A CASE CONTROL STUDY TO COMPARE DISTAL FEMUR TUNNEL WIDENING BETWEEN SUSPENSORY FIXATION AND SUSPENSORY FIXATION AUGMENTED WITH BIOABSORBABLE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT

A dissertation submitted in partial fulfillment of

MS (Orthopedics) branch II Examination of Tamil Nadu

DR.M.G.R UNIVERISTY, CHENNAI

To be held in May 2019

DECLARATION CERTIFICATE

I hereby declare that this dissertation titled "A CASE CONTROL STUDY TO COMPARE DISTAL FEMUR TUNNEL WIDENING BETWEEN SUSPENSORY FIXATION AND SUSPENSORY FIXATION AUGMENTED WITH BIOABSORBABLE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT " is carried out by me under the guidance and supervision of Dr Anil Thomas Oommen, Professor, Department of Orthopedics Unit II, Christian Medical College, Vellore.

This dissertation is submitted in partial fulfillment of the requirements of the Tamil Nadu Dr M.G.R Medical University for the degree of MS (Orthopedics) examination to be held in May 2019.

Dr Sam James Daniel

P.G. Registrar- Department of Orthopedics

Christian Medical College,

Vellore 632004, India

CERTIFICATE

This is to certify that the dissertation titled "A CASE CONTROL STUDY TO COMPARE DISTAL FEMUR TUNNEL WIDENING BETWEEN SUSPENSORY FIXATION AND SUSPENSORY FIXATION AUGMENTED WITH BIOABSORBABLE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT" is the original research work done by Dr Sam James Daniel and was carried out under my guidance and supervision towards partial fulfillment of the requirements of the Tamil Nadu Dr M.G.R Medical University for the degree of MS (Orthopedics) examination to be held in May 2019.

Dr Anil Thomas Oommen (Guide)

Professor - Department of OrthopedicsII

Christian Medical College,

Vellore 632004, India

CERTIFICATE

This is to certify that the dissertation titled "A CASE CONTROL STUDY TO COMPARE DISTAL FEMUR TUNNEL WIDENING BETWEEN SUSPENSORY FIXATION AND SUSPENSORY FIXATION AUGMENTED WITH BIOABSORBABLE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT" is the original research work done by Dr Sam James Daniel and was carried out under the guidance and supervision of Dr Anil Thomas Oommen, Professor, Orthopedics Unit II, Christian Medical College, Vellore, towards partial fulfillment of the requirements of the Tamil Nadu Dr M.G.R Medical University for the degree of MS (Orthopedics) examination to be held in May 2019.

Dr VTK Titus

Professor and Head of the department

Department of Orthopedics

Christian Medical College,

Vellore 632004

CERTIFICATE

This is to certify that the dissertation titled "A CASE CONTROL STUDY TO COMPARE DISTAL FEMUR TUNNEL WIDENING BETWEEN SUSPENSORY FIXATION AND SUSPENSORY FIXATION AUGMENTED WITH BIOABSORBABLE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT" is the original research work done by Dr Sam James Daniel and was carried out under the guidance and supervision of Dr Anil Thomas Oommen, Professor, Orthopedics Unit II, Christian Medical College, Vellore, towards partial fulfillment of the requirements of the Tamil Nadu Dr M.G.R Medical University for the degree of MS (Orthopedics) examination to be held in May 2019.

Dr Anna Pulimood,

Principal,

Christian Medical College and Hospital,

Vellore 632002

URKUND

Urkund Analysis Result

Analysed Document: Thesis final document.docx (D42759483)
Submitted: 10/19/2018 8:35:00 AM
Submitted By: sam.jd47@gmail.com
Significance: 0 %

Sources included in the report:

Instances where selected sources appear:

0

OFFICE OF RESEARCH
INSTITUTIONAL REVIEW BOARD (IRB)
CHRISTIAN MEDICAL COLLEGE, VELLORE, INDIA

Dr. B.J. Prashantham, M.A., M.A., Dr. Min (Clinical)
Director, Christian Counseling Center,
Chairperson, Ethics Committee.

Dr. Anna Benjamin Pulimood, M.B.B.S., MD., Ph.D.,
Chairperson, Research Committee & Principal

Dr. Biju George, M.B.B.S., MD., DM.,
Deputy Chairperson,
Secretary, Ethics Committee, IRB
Additional Vice-Principal (Research)

December 27, 2016

Dr. Sam James Daniel,
PG Registrar,
Department of Orthopaedics,
Christian Medical College,
Vellore - 632 004.

Sub: **Fluid Research Grant NEW PROPOSAL:**
Comparison of distal femoral tunnel widening between suspensory fixation and suspensory fixation augmented with bio-absorbable interference screw for Anterior Cruciate Ligament reconstruction with hamstring graft.
Dr. Sam James Daniel, Employment Number: 29545, PG Registrar, Department of Orthopaedics, Dr. Anil Oommen, Employment Number: 31288, Orthopaedics, Dr. Vignesh Prasad, Orthopaedics, Dr. Vinu Mathew George, Orthopaedics, Dr. Pradeep Poonnoose, Orthopaedics, Dr. Koyeli Mary Mahata, Radiology, Dr. Madhavi .K.

Ref: IRB Min No: 10367 [OBSERVE] dated 03.11.2016

Dear Dr. Sam James Daniel,

I enclose the following documents:-

1. Institutional Review Board approval 2. Agreement

Could you please sign the agreement and send it to Dr. Biju George, Addl. Vice Principal (Research), so that the grant money can be released.

