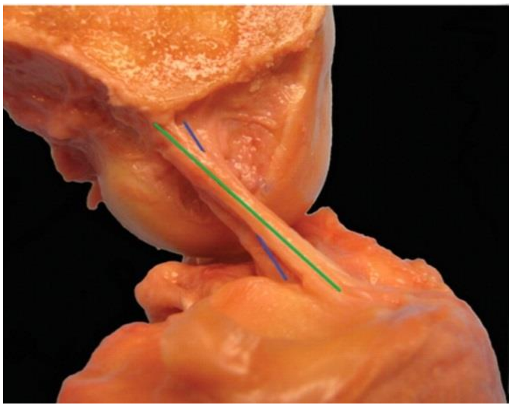


Figure 2: Bundles of ACL



In extension



In flexion

ranges from 7 to 12 mm. The ACL is narrowest in the mid substance. The ligament is 31.3 mm^2 in cross section [28, 29, 30]. The Anteromedial bundle becomes taut in flexion and the Posterolateral bundle becomes taut in extension.

FEMORAL ATTACHMENT

The femoral origin of the ACL is from the medial aspect of lateral femoral condyle, posterior to the lateral intercondylar ridge (Resident's ridge). The Anteromedial bundle arises superiorly and anteriorly and the Posterolateral bundle arises posteriorly and inferiorly [31].

Anatomically, femoral attachments of these bundles are separated from each other by the lateral bifurcate ridge, which runs from anterior to posterior on the femur [32]. Based on the posterior outlet of the femoral intercondylar notch, it is described that the Anteromedial bundle is attached between 9.30 and 11.30 o'clock position and Posterolateral bundle is attached between 8.30 and 10 o'clock position [33]. The centers of these two bundles are about 8 to 10 mm away [34].

TIBIAL ATTACHMENT

The anterior cruciate ligament originates from the medial tibial plateau, anterolateral to the anterior tibial spine, just medial to the insertion of the anterior horn of the lateral meniscus. The tibial insertion site is 120% larger and hence more secure than the femoral insertion site [35]. The most commonly used landmarks for the tibial foot print are the PCL (ACL lies about 7 to 10.4 mm anterior to the PCL), the posterior border of the anterior horn of the lateral meniscus which usually aligns with the centre of the AM bundle, and the medial tibial spine (PL bundle is 4 ± 1 mm and the AM bundle is 5 ± 1 mm from medial tibial spine) [36, 37, 38].

VASCULAR SUPPLY

Middle geniculate artery contributes to the major blood supply of ACL, which enters the intercondylar notch piercing the posterior capsule near the femoral attachment. The inferior, medial and lateral geniculate arteries also supply the Anterior cruciate ligament through the retropatellar fat pad. The bony insertion sites of the anterior cruciate ligament contribute little to its vascularity. In addition to the above

Figure 3 : Tibial and Femoral Attachments of ACL

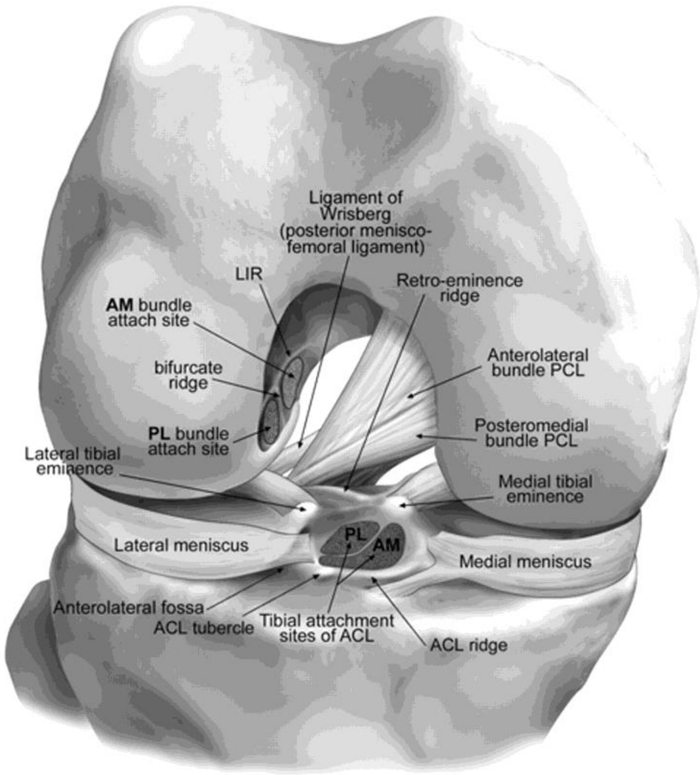
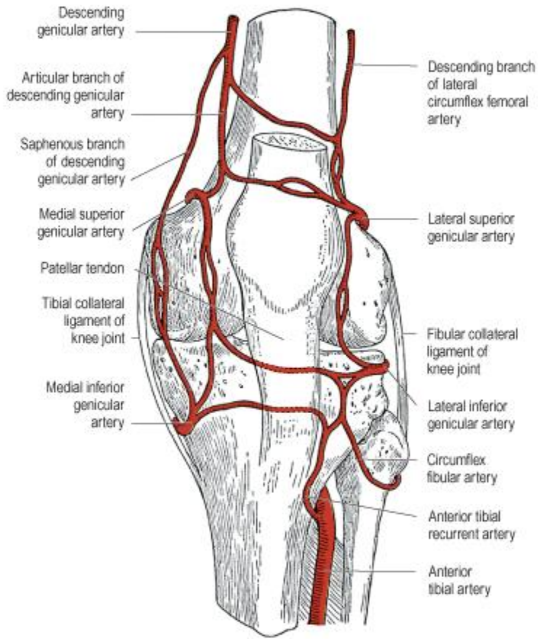


Figure 4 : Blood Supply of ACL



sources, the ACL also receives nutrition by diffusion from the synovial fluid [39].

NERVE SUPPLY

Posterior articular nerve, a branch of the tibial nerve innervates the Anterior cruciate ligament. Histological studies reveal that the intra fascicular spaces contain nerve fibers that transmit pain. Surface of the ACL contains Mechanoreceptors at their insertions, beneath the external synovial sheath especially near the femoral attachment. The receptors found are primarily Ruffini receptors and free nerve endings which function as stretch receptors and nociceptors respectively [40].

FUNCTION

Being the prime stabilizer of the knee, the major function of Anterior cruciate ligament is to resist anterior translation of the tibia on the femur and guides tibial rotation during the screw home mechanism allowing smooth locking of the knee [41].

The Posterolateral bundle resists anterior tibial translation in extension and the Anteromedial bundle resists anterior tibial translation in flexion. In extension, the Posterolateral bundle is taut, and the Anteromedial bundle is lax. With knee flexion, the ACL becomes more horizontal, allowing the vertical Posterolateral bundle to lose tension and at the same time tightens the more horizontal Anteromedial bundle [28].

Secondary functions of the Anterior cruciate ligament include resistance to tibial rotation and varus and valgus angulation. Recent studies have demonstrated proprioceptive function due to the free nerve endings in the ACL [42].

HISTOLOGY [43]

The anterior cruciate ligament consists of multiple fascicles arranged longitudinally which is surrounded by connective tissue called the paratenon.

There are multiple sub fascicles within each fascicle and are enclosed by an Epitenon. The sub fascicle appears to have an undulating course arranged in various directions. They consist of group of sub fascicular units (100-250 µm in diameter), which are composed of fibres (1-20 µm in diameter) surrounded by the endotenon. Each fibre which is made up of collagen fibrils interlaces to form complex networks. Cells and elastic components account for 6% of all ACL tissue. Elastic and oxytalan fibres can be found distributed along individual bundles.

The fibrils of ACL are organized in a combination of a helical and planar wave pattern which is quite unique. The combination of parallel or twisted, nonlinear networks enhances the ACL to withstand enormous loads. The wave pattern is interpreted as a crimp and non linear pattern is interpreted as recruitment. At small loads, fibril crimp straightens before large loads affect elongation. With increasing tensile deformation, more of these fibrils become load bearing. During biomechanical testing, this results in non-linear load deformation curve with increasing tissue stiffness under increased load. This phenomenon offers the ACL to protect the joint further rapidly.

BIOMECHANICS

The normal Anterior cruciate ligament withstands loads throughout the entire range of movement of the knee. The ligamentous structures compensate for tensile stresses providing stability to the knee joint. Consequently, the ACL can fail at different loads, which depends on the direction of the load and position of the knee at the time of injury. Tensile strength of the Anterior cruciate ligament depends on age, range of knee flexion, direction of load and the rate at which the load is applied. Hence the maximal strength of the ACL is not a fixed value. The ultimate load and stiffness of ACL is 1725 ± 269 N and 182 ± 33N/mm. The energy absorbed to failure is 12.8 ± 2.2 N-m [44]. In younger individuals, the ultimate load of ACL is 2160 ± 157 N and the stiffness 242 ± 28 N/mm [45].

The anteromedial fibres of the ACL are tense principally in flexion while the posterolateral fibres are in increasing tension as the knee is extended. The reciprocal relationship of the bundles provides stability throughout the entire arc of knee motion administering assistance to the roll and glide mechanism of the femur condyles over the tibial plateau [46].

MECHANISM OF INJURY

ACL injuries occur due to contact or more frequently noncontact mechanisms of injury. ACL injury can occur by any of the following mechanisms

(1) Flexion, abduction and internal rotation

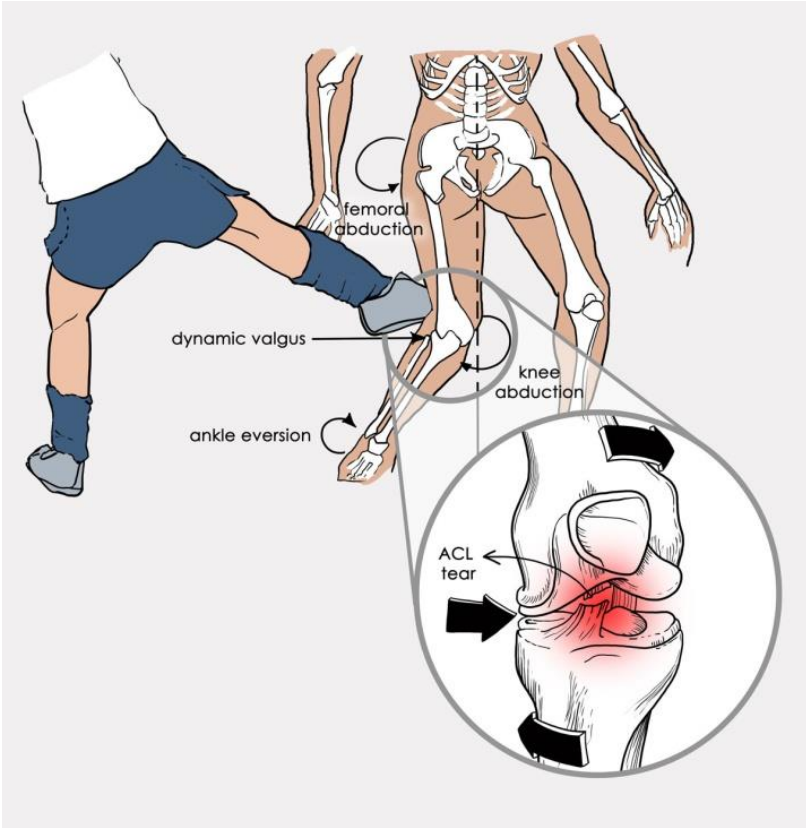
(2) Hyperextension and

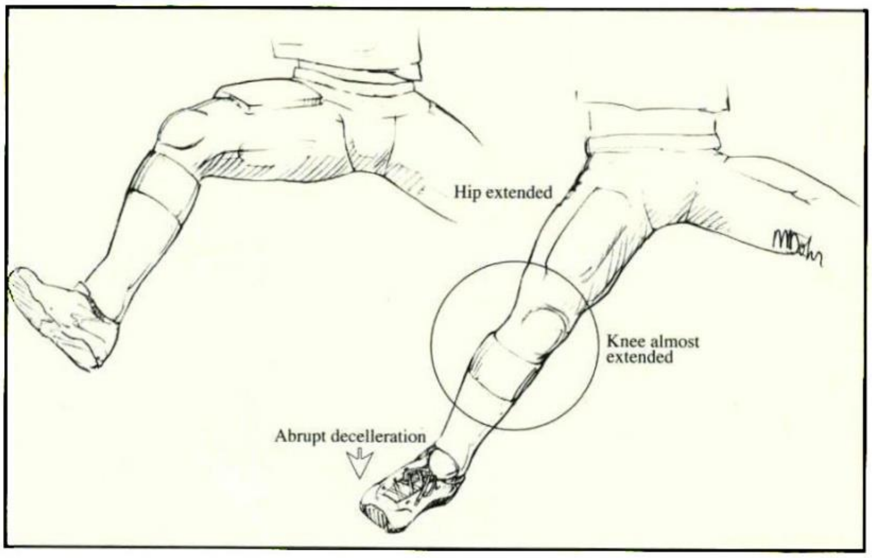
(3) Anteroposterior displacement.

