

Evaluation of the results of anatomical double bundle anterior cruciate ligament reconstruction using Hamstring tendon graft.

The Study done at Northern Railways Central Hospital

New Delhi



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M.Ch (Orthopaedic Surgery)

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ABSTRACT

CONTEST: Evaluation of the results of anatomical double bundle anterior cruciate ligament reconstruction using Hamstring tendon graft.

OBJECTIVE : To assess the functional results of anatomical double bundle ACL reconstruction in terms of stability of reconstruction and evaluation by lysholm score.

DESIGN : It was prospective study with the minimum follow up 12 months (1 year)

STUDY GROUP: Enrolment has been done from patient's presenting with acute or chronic ACL tear in the OPD in the department of orthopaedics at Northern railways Central Hospital during the period of March 2007 – March 2008.

SAMPLE SIZE: Total of 40 patients with ACL tear fulfilling the inclusion criteria were operated but 7 were lost in immediate the follow so 33 patients were included in this study.

METHODOLOGY: A total of 33 patients, 27 male and 6 female with 19 right knee and 14 left knee involvement with ACL tear were operated in supine position arthroscopically anatomical double bundle (AM and PL bundle) ACL reconstruction with hamstring tendon graft and were fixed with endobutton CL (smith and nephew) fixation system on the femoral side and ligament staple or bioscrews on tibial side. Patient strictly followed rehabilitation protocol.

RESULTS: The lysholm score and pivot shift test reflected highly significant improvement in the stability, mainly rotational and anterior stability when preoperative score were compared with the score of most recent follow up i.e.12 months. ($p = 0.0001$). The average total score increased from $1.30 + 0.47$ to $3.00 + 0.56$ using lysholm score.

CONCLUSION: Anatomical double bundle ACL reconstruction is excellent technique for treating patients with ACL tear who are specially involved in the activities which involve pivoting most of the times in there life time for example athletes

KEY WORDS: Arthroscopy, Double Bundle (AM and PL), ACL

INTRODUCTION

The knee joint is frequently involved in sports injuries and as modern sport is being more and more competitive, more complex knee injury patterns are being recognized. Anterior cruciate ligament is a very commonly involved ligament in these injuries. More and more cases of ACL tear are being diagnosed nowadays due to the increasing role of MRI as a diagnostic tool.

Anterior cruciate ligament stands as the ligament which has been the written and researched afoot most in last 50 years.

Anterior cruciate ligament is one of the most important intra-articular ligaments of the knee joint. It is an intra-articular, extrasynovial structure present in the central complex of knee joint. It functions in concert with all other anatomical structures in the knee joint to control and limit motion and to maintain both static and dynamic equilibrium.

It is attached proximally to the posterior part of the intercondylar surface of the lateral femoral condyle and distally just anteriolateral to the anterior tibial spine.

ACL consist of two major fiber bundles, namely anteriomedial bundle and posterolateral bundle. When the knee is extended, posterolateral bundle (PL) is tight and the anteriomedial bundle is moderately lax. As the knee is flexed, the femoral attachment of the ACL becomes a more horizontal orientation; causing the AM bundle to tighten and the PL bundle to relax. There is some degree of variability for the femoral attachment of AM and PL bundle. The AM bundle is located proximal and anterior in the femoral ACL origin (high and deep in the notch when the knee is flexed at 90 degree); posterolateral bundle starts in the distal and posterior aspect of the femoral ACL origin (shallow and low when the knee is flexed at 90 degree).

In the frontal plane the AM bundle origin is in the 10:30 clock position and the posterolateral bundle origin in the 9:30 clock position. At the tibial insertion the

ACL fan out to form the foot region. The AM bundle insertion is in the anterior part of the tibial ACL footprint, the posteriolateral bundle in the posterior part. While the AM bundle is primary restraint to against anterior tibial translation, the posterior lateral bundle tends to stabilize the knee near full extension, particularly against rotatory loads.

ACL injury commonly occurs in football, volleyball, basketball, skiing etc and are usually caused by deceleration, twisting, cutting and jumping maneuvers or by hyperextension of the knee.

In traditional Indian sport like kabaddi, playing Kho- Kho, rural wrestling pivoting is more common. Even day to day activities patient can sustain ACL injuries like stepping down from bus, fall from stairs etc.

The history often can provide valuable information, and surgeon can have a high suspicion for ACL injury before patient is examined. Forty percent of these injuries are associated with a “pop” at the time of injury and the patient are usually unable to continue further participation. A haemarthrosis usually develops within 2-3 hours. In the chronic case the patient will complain of recurrent painful giving way of the knee associated with swelling and stiffness after each such episode.

Treatment of anterior cruciate ligament (ACL) injuries requires a careful evaluation of the amount of instability present and of any associated injuries.

The goal of the surgical treatment is to restore knee stability, thus preventing recurrent knee injury while allowing the patient to return to his preinjury activity levels and sports. Young patients who are unwilling to modify their active lifestyle and who have further interest in sports should be considered for surgical intervention. Obtaining the normal range of motion and regaining strength equal to uninjured leg are important.

The application of knee arthroscopy to patient care has steadily expanded over the past two decades. Arthroscopically assisted techniques for ACL reconstruction have resulted in smaller incisions without disturbing adjacent uninjured anatomic structures. The recovery and rehabilitation following these procedures has also been shortened.

The advantages to surgeons include visual enhancement and magnification of the intercondylar notch as well as assessing and treating associated articular cartilage and meniscus injuries.

Various surgical procedures and graft selections have been proposed for ACL reconstruction such as bone-tendon-bone (BTB), semitendinosus tendon (ST), iliotibial band, allograft, and quadriceps tendon. Among these the central third of patellar tendon and hamstring tendons have been the most common type of graft used. Bony fixation and mechanical strength may explain the success of the patellar tendon graft, whereas the use of a four-bundle semitendinosus-gracilis graft guarantees high graft strength and a clinical outcome similar to that found in BTB graft.

Various modes of fixation are also available like transfixation device, endobutton, bioscrews, ligament staples etc.

To control rotatory instability number of authors has suggested reconstruction of not only antero-medial but also posterior-lateral instability.

Double bundle has several advantages over single bundle reconstruction with a multi-stranded tendon with respect to regaining a structure that closely resembles the normal ACL. First double bundle ACL has wider contact areas between the bone and grafted tendon than a single bundle ACL via hamstring tendon, which means that only the margins of the tendon graft is anchored to collagen fibers resembling Sharpey's fibers and the tunnel wall in ACL reconstruction.

Double bundle ACL reconstruction allow AM and PL bundles to be created anatomically and independently.

Muneta et al⁹ and Yasuda et. Al⁸ reported that side to side anterior laxity of double bundle ACL reconstruction was significantly better than that of single bundle reconstruction.

Mae et. Al¹⁰ and **Yagi et al¹²** found that double bundle reconstruction is superior to single bundle reconstruction in terms anterior stability based on cadaveric knee studies using robotic sensor system.

Yagi et al¹² reported that single bundle ACL reconstruction cannot completely restore normal anterior laxity and that it does not seems to be effective for rotatory instability. According to **Georgoules et. al²⁹** single bundle reconstruction cannot sufficiently improve increased rotatory instability during walking.

Mae et al¹⁰ performed a cadaveric study to compare the Biomechanical difference between the single and double bundle reconstruction and found better stability with double bundle.

Present study aims to examine the results of Anatomical reconstruction of antero-medial and posteriolateral bundles of the anterior cruciate ligament using hamstring tendon graft with two femoral and two Tibial tunnels.

AIMS AND OBJECTIVES

1. To assess the functional results of anatomical double bundle reconstruction of anterior Cruciate ligament by recreating the anteriomedial and Posteriolateral bundle of ACL using the hamstring tendon graft.
2. To assess the effectiveness of anatomical double bundle ACL reconstruction regarding the stability of the reconstruction

EVALUATION OF CONCEPT OF DOUBLE BUNDLE ACL RECONSTRUCTION

Reconstruction has evolved as the mainstay of the surgical correction of anterior cruciate ligament deficient knees.

In conventional ACL reconstruction procedures, only a single bundle that mimic the anteriomedial bundle (AMB) of the ACL has been grafted. However, the normal ACL consists of the anterior medial bundle and posteriolateral bundle (PLB) which have different functions ^{130 - 133}.

For example, Sakane et al ¹³² reported that an anterior drawer force to the tibia is distributed to the PLB to a greater degree than to the AMB in the nearly extended position, whereas it is distributed to the AMB to a greater degree than to PLB in the flexed position. To improve the single bundle procedures using the hamstring tendon graft, several double bundle reconstruction procedures have developed till date ^{2,6,134, 135}.

Mcintosh et al (1972) described pivot shift test as pathogonomic of anterior cruciate ligament insufficiency. Slocum and associates described variation of pivot shift test.

Howell S M (1993) studied the failure of reconstruction of ACL due to impingement by intercondylar roof and found out that there was no impingement in the knees in which the entire articular opening of the tibial tunnel was posterior to the slope of the intercondylar roof, and these were associated with the lowest rate of graft failure.

Graf BK (1994) studied the risk factors for reduced motion after ACL reconstruction followed by early mobilization was associated with lowest rate of motion problem.

Lohmander LS, Osterberg A, Englund M, et al ³⁵ High prevalence of osteoarthritis, pain and functional limitation in female soccer player 12 years after single bundle ACL reconstruction . Therefore, a more anatomical approach to reconstructing both the bundles of the ACL has evoked the interest of many surgeons.

Gabriel MT, Wong Ek, Woo SL, Yagi M, et al (2004)¹³³ Distribution of in situ forces in the anterior cruciate ligament in response to rotatory loads. Cadaveric study revealed single bundle ACL reconstruction is insufficient to control the combined rotatory load of internal and valgus torque, and stress the function of the posteriolateral bundle.

Yagi M, Wong EK Kanamoria, Debski Re, ET AL¹² Biomechanical analysis of an anatomic anterior cruciate ligament reconstruction. In this study, anterior tibial translation for the double bundle reconstruction was substantially closer to the intact knee than to the single bundle reconstruction.

Maurilio maracacci, Alessandro Paladini Molgora et al. Anatomic Double bundle anterior cruciate ligament reconstruction with gracilis and semitendinosus technique that guarantees a more anatomical ACL reconstruction and avoid the surgeon to avoid the use of hardware for graft fixation. The tendons are harvested maintaining their tibial insertion.

N. Adachi, M. Ochi, Y Uchio, J Iwasa, M. Kuriwaka, Y.Ito (2004)⁴ They prospectively randomized for arthroscopic single – or double bundle reconstruction of the ligament using hamstring tendons. The same post operative protocol was used for all. They measured the anterior laxity and joint position sense at different angles of flexion of the knee to determine whether both the bundles in double bundle reconstruction contributed to the stability of the joint and proprioception. No significant difference was found between the two groups neither with regard to anterior laxity measured by KT-2000 arthrometer with the knees at 20 degrees or 70 degrees flexion nor with regard

to proprioception. A notchplasty was required less often in the double – compared to single bundle reconstruction.

They did not find any advantage in double bundle as opposed to a single bundle reconstruction in terms of stability or proprioception.

Guy Beller, Pascal Christel, Philippe Clombet (2004)¹ Gave technical notes on double bundle hamstring graft for anterior cruciate ligament reconstruction. Current techniques for ACL reconstruction do not completely reproduce the anatomy and function of the ACL. They address only the anteriomedial bundle and do not fully restore ACL function throughout the range of motion. Current graft control anterior tibial subluxation near extension but are less efficacious in providing rotatory stability. Recently, several authors have suggested reconstruction not just the anteriomedial bundle but also the posteriolateral bundle. They gave technical notes on a double bundle ACL reconstruction using hamstring tendons routed through 2 tibial and 2 femoral independent tunnels.