With best wishes,

Dr. Biju George
Secretary (Ethics Committee)
Institutional Review Board

Dr. BIJU GEORGE
MBBS., MD., DM.,
SECRETARY - (ETHICS COMMITTEE)
Institutional Review Board,
Christian Medical College, Vellore - 632 002.

Cc: Dr. Anil Oommen, Dept. of Orthopaedics, CMC, Vellore

OFFICE OF RESEARCH
INSTITUTIONAL REVIEW BOARD (IRB)
CHRISTIAN MEDICAL COLLEGE, VELLORE, INDIA

Dr. B.J. Prashantham, M.A., M.A., Dr. Min (Clinical)
Director, Christian Counseling Center,
Chairperson, Ethics Committee.

Dr. Anna Benjamin Pulimood, M.B.B.S., MD., Ph.D.,
Chairperson, Research Committee & Principal

Dr. Biju George, M.B.B.S., MD., DM.,
Deputy Chairperson,
Secretary, Ethics Committee, IRB
Additional Vice-Principal (Research)

December 27, 2016

Dr. Sam James Daniel,
PG Registrar,
Department of Orthopaedics,
Christian Medical College,
Vellore - 632 004.

Sub: **Fluid Research Grant NEW PROPOSAL:**
Comparison of distal femoral tunnel widening between suspensory fixation and suspensory fixation augmented with bio-absorbable interference screw for Anterior Cruciate Ligament reconstruction with hamstring graft.
Dr. Sam James Daniel, Employment Number: 29545, PG Registrar, Department of Orthopaedics, Dr. Anil Oommen, Employment Number: 31288, Orthopaedics, Dr. Vignesh Prasad, Orthopaedics, Dr. Vinu Mathew George, Orthopaedics, Dr. Pradeep Poonnoose, Orthopaedics, Dr. Koyeli Mary Mahata, Radiology, Dr. Madhavi .K.

Ref: IRB Min No: 10367 [OBSERVE] dated 03.11.2016

Dear Dr. Sam James Daniel,

The Institutional Review Board (Blue, Research and Ethics Committee) of the Christian Medical College, Vellore, reviewed and discussed your project titled "Comparison of distal femoral tunnel widening between suspensory fixation and suspensory fixation augmented with bio absorbable interference screw for Anterior Cruciate Ligament reconstruction with hamstring graft" on November 03rd 2016.

The Committee reviewed the following documents:

1. IRB Application format
2. IKDC and Lysholm Scoring Sheet
3. Patient Information Sheet and Informed Consent Form (English and Telugu)
4. Proforma
5. No. of documents 1- 4

The following Institutional Review Board (Blue, Research & Ethics Committee) members were present at the meeting held on November 03rd 2016 in the BRTC Conference Room, Christian Medical College, Bagayam, Vellore 632002.

Dr. B.J. Prashantham, M.A., M.A., Dr. Min (Clinical)
Director, Christian Counseling Center,
Chairperson, Ethics Committee.

Dr. Anna Benjamin Pulimood, M.B.B.S., MD., Ph.D.,
Chairperson, Research Committee & Principal

Dr. Biju George, M.B.B.S., MD., DM.,
Deputy Chairperson,
Secretary, Ethics Committee, IRB
Additional Vice-Principal (Research)

Name	Qualification	Designation	Affiliation
Dr. Biju George	MBBS, MD, DM	Professor, Haematology, Research), Additional Vice Principal , Deputy Chairperson (Research Committee), Member Secretary (Ethics Committee), IRB, CMC,Vellore	Internal, Clinician
Dr. B. J. Prashantham	MA(Counseling Psychology), MA (Theology), Dr. Min (Clinical Counselling)	Chairperson, Ethics Committee, IRB. Director, Christian Counseling Centre, Vellore	External, Social Scientist
Dr. Ratna Prabha	MBBS, MD (Pharma)	Associate Professor, Clinical Pharmacology, CMC, Vellore	Internal, Pharmacologist
Dr. Rekha Pai	BSc, MSc, PhD	Associate Professor, Pathology, CMC, Vellore	Internal,Basic Medical Scientist
Rev. Joseph Devaraj	BSc, BD	Chaplaincy Department, CMC, Vellore	Internal, Social Scientist
Mr. C. Sampath	BSc, BL	Advocate, Vellore	External, Legal Expert
Dr. Ranjith K Moorthy	MBBS, MCh	Professor, Neurological Sciences, CMC, Vellore	Internal, Clinician
Mrs. Sheela Durai	MSc Nursing	Professor, Medical Surgical Nursing, CMC, Vellore	Internal, Nurse
Ms. Grace Rebekha	M.Sc., (Biostatistics)	Lecturer, Biostatistics, CMC, Vellore	Internal, Statistician
Mrs. Pattabiraman	BSc, DSSA	Social Worker, Vellore	External, Lay Person
Dr. Anand Zachariah	MBBS, PhD	Professor, Medicine, CMC, Vellore	Internal, Clinician
Dr. Balamugesh	MBBS, MD(Int Med), DM, FCCP (USA)	Professor, Pulmonary Medicine, CMC, Vellore	Internal, Clinician

Dr. B.J. Prashantham, M.A., M.A., Dr. Min (Clinical)
Director, Christian Counseling Center,
Chairperson, Ethics Committee.