Injury to the ACL may be isolated or associated with injuries to other structures of the knee. When the weight bearing leg is struck from the lateral aspect as in a sport, abduction, flexion, and internal rotation of the femur on the tibia occur, which is the most common mechanism of ACL injury. ACL injury is sometimes associated with injury to the medial collateral ligament and medial meniscus resulting in "the unhappy triad" of O'Donoghue.

Hyperextension produces high tibio-femoral compressive forces, which causes the anterior translation of tibia to rupture the ACL. Dashboard injuries, where femur and tibia are subjected to Anteroposterior forces can result in ACL tear depending on the direction towards which the tibia displaces.

Figure 5 : Mechanism of Injury of ACL





Isolated ACL disruption is more common than other structures of the knee. Pure deceleration possibly disrupts only the Anterior cruciate ligament with no or minimal injury to associated structures [47].

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. Sudden disruption of the screw home mechanism leads to the injury of ACL.

Various intrinsic and extrinsic factors contribute to ACL tear. Intrinsic factors are those which cannot be modified such as the size of the ligament, notch width, physiological alignment of the joint, laxity, hormonal effects, inherited skills and coordination. Extrinsic factors are those which can be modified such as strength, conditioning and motivation. Though many factors influence, the most important factor contributing to ACL tear is the dynamic movement pattern rather than the static anatomic measurements.

NATURAL HISTORY

Natural history of the injury influences the modality of treatment and its forthcoming complications. Since all knee injuries are not reported and not all ACL injuries are symptomatic, the path which an

ACL deficient knee follows is still controversial. It is a well known fact that when an ACL deficient knee is subjected to repetitive episodes of instability, meniscal tears and osteochondral injuries eventually occurs that finally lead to arthrosis[48].

Meniscal tears are more common with acute Anterior cruciate ligament injuries and its incidence ranges from 50% to 70%. Lateral meniscal tear occurs more frequently in acute knee injuries, whereas in chronic knee injuries medial meniscal tears are more common [49].

The incidence of osteochondral damage which occurs during the initial injury ranges from 21% to 31% and has an impact on the prognosis. Osteochondral injuries are thought to be a precursor of osteoarthritis, which further leads to arthrosis.

CLINICAL EVALUATION

Clinical evaluation begins with obtaining a complete and accurate history of the patients complaint, the mode of its onset and the order in which the symptoms were first observed.

A twisting injury to the knee due to a fall or RTA or sporting activity is usually the most common history. An audible pop during the injury, inability to walk after the injury and increasing swelling of the knee joint are suggestive of Anterior cruciate ligament tear. With associated hemarthrosis, the possibility of ACL tear is around 70%. Pain and sense of giving way are the usual symptoms at presentation. Non contact injuries are commonly associated with ACL tear while contact injuries are commonly associated with multi ligament injuries. 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 cruciates. 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. Patient's socioeconomic status, occupational and personal requirements are important in individualizing patient treatment.

EXAMINATION OF ACL

General examination of the patient with inspection, palpation, measurements and movements of the knee joint are done, which is followed by various tests to accomplish the diagnosis and plan the treatment. The tests for Anterior cruciate ligament are

1. Anterior drawer test
2. Lachman's test
3. Pivot shift test
4. Slocum test

Other tests include

1. McMurray's test for meniscus
2. Valgus/varus stress test for collateral ligaments
3. Reverse pivot shift test
4. Dial test

Anterior Drawer Test [50]

The Anterior drawer test is done with the patient in supine position. The hip joint is flexed to 45 degrees and knee joint is flexed to

90° and foot is stabilised by sitting over the anterior surface of foot. With both the hands holding the proximal tibia and the index fingers relax the hamstrings, the tibia is pulled forwards. Any movement of tibia over the femur is observed and compared with the opposite side. A pull of more than 6mm in comparison to the opposite knee with a soft end point indicates ACL tear.

Lachman's Test [51]

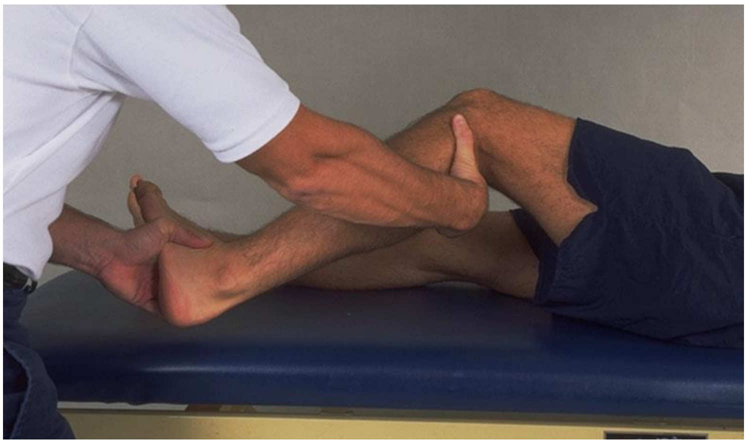
The Lachman's test is done with the patient in supine position and with the knee in 30 degree flexion. The thigh is stabilized with one of the hands, and the other hand holds the proximal leg. Holding the limb in this position, a firm pressure is applied in an attempt to displace the proximal tibia anteriorly and posteriorly. Any anterior translation of tibia with a soft end point signifies ACL tear. The Lachman's test is graded as 1 (1 to 5 mm of translation), 2 (6 to 10 mm), or 3 (>10 mm). In obese patients, this test can be performed by fixing the femur between the hand and flexed knee over the couch.

In patients with acute knee injury, the patient presents with haemarthrosis and 90 degree flexion of the knee is difficult. Performing anterior drawer test in such conditions is difficult. Also anterior drawer

Figure 6 : Anterior Drawer Test

Figure 7 : Lachman's Test

Figure 8 : Pivot Shift Test



test can be false negative in patients with ACL tear associated with posterior horn of medial meniscus tear. Hence Lachman's test can be used to examine for ACL injury in acute conditions and in patients with associated posterior horn of medial meniscus tear.

Pivot Shift Test [52]

This test demonstrates a relative subluxation reduction phenomenon of the ACL-deficient knee. The foot is lifted with the knee in extension and internal rotation. With the opposite hand, Valgus stress is applied over the fibular head and the knee is slowly flexed maintaining the valgus and internal rotation, the anteriorly subluxated knee slowly relocates around 15 and 20 degrees of flexion. The magnitude of the pivot shift phenomenon is classified as grade 1 (slip or spin), grade 2 (jump), or grade 3 (transient lock).This test is difficult to do with muscle spasm and it can be demonstrated easily with the patient anaesthetized.

The most sensitive test to detect an ACL tear is Lachman's test, whereas the pivot shift test is pathognomonic of an ACL-deficient knee. The anterior drawer test has poor sensitivity.

Slocum Test [53]

The Slocums modification of anterior drawer test is performing the anterior drawer test in neutral, in 30 degrees external rotation of the knee and in 15 degrees internal rotation of the knee. Accentuated anterior translation in external rotation indicates anteromedial instability and increased translation in internal rotation indicates anterolateral instability.

Along with the standard ACL tests, we should perform a Posterior cruciate ligament examination that includes the posterior drawer test and posterior sag tests. Varus - valgus testing at 0 and 30 degrees is performed to exclude the presence of a medial or lateral collateral ligament injury. McMurray’s test in both flexion and extension should be performed to clinically evaluate meniscal injury.

RADIOGRAPHIC EVALUATION

X-RAYS

The use of radiographs is limited in diagnosing ACL injury. X ray of the knee joint, both anteroposterior(AP) and lateral views are necessary to diagnose fractures, degenerative changes and malalignment. Plain films can demonstrate haziness in Hoffa's fat, a joint effusion and may reveal subtle fractures or an avulsion fracture of the proximal tibia immediately distal to the lateral plateau known as segond fracture or lateral capsular sign. Segond fracture is pathognomic of ACL injury. 75% to 100% of patients with segond fracture have an associated ACL injury. Tibial attachment avulsions are more commonly detected on plain radiographs. Stress views are taken to demonstrate ACL injury. Anterior drawer sign is elicited and lateral views are taken with or without stress. An anterior translation of more than 5mm is abnormal. A difference of more than 3 mm with the contralateral knee is significant.

COMPUTED TOMOGRAPHY

Though ACL can be visualized on CT, it is difficult to delineate its structure and contour in the presence of hemarthrosis. If an avulsion injury is diagnosed in an x- ray, the size and comminution of the avulsed bone fragment can be evaluated with a CT. Three-dimensional reconstruction allows adequate fracture understanding. CT arthrography can also be taken but its accuracy in detecting cruciate and meniscal injuries are equivocal with MRI [54].

MAGNETIC RESONANCE IMAGING

MRI is taken in supine position with the knee within the extremity coil, avoiding excessive extension or flexion. The sagittal images of the knee are taken in 15 degrees internal rotation from true sagittal plane which is parallel to the course of Anterior cruciate ligament.

MRI offers direct, non invasive visualization of the ACL and other soft tissue structures improving the pre operative assessment of internal derangement. MRI has 92% sensitivity, 95% specificity and 94% accuracy in diagnosing ACL injuries [55].

Normal ACL

The normal ACL with the knee in extension should have a taut, straight anterior margin with hypo intense band with mixed areas of low to intermediate signal. The tibial attachment of the ACL has relatively increased signal density. On the sagittal images, the normal ACL

Figure 9 : Normal ACL in MRI

Figure 10 : Injured ACL in MRI

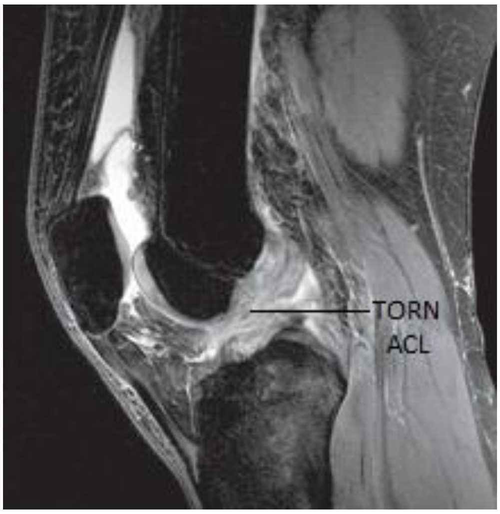
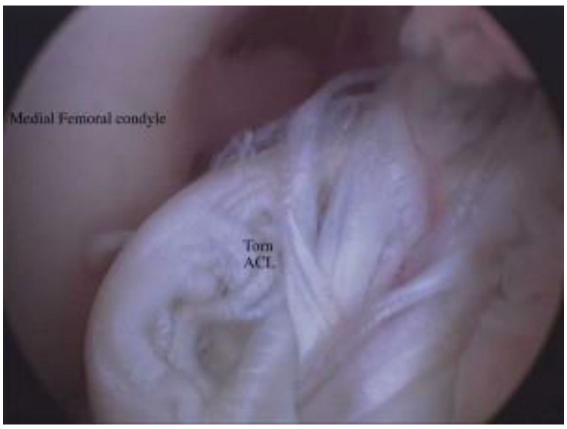


Figure 11 : ACL Tear in Diagnostic Arthroscopy



appears as solid or striated band and its course is in parallel orientation to the roof of the intercondylar notch.