Kazunori Yasuda, Eiji Kondo, Hiroki Ichiyama, Nobuto Kitamura¹⁵ Anatomic reconstruction of the anteriomedial and posteriolateral bundles of the anterior cruciate ligament using hamstring tendon graft. They developed the arthroscopically assisted anatomic reconstruction procedure of the posteriolateral and anteriomedial bundle, involving a new method of creating the tibial and femoral tunnels for the posteriolateral bundle. To visualize the femoral attachment of the posteriolateral bundle, the medial infrapatellar portal was more useful than the lateral portal. In clinical results, the side to side difference of anterior laxity averaged 1.0 mm with standard deviation of 0.9. They concluded that anatomic reconstruction of the anteriomedial and posteriolateral bundles using hamstring tendon auto-graft is clinically practical in the treatment for ACL deficient knee.

Takeshi Muneta, Hideyuki koga, Toshiyuki Morito⁹ A retrospective study of the midterm outcome of two bundle anterior cruciate ligament reconstruction using quadrupled semitendonis tendon in comparison with one bundle reconstruction. They concluded there were no statistical difference based on IKDC, Lysholm, and subjective analysis.

However, there was a statistical difference in lachman test, anterior drawer test, and KT-1000 measurements.

David N.M.caborn, Haw Chong Chang. They described new technique of single femoral socket double bundle ACL reconstruction using tibialis anterior tendon.

The native ACL has been shown to consist of 2 function bundles with independent behavior throughout the range of knee motion. Conventional arthroscopic ACL reconstruction techniques selectively recreate the anteriomedial bundle of native ACL only. Numerous studies have reported the failure to restore the normal knee kinematics in an ACL deficient knee using single bundle ACL reconstruction. It has been suggested that by reconstructing both the anteriomedial and posteriolateral bundles of the ACL, more normal knee kinematics can be achieved. Several authors have described surgical techniques to recreate the functional bundles and they range from using 2 femoral tunnels to using single femoral tunnel with the other bundle passed over the top.

Peter S Cha, Peter U Brucker, Robin V West...The authors from two academic center presented a technique of arthroscopic ACL reconstruction that restores both the anteriomedial and posteriolateral bundle using either semitendinosus or gracilis auto-graft or tibialis anterior auto-grafts. This technique represents a novel approach to restore the anteriomedial and posteriolateral bundle at their anatomic insertion sites of the anterior cruciate

ligament on the tibia and femur while more closely recreating the biomechanical function of the native ligament.

Kazunori Yasuda, Eiji Kondo, Hiroki Ichiyama, Yoshie Tanabe¹⁵ Compared the clinical outcome of anatomical double bundle anterior cruciate ligament with that of non-anatomic single and double bundle reconstruction. They concluded on the basis of KT-2000 measurement, the side to side anterior laxity of our anatomic double bundle ACL reconstruction was significantly better than that of single bundle reconstruction with the hamstring tendon graft, although there was no significant differences in the other clinical measures among any of the 3 procedures.

Jinzhong Zhao, Yaohua He and Jianhua Wang. Double bundle ACL reconstruction four versus eight strands of hamstring tendon graft. On the basis of KT 1000 examination and clinical measures, double bundles ACL reconstruction with 8SHG yields better results double bundle ACL reconstruction with 4 SHG, with the mean side to side difference in anterior knee laxity.

Hiroto Asagumo, Masashi Kimura, Yasukazu Kobayash¹³ Retrospectively compare the clinical outcomes of anatomic double bundle anterior cruciate ligament reconstruction via a hamstring tendon with single bundle reconstruction.

No significant difference was found between the two procedures with regard to manual knee laxity, anterior knee laxity measured by KT-1000 arthrometer, Knee extension and flexion strength and Lysholm score. In contrast, there was a significant difference in the range of knee motion between the two groups. The finding of our study does not support the routine adoption of the double bundle reconstruction.

Takeshi Muneta, Hideyuki Koga, Tomoyuki Mochizuki¹⁴ A prospective randomized study of four stranded semitendinosus tendon anterior cruciate

ligament reconstruction comparing single bundle and double bundle techniques. This randomized control trial indicated the DB ACL reconstruction via 4 – strands ST is superior to SB technique with regard to anterior and rotational stability, however it fails to show any subjective difference.

Eiji Kondo, Kajunori Yasuda, Hiroki Ichiyama. Radiological evaluation of femoral and tibial tunnels created with the transtibial tunnel technique for anatomic double bundle anterior cruciate ligament reconstruction.

Till date no study has been conducted on double bundle ACL reconstruction in the INDIAN patients, even through ACL injuries are getting so common on these Indian patient due to changing lifestyle. Indian patients differ from Englishmen in there body structure, they are indulge in more strenuous work, life style and working condition is different. In traditional Indian sport like kabbadi, playing Kho-Kho, ruler wrestling pivoting is more common. Even day to day activities patient can sustain ACL injuries like stepping down from bus, fall from stairs etc.

This study is conducted first time in Indian patients in Northern railways central hospital.

MATERIALS AND METHODS

The prospective study was conducted in **Northern Railways Central Hospital Basant Lane, New Delhi** .

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 of Northern railways central hospital, New Delhi 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) Lachman test
- 2) Anterior drawer test
- 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 (for menisci)
- 3) Posterior drawer test (for posterior cruciate ligament)
- 4) Reverse pivot shift test (for Posterolateral complex)

Routine skiagram of both knees in standing position in antero-posterior view and lateral view of the affected knee were taken and lateral view in 45⁰ of flexion of the affected knee was also done. MRI of the knee was done in cases with equivocal clinical findings. Diagnostic arthroscopic examination of the knees was used as last resort for patients with negative or equivocal clinical and radiological findings but consistent symptoms suggesting anterior cruciate ligament deficiency.

Inclusion criteria:

The following patients were included

- 1) Clinical / radiological / arthroscopic evidence of anterior cruciate ligament deficiency which is symptomatic even after conservative therapy of adequate duration.
- 2) Young and middle aged, active, motivated patients with future interest in professional / recreational sports or who are involved in vigorous activities, unwilling to change their active life style.
- 3) A normal contra lateral knee.
- 4) Associated with medial or lateral meniscus tear may or may not requiring treatment.
- 5) The acute inflammatory phase of the injury has subsided and full range of motion and good quadriceps strength has been regained with no extensor lag (usually after 4-6 weeks of injury)

Exclusion criteria:

The following patients were not included in the study.

1. Patients with bilateral ACL tear.
2. Patients with other systemic diseases compromising their Pre-anaesthetic fitness.
3. Patients with associated fractures of lower limb and spine.
4. Patients with any other associated ligament injuries of the Knee (complete tear of posterior cruciate ligament, medial and lateral collateral ligament requiring treatment)
5. Patients who underwent ACL reconstruction of both the knees and those with open physis were excluded from the study.

6. Patients with other ligamentous instability and those with articular cartilage lesion exceeding grade 3 were also excluded.
7. Patients with local skin infections.
8. Patients having remote infection which might have seeded in the joint.

Pre operative period:

A single dose of a third generation cephalosporin (ceftriaxone; 1 gm) was administered intravenous about ½ hr prior to procedure. The affected limb was marked pre-operatively.

Patient Preparation:

After giving the anesthesia (spinal, epidural or general) patient was placed in supine position on the operating table with the non operative limb positioned in a well leg holder in a flexed and abducted position.

The affected knee was examined, doing the relevant clinical tests, now under anaesthesia, to confirm anterior cruciate ligament deficiency.

Pneumatic tourniquet was applied to the operative leg after the limb was exsanguinated. The affected leg was then secured with lateral thigh post, which allows the movement from full extension to full flexion, the foot was also secured and supported.

Tibial tubercle, patella, the medial and lateral borders of the patellar tendon and the medial and lateral joint lines were identified and marked.

TECHNIQUE

Arthroscopy of the knee joint was done under spinal / general anesthesia for which patient was evaluated completely by haematological studies, urine analysis, and radiographic examination of chest.

The technique used was based on the performance of the two femoral and two tibial tunnels for which centers corresponds to the center of the anatomical AM and PL attachment sites. The femoral tunnel was prepared independently from the tibial tunnels. By drilling the femoral tunnels through the AM portals, the anatomical location with regard to native femoral footprint can be ensured.

Graft fixation was achieved with the two endobutton CL on the femoral side and two interference screw on the tibial side.

GRAFT HARVESTING AND PREPARATION:

A longitudinal incision of about 4 cm was given centered approximately 4 cm medial and just distal to the tibial tubercle or about three finger width below the medial joint line. This incision was also used for the harvesting and passage of grafts as well as the creation of the tibial tunnels. Subcutaneous tissue and fat was dissected in line with the incision taking care not to injure the infrapatellar branch of the saphenous nerve. Sartorius fascia was exposed by blunt dissection. The tendon of gracilis and semitendinosus could be palpated below this layer by rolling the finger over the anteromedial surface of tibia where they felt like the bumps of speed breakers, the lower one being semitendinosus. 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 angle artery forceps first the gracilis and then the semitendinosus tendon was hooked and delivered in the wound. Dissection was carried out distally to point where they became a conjoint structure and then amputated there to maximize their length. Each tendon at its distal end was tied with double looped knot to give traction.

After placing the knee in 90 – 100 degrees of flexed position, the tendon were dissected proximally by using blunt fingers towards their musculo-tendinous junction to release adhesion and accessory bands, while constant traction was applied on the threads. Special consideration was given to 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. Then a open/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 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. The tendon end were carefully trimmed to uniform size and 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. Circular marks were made 3cm distal to proximal end of the loop for viewing arthroscopically the accurate placement of the graft inside the femoral tunnel. 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*.

AM graft was generally made larger than the PL graft.

An 8-9 mm graft for the AM bundle and a 7-8 mm graft for the PL bundle was made with minimum graft length of 26 cm for the gracilis and 28 cm for the semitendinosus tendon. Semi tendinous graft was used for anteriomedial bundle and gracilis graft was used for Posterolateral lateral bundle.

ARTHROSCOPY

While the assistant was preparing the graft, the knee was examined with an arthroscope. With the knee flexed at about 90 degrees, a high anterolateral portal (viewing portal) was made using no. 11 blade at the level of inferior pole of patella, just lateral to patellar tendon. The scope was introduced and knee was examined systematically in the 'W' sequence, starting from the suprapatellar pouch, then the patellofemoral joint, medial gutter, medial meniscus, intercondylar notch, lateral meniscus and lateral gutter. Once all the pathologies were recorded a second anteromedial portal (working portal) was made at the inferior pole of patella, just medial to patellar tendon. All associated pathologies were dealt appropriately like partial menisectomy done for a meniscal tear that was unstable to probing, chondral defect shaved and loose bodies removed.

NOTCH PREPERATION

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 5.5 mm aggressive plus resector. All soft tissues from the lateral wall of the notch were removed. Synovium overlying the lateral aspect of posterior cruciate ligament was also shaved sometimes to identify 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.

Arthroscopic Reconstruction

PORTAL ESTABLISHMENT

For the anatomical ACL reconstruction surgery, we placed anterolateral and anteromedial arthroscopic portals immediately adjacent to the lateral and medial patella tendon borders at the level of the inferior pole of patella. These portals were slightly higher than usual arthroscopic portals used for knee arthroscopy. An anteriolateral portal was created, through which an arthroscope was inserted, and the instruments were introduced by way of the anteromedial portal. Complete diagnostic arthroscopy was performed, any intra-articular pathology (meniscus or chondral injury) addressed. The anatomical insertion of the AM and PL bundles of the ACL on the lateral wall of the intercondylar notch was identified and marked with either an RF probe or an awl.

Following the arthroscopic evaluation and the treatment of the related conditions, the tunnels were created, starting with the femoral tunnel. The notch and inner aspect of the lateral femoral condyle were prepared to the

point where the posterior aspect of the lateral condyle and the origin of ACL were visualized (9 – to 12° clock position for the right knee and 12 to 3° clock position for left knee).

DRILLING AND MEASURING THE AM FEMORAL TUNNEL

The anterioromedial femoral tunnel was drilled through the AM portal using either 4mm or 5mm Smith and Nephew Offset Endofemoral Aimer. The knee was kept bent 90° to place the guide and once the guide was in place, knee was flexed slowly between 110 – 120 degrees to ensure the proper orientation of the AM tunnel. For the anteromedial bundle, the guide wire is

placed 5 – 10 mm from posterior border of the lateral femoral condyle, in the standard 1-o clock position for the left knee, and 11-o clock position for the right knee.