Dr. Anna Benjamin Pulimood, M.B.B.S., MD., Ph.D.,
Chairperson, Research Committee & Principal

Dr. Biju George, M.B.B.S., MD., DM.,
Deputy Chairperson,
Secretary, Ethics Committee, IRB
Additional Vice-Principal (Research)

Dr. Sneha Varkki	MBBS, DCH, DNB	Professor, Paediatrics, CMC, Vellore	Internal, Clinician
Mrs. Emily Daniel	MSc Nursing	Professor, Medical Surgical Nursing, CMC, Vellore	Internal, Nurse
Dr. Sathish Kumar	MBBS, MD, DCH	Professor, Child Health, CMC, Vellore	Internal, Clinician
Dr. Visalakshi. J	MPH, PhD	Lecturer, Biostatistics, CMC, Vellore	Internal, Statistician
Dr. Mathew Joseph	MBBS, MCH	Professor, Neurosurgery, CMC, Vellore	Internal, Clinician

We approve the project to be conducted as presented.

Kindly provide the total number of patients enrolled in your study and the total number of withdrawals for the study entitled: "Comparison of distal femoral tunnel widening between suspensory fixation and suspensory fixation augmented with bio-absorbable interference screw for Anterior Cruciate Ligament reconstruction with hamstring graft" on a monthly basis. Please send copies of this to the Research Office (research@cmcvellore.ac.in).

Fluid Grant Allocation:
A sum of 1,00,000/- INR (Rupees One lakh Only) will be granted for 2 years. 50,000/- INR (Rupees Fifty Thousand only) will be granted for 12 months as an Ist Installment. The rest of the 50,000/- INR (Rupees Fifty Thousand only) each will be released at the end of the first year as 2 nd Installment.

Yours sincerely,

Dr. Biju George
Secretary (Ethics Committee)
Institutional Review Board

Dr. BIJU GEORGE
MBBS., MD., DM.
SECRETARY - (ETHICS COMMITTEE)
Institutional Review Board,
Christian Medical College, Vellore - 632 002.

IRB Min No: 10367 [OBSERVE] dated 03.11.2016

ACKNOWLEDGEMENTS

I wish to express my sincere and heartfelt thanks and deep sense of gratitude to my guide Dr Anil Oommen, Professor, Department of Orthopedics Unit II, CMC, Vellore for all his encouragement, guidance, help and support at every stage of this study and preparation of this dissertation.

I am extremely grateful to Dr Pradeep Poonnoose, my co-guide for his guidance and encouragement and his willingness to spare his valuable time to help me in this study.

I am extremely thankful to Ms. Reka K for helping me out with the statistical analysis.

I would like to thank the Dr. V.J.Chandy. Dr. Hariharan, Dr. Jerry George, Dr. Vignesh Prasad and Dr. Vinu Mathew for timely help in recruiting patients for the study.

I would like to thank my colleagues, friends and other faculty of the department of Orthopedics for help, advice and encouragement.

I am indebted to the patients, without whose consent and cooperation, this study would not have been possible.

A special thanks to all my family members, especially my wife Irene Sam who helped me in completing this study.

Above all, I thank God almighty for giving me strength to go through this period of study.

CONTENTS

TITLE

A CASE CONTROL STUDY TO COMPARE DISTAL FEMUR TUNNEL WIDENING BETWEEN SUSPENSORY FIXATION VERSUS SUSPENSORY FIXATION AUGMENTED WITH BIOABSORBABLE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT

INTRODUCTION

Among sports related injuries, Anterior Cruciate ligament injuries are the most common among sports related injuries. ACL reconstruction using hamstring grafts is the most common technique followed worldwide (63%)(1). Two common modalities used worldwide for Anterior Cruciate Ligament reconstruction are suspensory fixation with an Endo-button and Aperture fixation with an Interference screw. Endo-button fixation is the most common type of fixation of the hamstring graft (40%) worldwide(1). Hamstring grafts are used as it results in less anterior knee pain which helps in early post operative rehabilitation period and in the long term period compared to patellar tendon autograft.

The patients who undergo ACL fixation with endobutton develop widening of the femoral and tibial tunnel. The widening is more in the femoral tunnel(72%- twice as that of the tibial side) than the tibial tunnel(38%)(2). The widening in the tunnel was found to be due to movement of the graft inside the tunnel, as the tunnel is slightly larger than the graft, a phenomenon called windshield wiper effect(2,3). The tunnel widening happens more when the fixation points are far apart than when the fixation points are close to each other, because when the fixation points are far it causes more mobility of the intervening graft(4). The tunnel widening happens maximum within 6weeks(3)of the surgery and is almost complete by 3 months(5)and remains the same till 12 months after the surgery, hence a 6 month to 2 year follow up was taken.

We place the tunnel in an anatomical position to the original ACL bundle. This study is aimed at studying the bone tunnel widening in the distal femur at 6 months to 2 year follow up

using x-ray and CT scans for exact quantification and comparing it with International Knee Documentation Committee (IKDC) and Lysholm scores. The radiation exposure of CT scan is minimal and can be safely used in studying the tunnel widening without causing any adverse effect to the patient(5).

ABSTRACT

Purpose: Tunnel widening in ACL reconstruction is a common problem noted in suspensory fixation with hamstring grafts. Our hypothesis was that augmentation of the femoral side suspensory fixation with an interference screw (aperture fixation) negates this tunnel widening possibly caused by windshield wiper effect.