Injured ACL

Signs of acute ACL tear include non visualization of ACL, disruption of signal intensity, deviation from its normal axis where its course is not parallel to the roof of intercondylar notch and abrupt angulation or wavy appearance. Chronic tears are evident with, absent surrounding edema like signal intensity and “empty notch sign” where the ACL is absent. Anterior translation of the tibia over the femur in MRI is highly specific for acute and chronic ACL tears. Secondary signs of ACL injury in MRI include buckling of the Posterior cruciate ligament, bone contusions in lateral femoral condyle and posterolateral tibial plateau, uncovered posterior horn of the lateral meniscus and anterior drawer sign (>7mm anterior tibial translation).

DIAGNOSTIC ARTHROSCOPY [56]

Arthroscopy, with easy accessibility has evolved as a diagnostic modality with higher sensitivity and specificity than MRI. Diagnostic arthroscopy done with the knee in 45 to 90 degree flexion allows better exploration of the Anterior cruciate ligament. Since 80% of ACL tears are usually at the femoral insertion, it is important to visualize the origin clearly.

The anterolateral portal offers adequate visualization of the tibial insertion and whole of the ACL. Anteromedial portal best visualizes the femoral insertion of the ACL and arthroscopic exploration is easier and comfortable with this portal.

The appearance of the Anterior cruciate ligament varies from patient to patient, depending on its anatomy, the presence or absence of injury, and the synovial covering. Occasionally, the various anatomical bands of the anterior cruciate ligament appear as distinct bundles. In a normal Anterior cruciate ligament, the synovial covering usually is thin, with small capillaries coursing on the surface.

ACL is usually covered by a synovial covering which may or may not be present following an injury. In complete ACL tear hemorrhage is observed within synovial tissues. In presence of inflammation, retraction of fat pad, ligamentum mucosae and other tissues may be necessary to visualize the Anterior cruciate ligament. Injury to the synovial covering exposes the fibres of the torn ACL as white “mop end” structures. ACL needs to be probed and it is necessary to examine its tension under arthroscopic vision. Normal ACL feels stiff and tense when pulled with a probe, whereas a torn ACL feels soft without tension. Intra operatively, Anterior drawer test and Lachman’s test are performed under vision and anteroposterior stability is visualized. In Anterior cruciate ligament tear anterior translation of tibia is evident while these tests are performed.

MANAGEMENT [56]

The aim of ACL reconstruction is to attain functional stability of the knee. An isolated ACL tear is extremely common and resulting in instability of the knee. As ACL doesn’t heal with repair, reconstruction is the only possibility. For an active, healthy person who wishes to return to daily routine, reconstruction of the ACL is necessary.

There are three types of procedures for ACL insufficiency.

1. Extraarticular reconstruction
2. Intraarticular reconstruction
3. Combined

EXTRAARTICULAR RECONSTRUCTION

These procedures aid in supporting the lateral aspect of the knee by creating a rigid band parallel to the anterior cruciate ligament without interfering with intraarticular vascularity. Extraarticular procedures most commonly use the iliotibial band for reconstruction of ACL which connects the lateral femoral condyle in the superior aspect to the Gerdy tubercle inferiorly. Since the lateral side of the knee is stabilized with extraarticular reconstruction they may reduce the anterolateral rotatory subluxation whereas they fail to recreate the anatomy or function of native ACL. Due to these limitations, extraarticular techniques had high failure rates and were considered futile when performed as a sole procedure. The various extraarticular techniques described by MacIntosh, MacIntosh modified by Losee and Andrews are as follows

1. Iliotibial band tenodesis
2. Biceps plasty

INTRA ARTICULAR RECONSTRUCTION

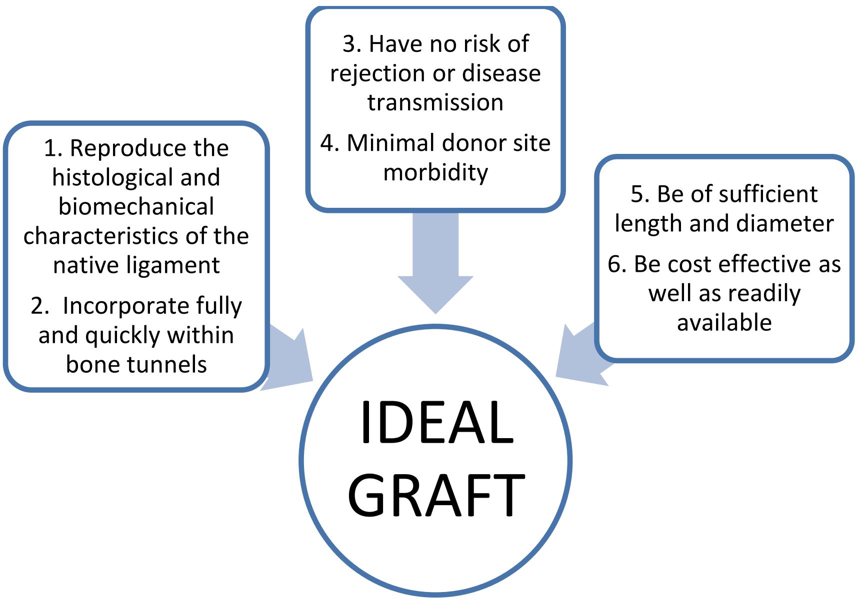
Open intraarticular reconstruction of the ACL was initially done, followed by mini open techniques. Advancements in instrumentation and high demand of the patients led to the evolution of arthroscopic reconstruction of ACL. Arthroscopic reconstruction has the advantages of earlier resolution of postoperative pain, minimal donor site morbidities and earlier return to daily routine. With either technique, it is preferable to reconstruct the ACL only after the resolution of inflammation to prevent arthrofibrosis. The intraarticular techniques include

1. Trans tibial technique
2. Trans portal technique

3. Single bundle reconstruction
4. Double bundle reconstruction

GRAFT SELECTION

The ideal graft is a graft which would satisfy the following



Various graft choices available for ACL reconstruction are autografts (bone patellar tendon bone graft, hamstring tendon graft, quadriceps tendon graft, peroneus longus tendon graft), allografts (tendoachilles allograft, quadriceps tendon allograft) and prosthetic grafts [57].

The various graft choices and their advantages and disadvantages are as follows

	GRAFT CHOICES	ADVANTAGES	DISADVANTAGES
1.	Patellar tendon autograft	1. High tensile strength 2. Good bone to bone healing	1. Patellofemoral pain 2. Tendinitis 3. Fracture of patella 4. Neuropathy
2.	Hamstring tendon autograft	1. Lesser donor site morbidity	1. Ultimate tensile load is obtained only when the strands are tripled or quadrupled 2. Lack of rigid bony fixation
3.	Allograft	1. Improved cosmesis 2. Less operative time 3. Eliminates donor site morbidity 4. Unlimited graft supply	1. High cost 2. Delay in graft incorporation 3. Higher rates of infection 4. Immune response
4.	Prosthetic graft	1. Good post operative results	1. Eventual mechanical failure

MATERIALS AND METHODS

This is a study done on 20 patients presenting with knee instability treated with arthroscopic reconstruction of ACL with hamstring tendon autograft between July 2015 and July 2016 at Government Stanley Hospital, Chennai.

INCLUSION CRITERIA

Patients aged more than 18 years of age irrespective of sex with

1. Isolated ACL injury (clinical instability / MRI evidence of ACL injury)
2. ACL injury (clinical instability / MRI evidence of ACL injury) associated with medial / lateral meniscal tears

EXCLUSION CRITERIA

1. Patients less than 18 years of age
2. Patients with ACL injury associated with multi ligament injuries
3. Patients with joint laxity;Beighton score > 4
4. Patients with associated fractures

5. Patients with signs of infection
6. Patients with Malalignment and deformity
7. Patients with prior knee surgery

INSTRUMENTATION

A variety of specialised instruments are required for Arthroscopic reconstruction of ACL. Improvements in instrumentation allow refining the precision of the technique. Arthroscopic instruments for ACL reconstruction consists of

1. Arthroscope (30 degree)
2. Camera
3. Light source and fibre optic light source cable
4. Television monitor
5. Motorised shaving system with shaver blades

Other equipment's needed for surgery are

1. Tourniquet set (pneumatic)
2. Irrigation system
3. 2.4 mm drill tip guide pins

Figure 12 : Instruments in Knee Arthroscopy

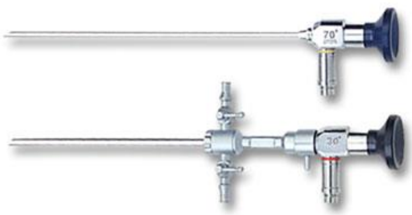
Grasping Forceps & Basket Forceps

Probe

Motorised Shaver System

ACL Set

Arthroscope



Trocar and Cannula

4. Trocar
5. Canula
6. Probe
7. Basket forceps
8. Grasping forceps
9. Tibial zig
10. Cannulated headed reamers (size 5mm to 10mm)
11. Bone awl
12. Extra long 2.4 mm guide pin with suture eye (Beath – type guide pin)
13. 4.5 mm cannulated reamer for passage of endobutton
14. Depth gauge
15. Sizing block

GRAFT FIXATION IMPLANTS

1. Cannulated Interference screw
2. Endobutton

Soft tissue grafts can be fixed with either direct fixation devices or indirect fixation devices. Direct fixation devices where the graft is anchored to the tunnel without any additional support other than the fixation device itself includes interference screws, staples, washers, and cross pins. Indirect fixation devices are devices which provide linkage between the graft and the fixation device that includes endobutton, suture post and anchors. In this study endobutton has been used for femoral tunnel fixation and interference screws for tibial tunnel fixation.

Interference Screw

Interference screw is the most favored fixation device, which holds the graft to the bone following insertion between the graft and the bone tunnel. Interference screws are made up of variety of materials. Metal screws, bio absorbable screws and titanium screws are available. Interference screw should be placed parallel to the graft and the bone tunnel to avoid screw divergence. Though this device provides rigid fixation to the soft tissue graft, technical implementation during fixation significantly affects the ultimate failure load. Failure of this device may occur due to the following complications.

1. Inadvertent graft advancement

2. Laceration of the soft tissue graft by the screw threads

3. Blowout of the tunnel (most commonly in femur)

Figure 12A: Implants

ENDOBUTTON

CANNULATED INTERFERENCE SCREW

Despite the complications, interference screw used as a fixation device has shown comparable results in fixation of both soft tissue grafts and bone patellar tendon bone grafts.

Endobutton

Endobutton is an indirect fixation device which aids in maintaining strong and secure fixation of the soft tissue graft. Endobutton offers easy technical placement and additional protection from laceration of soft tissue graft and blowout of the tunnel. Endobutton has four holes of which the two centre holes are used to create the loop for the graft and the peripheral two holes are for passing the ethibond which are used to flip the endobutton. Endobutton allows more posterior placement of the femoral tunnel which prevents graft impingement and ensures complete bone to graft contact.

METHODS

PRE OPERATIVE WORK UP

Patients presenting to the OPD with knee instability were clinically examined for ACL insufficiency and confirmed with MRI were admitted in Govt. Stanley Hospital. Routine blood investigations such as Haemoglobin, Total counts, Differential counts, Platelet count, ESR, CRP, Blood sugar, Renal parameters, Chest x ray and ECG were taken and anaesthetist fitness was obtained for regional and general anaesthesia. Static and dynamic quadriceps exercises were taught to patients while awaiting surgery.