For the *Posterolateral (PL)* bundle, the guide wire is place at the 2:30° – clock position for the right knee. The AM tunnel is more vertical than its PL counter part, and the solid bony bridge separate the two tunnels.

A 2.4 mm drill tip guide wire was advanced through the offset endo-femoral guide and drilled through the femur until the guide wire “breaks” through the lateral femoral cortex. The 2.4mm guide wire was felt just under the skin after it exit the cortex to determine its position. A cannulated 4.5 mm endobutton drill bit was advanced over the passing pin and the lateral femoral cortex breached.2.4mm guide wire was than removed.

Endobutton depth probe was used to measure the total length of the AM femoral tunnel and the appropriate endobutton CL length calculated.

AM AND PL GRAFT PREPARATION

ANTERIOMEDIAL BUNDLE

We fashion the tendon into double stranded graft with minimum length of 10-14 cm, depending on the size of the knee. Loop the AM bundle through the endobutton CL device that was chosen based on the length of the tunnel. We used smith and nephew sizing tubes to determine the diameter of the graft.

POSTEROLATERAL BUNDLE

We fashioned the tendon into double stranded graft, ensuring that the diameter is a minimum of 5mm. determine actual diameter of the PL bundle by again using the graft sizing tube, than loop the PL bundle through a 15 mm endobutton CL device.

DRILLING THE AM TUNNEL SOCKET

Anteromedial tunnel:

Smith and nephew wingless RCL router or endoscopic drill bit was chosen that matched the graft diameter used to produce the AM femoral socket. Depth was regulated according to the desired insertion length and was kept 9-10 mm greater than the desired graft insertion to allow for the endobutton flip.

DRILLING THE PL TUNNEL AND SOCKET

Posterolateral tunnel:

While keeping the knee flexed to 120°, the smith and nephew anatomic ACLR PL Femoral aimer was inserted with an appropriate sized post into the AM tunnel ensuring that shoulder of the AM post is in contact with the lateral wall of the intercondylar notch. Aimer will be rotated until the laser mark on the aimer aligned with the center of RF probe/ awl marked.

The aimer was than placed 2 or 3mm from the cartilage surface. Once aimer Placed properly, 4.5 mm non cannulated drill bit inserted and drilled through lateral femoral cortex. The PI femoral aimer was than removed the length of PL tunnel measured with endobutton depth probe. Than 2.4mm drill tip guide inserted through the PI tunnel.

PL femoral socket will be produced with a smith and nephew wingless RCL router or endoscopic drill bit that matches the graft diameter.

Depth was regulated according to desired insertion length and was taken 9-10 mm greater then the desired graft insertion to allow the endobutton device rotation.

DRILLING THE TIBIAL TUNNELS

Anteromedial tunnel:

Anatomic insertion of the AM and PL bundles was identified on the tibia and marked with either an RF probe or an awl.

Smith and nephew Accuflex director ACL tip aimer was set to 55 degree for the placement of the anteriomedial guide wire, which exited at the center of the AM bundle and *not the center of ACL*. The AM tibial tunnel was more anteriorly located than in the traditional single bundle reconstruction. A 2.4 mm drill tip guide wire than advanced through the tibia, once acceptable placement of the tibial guide wire was obtained, appropriate sizes cannulated drill bit were advanced into the joint space.

Posterolateral Tunnel :

The appropriately sized post was placed on the smith and nephew anatomical ACLR PL tibial aimer. Once the post secured, it was inserted into the AM tibial tunnel until the distal end flushed with the tibial surface. It was ensured that the post not protruding into the joint nor recessed in the tunnel. The tibial aimer has a slot at the tip of the AM tunnel post, this slot was oriented to align with the anticipated center of the PL bundle. Once the proper alignment was achieved bullet advanced against the tibia. PL bundle has a more medial and distal entry point on the tibial cortex than the standard ACL tibial tunnel. A 2.4mm drill tip guide wire was advanced through the tibia. Once acceptable placement of the tibial guide wire obtained, the appropriately sized cannulated drill bit advanced into the joint space. An osseous bridge of approximately 2-3 mm remain between the two tunnel inside the joint.

FINAL GRAFT PREPARATION AND INSERTION

A 2.7 mm endobutton passing pin was used through the AM portal to insert he two passing sutures of different colors through the AM and PL femoral tunnels. Grasping forceps was used to retrieve the suture through the corresponding

tibial tunnels. A # 5 polyester braided suture attached to one outside hole of the endobutton device to lead and pass the device, Than # 2 polyester braided suture attach to the opposite side hole of the endobutton device to rotate, or “flip” the endobutton device as it exits the femoral cortex.

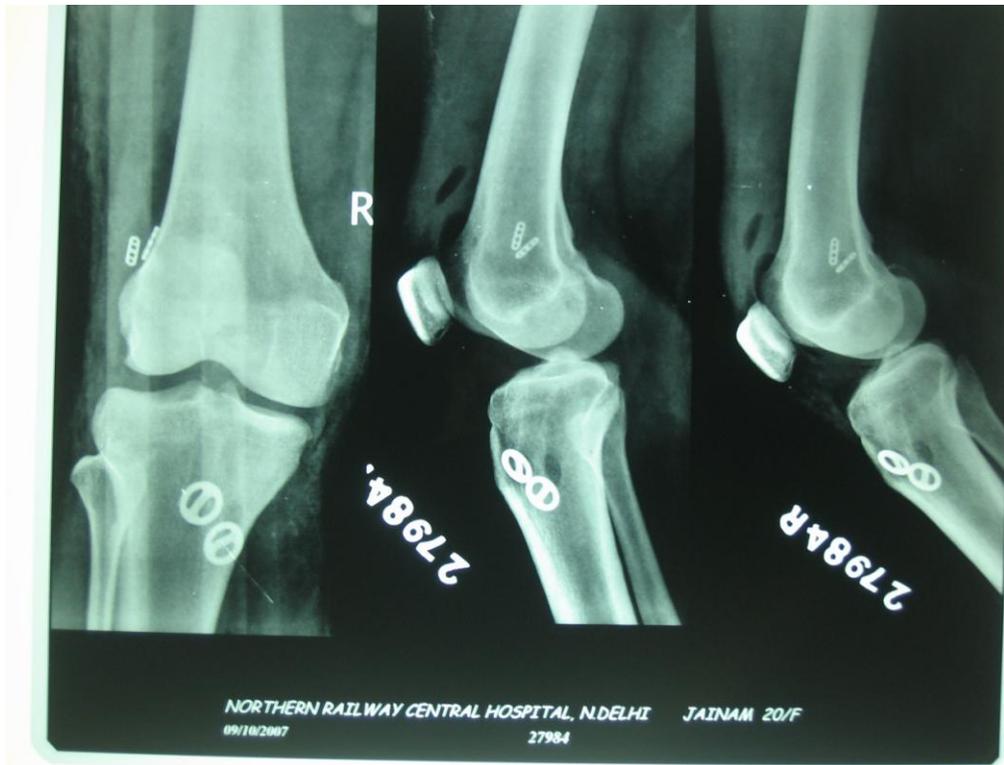
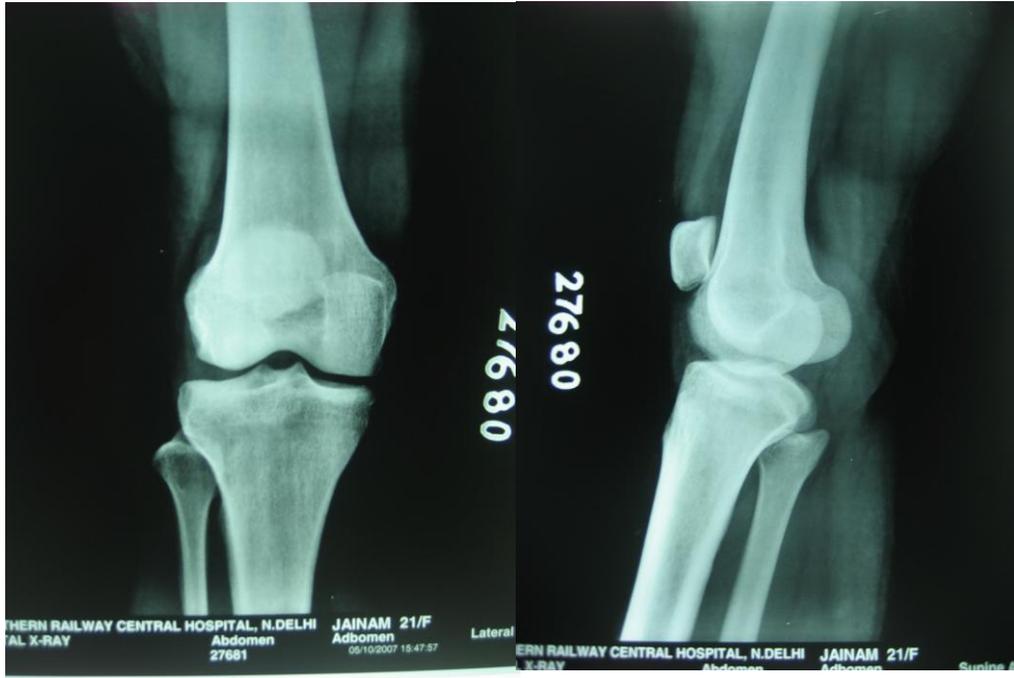
The graft of PL bundle was passed until it breaches the femoral cortex and flip the endobutton than the graft was pulled back to ensure the proper fixation of the endobutton. Next, the same procedure was followed to pass the graft of AM bundle. While holding the graft, the knee was cycled through the full range of motion from 0- 120 degree approx. 20 times. The graft that lie external to the tibia was marked with the skin pencil, close to tunnel entrance.

Variation of each bundle was visualized from full extension to full flexion. While pushing backwards on the tibia, tension was applied and AM bundle fixed between 45-60 degrees of flexion. Than tension was applied and PL bundle fixed. Generally fixation of PL bundle was done between 30 and 10 degree. After fixation it was ensured that full range of motion achieved after fixation of AM and PL bundle. It was also ensured that there was no impingement with the intercondylar notch- especially with the lateral condyle wall – in full extension, nor with the PCL in full flexion. If necessary notchplasty was performed.

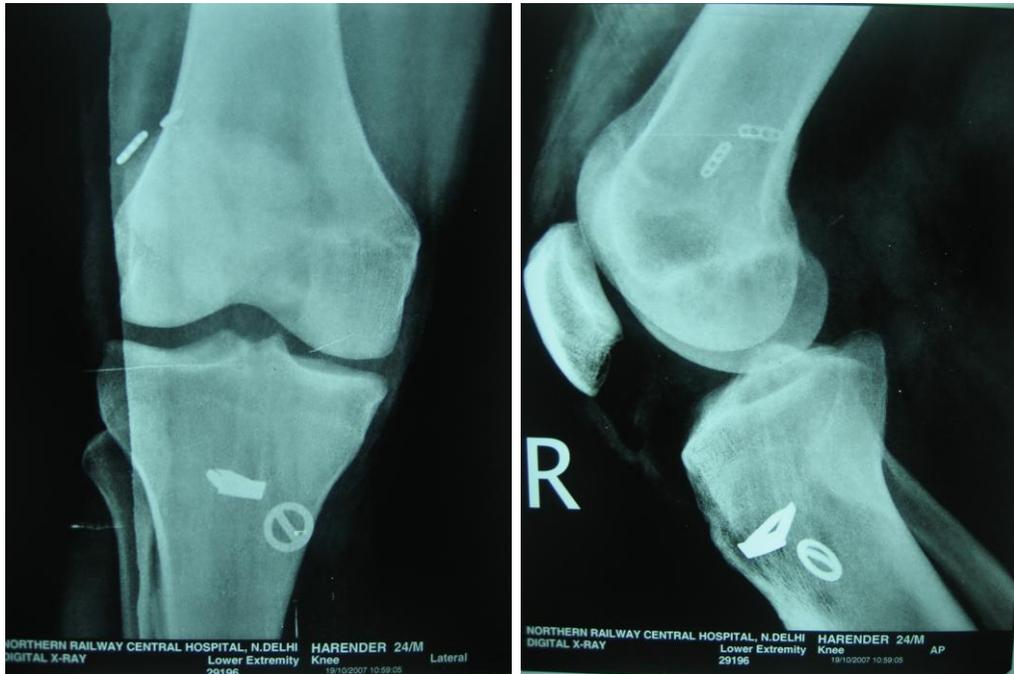
Pictorial representation of the technique is shown from Fig.3 to Fig.41.