Methods: In our study we used quadrupled hamstring graft which was fixed with suspensory fixation on both sides with an aperture fixation on the tibial side in both the groups. We observed tunnel widening in patients without augmentation and with augmentation using immediate post operative x-ray and follow up x-ray. A CT scan assessment was also done at follow up.

Results: Femoral tunnel widening measured by x-ray in the augmentation group measured at the widest point of the tunnel point 'D' was 0.74 ± 1.05 (AP), 1.01 ± 1.04 (lateral) and in the endobutton only group was 1.54 ± 1.48 (AP) and 1.79 ± 1.47(lateral), both of which were statistically significant(p-0.038, p-0.038). Widening at the point 'E' (aperture) in the augmentation group was 1.25 ± 1.10 (AP), 1.09 ± 0.98 (lateral) and in the endobutton only group was 1.53 ±1.30 (AP), 1.65 ± 1.29 (lateral), it was not statistically significant. The values were comparable to CT. There were also better clinical outcomes in the augmentation group

Conclusion: Our hypothesis which assumed that tunnel widening would be reduced by the addition of the interference screw on the femoral side in addition to the suspensory fixation contributed to decrease in tunnel widening as well as better functional outcome true. In addition to the radiological improvement, there was also clinical improvement noted in the patients both during immediate post operative period and during their follow up.

ABBREVIATIONS

ACL- Anterior cruciate ligament

PCL- Posterior cruciate ligament

MCL- Medial collateral ligament

LCL- Lateral collateral ligament

IKDC- International Knee Documentation Committee

BMI- Body mass index

CT- Computer tomography

MRI- Magnetic resonance imaging

RTA- Road traffic accidents

US- United States; USA- United States of America

PT graft/ BPTB - Patellar tendon graft/ bone-patellar tendon bone

HS- Hamstring

HA- Hydroxy-apatite

PLLA- Poly-L-lactic acid

PLGA- poly-glycolic acid

PLGA (TCP)- poly-D,L-lactide-tricalcium phosphate

PEEK-polyetheretherketone

AIMS AND OBJECTIVES

To compare the amount of tunnel widening between suspensory fixation to suspensory fixation augmented with interference screw fixation in the distal femur after hamstring graft Anterior Cruciate Ligament reconstruction,

-To assess tunnel widening using x-ray comparison and CT scan evaluation at 6 month- 2 year follow up

-To compare tunnel widening to functional knee scores like, International Knee documentation committee score and Lysholm score.

-To see if augmentation of the suspensory fixation (endobutton) with aperture fixation (interference screw) results in decrease in femoral tunnel widening in ACL reconstruction

LITERATURE REVIEW

Introduction

Bone tunnel widening following an anterior cruciate ligament is a commonly encountered phenomenon. The cause of the tunnel widening is multifactorial, a combination of biological and biomechanical factors. Micro motion of the graft within the tunnel is believed to cause inflammatory response(6,7).

Early reports suggested that bone tunnel enlargement is mainly the result of an immune response to allograft tissue; more recent studies imply that other mechanical as well as biological factors play a more important role. Biological factors associated with tunnel enlargement are non-specific inflammatory response (osteolysis around implants), foreign-body immune response (against allograft), cell necrosis due to toxic products in the tunnel (ethylene oxide, metal), and heat necrosis as a response to drilling (natural course)(8). Mechanical factors that contribute to tunnel enlargement include stress deprivation of bone within the tunnel wall, improper tunnel placement, graft-tunnel motion, and aggressive rehabilitation. Graft-tunnel motion refers to transverse and longitudinal motion of the graft within the bone tunnel and can occur with various graft types and fixation techniques especially in a suspensory type fixation(9). An aggressive rehabilitation program may contribute to tunnel enlargement as the graft-bone interface is subjected to early stress before biological incorporation is complete(10). Improved and more

anatomical surgical fixation techniques may be useful for the prevention of bone tunnel enlargement.

Anterior cruciate ligament (ACL) reconstruction tunnel widening tends to occur mostly in the early post-operative period within 3months and no significant change is seen from 3 months to 2 years(11). There is no correlation between bone tunnel enlargement and clinical outcome of the patients that has been reported so far (6,12–14)

Global Epidemiology

The majority of ACL injuries (70%) are sports related. The highest incidence is in the age group 15-25 years old who participate in contact sports involving pivoting movement of the knee (15). The incidence was 33 cases in 100 000 in 1994 and it rose to between 40 and 60 incidents in 100 000 in 2014 in the United States(16). It is estimated that approximately 200 000 ACL reconstructions are performed in the USA alone each year(16).The incidence on Swedish National Knee Ligament Register 2014 was up to 80 ACL disruptions in 100,000 populations. National incidence in New Zealand in 2005 was 1193 per 100,000 person-years(17). This number is expected to increase further as a result of increased participation in athletic activities.

Indian Epidemiology

In the Indian cohort studies, 58% were associated with sporting injuries, 26% with Road traffic accidents (RTA), and 16% were related to other nonsporting injuries like falls from heights, tripping down stairs, and other causes (18).

Mechanism of injury

ACL and PCL injuries are one of the most common and significant injuries which can occur with virtually any mechanism of injury, if the force exceeds the ligaments capacity to stretch (10-25% of the usual resting length).