PATIENT POSITIONING

All patients were operated with strict aseptic precautions and under spinal anaesthesia. Anterior drawer test, Lachman's test and Pivot shift test were done under anaesthesia. With the patient supine, knee is flexed to 90 degrees and a removable side support is fixed to support the thigh. A bolster is placed beneath the foot holding the knee in 90 degree flexion. In all cases, a pneumatic tourniquet was applied over the proximal thigh with adequate padding and leg holder was applied over it. The limb was prepared and betadine pre scrub was given to entire

Figure 13 : Patient Positioning

lower limb. Then parts were painted and draped exposing only the distal thigh, knee and proximal leg. Preoperative antibiotic usually of 1 g Cefotaxime was given before inflating the tourniquet.

ARTHROSCOPIC PROCEDURE

The outlines of the patella, medial and lateral border of the patellar tendon and medial and lateral joint lines were drawn with a skin marking pen. An anterolateral portal was established just below the inferior pole of patella immediately next to the lateral border of patellar tendon. With the knee extended trocar and canula were inserted in to the suprapatellar pouch. Continuous flow of normal saline from 3 litre saline bottles was maintained through the TURP set. After adequate distension of the joint, scope was introduced and diagnostic arthroscopy was done visualising the suprapatellar pouch, lateral gutter, intercondylar notch, under surface of patella, medial gutter and articular surfaces of femoral condyles and proximal tibia. An anteromedial portal or the working portal was established 1 cm above the medial joint line, 1 cm below the inferior pole of the patella, and 1 cm medial to the edge of the patellar tendon. The menisci were visualised and probed to reveal meniscal tears. ACL is probed to reveal the site and amount of tear.

Depending on the site and type of meniscal tear, meniscal injuries were treated with partial menisectomy and debridement.

GRAFT HARVEST AND PREPARATION

A 4-cm oblique skin incision was made over the anteromedial surface of the proximal tibia which is about 4 cm below the medial joint line and 3 cm medial to the tibial tuberosity. The subcutaneous tissues were dissected and pes anserinus insertion was identified. The semitendinosus and gracilis tendon were palpated by running the fingers from above downwards in the anteromedial aspect of the proximal tibia. The incision was further elongated if required and Sartorius fascia was exposed and cut. Gracilis and semitendinosus tendons were carefully dissected from the surrounding soft tissues and identified and localised using a right angle forceps. The tendons were released from the fibrous extensions and secured. A closed tendon stripper encircling the tendon was advanced with minimal counter traction securing the tendon. The stripper was carefully advanced with the knee held in 70 degree flexion and precautions were taken to prevent the amputation of the graft. The stripper is advanced till the tendon muscle junction was cut and the tendon is harvested.

Figure 14 : Graft Harvesting & Preparation

The harvested graft was prepared by clearing the muscle remnants and the graft ends were stitched together with a running whip stitch 4 to 5 cm from the free ends with polybraided nonabsorbable suture material (number 2 ethibond). The graft size was then measured using a sizer, by pulling the graft across the sizer and the prepared graft was protected in a moist cotton gauze piece.

INTRAARTICULAR PREPARATION

The arthroscope was introduced through the anterlateral portal and motorised shaver system with the shaver blade was inserted through the anteromedial portal and the joint was debrided of the ligamentum plicae, fat pad and some synovial reflections which hinder a thorough visualisation of the lateral intercondylar ridge and the tibial and the femoral foot print of the anterior cruciate ligament. The medial surface of the lateral femoral condyle was debrided and the lateral intercondylar ridge (resident’s ridge) is identified. Remnants of native ACL were retained to allow better proprioception. The tibial foot print of ACL was then identified and debrided. While debridement, undue care was taken not to injure the native Posterior cruciate ligament.

FEMORAL TUNNEL

In this study, the femoral tunnel was created by trans portal technique. With the knee in 90 degree flexion, under arthroscopic vision, bone awl is passed through the anteromedial portal and tunnel entry is made over the femoral foot print of ACL. Femoral tunnel entry is placed at the posterior edge of the notch approximately 7 mm lateral to the posterior cruciate ligament and to leave atleast 2mm of intact posterior cortex to avoid blow out. If the graft diameter was greater than 10 mm then the femoral tunnel entry was placed little more anteriorly to avoid posterior blow out. The long drill tip guide wire was then drilled through the entry made at lateral femoral condyle to exit through the anterolateral aspect of lower thigh.

The intraarticular length of the graft was then measured and the lateral femoral condyle was drilled with 4.5 mm reamer and the anterolateral cortex was breached to establish a tunnel for the passage of endobutton.

After reaming the femoral tunnel with a 4.5 mm reamer, the length of the femoral tunnel was measured with a depth gauge. Having known the intraarticular length of the graft and the whole length of the graft, the length of the graft to be in the femoral condyle was marked as desired.

Having known the length of the femoral tunnel and the desired graft length in femur, the loop length in the endobutton was calculated and an adequate loop length endobutton CL ultra was chosen. The harvested graft was then passed through the loop made in the endobutton and the free ends of combined gracilis and semitendinosus tendons were again whip stitched with a number 2 ethibond. The femoral condyle was then reamed over the guide pin with serial cannulated calibrated reamers to a length of around 5 to 6 mm greater than the desired graft length for the turning radius of the endobutton. Once the femoral tunnel was prepared, debri surrounding the tunnel were shaved off to allow smooth graft passage.

TIBIAL TUNNEL

After debridement of the tibial foot print of ACL, tibial tunnel was created with the tibial guide / tibial zig. With the guide set in 55 degrees, the tip of the guide was positioned at the centre of the ACL foot print of tibia. In chronic ACL tears where the ACL foot print could not be identified, the tip of the guide pin was positioned at the inner border of the anterior horn of the lateral meniscus, approximately 2 to 3mm anterior to the peak of medial tibial spine.

With the guide tip in correct position, the guide sleeve was inserted and advanced to the anteromedial part of the tibia through the previous incision made for harvesting the graft. The guide pin sleeve was flushed with the anteromedial cortex of proximal tibia, which eventually is at an angle of about 30 to 40 degrees with the tibia.

2.4 mm drill tip guide wire is advanced inside the sleeve and drilled through the tibial cortex to exit intraarticularly under arthroscopic vision. After ensuring the correct entry of 2.4 mm drill tip guide wire with the arthroscope, the tibial guide and the guide sleeve was removed. The tibial tunnel was then progressively reamed over the guide pin with serial cannulated calibrated reamers up to the desired size. During drilling and reaming, a small curved curette was placed intraarticularly to protect the tip of the guide pin or the reamers from injuring the articular surface. Once the tibial tunnel was created, debri surrounding the intraarticular exit were shaved off to allow easy graft passage and to avoid graft damage.

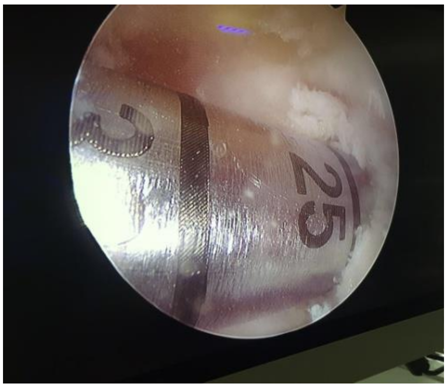
GRAFT PASSAGE AND FIXATION

The endobutton along with the graft in the loop and the leading and flipping suture in the peripheral holes were prepared and the sutures were passed through the eye of the guide pin. The guide pin is now pulled across the tibial and femoral tunnel and extracted along with the suture material across the anterolateral aspect of the lower thigh. The leading suture was pulled so that the graft was pulled through the tunnels headed by the end of the endobutton to which the leading suture is passed. Once the desired length of the graft was pulled in to the femoral condyle which was already marked, the flipping suture was pulled to flip the endobutton.

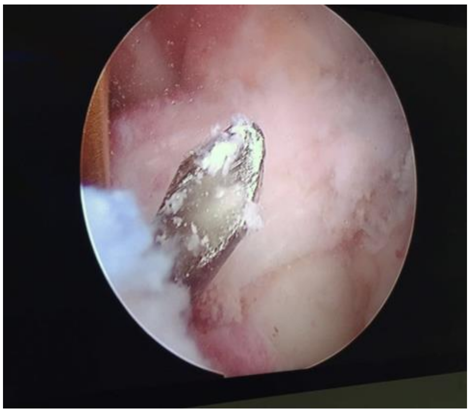
Once the endobutton is flipped and confirmed, the distal part of the graft was pulled down to seat the endobutton. With manual tension to the distal graft, cyclic loading of the graft was done with repeated flexion and extension of the knee and checked for impingement. After tensioning the graft, the position of the reconstructed ACL was confirmed and when there was no impingement with flexion and extension of the knee under arthroscopic vision, the tibial site was fixed with appropriate size interference screw and ensured that the screw has not breached the tibial articular surface.

Figure 15 : ACL Reconstruction

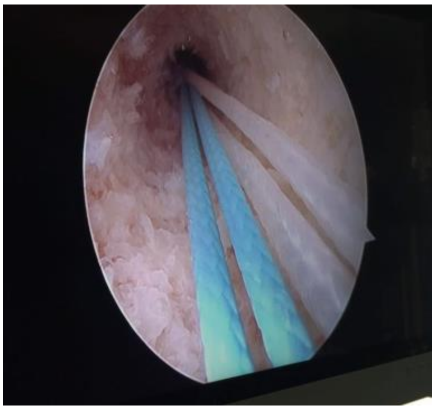
Femoral Tunnel Drilling



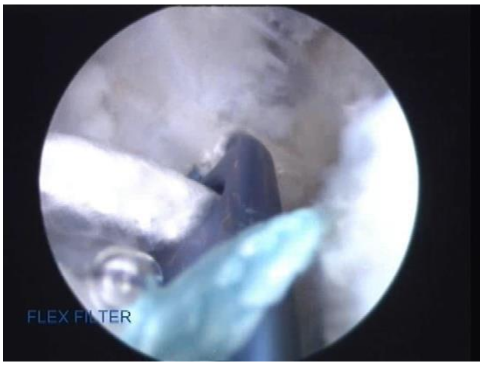
Guide Pin through Tibial Foot print



Femoral Tunnel



Passing Endobutton across the Tunnels



Reconstructed ACL

CLOSURE

Thorough wound wash was given and closed in layers at the graft harvest site. Intraarticular suction drain was placed and the portals were closed with non absorbable sutures. Sterile dressing was applied, tourniquet deflated and released and the knee was protected in full extension with a long knee brace. Distal pulse and neurological examination were done post operatively to check for neurovascular deficits.

POST OPERATIVE MANAGEMENT

The operated limb is immobilised in a long knee brace and kept in limb elevation in immediate post operative period.

Intravenous antibiotics were administered for 3 days. Drain removal was done routinely on the 2nd post operative day. Wound inspection and dressing was changed on 2nd, 5th, 7th and 10th post operative days. Suture removal was done on 12th post operative day. Rehabilitation was started as per the standard protocol and the patients were followed up at 4 weeks, 3 months and 6 months.

POST OPERATIVE REHABILITATION

The standard protocol for Anterior cruciate ligament rehabilitation was followed for each patient. Measures to prevent arthrofibrosis, joint contracture and joint laxity were taken.

Goal: To attain a stable knee with painless complete range of motion and normal muscle power.