(Attached with hard copy)

CASE 1



CASE 2



POST –OPERATIVE CARE AND FOLLOW UP :

Patients were given intravenous antibiotics for 3 days post-operatively. Wound inspection was done on the 3rd postoperative day and the patient is discharged on oral antibiotics if the wound was good. On the 14th day stitch removal was done.

Post-operatively patient were placed in knee brace. Partial weight bearing with crutches, with 50% of the body weight was allowed for one month. Mobilization was started immediately, giving priority to the recovery of full extension. CPM was also used to help flexion. Active static quadriceps exercises and ankle pumps were started as soon as the patient recovered from anesthesia. . The crutches are maintained until quadriceps control was reestablished: typically about 4-6 weeks. Standard ACL reconstruction rehabilitation protocol was than followed.

Non cutting, non pivoting sports was allowed after 3 months. Cutting and pivoting sport activities was started by 6 months.

Rehabilitation Protocol:

The rehabilitation programme was divided into 4 phases with following goals:

1) Immediate phase(0-2 weeks)

- Control of pain and swelling with rest, cryotherapy, NSAIDs and compression bandage.
- Recovery of full range of motion with active flexion and passive/ self assisted extension, especially in the last 45⁰.
- Isometric quadriceps and hamstring exercises with ankle pumps.
- Reestablishment of normal gait by walking with crutches and knee brace.

2) Early phase(2-5 weeks)

- Full range of motion, active extension from 0-45⁰, 60-65% quadriceps strength.
- Begin agility drills and proprioception activities by 5th week.
- Brace-free, normal gait pattern without crutches.

3) Middle phase(5-12 weeks)

- Critical period, as revascularization occurs during this time.
- Full active range of motion, 70-75% isokinetic quadriceps strength, start athletic activity (Swimming, bike).

4) Late phase(3-6 months)

- 80-85% isokinetic quadriceps activity by 4 months when return to non-contact sports was advised.
- 90% isokinetic quadriceps activity by 6 months when full return to sports (including contact) was allowed.

All knees were examined before surgery; in the operating room immediately after the procedure; and at two, four, six, and twelve months.

Ability to bear weight (graded as full, partial, or impossible) was assessed preoperatively and at two, four, six, and twelve months.

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 preoperative, four, six, and twelve month visits).

Presence or absence of anterior knee pain was documented at two, four, six, and twelve months.

EVALUATION IN THE FOLLOW UP PERIOD

The results were evaluated from the one published by **LYSHOLM KNEE SCORE**.

Lysholm Knee score

1. Limp (5 points)

- None 5
- Slight or periodic 3
- Severe and constant 0

2. Support (5 points)

- Full support 5
- Cane or crutch 3
- Weight bearing impossible 0

3. Stairs climbing (points)

- No problem 5
- Slightly impaired 3
- One step at a time 2
- Unable 0

4. Squatting (5 points)

- No problem 5
- Lightly impaired 3
- No past 90 degrees 2
- Unable 0

5. Walking, Running and jumping

- Instability (30 points)
- Never giving way 30
- Rarely gives way except for athletic or other severe exertion 25
- Gives way frequently during athletic events or severe exertion 0
- Occasionally in daily activities 5

6. Swelling (10 points)

- None 10
- With giving way 7
- On severe exertion 5
- On ordinary exertion 2
- constant 0

7. Pain (30 points)

- None 30
- Inconstant and slight during severe exertion 25
- Marked on giving way 20
- Marked during severe exertion 15
- marked on or walking more than 1 1/4 miles 10

8. Atrophy of thigh (5 points)

- none 5
- 1-2 cm 3
- > 2 cm 0

- marked on or walking
less than 1 1/4 miles 5
- Constant and severe 0
- Total =.....

The results are interoperated as follows if scores are

- < 60 = Poor
- 61- 76 = Fair
- 77- 90 = Good
- > 91 = Excellent

Outcomes and Analysis

This study was conducted in Northern Railways central hospital, New Delhi over a period of 15 months from March 2007 to May 2008. This study comprised of 40 cases out of which 7 were lost in follow up.

Age and Sex Distribution

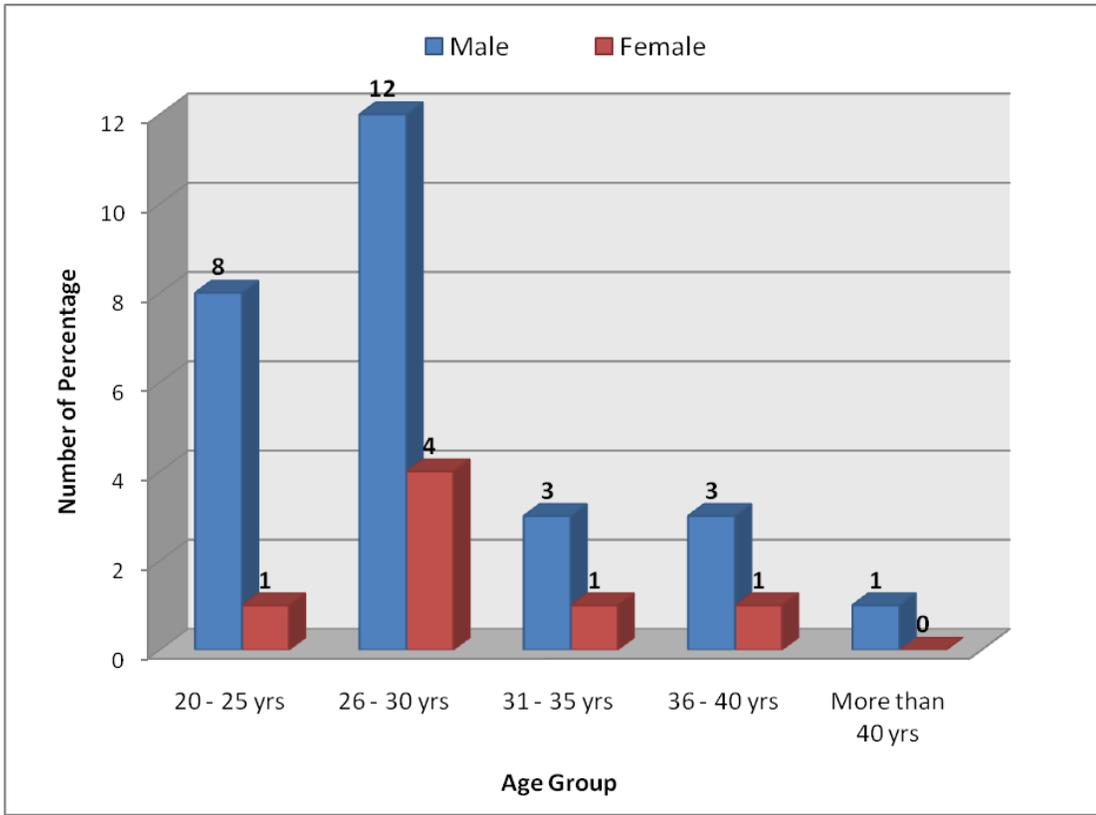
Most of our patients in our series 16 cases (51.51%) were in the age group 26 – 30 years in the overall series followed by 20 – 25 years age group 27.3% (9 cases). Males predominantly belonged to age group 26 – 30 years and females also predominantly belong to age group 26 – 30 years.

The age of the patients ranged from 21 – 40 years with the mean age of 29.8 years .

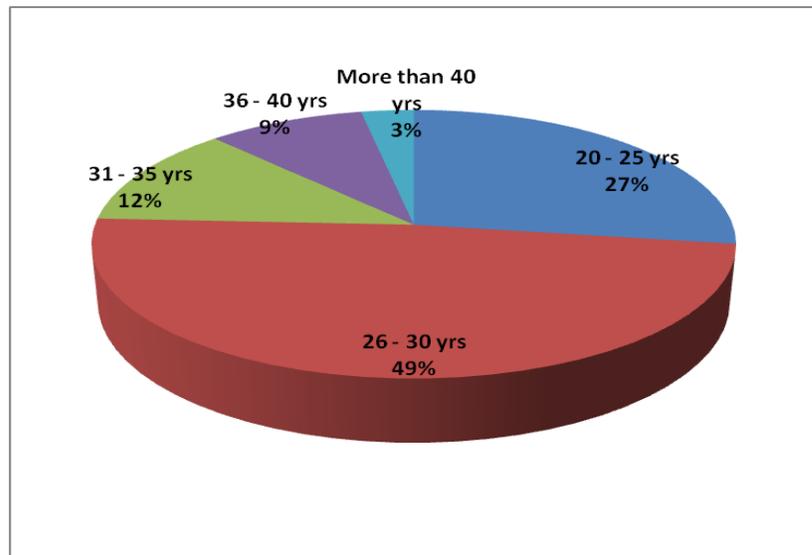
The Ratio of male to female patients was 4.5 : 1 .

Table I
(Age and Sex distribution)

S. No.	Age Groups (yrs)	No. of Patients	%	Male	%	Female	%
1.	20 - 25	9	27.3%	8	24.2%	1	3.0%
2.	26 - 30	16	48.5%	12	36.3%	4	12.1%
3.	31 – 35	4	12.1%	3	9.0%	1	3.0%
4.	36 – 40	3	9.1%	3	9.0%	0	0%
5.	41 – 45	1	3.0%	1	3.0%	0	0%
Total		33		27	81.8%	6	18.2%



Graph 1



Graph 2

The above pie charts shows the distribution of age along with the percentage of patients belonging to particular age group.

JOINTS INVOLVED

The total of 19 cases (57.57%) of the right knees were involved and 14 (42.42%) of the left knee were involved in the study. The ratio of right knee to left knee involved in ACL injury was 1.35 : 1. There were no bilateral cases in this study. (Table II).

Table II

S.No.	Joint Involved	No. of cases	Percentage
1.	Right knee	19	57.57%
2	Left Knee	14	42.42%

MODE OF INJURY

Vehicular accidents accounted for 24.24 % (8 cases) of patients while 69.69 % (23 cases) were due to sports injury. Injury sustained during daily activities of life accounted for 6.0 % (2 Case) of Patients. (Table III)

Table III

S. No .	Mode of injury	No. of Cases	Percentage
1.	Sports injury	23	69.69 %
2.	Vehicular accidents	8	24.24 %
3.	Daily activities	2	6.0 %

DURATION OF SYMPTOMS:

Majority of the patients presented with 2 to 6 months of sustaining the injury. There were 21 cases (63.63%) who presented with 2 – 6 months and 9 cases (27.27%) presented within 7 to 10 months and there were only 3 cases who presented late after 11 month. Only those patients whose inflammation subsided after the injury were included in the study.