Mechanism of injury can either due be direct or indirect trauma. Palmer described four mechanisms of injury to the ligament(19).

1. Flexion, Abduction and Internal rotation of femur on tibia.
2. Flexion, Abduction and External rotation of femur on tibia.
3. Hyperextension of the knee
4. Antero-posterior displacement.

Abduction, flexion and internal rotation is the most common mechanism and, if the injury is severe it can result in the "O‟ Donoghue" triad i.e. an injury to ACL, MCL and medial meniscus. The 2nd most common type is due to hyperextension. Usually no single ligament can be disrupted without sustaining some degree of injury to the other

supporting structures. The injury to the other supporting structure may be minimal and may heal with conservative measures leaving what is apparently and isolated injury of the ACL on clinical examination.

Examination

The most commonly used physical examinations are the Lachman test, anterior drawer test, pivot shift test and single foot hopping test. These tests are not only used to diagnose an ACL tear but also used to examine patients post operatively.

Lachman test:

The knee is flexed at 20–30 degrees with the patient supine. The examiner should place one hand behind the proximal tibia and the other grasping the patient's distal thigh. The examiner's thumb is placed on the tibial tuberosity and the fingers placed on the posterior aspect of the calf. The tibia is pulled forward to assess the amount of anterior translation of the tibia in comparison to the femur. An intact ACL should prevent forward translational movement ("firm endpoint") while an ACL-deficient knee will demonstrate increased forward translation without a decisive 'end-point' - a soft endpoint indicative of a positive test. More than 2 mm of anterior translation compared to the uninvolved knee suggests a torn ACL.

Lachman test is considered more sensitive as compared to the anterior drawer as it negates the door stopper effect of the meniscus(20). But recent arthroscopic studies show equal sensitivity of lachman and anterior drawer test(21).

Lachman test is graded as follows

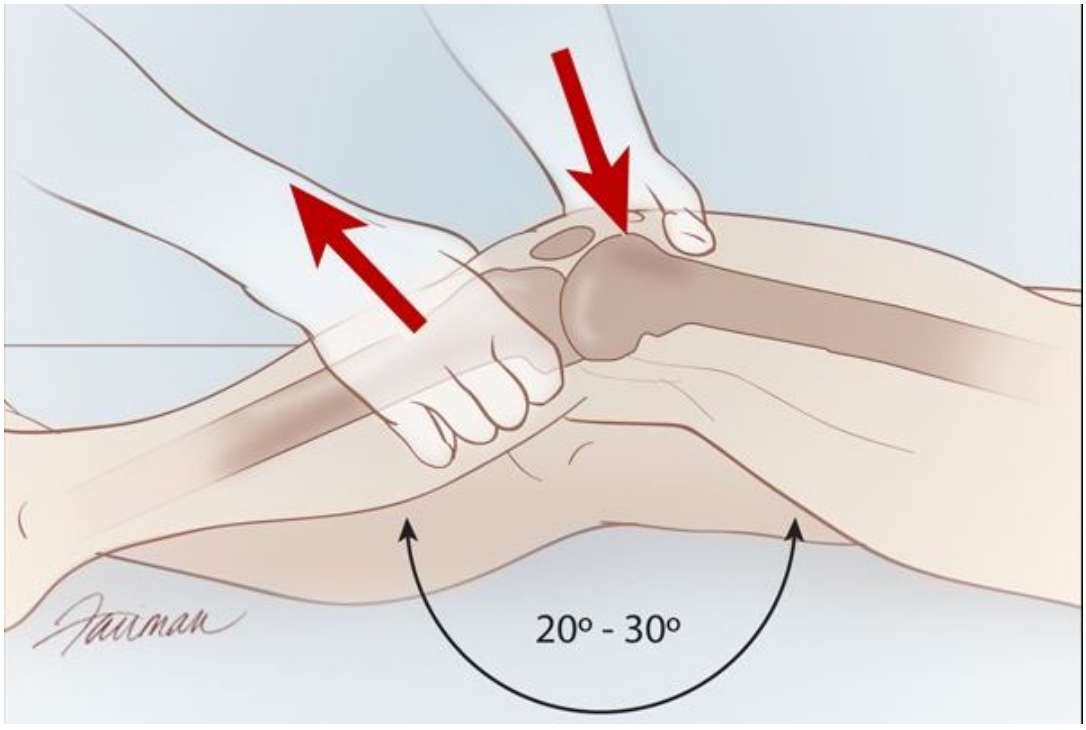
Grade 0- proprioceptive appreciation of a positive test (1-2mm translation)

Grade I- visible anterior translation of the tibia (3-5mm)

Grade II- passive subluxation of the tibia with the patient supine (6-10mm)