1st Post operative day

1. Rest with the limb in full extension immobilised in a long knee brace
2. Static quadriceps and hamstring exercises
3. Ankle and foot movement

0 to 2 weeks

1. Full knee extension range of motion
2. 90 degree knee flexion range of motion achieved through passive, active and active – assisted ROM knee flexion
3. Good quadriceps setting
4. Straight leg raise without extension lag

5. Emphasize normal gait pattern
6. Partial weight bearing or weight bearing as tolerated with knee brace aided by a walker

3 to 4 weeks

1. Range of motion 0 to 120 degrees
2. Full weight bearing without walker
3. Progress straight leg raise with weights

5 to 10 weeks

1. Progress to full range of motion
2. Progress closed chain exercises
3. Progress hamstring and quadriceps exercises

11 to 18 weeks

1. Full range of motion knee extension exercises
2. Knee extension with low weight / high repetitions
3. Jogging program is initiated

5 to 6 months

1. To start agility training
2. To start sport specific drills

After 6 months

1. Return to sports once the training is completed
2. To continue maintenance exercises 2 to 3 times in a week

EVALUATION

Patients were followed up at 4 weeks, 3 months, 6 months and once in every 6 months thereafter. An anteroposterior and lateral radiograph of the knee joint were taken for each patient to determine the tunnel placement, position of the endobutton in femur and interference screw in tibia.

All patients were evaluated and graded with International Knee Documentation Committee (IKDC) examination form.

2000 - IKDC KNEE EXAMINATION FORM

Patient Name: **Date of Birth:** / / (Day Month Year)

Gender: ☐Male ☐ Female **Age:** **Date of Examination:** / / (Day Month Year)

Generalized Laxity:	☐ tight	☐ Normal	☐ Lax
Alignment:	☐ Obvious varus	☐ Normal	☐ Obvious valgus
Patella Position:	☐ Obvious Baja	☐ Normal	☐ Obvious Alta
Patella Subluxation / Dislocation:	☐ centered	☐Subluxable	☐Subluxed☐ Dislocated

Range of Motion (Ext/Flex): Index side: Passive / /Active / /
Opposite side: Passive / / Active / /

	SEVEN GROUPS		**FOUR GRADES** **A** **Normal**		**B** **Nearly Normal**		**C** **Abnormal**		**D** **Severely Abnormal**	***Group Grade** **A**	**B**	**C**	**D**
1.	**Effusion**	☐	None	☐	Mild	☐	Moderate	☐	Severe	☐	☐	☐	☐
2.	**Passive Motion deficit**												
	∆Lack of extension	☐	$<3^o$	☐	3 to 5^o	☐	6 to10^o	☐	$>10^o$				
	∆Lack of Flexion	☐	1 to 5^o	☐	6 to 15^o	☐	16 to 25^o	☐	$>25^o$	☐	☐	☐	☐
3.	**Ligament Examination**												
	(Manual, Instrumented, X-ray)												
	∆Lachman (25^o Flex) (134N)	☐	-1 to 2mm	☐	3 to 5mm (1^+)	☐	6 to 10mm (2^+)	☐	>10mm(3^+)				
				☐	<-1to-3	☐	<-3 stiff						
	∆Lachman (25^o Flex) (Manual max)	☐	-1 to 2mm	☐	3 to 5mm	☐	6 to 10mm	☐	>10mm				
	Anterior endpoint	☐	Firm			☐	Soft						
	∆Total AP translation (25^o flex)	☐	1 to 2mm	☐	3 to 5mm	☐	6 to 10mm	☐	>10mm				
	∆Total AP translation (70^o flex)	☐	1 to 2mm	☐	3 to 5mm	☐	6 to 10mm	☐	>10mm				
	∆Posterior Drawer Test (70^o flex)	☐	1 to 2mm	☐	3 to 5mm	☐	6 to 10mm	☐	>10mm				
	∆Med Joint Opening (20^o flex/Valgus Rot)	☐	1 to 2mm	☐	3 to 5mm	☐	6 to 10mm	☐	>10mm				
	∆Lat Joint Opening (20^o flex/Varus Rot)	☐	1 to 2mm	☐	3 to 5mm	☐	6 to 10mm	☐	>10mm				
	∆External Rotation Test (30^o flex Prone)	☐	$<5^O$	☐	6 to 10^o	☐	11 to 19^o	☐	$>20^o$				
	∆ External Rotation Test (90^o flex Prone)	☐	$<5^O$	☐	6 to 10^o	☐	11 to 19^o	☐	$>20^o$				
	∆Pivot Shift	☐	Equal	☐	+glide	☐	++ (Clunk)	☐	+++(gross)				
	∆Reverse Pivot Shift	☐	Equal	☐	glide	☐	Gross	☐	Marked				
										☐	☐	☐	☐
4.	**Compartment Findings**						**Crepitation with**						
	∆Crepitus Ant. Compartment	☐	None	☐	Moderate	☐	Mild pain	☐	>Mild pain				
	∆Crepitus Med. Compartment	☐	None	☐	Moderate	☐	Mild pain	☐	>Mild pain				
	∆Crepitus Lat. Compartment	☐	None	☐	Moderate	☐	Mild pain	☐	>Mild pain				
5.	**Harvest Site Pathology**	☐	None	☐	Mild	☐	Moderate	☐	Severe				
6.	**X-ray Findings**												
	Med. Joint Space	☐	None	☐	Mild	☐	Moderate	☐	Severe				
	Lat. Joint Space	☐	None	☐	Mild	☐	Moderate	☐	Severe				
	Patellofemoral	☐	None	☐	Mild	☐	Moderate	☐	Severe				
	Ant. Joint Space (Sagittal)	☐	None	☐	Mild	☐	Moderate	☐	Severe				
	Post. Joint Space (Sagittal)	☐	None	☐	Mild	☐	Moderate	☐	Severe				
7.	**Functional Test**												
	One Leg Hop (% of opposite side)	☐	≥90%	☐	89 to 76%	☐	75 to 50%	☐	<50%				
**** Final Evaluation**										☐	☐	☐	☐

* Group grade: The lowest grade within a group determines the group grade.

** Final Evaluation: the worst group grade determines the final evaluation for acute and subacute patients. For chronic patients compare preoperative and postoperative evaluations. In a final evaluation only the first 3 groups are evaluated but all groups must be documented.

∆Difference in involved knee compared to normal or what is assumed to be normal

OBSERVATION AND RESULTS

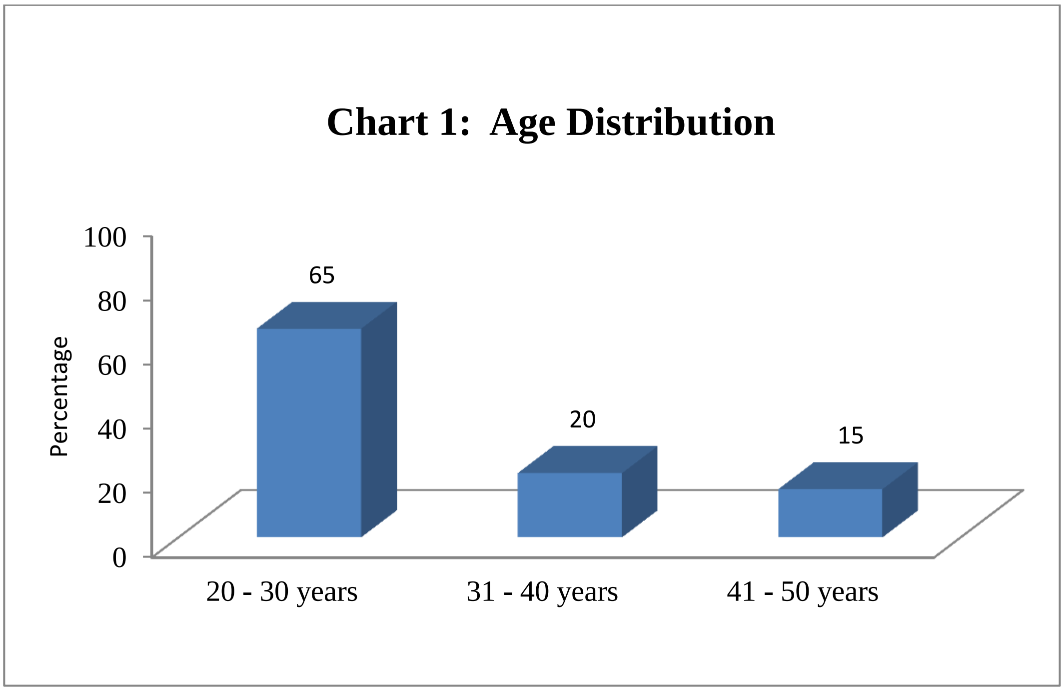
20 cases of arthroscopic reconstruction of Anterior cruciate ligament with hamstring tendon autograft using endobutton as the femoral fixation device and interference screw as the tibial fixation device were followed up from 3 months to 15 months. The mean follow up was 9 months.

AGE DISTRIBUTION

In this study the minimum age was 20 years and maximum age was 47 years with a mean age of 29.75 years (Table 1 and Chart 1).

Table 1: Age distribution

AGE	PATIENTS	PERCENTAGE
20-30	13	65
31-40	4	20
41-50	3	15
TOTAL	**20**	**100**



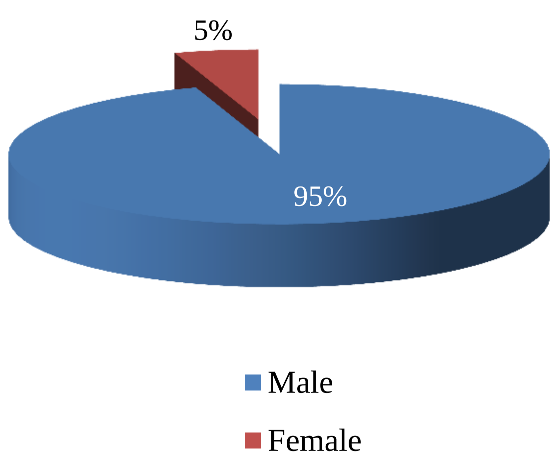
SEX DISTRIBUTION

In this study 19 patients are males and one patient is a female (Table 2 and Chart 2).

Table 2: Sex distribution

SEX	PATIENTS	PERCENTAGE
Male	19	95
Female	1	5
TOTAL	**20**	**100**

Chart 2: Sex Distribution

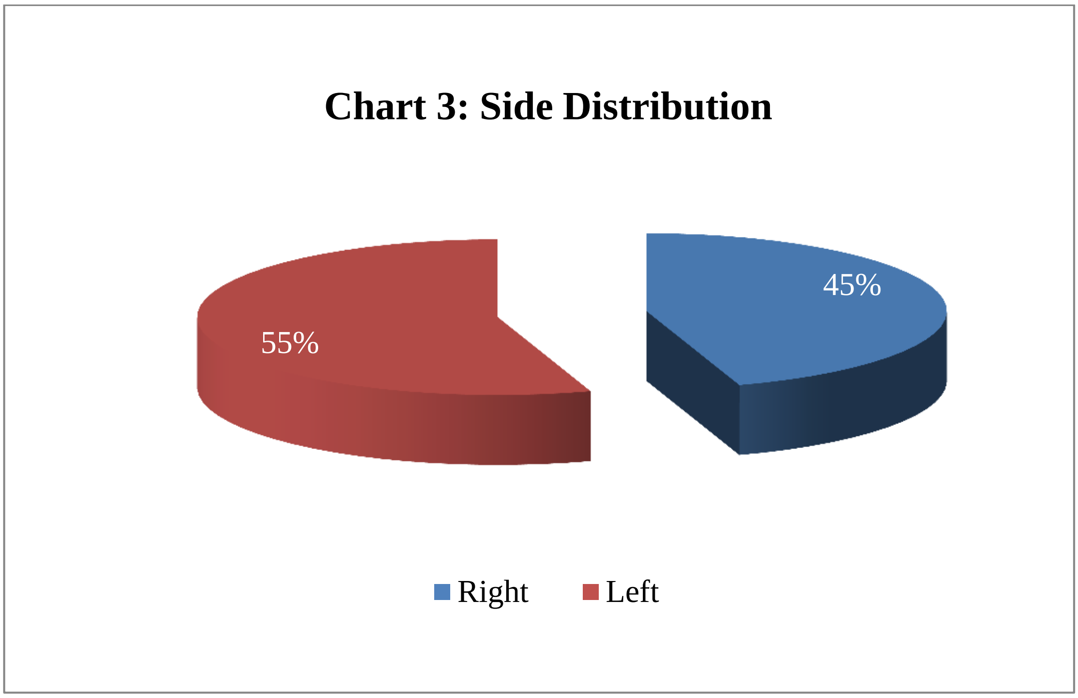


SIDE INVOLVED

In this study, 9 patients had injury in the right knee and 11 patients had injury in the left knee (Table 3 and Chart 3).