Table IV

S.No.	Duration	No. of cases	Percentage
1.	2 – 6 months	21	63.63 %
2.	7 – 10 months	9	27.27 %
3.	11 months and above	3	9.1 %

Sports Causing ACL tear

In our series most common cause of ACL tear were football players in which sports pivoting is most commonly involved about 56.52% (13 cases), second most common sport injury was due to cricket (26.0 %), other sports activity responsible for ACL injury was only 17.39 % in our series. (Table V) **Table V**

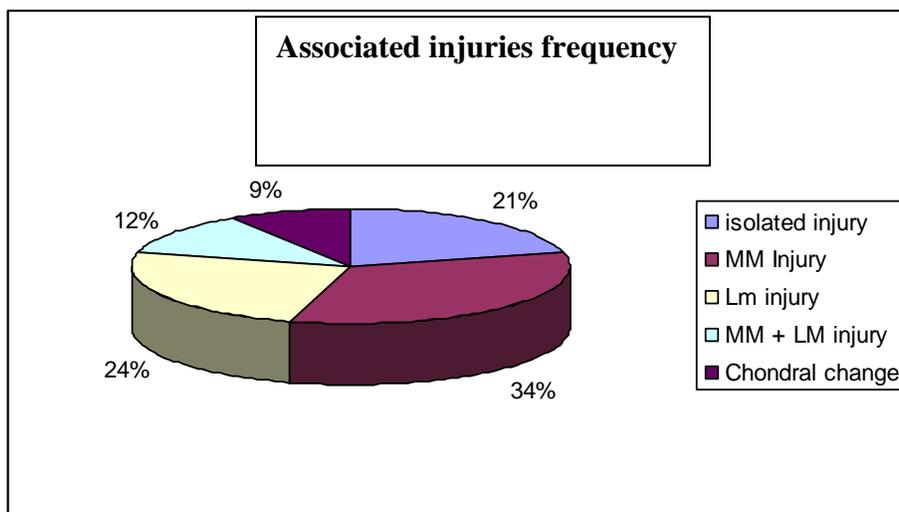
S.No.	Sports	No.of patients	Percentage
1.	Cricket	6	26.0%
2.	Football	13	56.52%
3.	Kabbadi	2	8.6%
4.	Hockey	1	4.34%
5.	Others	1	4.34%
6.	Total	23	100%

Associated Injuries (Clinical / Arthroscopic) :

A Total of 78.78% (26 cases) patients had associated injuries usually the meniscal tear (23 cases). Isolated medial meniscal tear were found in 33.3 % (11 cases) while isolated lateral meniscus tear were found in 24.2 % (8 patients) of cases. Combined medial and lateral meniscus tear were found in 12.1 % (4 cases). Chondral changes requiring the debridement were found in 9.1 % (3 cases) and posterior cruciate ligament tear was found in none. (Table no. VI)**Table VI**

S.No.	Associated injury	No. of cases	Percentage
1.	Isolated ACL injury	7	21.2%
2.	Medial meniscus injury	11	42.30%
3.	Lateral meniscus injury	8	30.76%
4.	Medial + Lateral meniscus tear	4	15.38 %
5.	Posterior cruciate ligament tear	0	0 %
6.	Chondral changes	3	11.5%
7.	Medial collateral ligament tear	0	0 %
8.	Lateral collateral ligament tear	0	0 %
Total		33	100.0%

There were 21.21 % (7 cases) with isolated tears of the anterior cruciate ligament Medial collateral ligament tear and lateral collateral ligament injuries were not found in our series as the cases associated with these injuries were excluded. Similarly none of our cases had associated fracture of the tibial plateau, femoral condyles, or the patella as shown in graph 3.



Graph 3

Presenting complaints:

Majority of the patients 60% (20 cases) presented with a feeling of giving way of the knee during routine work and guarded walking due to apprehension usually without pain. 40 % (13 cases) patient had a feeling of giving way during heavy labour or playing usually with pain. (Table no. VII).

**Table VII
(Presenting complaints)**

S.No.	Presenting Complaint	No. of cases	Percentage
1.	Giving way with guarded walking during normal activity	20	60.00%
2.	Giving way during heavy labour or playing with pain	13	40.00%

Associated Clinical Findings:

The most common clinical finding associated in the patients of ACL tear was effusion which was present in 75.75% (25 patients) of cases. The joint line

tenderness was present in 51.5% (17 patients) of the cases. There were 18.1% cases (6 patients) with flexion < 100 degrees . There were only. There were only two cases (6.0%) who had Flexion < 10 degrees. The associated clinical findings recorded are as in table (VIII)**Table VIII**

Clinical signs	Cases	Percentage
Effusion	25	75.7%
Joint line tenderness	17	51.5%
< 100 degree flexion	06	18.1%
Flexion deformity < 10 Degree	02	06.0%

RESULTS OF MANUAL KNEE LAXICITY TEST BEFORE ACL RECONSTRUCTION

Manual knee laxity test were performed in all cases of ACL injury. First it was performed in normal knee which was taken as standard of that patient than it was performed in injured side.

It was recorded as +, ++, +++ (if positive) and - (if negative). Anterior Drawer Test, Lachman test and Pivot shift test were positive in 100% . Various grades of these tests shown in (Table IX)

Table IX
(Pre-operative manual knee laxity test)

S. No.	Test	Negative	Positive +		Positive ++		Positive +++	
1	Lachman test	0	0	0%	4	12.1%	29	87.9%
2	Anterior Drawer Test	0	0	0%	8	24.2%	25	75.8%
3	Pivot shift	0	2	6.1%	7	21.2%	24	72.7 %

	test								
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RESULTS OF KNEE LAXITY TEST AFTER ANATOMICAL DOUBLE BUNDLE ACL RECONSTRUCTION

Results of anatomical double bundle ACL reconstruction were 90.90% (30 cases) were negative Lachman test, 6.06% (2 cases) were + positive and only one case (3.03%) was ++ positive for Lachman test after the ACL reconstruction. Results of Anterior Drawer Test after double bundle ACL reconstruction were 93.93 % (31 cases) were negative, 3.03% (1 case) was + positive and only case was ++ positive.

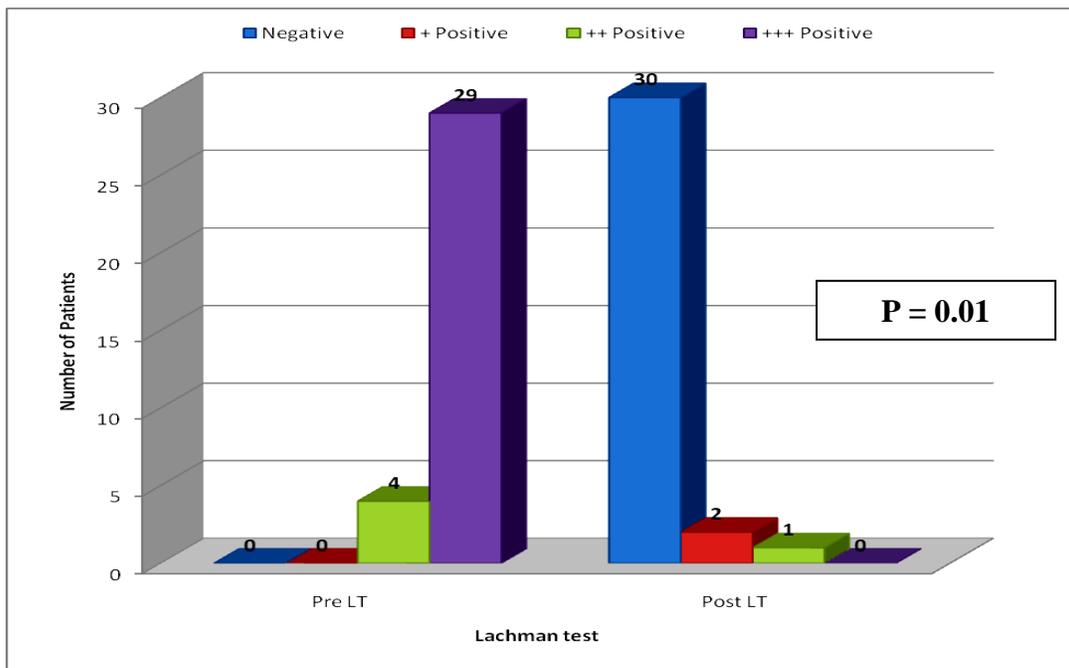
Results of Pivot shift test after double bundle ACL reconstruction were 90.09% (30 cases) were negative, 2 cases (6.0%) were + positive and only one case (3.03 %) was ++ positive.

There were no cases of severe instability in our series with +++ positive for Lachman test, Anterior drawer test and Pivot shift test as shown in Table X

**Table X
(Postoperative manual knee laxity test)**

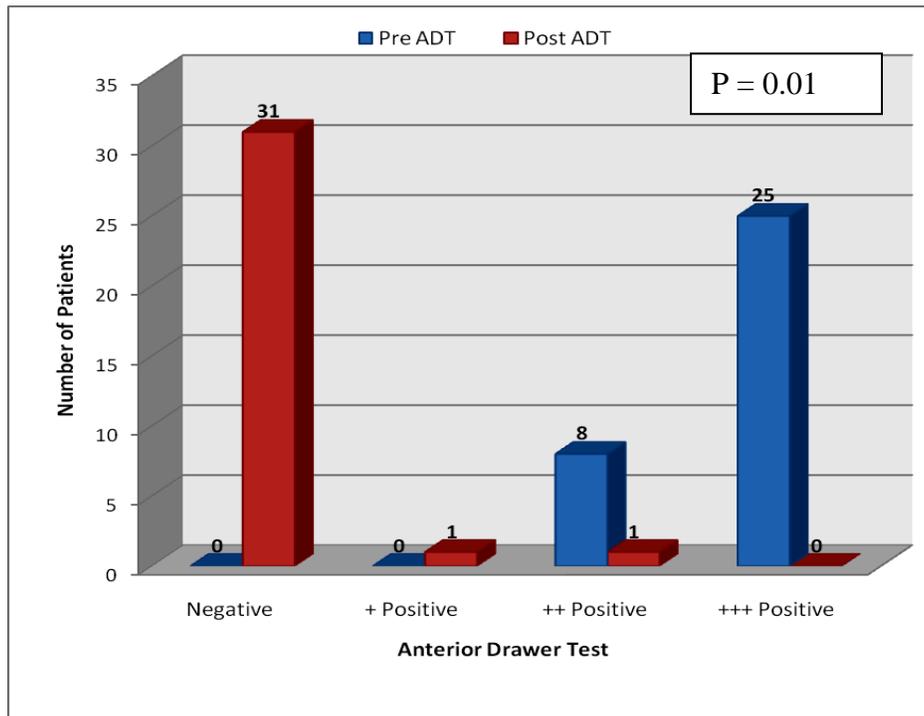
S. NO	TEST	Negative		+ Positive		++ Positive		+++ Positive	
1	Lachman Test	30	90.9%	2	6.1 %	1	3.0%	0	0%
2	Anterior Drawer Test	31	93.9%	1	3.0 %	1	3.0%	0	0%
3	Pivot shift test	30	90.9%	2	6.1 %	1	3.0%	0	0%

The results were evaluated statistically between manual knee laxity test *before* double bundle ACL reconstruction and manual knee laxity *after* ACL reconstruction using the paired T test at 5% level of significance, the results were found to be significant. The results of Pre operative lachman Test and Post operative Lachmen test were statistically evaluated and the mean of pre operative Lachman test was 3.88 ± 0.33 SD and post operative lachman test has mean 1.12 ± 0.42 SD with significant p value 0.01 (graph 4)