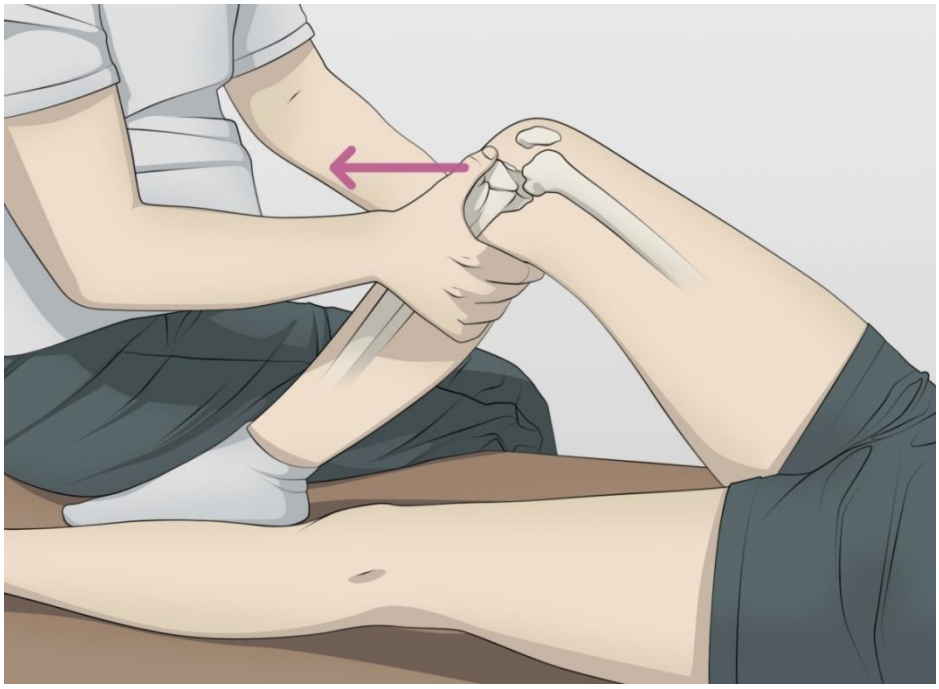
Grade III- ability of the patient with a cruciate-deficient knee to actively sublux the proximal tibia (more than 10mm)

Gurtler, JS Torg, Dr. John Lachman's colleagues published Dr. Lachman's findings.



Anterior drawer test:

The patient should be supine with the hips flexed to 45 degrees, the knees flexed to 90 degrees and the feet flat on table(22). In this position, it is noted that the medial tibial plateau is 1cm anterior to the medial femoral condyle in the normal knee. The examiner sits on the examination table by the patient and over the foot, in front of the involved knee. Both the hands grasp the tibia with both the thumbs just below the joint line of on either side of the patellar tendon. Both the index fingers are placed over the back of the knee to ensure that the hamstrings are relaxed. The tibia is then drawn forward anteriorly. An increase in the amount of anterior tibial translation compared with the opposite limb or lack of a firm end-point may indicate either a sprain of the anteromedial bundle or complete tear of the ACL. The anterior drawer test is done after ruling out a sag sign in the proximal tibia.



Anterior drawer is graded as

Grade 0- drawer same as compared to the opposite knee.

Grade I- proprioceptive appreciation of a positive test, $1/3^{rd}$ anterior translation compared to the opposite knee. (3-5mm)

Grade II- visible anterior translation of the tibia,$2/3^{rd}$ anterior translation compared to the opposite normal knee. (5-10mm)

Grade III- passive subluxation of the tibia with the patient supine and gross subluxation compared to the opposite knee. (>10mm)

Pivot shift test of Macintosh:

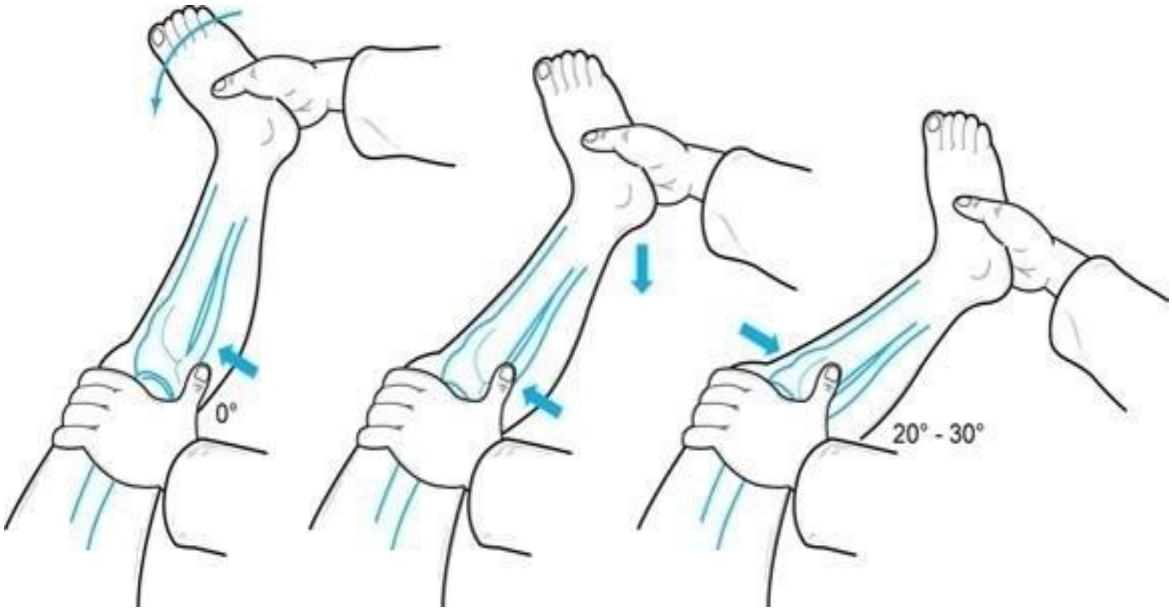
The patient is supine with the leg extended, and the examiner stands on the affected side of the patient(23). The examiner places the hand (which is toward the head of the patient), over the lateral aspect of the proximal tibia and fibula. The other hand grasp the ankle and internally rotates the foot and make sure that the knee is in starting position of full extension .The knee is subluxed in an anterior cruciate deficient knee. A valgus stress is applied following which the knee is gradually flexed. The knee relocates with a clunk at about 30 degree knee flexion. Reduction is due to the pull of the iliotibial band when its line of pull changes from anterior to posterior to the knee and due to the convexity of the lateral tibial condyle

Grading of Pivot shift:(24)

Grade I: ‘glide’, when the tibia is held in maximal medial rotation, there is an abnormal movement that can be felt as a small and gentle sliding reduction. This glide does not occur in neutral or lateral rotation. A grade I knee is the result of residual laxity after reconstruction or partial cruciate injury. The result is an instability which is mainly anterolateral.