Table 3: Side involved

SIDE INVOLVED	PATIENTS	PERCENTAGE
Right	9	45
Left	11	55
TOTAL	**20**	**100**

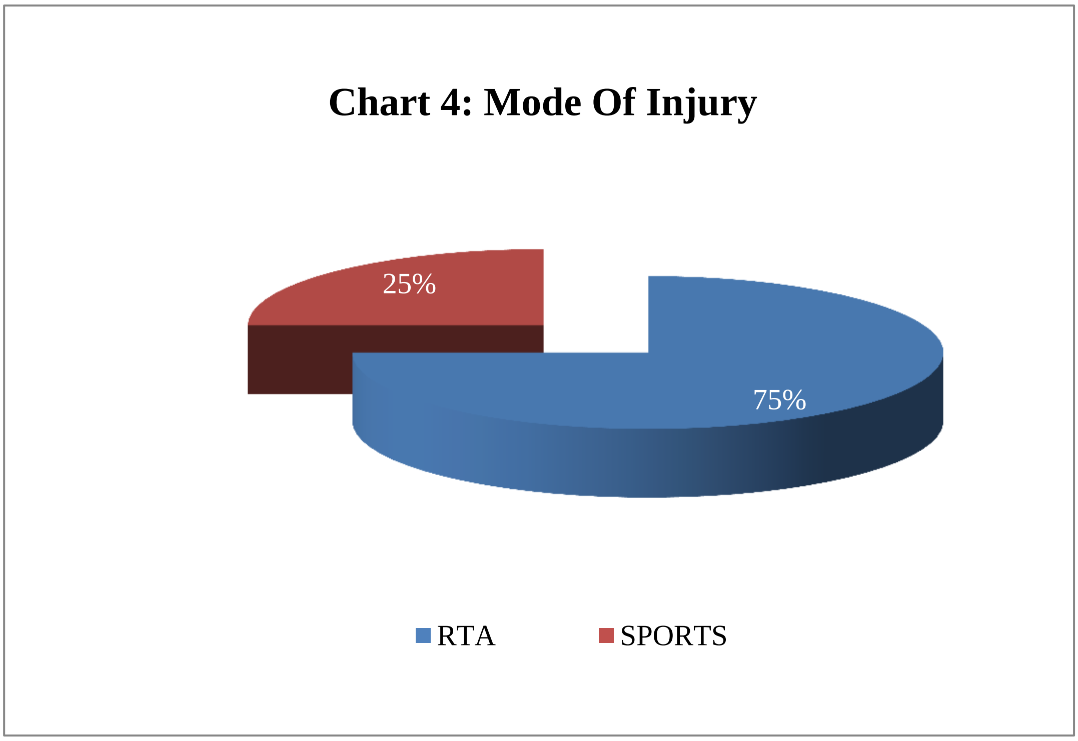


MODE OF INJURY

In this study RTA was the most common mode of injury followed by sports, either kabaddi or football (Table 4 and chart 4).

Table4: Mode of injury

MODE OF INJURY	PATIENTS	PERCENTAGE
RTA	15	75
Sports (kabaddi/football)	5	25
TOTAL	**20**	**100**

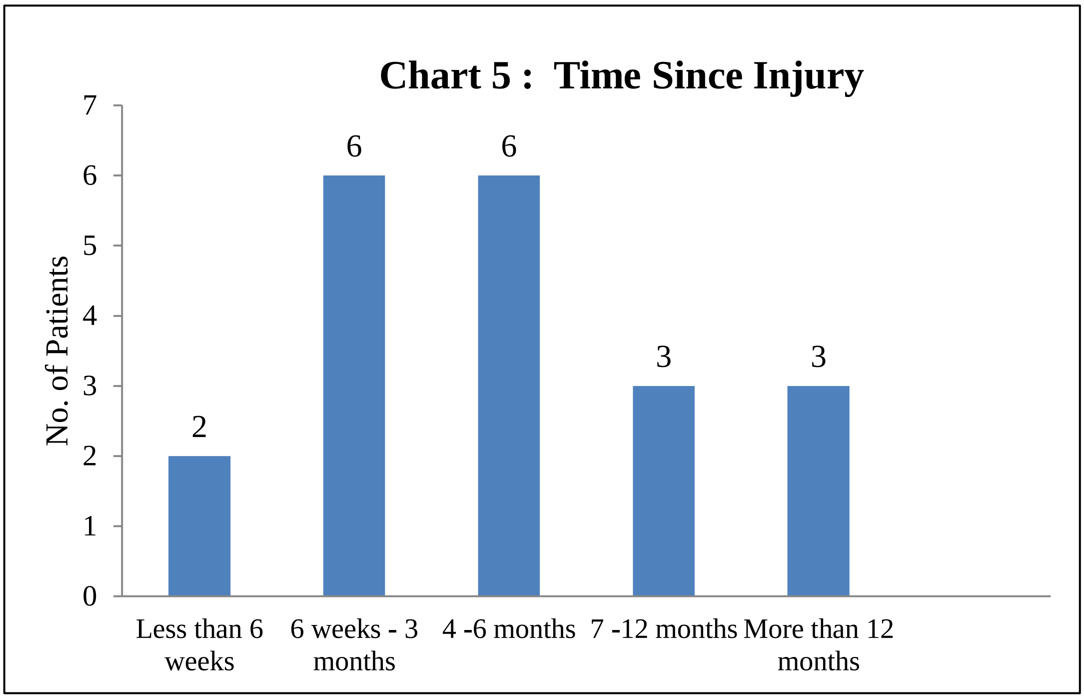


TIME SINCE INJURY

In this study, only 2 patients presented less than 6 weeks of injury (table 5 and chart 5).

Table5: Time since injury

TIME SINCE INJURY	PATIENTS	PERCENTAGE
Less than 6 weeks	2	10
6 weeks- 3 months	6	30
4 months- 6 months	6	30
7 months- 12 months	3	15
more than 12 months	3	15
TOTAL	**20**	**100**



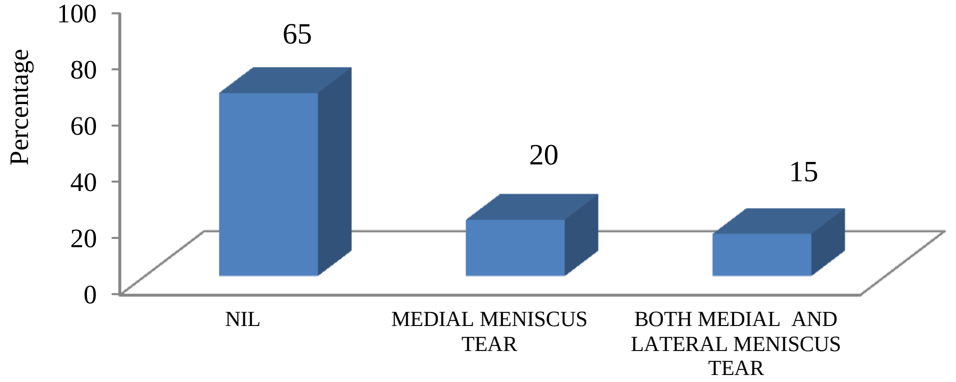
ASSOCIATED INJURY

In this study, medial meniscus tear was seen in four patients and both medial and lateral meniscus tears were seen in 3 patients (table 6 and chart 6).

Table 6: Associated injury

ASSOCIATED INJURY	PATIENTS	PERCENTAGE
Medial Meniscal Tear	4	20
Both Medial and Lateral Meniscal Tear	3	15
Nil	13	65
TOTAL	**20**	**100**

Chart 6: Associated Injuries

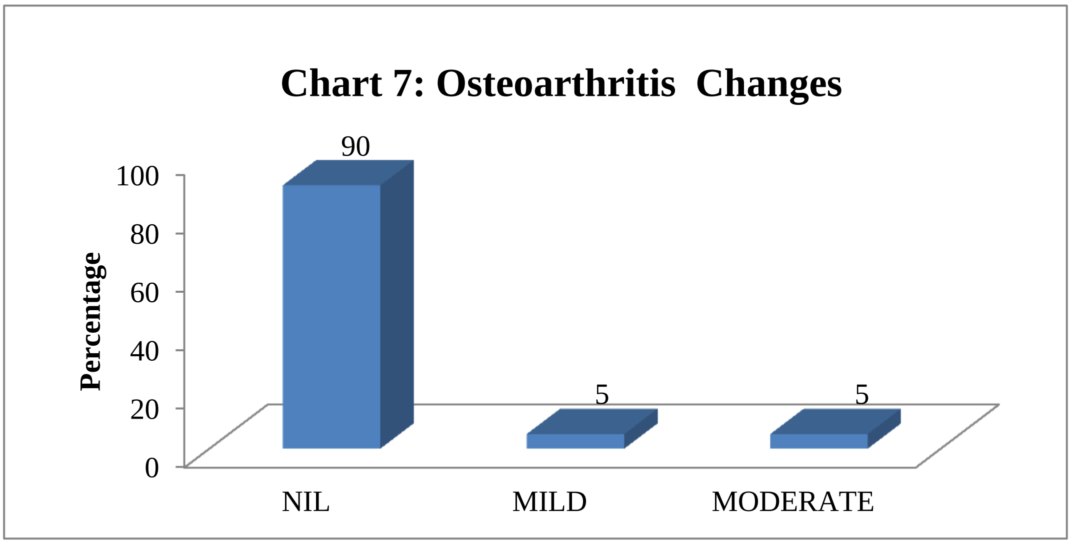


OSTEOARTHRITIS CHANGES

In our study during the follow up, it was observed that 2 patients developed osteoarthritis changes in the knee, among which one patient (age : 41 years) developed mild osteoarthritis changes and the other patient (age : 36 years) progressed to moderate osteoarthritis from the pre existing mild osteoarthritis (table 7 and chart 7).

Table 7: Osteoarthritis Changes

OA CHANGES	PATIENTS	PERCENTAGE
Mild	1	5
Moderate	1 (progressed from pre existing mild OA)	5
Nil	18	90
TOTAL	**20**	**100**



OBSERVATION

- Younger age group between 20 to 30 years constitutes the majority of patients in our study.
- Male preponderance was noted in our study.
- Left sided injuries were predominant in our study.
- Road traffic accident accounted to the most common cause of ACL injury.
- Medial meniscus injury was more frequently associated with ACL tear in our study.
- Osteoarthritis changes were noted in patients with chronic injuries, rather than acute injuries.

GRADING ANALYSIS

20 patients of Arthroscopic reconstruction of ACL with hamstring tendon autograft were followed for a minimum period of 3 months and a maximum period of 1.25 years. All patients were evaluated and graded with International Knee Documentation committee (IKDC) knee examination form. The functional outcome was analysed with various

variables which include Knee effusion, Passive motion deficit, Ligament examination, Compartment findings, harvest site pathology, X-ray findings and Functional tests. Based on the above variables, the final grade of the injured knee was obtained as below

IKDC GRADES

Grade A – normal

Grade B – Nearly normal

Grade C – Abnormal

Grade D – Severely abnormal

Grade A: Normal Knee

In this study, 15 patients had a normal knee with no knee effusion, a very minimal passive motion deficit and the manual ligament examination was equivocal with the opposite knee. None of our patients had crepitations in the anterior, medial and the posterior compartments. A few had minimal harvest site pathology. Two patients had osteoarthritis changes in x-ray. The functional one leg hop test was more than 90 % in all the patients. One patient had developed infection over the tibial interference screw fixation site 6 months post operatively. The infection resolved with subsequent screw removal and with appropriate antibiotics. After screw removal, clinical tests for Anterior cruciate ligament of the injured knee were equivocal to the opposite knee.