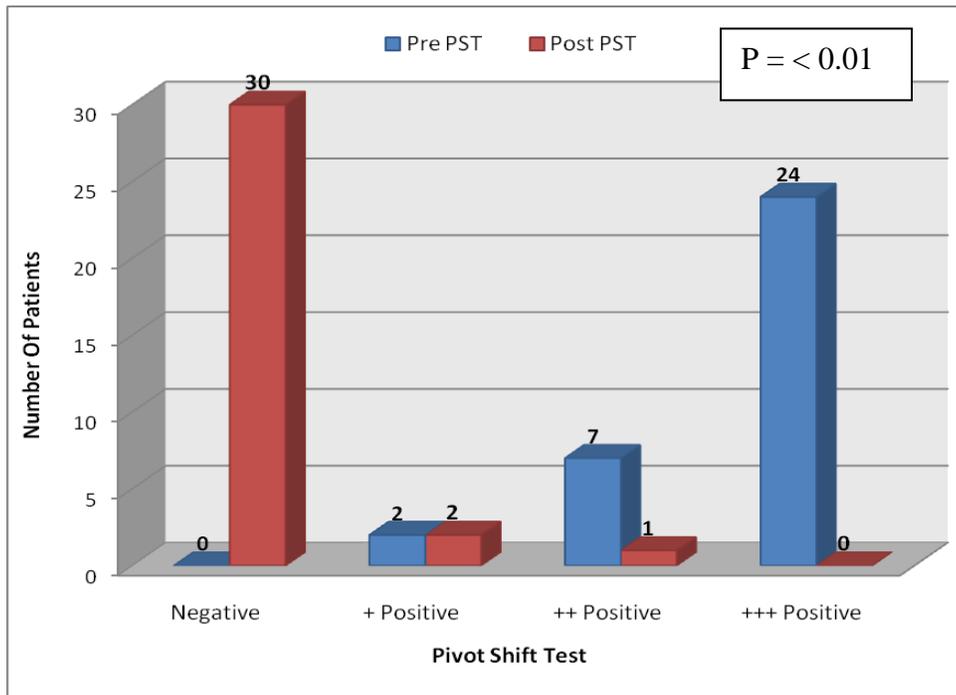
Graph 4

The results of Pre operative Anterior Drawer Test (ADT) and Post operative Anterior Drawer test were statistically analysed and the mean of pre operative ADT was 3.36 ± 0.44 SD and Post operative PST was 1.09 ± 0.38 SD and post operative lachman test has mean 1.12 ± 0.42 SD with significant p value < 0.01 . (graph 5)



Graph. 5

Similarly the results of preoperative Pivot shift test (PST) and Post operative Pivot shift test were statistically analysed. The mean preoperative PST was 3.67 ± 0.60 SD and post operative was 1.12 ± 0.42 with significant p value < 0.01 . Comparison between preoperative PST and post operative PST is shown in graph 6



Graph 6

RESULTS OF ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION IN ASSOCIATED INJURIES

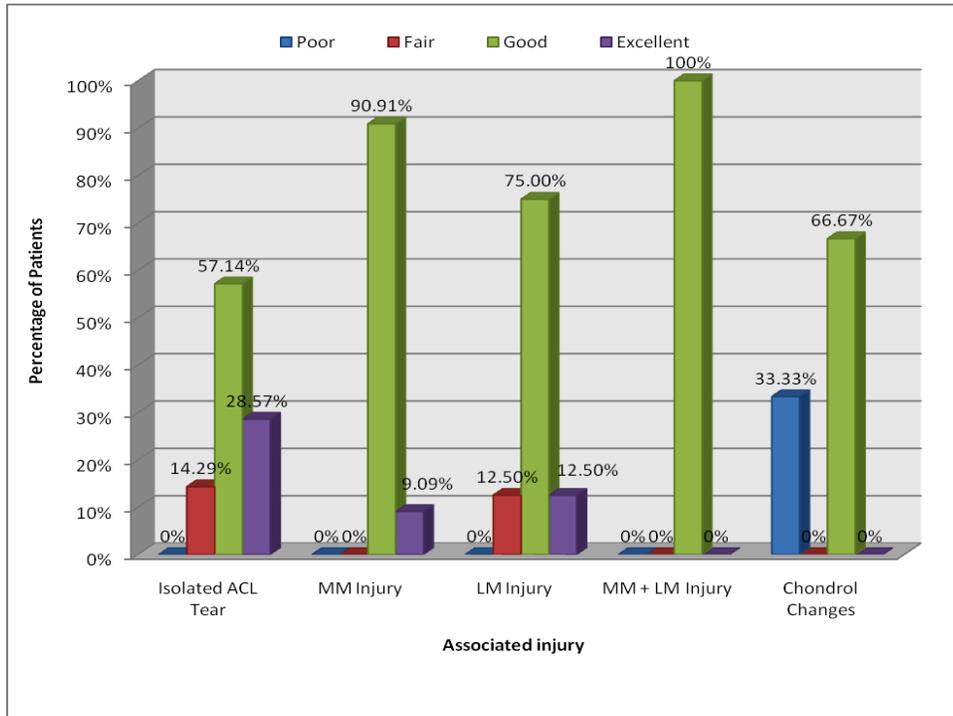
We had total of 11 patients with associated isolated medial meniscus with 9.1% (1 Case) with excellent result and 90.90 % (10 cases) with good results. There were total of 100 % (excellent + Good) satisfactory results in this group. There were fair or poor result in this group.

There were 8 patients with isolated Lateral meniscus injury. We had 12.5 % (1 Case) with excellent result. There 75.0% (6 cases) which had good results. There were 87.5% (excellent + good) satisfactory results in this group. There 1 case (12.5%) with fair result and there no poor results in this category.

There were 4 patients with combined medial meniscus and lateral meniscus injury all of which showed good result. There were 3 patients with chondral changes which required debridement. 1 case had poor result and other 2 cases had good results. (Table XI)

**Table XI
(Associated injuries)**

S. No	Results	Isolated injury	MM injury	LM injury	MM + LM injury	Chondral changes
1.	Excellent	2 (28.6%)	1 (9.1%)	1 (12.5 %)	0 (0 %)	0 (0 %)
2.	Good	4 (57.1%)	10 (90.9%)	6 (75.0%)	4 (100%)	2 (66.7 %)
3.	Fair	1 (14.3 %)	0 (0%)	1 (12.5%)	0 (0 %)	0 (0 %)
4.	Poor	0 (0%)	0 (0 %)	0 (0%)	0 (0 %)	1 (33.3 %)
5.	Total	7	11	8	4	3



Graph 8

The above bar diagram shows results of associated injuries

Results in isolated tears of ACL

We had 28.6 % (2 cases) with excellent results, 57.1 % (4 cases) had good results, 14.28% (1 case) had fair results and no poor results in the isolated tears of anterior cruciate ligament

**Table XII
(Results in isolated tears of ACL)**

S.no.	Results	No. of cases	Percentage
1	Excellent	2	28.57%
2	Good	4	57.14%
3	Fair	1	14.28%
4	Poor	0	0

Overall Results (Lysholm Knee Score):

Overall results of ACL reconstruction with anatomic double bundle ACL reconstruction was score by lysholm score and results in our series were 12.12 % (4 cases) excellent, 78.78 % (26 cases) were good, and 6.0% (2 cases) fair and 3.04 % (1 Case) poor results in our series. Thus we had 90.90% (excellent + good) satisfactory results in our series (Table XIII)

**Table XIII
Overall Results (Lysholm Knee Score)**

S.No.	Results	No. of cases	Percentage
1	Excellent	4	12.12 %
2	Good	26	78.78%
3	Fair	2	6.0 %
4	Poor	1	3.04 %

Overall Lysholm score Preoperative and after ACL reconstruction:

Overall results of ACL reconstruction with anatomic double bundle ACL reconstruction was score by lysholm score. All patients strictly followed the rehabilitation and were evaluated according to lysholm score every three months. In this series lysholm score was recorded at 6 months and 1 year postoperatively. At 6 month there were only 9 % (3 cases) who had excellent result and 57.7 % (19 Cases) with good results. Overall satisfactory results at 6 months was 66.5%. Patients strictly followed and at 1 year we had 12.12 % (4 cases) excellent, 78.78 % (26 cases) were good, and 6.0% (2 cases) fair and 3.04 % (1 Case) poor results in our series. Thus we had 90.90% (excellent + good) satisfactory results in our series. There were 12.12% (4 cases) with fair results. There were only 1 case with poor result in this series.

Table XIV

Lysholm score	Pre-operative (cases)	Post – operative cases at 6 months	Post – operative cases at 1 year
< 60	23 (69.6%)	1 (3.03)	1 (3.03 %)
60 – 76	10 (30.4%)	7 (21.2)	2 (6.0%)
77 – 90	0 %	22 (66.6%)	26 (78.78%)
>91	0 %	3 (9.0)	4 (12.12%)

The results of lysholm score were statistically analyzed using the paired test at 5% level of significance the mean preoperative 1.30 ± 0.47 SD and postoperative mean of $3.0 + 0.56$ SD. There was highly significant values with P value < 0.001

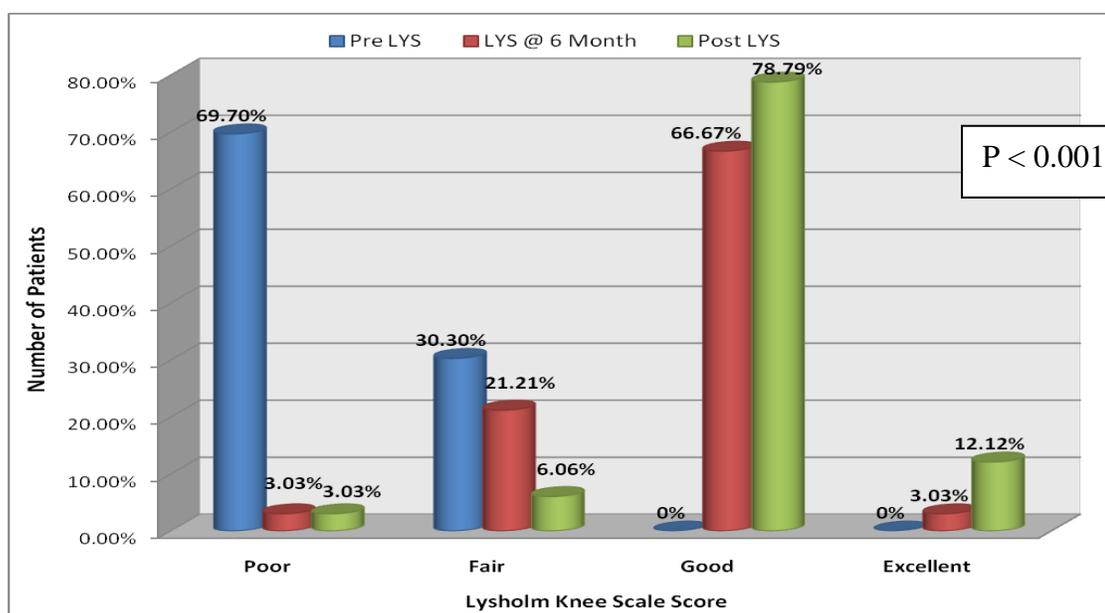


Fig. 9

Range of Motion after Anterior cruciate ligament anatomical double bundle reconstruction :

Most of the patients in our series regained good range of motion. 87.88 % (29 cases) regained good range of motion (0 -120 degree and above, 3 cases (9.09 % of the cases had > 15 degree restriction of terminal flexion out of

these only one case (3.03) had > 5 degree of restriction of terminal extension.
(Table XV)

Table XV
(Range of motion)

S. No .	Range of motion	No. of patients	Percentage
1	0 – 120 degree and above	29	87.88 %
2	> 15 degree of loss of terminal flexion	3	9.09 %
3	> 5 degree terminal extension	1	3.03 %

EFFECT OF DURATION OF SYMPTOMS ON THE RESULTS OF DOUBLE BUNDLE ACL RECONSTRUCTION:

The results of the cases who were operated earlier after the injury were better than those operated late but no co- relation could be cited as there were no cases that were operated before 2 months after injury. (Table XVI)

Table XVI.

Duration of symptoms (D.O.S)	Results									Total	Excellent + Good (within DOS)
	Excellent		Good		Fair		Poor				
	No.	% (within DOS)	No.	% (within DOS)	No.	% (within DOS)	No.	% (within DOS)			
2-6 months	4	19.0 %	15	71.4%	2	9.5%	0	0%	21	19 (90.4%)	
7-10 months	0	0%	9	100%	0	0%	0	0%	9	9 (100%)	
11 months and above	0	0%	2	66.7%	0	0%	1	33.3%	3	2 (66.7%)	

EFFECT OF AGE ON ANATOMIC DOUBLE BUNDLE ACL RECONSTRUCTION:

No correlation was found between the ages at the time of operation and the result of surgery. (Table XVII).