Grade II: ‘clunk’, when the tibia is in the medially rotated position and there is an abnormal movement in the neutral position. The test is mostly negative when the tibia is held in a position of definite lateral rotation.

Grade III: ’gross shift’, when the tibia is held in neutral or moderate lateral rotation, an abnormal movement with a pronounced clunk takes place.



Slocum test:

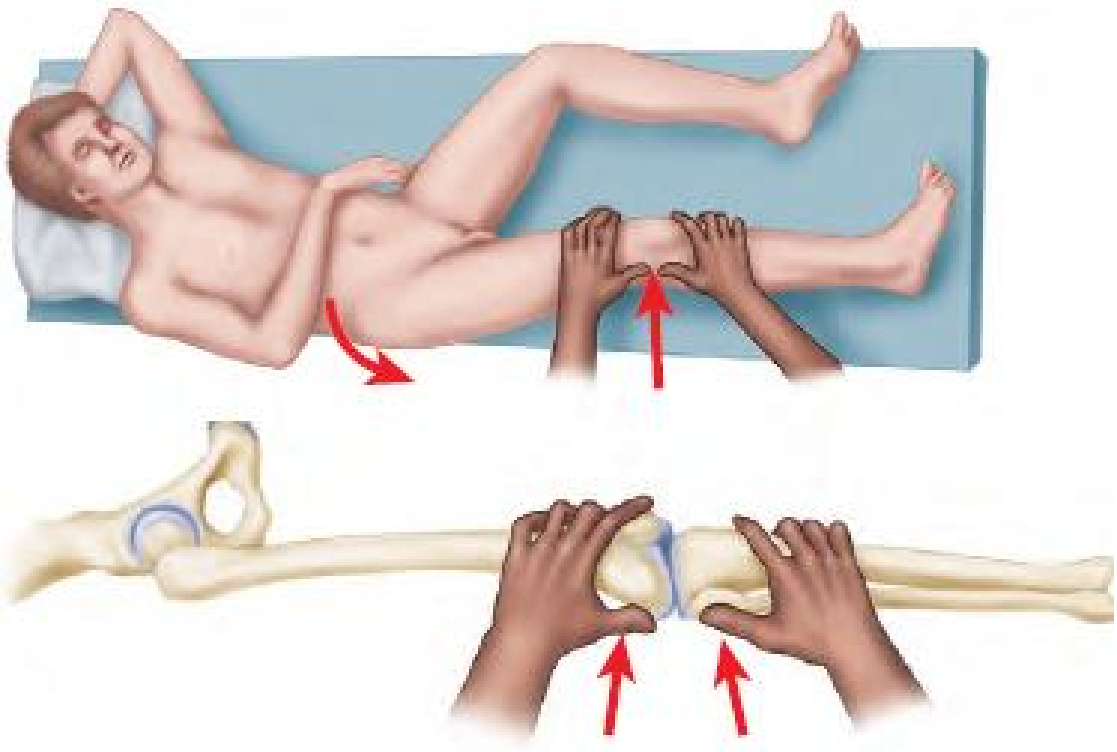
Slocum reported that more subtle degrees of rotary instability can be detected by this test. The patient is placed in a lateral position with the affected side up. The medial side of the foot is placed on the firm examining table with the knee in full extension. This position eliminates the rotational effects of the hip, internally rotates the tibia on the femur and allows the knee to fall into a valgus position. A thumb is placed on each of the femoral and tibial sides posteriorly, and an index finger is placed across the joint anteriorly. The knee is then pressed gently forward into flexion. A test result is positive if reduction of the subluxed knee occurs as the knee passes the 25- to 45-degree range of flexion.

Grade I- smooth glide

Grade II- sudden palpable glide

Grade III- gross repositioning of the subluxated tibia

Lesser degrees of instability are detected by Slocum's method, which also is not as likely to be painful.