Grade B: Nearly Normal Knee

4 of our patients had a nearly normal knee with no knee effusion. Manual ligament examination with Lachman’s test revealed 3 to 5 mm translation in two of our patients. Two patients had 6 to 15^o lack of flexion in comparison to the opposite knee. There was minimal pain in the graft harvest site in one of our patient. None of our patients had crepitations in the anterior, medial and lateral compartments and their x-ray findings were normal. Functional one leg hop test was more than 90% in two of our patients and the other two patients had a one leg hop of 50 to 75% of the opposite side. One patient had a superficial infection in the immediate post operative period which resolved with appropriate antibiotics.

Grade C: Abnormal Knee

One of our patients had an abnormal knee with minimal knee effusion, with 20^o lack of flexion in comparison to the opposite knee. The manual ligament examination was equivocal with the opposite knee. Functional one leg hop was less than 50% of the opposite side. There were no harvest site pathology, compartment findings and x-ray findings.

Grade D: Severely Abnormal

In our study, none of our patients had a severely abnormal knee.

COMPLICATIONS:

As proposed by various studies, the most common complication, premature amputation of the graft was not encountered in our study. Two patients had post operative infection. One patient presented with a superficial infection in the immediate post operative period which subsided eventually with appropriate antibiotics. The other patient had developed superficial infection over the tibial interference screw fixation site 6 months post operatively. The infection resolved with subsequent screw removal and appropriate antibiotics.

DISCUSSION

The incidence of Anterior cruciate ligament reconstruction had increased significantly in the past decade owing to the increased number of road traffic accidents and sports injuries. Open ACL reconstruction is rarely used nowadays and Arthroscopic ACL reconstruction has become the gold standard treatment.

The advantage of arthroscopic ACL reconstruction includes decreased donor site morbidities like anterior knee pain and minimal incidence of patellofemoral adhesions. Technical advantages include better visualisation of the intraarticular structures which helps in the accurate placement of the tibial and femoral tunnels.

Studies by Cyril B. Frank have reported that arthroscopic reconstruction of ACL has a better functional outcome in the short term and the long term outcomes are not significantly different [58].

Hamid Barzegar, in his study has concluded that the arthroscopic reconstruction of ACL is the method of choice in preventing further worsening of the chronically instable knee [59]. As arthroscopy offers minimal invasion and improved cosmesis, it has eventually overshadowed the open procedures.

Eventhough arthroscopic reconstruction is the gold standard, controversies still exists regarding the graft choice, methods to fix the graft and techniques of reconstruction.

The goal of ACL reconstruction is to provide a functionally stable joint with full range of movements and to prevent the subsequent meniscal injury and secondary osteoarthritis.

This study was to analyse the functional outcome of arthroscopic single bundle ACL reconstruction with hamstring tendon autograft through trans portal technique using endobutton as femoral fixation device and interference screw as tibial fixation device.

In this study majority of the injuries were due to road traffic accidents which accounted for 75% of the injuries.

In contrary to all international studies, sports injuries accounted only 25%.

Studies by D W Lewis reported that 58% of ACL injuries were associated with meniscal injury at presentation. Medial meniscus was more frequently involved than the lateral meniscus in his study and concluded that a meniscal repair or resection did not alter the functional outcome. In 2009, Stephen Lyman reported more than 50% meniscal procedures with ACL reconstruction. In this study 20% of patients had meniscal injury at presentation and medial meniscus was injured more frequently than the lateral meniscus like other studies. Functional outcome following isolated ACL injury were found to be equivocal with the functional outcome of ACL injuries associated with either medial or lateral meniscus injury or both.

The variety of graft options available often puts the Orthopaedic surgeon in dilemma choose the ideal graft. The graft options include, bone patellar tendon bone autograft, hamstring tendon autograft, quadriceps tendon autograft, peroneus longus tendon autograft, allografts and synthetic grafts. Bone patellar tendon bone graft has been the gold standard till recent past as many studies have proven early stability with bone patellar tendon bone graft due its strength and direct bone to bone healing. Demerits of ACL reconstruction with bone patellar tendon bone graft include Post operative stiffness, prolonged rehabilitation and donor site morbidities.

With recent advancements, studies on soft tissue fixation devices have proven hamstring graft to be superior in strength and avoiding donor site morbidities. Animal studies by A Harvey in 2005 revealed that incorporation of soft tissue graft is by indirect integration producing sharpey fibres in the graft bone interface, which achieved adequate pull out strength by 12 weeks [60].

Aune et al compared the functional outcomes of ACL reconstruction with hamstring graft and bone patellar tendon bone graft and reported a significantly improved outcome with hamstring graft during the initial months of follow up, but the outcome was equivocal during the latter months [61]. Studies by Thomas D Rosenberg reported anterior knee pain and patellar chondrosis with the use of bone patellar tendon bone graft. David D Greenberg proposed allografts as a good alternative, but it carried a huge risk of disease transmission [62]. In our study hamstring tendon autograft was used in all for Anterior cruciate ligament reconstruction.

Dawn T Gulick proposed that the fixation of the graft is the site of failure rather than the graft itself regardless of the type of graft used. He also proposed that the fixation site is more prone to failure during the early rehabilitation phase when the graft integration has not taken place. Further he added that after 8 to 12 weeks, when the graft has integrated with the bone, the fixation site is least prone for failure [63].

Various graft fixation devices have evolved recently, which increased the reliability of soft tissue grafts. Steiner et al proposed strong fixation as the key to success in usage of soft tissue grafts.

Based on biomechanical studies on comparing various graft fixation devices, Petterikousa concluded that the bone mulch screw is superior to any other soft tissue fixation devices, followed by endobutton [25].

In this study, endobuttons were used as femoral fixation device and interference screw as tibial fixation device. Though bungee effect which allows graft movement within the bone tunnels was a concern while using endobutton, resulting in tunnel widening and hindrance to graft incorporation, recent studies had reported that only biological factors had attributed to tunnel widening rather than mechanical factors of the fixation device.

In this study, there was no graft site fixation failure or pullout with endobutton and interfence screw as fixation devices and both were able to withstand the standard postoperative rehabilitation.

Though double bundle reconstruction have gained popularity and considered to be superior in providing stability, studies by Adachi, Ochi and Uchio [64] showed no significant advantage of double bundle reconstruction over anatomic single bundle reconstruction in factors of stability and proprioception in general population.

In this study 75% of the patients achieved a normal knee, 20% of the patients returned to have a nearly normal knee and 5% of the patients ended up with an abnormal knee.

Lewis et al reported 81% good results in his review article which showed 19% patients had positive pivot shift post operatively. In this study 10% patients had passive flexion deficit and 10% had minimal anteroposterior laxity. Overall patient satisfaction was good in 18 patients. Riley J Williams reported 2% joint infection in his study which required arthroscopic joint lavage [65]. In our study there was no patient with post operative joint infection. Two patients had superficial infection over the tibial interference screw insertion site. Infection subsided with appropriate antibiotics in one patient and in the other patient infection eventually subsided with screw removal and appropriate antibiotics.

Ahlen et al [66] reported that patients who underwent ACL reconstruction within 5 months of injury had better functional outcome without degenerative changes. Lewis et al recorded that 50% patients in his study had arthritic changes during long term follow up compared to 10% (two patients) in our study. One patient developed mild osteoarthritis changes and the other patient progressed to moderate osteoarthritis from the pre existing mild osteoarthritis. Both these patients had presented more than three years since the initial injury.

In this study patients were put on home based physiotherapy program, insisting on knee flexion, extension, active straight leg raise and quadriceps strengthening. J A Grant proposed that home based physiotherapy was cost effective not significantly inferior to supervised programs [67].

In conclusion, several factors like graft choice, graft fixation device, tunnel placement and graft tensioning play a vital role in influencing the functional outcome of arthroscopic ACL reconstruction.

CONCLUSION

The arthroscopic technique of hamstring tendon autograft for ACL reconstruction using the endobutton for femoral fixation and interference screw for tibial fixation has low morbidity and excellent functional results.

With recent advancements in surgical techniques and fixation devices, excellent functional results can be obtained with hamstring tendon autograft.

The principles of surgical technique, graft fixation and post operative rehabilitation are more important in Anterior cruciate ligament reconstruction.

Anterior cruciate ligament injury presenting more than three years since initial trauma ended up with osteoarthritis changes in the knee. Furthermore, since the study group is too small, duration of follow up is too short and the analysis of outcomes are varied, it is not known whether the reconstruction of Anterior cruciate ligament changes the long term natural history of an injured Anterior cruciate ligament.

CASE ILLUSTRATIONS

CASE NO: 1

Name: Muthukumar

Age: 27

Sex: Male

Occupation: Supervisor

Mode of injury: RTA

Time since injury: 6 Months

Side involved: Right

Associated injuries: NIL

Anaesthesia: Spinal

Complications: NIL

IKDC Grade: A

Post operative follow up: 15 months

Injured ACL in MRI **15 Months follow up Post op x-ray**

15 months follow up range of movements

CASE NO: 2

Name: Rajasekar

Age: 24

Sex: Male

Occupation: Student

Mode of injury: RTA

Time since injury: 10 Months

Side involved: Right

Associated injuries: Medial and Lateral meniscus tear

Anaesthesia: Spinal

Complications: NIL

IKDC Grade: A

Post operative follow up: 11 months

Injured ACL in MRI **11 Months follow up Post op x-ray**

11 months follow up range of movements

CASE NO: 3

Name: Devanathan

Age: 29

Sex: Male

Occupation: Manual labour

Mode of injury: sports

Time since injury: 6 Months

Side involved: Left

Associated injuries: NIL

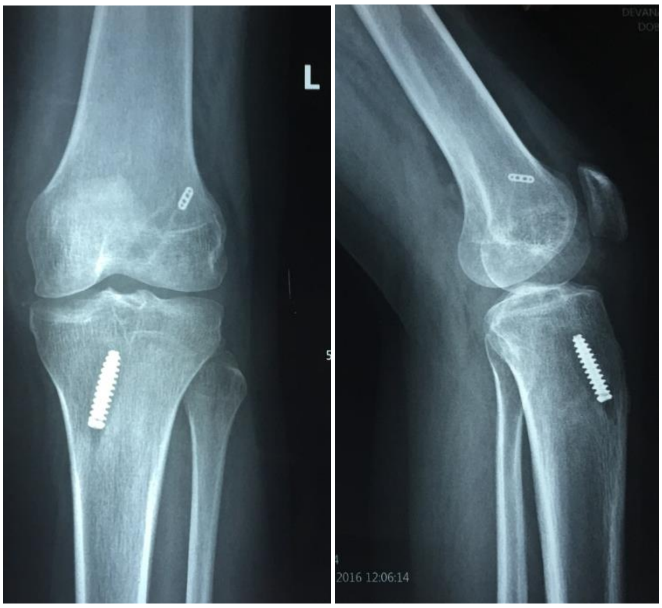
Anaesthesia: Spinal

Complications: NIL

IKDC Grade: B

Post operative follow up: 4 months

Injured ACL in MRI **4 Months follow up Post op x-ray**



4 months follow up range of movements

CASE NO: 4

Name: William Issac

Age: 41

Sex: Male

Occupation: Driver

Mode of injury: sports

Time since injury: 2 Months

Side involved: Right

Associated injuries: NIL

Anaesthesia: Spinal

Complications: NIL

IKDC Grade: A

Post operative follow up: 10 months

Injured ACL in MRI **10 Months follow up Post op x-ray**

10 Months follow up Range of Movements

CASE NO: 5

Name: Elavarasan

Age: 36

Sex: Male

Occupation: Daily Labour

Mode of injury: RTA

Time since injury: 9 Years

Side involved: Right

Associated injuries: Medial Meniscus tear

Anaesthesia: Spinal

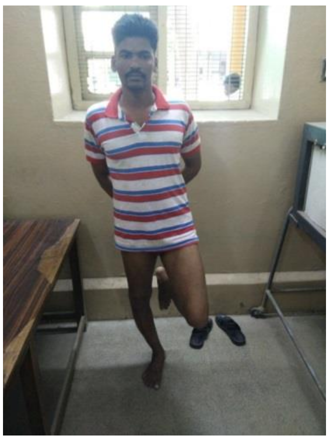
Complications: Moderate Osteoarthritis changes

IKDC Grade: A

Post operative follow up: 7 Months

Injured ACL in MRI **7 Months follow up Post op x-ray**

11 months follow up range of movements



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INSTITUTIONAL ETHICAL COMMITTEE,
STANLEY MEDICAL COLLEGE, CHENNAI-1

Title of the Work	:	"Assessment of the Functional Outcome of Arthroscopic Reconstruction of ACL using hamstring tendon Auto graft"
Principal Investigator	:	Dr. S. R. Venkateswaran,
Designation	:	M.S. (Orthopedics)
Department	:	Department of Orthopedics Government Stanley Medical College, Chennai-01

The request for an approval from the Institutional Ethical Committee (IEC) was considered on the IEC meeting held on 29.09.2015 at the Council Hall, Stanley Medical College, Chennai-1 at 2PM

The members of the Committee, the secretary and the Chairman are pleased to approve the proposed work mentioned above, submitted by the principal investigator.