Table XVII

Age at operation (In years)	Results								Total	Excellent + Good Results
	Excellent		Good		Fair		Poor			
	No.	% (within the age)	No.	% (within the age)	No.	% (within the age)	No.	% (within the age)		
20 – 25 years	4	44.44 %	5	55.6%	0	0%	0	0%	9	9
26 – 30 years	0	0%	15	93.8%	1	6.3%	0	0%	16	15 (93.8%)
31 – 35 years	0	0%	3	75.0%	1	25.0%	0	0%	4	3 (75.0%)
36 – 40 years	0	0%	0	0%	0	0%	1	100%	1	nil

COMPLICATIONS:

No major complication were seen in our series except superficial infection in 3 cases (9.09%) . 3 cases (9.09%) had difficulty in regaining the motion. Graft impingement occurred in 1 case (3.03%) was detected after the graft fixation which was treated in same sitting by notchplasty. There were no cases in our series which had graft avulsion. There were 3 cases (9.09%) of superficial infection which were all treated and responded well to intravenous antibiotics. The average tourniquet time in our series was 50 minutes and there were no case of tourniquet palsy in our series.

Table XVIII

S. NO.	Complication	No. of Cases	Percentage
1	Difficulty in regaining motion	3	9.09%
2	Superficial infection	3	9.09%
3	Graft impingement	1	3.03%

DISCUSSION

Anterior cruciate ligament is a common occurrence these days due to increased participation in sports and vehicular accidents. It was controversial whether all patients with anterior cruciate deficient knee require construction of ACL. **Mcdaniel and Dameron**⁵⁷ and **Balkfors**¹³⁷ have presented patients with ACL injuries who resumed normal lifestyle without surgical intervention. In contrast to this Johnson et al reported high incidence of meniscus tears, early traumatic arthritis and functional instability in individuals with ACL deficient knees. There is now little doubt that anterior cruciate ligament deficiency causes progressive deterioration of knee function and stability in due course of time, especially in active individuals.

Surgical reconstruction has become the standard of care in the treatment. The primary goal of the reconstruction is to restore the stability to the knee and thereby, presumably to restore its function and allow the patient to return to normal activities, including sports. Another goal is to prevent early degenerative changes.

Now there is controversy whether ACL reconstruction should be done as single bundle reconstruction or there should be anatomical double bundle ACL reconstruction of the two bundles of the ACL.

The major goal of surgical ACL reconstruction is the restoration of normal knee kinematics. Although it has been well known for many years that the ACL consist of 2 major functional bundles, most surgical ACL reconstruction techniques have focused on the reconstruction of the AM bundle only. Cadaveric studies clearly have indicated that the AM bundle is the primary restraint of the anteroposterior knee stability and therefore has been focus of our efforts to replace the ACL. Two bundle ACL reconstruction using multistrand tendon has several theoretical advantages over conventional ACL reconstruction. The basic advantage is that the massive volume of multistrand

tendon can be positioned more easily in the natural ACL space because of its morphology^{43, 139.} consequently, operative method can minimize anterior notchplasty to avoid anterior impingement of the graft. The contact area between a graft and bone tunnel is increased with 2 route and 4 tunnel reconstruction, which can increase restraint force against anterior laxity and as well as anteriolateral rotational stability. Graft setting force and graft setting angle will provide more options for the 2 route 4 tunnel reconstruction with 2 bundles which could possibly improve ACL graft restraint potential against rotational as well as anterior direction.

Freddie Fu and Christian Latterman et al¹³⁸ suggest that anatomical ACL double bundle reconstruction may result in better restoration of in vivo kinematics of knee joint and can improve clinical outcomes in ACL surgery.

Takeshi Muneta et al³ in their study indicated that double bundle ACL reconstruction via 4 stranded ST is superior to the single bundle technique with regard to anterior and rotational stability.

Diagnostic and interventional arthroscopy has been going on at our institute for many years now. We decided to take up this study to address the problem of vast number of patients attending the out patient department and the arthroscopy and sport injury clinic in our hospital. Moreover the entire inventory and the facilities for the arthroscopic procedure are available with us. An attempt is made to evaluate the functional results and complications associated with arthroscopic anatomical double bundle ACL reconstruction.

Age and Sex distribution:

Most of our patients in our series 16 cases (51.51%) were in the age group 26 – 30 years in the overall series followed by 20 – 25 years age group 27.3% (9 cases). Males predominantly belonged to age group 26 – 30 years and females also predominantly belong to age group 26 – 30 years.

The age of the patients ranged from 21 – 40 years with the mean age of 29.8 years . The Ratio of male to female patients was 4.5 : 1

Brig VP Pathania, Lt Col GR Joshi et al¹⁸ in there study include soldier of the army. In there series the maximum number of patients, 10 cases (40%) were grouped between 25 – 30 years of the age.

A.J. Johnson, E. Eriksson, T. Haggmark and M.H. Pope (1984)¹⁷ in their series had patients whose age ranged from 17 to 48 years with the mean age of 26.3 years and median age 25.0 years. The study included 23 (92%) males and 2 (8%) females. Most of the males belong to the 15- 25 years age group.

William G . Clancy Jr (1993) had in his follow up 35 (70%) and 15 (30%) females.

Knee Involved :

In our series 57.5 % of the cases right knee was involved .The ratio of the right knee to left knee in this series was 1.3:1.

Brig VP Pathania, Lt Col GR Joshi et al.¹⁸ in there series 60 % of the cases right knee was involved.

A.J. Johnson, E. Eriksson, T. Haggmark and M.H. Pope (1984)¹⁷ had 89 patients during the follow up period of their study with right to left knee involvement ratio of 1.2 : 1.

Mode of Injury :

Sports injuries 69% (23 cases) and vehicular accidents 8 cases (24%) predominates as mode of injury in this series other injuries (daily activities) comprises of only 6.% (2 case) who sustain injury while stepping down from

moving bus. Amongst sports injuries football was the leading sports involved (54.5%) with cricket accounting for 27.2% of the cases.

William G Clancy, Jr Devon A. Nelson, Bruce Reider and Rajesh G

Narechania (1982) had 50 patients in their study during the follow up period and in 88% of their cases the mode of injury was sports especially football

Duration of symptoms:

The duration of symptoms ranged from 4 to 24 months in this series with an average period of 8.5 months.

William G . Clancy Jr (1993) had in his series the average interval from injury to surgery to 24 months. Moderately short duration of symptoms in this series can be explained due to the fact that most of the patients were employed in jobs where they had to walk and climbs stairs frequently and hence multiple episode of symptoms.

Associated Injuries

A total of 26 patients (78.7%) cases who had some associated injuries along with ACL tear. There were 23 cases (88.8%) associated with meniscal injury. Isolated medial meniscus tear were found in 42.3% (11 cases) while isolated lateral meniscus tear were present in 30.7% (8 cases) of the patients. Combined medial and lateral meniscus tears were found in cases (15.38%). All patients of meniscus injury were treated by partial menisectomy except one patient in which their was bucket handle tear of medial meniscus at periphery, that patient was treated with meniscus repair in the same sitting. Patient s with medial and lateral collateral ligament injuries were not included in the study. Patient with posterior cruciate ligament were also excluded .

Kruger- Franke M, Reinmuth S, Kugler A & Rosemeyer B. (1995)¹⁹ in their series of 107 patients found that 55% of the acute ACL ruptures involved a tear of the lateral meniscus., 45% of the medial meniscus,

and 34% had a lesion of medial collateral ligament. In their series the most frequent combination of the injuries with ACL rupture was the tear in both menisci and the lesion of the medial collateral ligament with the tear in the lateral meniscus.

Meniscus injury may occur at the time of initial injury along with ACL tear or later on in a chronic cruciate ligament deficient knee. In chronic ACL insufficiency meniscus damage occurs more often (60%) as seen in the series of **Russel F Warren and Martin Levy (1993)**.

Indelicato PA & Bittar ES (1995)²¹ in their series found that the incidence of the meniscus tear increased from 77% in the acute injuries to 91% in the chronically re-injured knee: furthermore, articular surface disease increased from 23% in the acute injury to 54 % in the chronically ACL lax knee. The majority of the meniscus tear in this series were medial.

Presenting Complaints and associated clinical signs

The major presenting complaint was guarded walking. In 60% (20 cases) presented with a feeling of giving way of the knee during routine work with no or minimal pain or guarded walking. In rest of the cases 40% (13 cases) patient had a feeling of giving way during heavy labor or sport usually with pain. However, they all had various associated complaints like Limp (74%) of the cases, Locking of the knee joint (16%) of the cases, difficulty in climbing staircase and difficulty in squatting.

In the series of **R.J.Johnson, E. Eriksson, T. H. Haggmrk amd M.H.Pope (1994)¹⁷** 73 patients (83.9%) complained of a feeling of giving way of the knee usually (in 92%) associated with joint effusion. The incidence of re-injury was

also high (85%).The disparity in our series can be explained by the fact that there were less number of episodes of re-injury in our series because either the patient stopped participating on sports or they were more careful after the initial injury and avoided activities that caused symptoms.

Results of anatomical double bundle ACL Reconstruction

Results of anatomical double bundles ACL reconstruction done and Lysholm score was used to grade the knee function. All the patients were evaluated symptomatically by lysholm score, clinically and radio logically at 2 weeks, one month, 3 months, 6 months, 9 months and one year and statistically analysis was done. We had four cases (12.2.4%) excellent, 78.78% (26 cases) good, and two cases (6.0%) fair and one case (3.03%) poor results in our series. All patients rated as excellent have returned to there pre injury level of the sports. At 6 months follow up 25 (75.7%) patients were satisfied with their results.

The average preoperative Lysholm score was 49 (27 – 75). Average post operative Lysholm score at 6 months follow up was 84 (65 – 94). The average increase in points were 27.5. After the average follow up of 9 months (87.8%) 29 patients were satisfied with there result and finally at 1 year of the follow up we had 90.9% of the satisfactory results.

Hiroto Asagumo, M.D., Masashi Kimura, M.D., et al¹³ worked on anatomical reconstruction of ACL using double bundle hamstring tendon: in their series Lysholm score averaged 70.1 ± 16.4 preoperatively and 98.8 ± 5.1 post-operatively in double bundle group.

Muneta T, koga H, Morito T, Yagishita K. (2006)⁹ Retrospective study of midterm outcome of two bundle anterior cruciate ligament reconstruction using quadrupled semitendinosus tendon in comparison with single double bundle reconstruction.The total score of the Lysholm knee scale averaged 93 points in both 1bundle and 2 bundle groups.

T muneta M.D., Ph.D H. Koga, M.D. et al . (2007)¹⁴. A prospective study of 4-strand semitendinosus tendon anterior cruciate ligament reconstruction comparing single bundle and double bundle technique. In their series total score on the Lysholm knee scale averaged 93.8 points in the single bundle group and 94.5 points in the double bundle group.

Results of isolated tears of anterior cruciate ligament

Out of 7 isolated tear in our study, We had 28.57 % (2 case) with excellent results, 57.14 % (4 cases) had good results, 14.28% (1 case) had fair results and no poor results in the isolated tears of anterior cruciate ligament.

There is no study in our knowledge till date in which results of ACL reconstruction in isolated tear has been mentioned separately. But there are few studies in which single bundle reconstruction was done in isolated tears.

Jarvela T, Kannus P, Jarvinen M (2001) compared the clinical and radiological results of an anterior cruciate ligament (ACL) reconstruction in patients with an isolated ACL tear and patients with an ACL tear and accompanying injuries. There were 34 patients with an isolated ACL tear (group A), and 38 patients with ACL tear and accompanying injuries (group B). Subjectively (overall assessment, pain, swelling, and giving way of the knee) and objectively (range of motion, stability, crepitation, Isokinetic strength testing, and radiological changes of the knee), the group did not have any significant difference in the 5 – 9 year results. Also, the final evaluation results using the IKDC and lysholm and the Marshall knee score were similar in both groups. However, there were significantly more subsequent knee surgeries in the injured knee in group B than in group A.