The Principal investigator and their team are directed to adhere to the guidelines given below:

1. You should inform the IEC in case of changes in study procedure, site investigator investigation or guide or any other changes.
2. You should not deviate from the area of the work for which you applied for ethical clearance.
3. You should inform the IEC immediately, in case of any adverse events or serious adverse reaction.
4. You should abide to the rules and regulation of the institution(s).
5. You should complete the work within the specified period and if any extension of time is required, you should apply for permission again and do the work.
6. You should submit the summary of the work to the ethical committee on completion of the work.

K Vasantha

MEMBER SECRETARY,
IEC, SMC, CHENNAI

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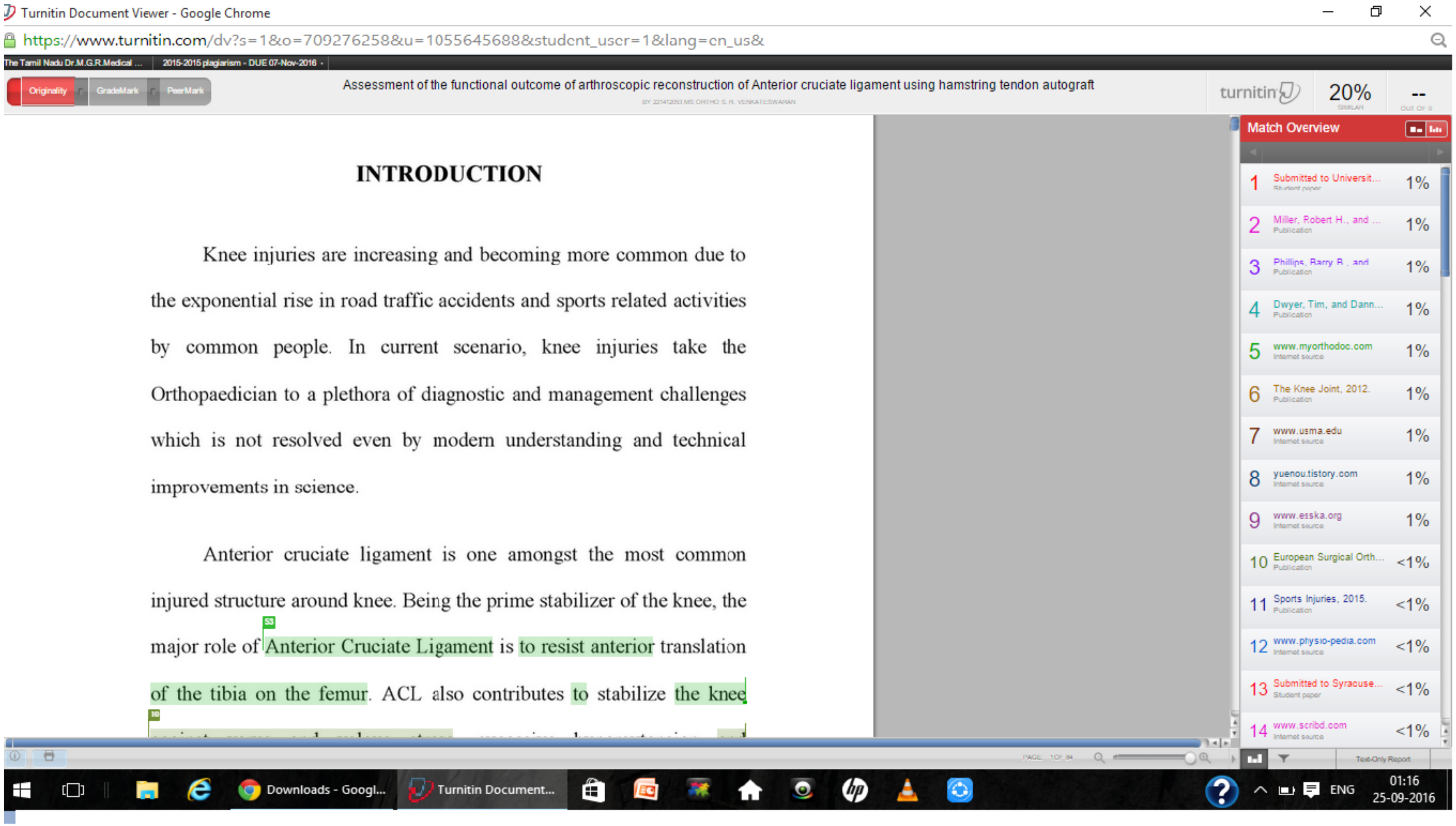

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Assessment of the functional outcome of arthroscopic reconstruction of Anterior cruciate ligament using hamstring tendon autograft

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INTRODUCTION

Knee injuries are increasing and becoming more common due to the exponential rise in road traffic accidents and sports related activities by common people. In current scenario, knee injuries take the Orthopaedician to a plethora of diagnostic and management challenges which is not resolved even by modern understanding and technical improvements in science.

Anterior cruciate ligament is one amongst the most common injured structure around knee. Being the prime stabilizer of the knee, the major role of Anterior Cruciate Ligament is to resist anterior translation of the tibia on the femur. ACL also contributes to stabilize the knee

Match Overview

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Text-Only Report

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PROFORMA

1. Name:
2. Age:
3. Sex:
4. Occupation:
5. Address:
6. I. P No:
7. Presenting history:

   Side: left / right

   Knee pain: yes / no

   Instability: yes / no

   Swelling: yes / no

   Locking: yes / no
8. History of trauma: yes / no (If yes, nature of trauma: fall / RTA / Sports / others
9. Time since injury:
10. Associated medical conditions:
11. Clinical examination findings:

    Anterior Drawer Test:

    Posterior Drawer Test:

    Lachman's test:

    Patellar tap:

    Mcmurray's test:

    Pivot shift test:

12.Radiological Investigations: X-ray / MRI

13.Associated injuries:

14.Type of Anaesthesia:

15.Menisectomy: done / not done

16.Suture removal on:

17.Knee brace used / not used (If used, for how many days)

18.Evaluation:

1^{st} week

2^{nd} week

6^{th} week

3^{rd} month

6^{th}month

12^{th} month

15^{th} month

19.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
Osteoarthritis changes:	yes / no

MASTER CHART

S.NO	NAME	AGE	SEX	IP NO	SIDE	MODE	TIME SINCE INJURY	ASSOCIATED INJURY	PRE OP X – RAY FINDINGS	TREATMENT	FOLLOW UP	OA CHANGES (POST OP)	FINAL GRADE
1.	VIJAYAKUMAR	34	M	1613790	RIGHT	RTA	6 MONTHS	MMT	NIL	RECON	6MONTHS	NIL	A
2.	MUTHUKUMAR	27	M	1541398	RIGHT	RTA	6 MONTHS	NIL	NIL	RECON	15 MONTHS	NIL	A
3.	PAWAN	20	M	1630250	LEFT	SPORTS	5 MONTHS	NIL	NIL	RECON	4 MONTHS	NIL	B
4.	JALAUDEEN	26	M	1605680	RIGHT	RTA	8 MONTHS	NIL	NIL	RECON	12 MONTHS	NIL	A
5.	TAMIL SELVAN	41	M	1560799	LEFT	RTA	3 YEARS	MMT	NIL	RECON, PMM	11 MONTHS	MILD	A
6.	SARAVANAN	21	M	1558642	RIGHT	SPORTS	2 MONTHS	NIL	NIL	RECON	11 MONTHS	NIL	A
7.	NANDAGOPAL	26	M	1552796	LEFT	RTA	1 YEAR	NIL	NIL	RECON	12 MONTHS	NIL	A
8.	ELAVARASAN	36	M	1606524	RIGHT	RTA	9 YEARS	MMT	MILD OA	RECON, PMM	7 MONTHS	MODERATE	A
9.	DEVANANTHAN	29	M	1620249	LEFT	SPORTS	6 MONTHS	NIL	NIL	RECON	4 MONTHS	NIL	B
10.	WILLIAM ISSAC	41	M	1568866	RIGHT	SPORTS	2 MONTHS	NIL	NIL	RECON	10 MONTHS	NIL	A
11.	DURGA DEVI	29	F	1550722	LEFT	RTA	3 MONTHS	MMT,LMT	NIL	RECON,PMM,PLM	12 MONTHS	NIL	A
12.	VINOTH KUMAR	38	M	1635297	RIGHT	RTA	3 MONTHS	MMT, LMT	NIL	RECON,PMM,PLM	3 MONTHS	NIL	C
13.	DEVENDIRAN	23	M	1559282	LEFT	RTA	1 MONTH	MMT	NIL	RECON, PMM	12 MONTHS	NIL	A
14.	RAJASEKAR	24	M	1555917	RIGHT	RTA	10 MONTHS	MMT, LMT	NIL	RECON,PMM,PLM	11 MONTHS	NIL	A
15.	VEERABATHRAN	47	M	1558391	LEFT	RTA	6 MONTHS	NIL	NIL	RECON	11 MONTHS	NIL	A
16.	SUTHIR	24	M	1629051	RIGHT	SPORTS	18 MONTHS	NIL	NIL	RECON	3 MONTHS	NIL	B
17.	AANANDH	26	M	1531931	LEFT	RTA	1 MONTH	NIL	NIL	RECON	15 MONTHS	NIL	A
18.	MUTHUKUMAR	25	M	1642727	LEFT	RTA	6 MONTHS	NIL	NIL	RECON	3 MONTHS	NIL	B
19.	RAMESH BABU	33	M	1601847	LEFT	RTA	2 MONTHS	NIL	NIL	RECON	8 MONTHS	NIL	A
20.	SARAVANAN	25	M	1646580	RIGHT	RTA	3 MONTHS	NIL	NIL	RECON	3 MONTHS	NIL	A

MASTER CHART KEY

M - Male

F - Female

MMT - Medial meniscus tear

LMT - Lateral meniscus tear

OA - Osteoarthritis

RECON - Arthroscopic Reconstruction of ACL using hamstring tendon

PMM - Partial medial menisectomy

PLM - Partial lateral menisectomy

Final grade: A- Normal knee

B- Nearly normal knee

C- Abnormal knee

D- Severely abnormal knee