RANGE OF MOTION AFTER ACL RECONSTRUCTION

Most of the patients in our series regained good range of motion. 87.88 % (29 cases) regained good range of motion (0 -120 degree and above, 3 cases

(9.09 % of the cases had > 15 degree restriction of terminal flexion out of these only one case (3.03) had > 5 degree of restriction of terminal extension.

Hiroto Asagumo, M.D., Masashi Kimura, M.D. et al. ¹³ worked on anatomical reconstruction of ACL using double bundle hamstring tendon: Surgical technique, clinical outcomes and complications. In the double bundle group an extension deficit of more than 5 degrees was found 26% and flexion deficit of more than 5 degree was found in 7%.

Kazunori Yasuda, M.D., Phd. D. Eiji Kondo, M.D., Hiroki Ichiyama, M.D. et al ¹⁵ concerning the post-operative range of knee motion, 2 of the 57 patients had an extension deficit of approximately 5 degree. Five patients had a flexion deficit of approximately 5 degree.

INSTABILITY AFTER ANATOMICAL DOUBLE BUNDLE ACL RECONSTRUCTION

Manual knee laxity test were performed in all cases of ACL injury. First it was performed in normal knee which was taken as standard of that patient than it was performed in injured side. It was recorded as +, ++, +++ (if positive) and negative. Anterior Drawer Test, Lachman test and Pivot shift test were positive in all the patients. Results of anatomical double bundle ACL reconstruction were 90.90% (30 cases) were negative Lachman test, 6.06% (2 cases) were + positive and only one case (3.03%) was ++ positive for Lachman test after the ACL reconstruction. The results of Pre operative lachman Test and Post operative Lachman test were statistically evaluated and the mean of pre operative Lachman test was 3.88 ± 0.33 SD and post operative lachman test has mean 1.12 ± 0.42 SD with highly significant p value 0.01 suggesting that stability was significantly improved after double bundle ACL reconstruction.

Results of anterior drawer test after double bundle ACL reconstruction were 93.93 % (31 cases) were negative, 3.03% (1 case) was + positive and only case was ++ positive. The results of Pre operative Anterior Drawer Test (ADT)

and Post operative Anterior Drawer test were statistically analysed and the mean of pre operative ADT was 3.36 ± 0.44 SD and Post operative PST was 1.09 ± 0.38 SD and post operative lachman test has mean 1.12 ± 0.42 SD with significant p value < 0.01 .

Results of Pivot shift test after double bundle ACL reconstruction were 90.09% (30 cases) were negative, 2 cases (6.0%) were + positive and only one case (3.03%) was ++ positive. Similarly the results of preoperative Pivot shift test (PST) and Post operative Pivot shift test were statistically analysed. The mean preoperative PST was 3.67 ± 0.60 SD and post operative was 1.12 ± 0.42 with highly significant p value < 0.01 . suggesting that there was highly significant improvement in the stability after double bundle ACL reconstruction. Comparison between preoperative PST and post operative PST.

There were no cases of severe instability after ACL reconstruction in our series with +++ positive for Lachman test, Anterior drawer test and Pivot shift test.

T. muneta M.D., Ph.D H. Koga, M.D. et al . (2007)¹⁴ A prospective study of 4-strand semitendinosus tendon anterior cruciate ligament reconstruction comparing single bundle and double bundle technique. In their series manual knee laxity testing revealed that negative Lachman and Pivot shift test results in more patient in double bundle group than in single bundle group. Post operatively they had statistically greater number of patients in single bundle group had positive finding based on the Lachman test (21 % in the single bundle group and only 3 % in double bundle group) and pivot shift test (41 % in the single bundle group and 15 % in the double bundle group.

Kazunori Yasuda, M.D., Phd. D. Eiji Kondo, M.D., Hiroki Ichiyama, M.D. et al ¹⁵ Anatomical reconstruction of the anteriomedial and posteriolateral bundles of the ACL using hamstring tendon graft. In their series regarding the

post operative manual knee laxity test, positive Lachman test were found in 4 patients (7.01%), all were evaluated as + and none was evaluated as ++, Positive pivot shift test were detected in only one patient (1.7%) . This patient was also evaluate as + positive and no patient was evaluated as ++ positive.

Masayoshi Yagi, Ryosuke Kuroda, M.D., et al ¹⁶ Double bundle anterior cruciate ligament reconstruction can improve rotational stability (2006).

In their series the Lachman test revealed positive results in two (10%) and three (15%) patients in the anteriomedial group and Posterolateral reconstruction group respectively, while no (0%) patient in double bundle group showed positive instability. However they found no difference in the negative rate in the Lachman test among the three group, double bundle reconstruction (85%) Similarly in the pivot shift test results, no difference was observed in the rate of negative test results among the groups. However, positive pivot shift test with clunk motion (grade 2) was observed only in the single bundle groups (two knees in the anteriomedial reconstruction and three knees in posteriolateral group), whereas all the reconstructed groups were rated as 0 (17 knees) or grade 1 (three knee) in the double bundle reconstruction group.

Muneta T, koga H, Morito T, Yagishita K. (2006) ⁹ In their series post-operative results of manual knee laxity tests. A statistically greater number of patients in the single bundle group were positive based on the Lachman test (34 % in the single bundle group and 13 % in the double bundle group, respectively).

Kazunori Yasuda, M.D., Phd. D. Eiji Kondo, M.D., Hiroki Ichiyama, M.D. et al ¹⁵ In their series regarding pivot shift test 9 (37.5%) patients were evaluated as + and 3 patients (12.5%) were evaluated as ++ in the single bundle group while 3 (12.5%) patients were evaluated as +, and no patient was evaluated as ++ in the double bundle group.

EFFECT OF AGE AND DURATION OF SYMPTOMS ON THE RESULTS OF DOUBLE BUNDLE ACL RECONSTRUCTION:

No correlation was found between the age of the patient and duration of symptoms at the time of surgery and functional results in this series.

Barber FA, Elrod BF, Mc Guire Da, Paulas LE (1996) found no correlation between the time of surgery and ultimate functional outcome in their study .

Hunter RE, Mastrangelo J, Freeman JR, Purnell ML and Jones RH (1996) in their series of 185 patients concluded that by using modern arthroscopic surgical techniques and aggressive post-operative physical therapy protocol, motion and stability can be restored in a high percentage of the patients and that surgical success is independent of the timing of surgery.

COMPLICATIONS:

No major complication were seen in our series except superficial infection in 3 cases (9.09%). 3 cases (9.09%) had difficulty in regaining the motion.

Graft impingement occurred in 1 case (3.03%) was detected after the graft fixation which was treated in same sitting by notchplasty. There were no cases in our series which had graft avulsion. There were 3 cases (9.09%) of superficial infection which were all treated and responded well to intravenous antibiotics. The average tourniquet time in our series was 50 minutes and there were no case of tourniquet palsy in our series.

Yasuda et al⁹ reported a case series of 57 consecutive patients undergoing anatomical double bundle ACL reconstruction. In their series, no major complication were recorded at a minimum follow up of 24 months, and they suggested that anatomical double bundle ACL reconstruction appears to be a safe and practicable technique.

Kazunori Yasuda, M.D., Ph.D. Eiji Kondo, M.D., Hiroki Ichiyama, M.D. et al (DEC.2004) ¹⁵ in their series they did not experience any intraoperative problems concerning tunnel positioning, the graft placement, or the graft fixation. There were no post-operative complication, such as infection, neurovascular injury, cartilage injury, injuries in other knee structures or delayed wound healing.

T muneta M.D., Ph.D H. Koga, M.D. et al . (2007)¹⁴ In their series there were no problematic loss of knee motion in either the single bundle or double bundle group. Prolonged joint inflammatory reaction that continued for more than 3 months after the surgery or that occurred at more than 3 months postoperatively was found in 4 (11%) patients in the single bundle group and 2 (5.5%) patients in double bundle group. Repaired meniscus were ruptured again in 3 patients in single bundle group and one patient in double bundle group. On the other hand one secondary injury of the meniscus occurred in both the single bundle and double bundle group.

ADVANTAGES AND DISADVANTAGES OF THE PROCEDURE

Now the advantages and disadvantages of the procedure should be discussed, the normal ACL has a 3 dimensional structure consisting of collagen fibrils that will respond to various sheer and rotational stresses to the knee.⁸⁻¹⁰ Theoretically, ACL reconstruction with the anatomical double bundle procedure has some advantages over the single bundle reconstruction.

First it can help to restore functions that resemble these of normal ACL. **Yagi et al** ¹² suggested biomechanical advantages of the double bundle procedure to the single bundle procedure in their in-vitro study. The second possible advantage is concerned with graft healing within the bone tunnel.

Because only the margins of the tendon graft anchors with collagen fibers resembling the sharpey's fiber to the tunnel wall in the ACL reconstruction.¹¹⁻¹² there is the high possibility that tendons located at core portion of the thick

multi-stranded graft are not directly fixed to the bone tunnel. From this point of view reconstruction with two thin bundles is superior to one thick bundle when the same tendon materials are used for reconstruction. On the other hand, possible disadvantage of the anatomical double bundle ACL reconstruction procedure involve the difficulty of the technique, subsequently long operation time, economically high cost, the dysfunction of the 2 reconstructed bundles.

CONCLUSION and Recommendations

This was prospective study was conducted in Northern Railways central hospital, New Delhi, to clinically evaluate the results of arthroscopic anatomical double bundle anterior cruciate ligament reconstruction. It comprises of 40 patients but 7 lost in follow up and than 33 were considered for the study with minimum of 1 year follow up. There were 27 males and 6 females in this study who sustain injury to there knee following either sport injury (23 cases, 69.9%), vehicle accident (8 cases, 24.4%) and daily activities (2 cases, 6.0%). The patients with > 2 months duration were included, after subsiding the acute inflammation after the injury. Patients who were young and middle aged, active, motivated patients with future interest in professional / 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 medial meniscus and lateral meniscus injury in the same were also included but the patients with associated ligamentuos injury and spinal fracture or fracture of the same extremity were excluded from the study. All patients who were selected were clinically evaluated after taking proper history they were evaluated for knee stability test and by lysholm knee score preoperatively and postoperatively and follow up at 2 week, 1 month, 3 months, 6 months 9 months and 12 months and necessary documentation were made. All patient strictly followed rehabilitation protocol. Most of the patients in our study were sport related injury (69.69%). Patients presented commonly (60%) with complains of giving way with guarded walking during normal activity with 75% of the patients presented with effusion and 50% patients presented with joint line tenderness. There were 90.90 % (Good + excellent cases) in our study. The following conclusions were drawn after results, analysis and discussion

- ACL double bundle reconstruction aims to reconstruct the two bundles of AM and PL as close to anatomical position as possible thus

theoretically provides stability and knee kinematics close to the anatomical ACL.

- Since we reconstruct the two bundle AM and PL bundle, PI bundle is stretched in extension and the AM in flexion. Thus the two bundles are under tension or relaxed at different angles of flexion, providing anterior and rotational stability.
- The statistically analysis comparing the preoperative and post operative Anterior drawer test and pivot shift test were highly significant suggesting that double bundle ACL reconstruction provides anterior and rotational stability.
- This subjective study suggest the most of patient undergoing double bundle ACL reconstruction were satisfied with results and achieved preinjury status.
- Since most of the patient in this study were sport related and young and were satisfied with there results this may imply that this is good technique for young and sport patients involving pivoting most of times in there life time but more quantitative and long term studies are required.
- Limitation was that it was the short period study and small number of patients in our study.
- It was the subjective study based on the lysholm score and our study was not objective based, as it required KT 1000 to quantify our results.
- The procedure has the long learning curve and the surgery should be performed by experienced surgeon in arthroscopy.
- Arthroscopic anatomical double bundle ACL reconstruction is bio-mechanically stable reconstruction closely resembling the anatomy of the ACL.
- It is good option for the ACL reconstruction in the treatment of athlete and high demanding patients who has to undergo pivoting

most often in their life time as anatomical double bundle reconstruction aims to restore anterior drawer and rotational stability.

- Long follow up studies are required in future to know long term outcomes of this procedure moreover this arthroscopic procedure has a long learning curve and should be performed by experienced arthroscopic surgeon.

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