Single foot hopping test:

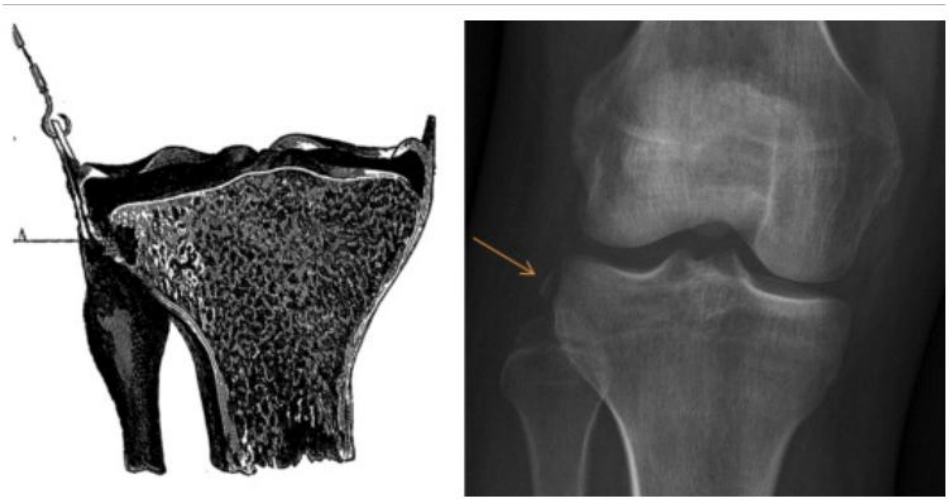
The patient is made to hop once to a distance on the affected knee. A patient with a complete ACL tear is unable to do so. Single-legged hop test is also conducted 6 months after ACL reconstruction can predict the likelihood of successful and unsuccessful outcome 1 year after ACL reconstruction. Patients demonstrating less than the 88% cutoff score at 6 months may benefit from targeted training to improve limb symmetry in an attempt to normalize function(25).

Diagnosis

X-rays:

Bony avulsion of the ACL is ruled out by plain radiograph of the knee. It is also performed together with measurements of the differential anterior translation has been shown to be important for diagnosing ACL injuries. In lateral radiographs, anterior translation of the tibia may be seen in individuals with complete tears, significant translation of the medial and lateral compartments can be seen, while in patients with partial tears, little translation is seen in relation to the normal side.(26)

The Segond fracture due to lateral capsular avulsion may be visualized on an antero-posterior view. Segond fracture occurs in 9-12% of all ACL injuries(27). This is an avulsion fracture of the lateral tibial plateau, located near the joint line and lateral to the Gerdy tubercle. The Segond fracture represents an avulsion of the anterolateral ligament of the knee(28). Segond fracture is direct evidence of a lateral capsule injury and indirect sign of an ACL injury.



The lateral notch fracture is located in the lateral femoral condyle. The likely mechanism is a hyperextension or impaction injury with a collision of the femoral condyle and the anterior tibial plateau during the rotational movement responsible for

injuring the ACL, most commonly the pivot-shift. This type of fractures is most commonly seen in chronic ACL-deficient knees. The physician must differentiate lateral notch fractures from osteochondral defects.

Magnetic resonance:

In spite of all the technological development that has taken place, it is still difficult to diagnose partial ACL tears. The imaging slices of 3mm are necessary in order to make a distinction between complete and partial tears using a 3 Tesla MRI. Van Dyck et al.(29) suggested that certain axial and perpendicular views would be more accurate in making diagnoses based on 3T magnetic resonance imaging.

The signs on an MRI are categorized into primary and secondary signs.

Primary signs:(30)

increased signal/ hyper intense signal of the ACL fibers on T2 images

ACL discontinuity

Change in the course of ACL- ACL angle that is less steep than Blumensaat's line: when drawing a line in the course of a normal ACL on the sagittal image the angle should be steeper than the intercondylar roof, so the apex is pointing posterior. If the line of the ACL is less steep than the intercondylar roof (i.e. the apex of the angle points anteriorly instead of posterior) means that ACL is

completely torn and collapsed. If the angle is normal and there is a hyper intense signal, a partial rupture is more likely than a complete rupture.

Empty notch sign, in case of avulsion of the ACL at the femoral attachment

ACL tears typically occur in the middle portion/ the midsubstance of the ligament and appear as discontinuity of the ligament or abnormal contour. If the angle is still normal and there is a hyper-intense signal, a partial rupture is more likely than a complete rupture(30).

Secondary signs(31)

bone contusion in lateral femoral condyle and posterolateral tibial plateau (at the origin and insertion of the ACL

>7 mm of anterior tibial translation

uncovered posterior horn of the lateral meniscus

Reduced PCL angle due to buckling of PCL, the PCL looks like a J shaped structure. This is also called unfolding of the PCL.

positive PCL line sign(31)

Arthroscopic evaluation

Arthroscopic evaluation has been proposed by some authors for diagnosing partial tears, however, in the light of the current knowledge; there is no indication for routine

arthroscopic evaluations for diagnosing such injuries. Arthroscopy makes it possible to diagnose the type of partial tear and, together with the clinical and imaging examinations; it determines the best type of reconstruction needed in cases if surgical treatment is indicated.

Treatment

The treatment needs to be appropriate and individualized for each patient's needs. Identifying patients with high and low risk of progression of the clinical deficiency of the ACL is fundamental for providing therapeutic guidance. Low-risk patients are the ones with low physical demands, without complaints of instability or associated injuries, whose clinical tests are negative. These patients' symptoms and signs generally tend not to progress and can be treated conservatively(26). High-risk patients are the ones with proven clinical instability and lifestyles that present a high risk of new torsion injury. In these cases, the best option would be to perform surgical reconstruction of the ACL(32). The treatment strategy needs to take into consideration the symptoms, clinical examination, percentage of fibers remaining, associated injuries, length of time since the injury and daily physical work demands.

Conservative treatment

Conservative treatment includes immobilization using a knee brace for a period of 4-6 weeks while the patient remains symptomatic. The individual is advised to use

crutches and protected weight bearing for 2 weeks. After 2 weeks once the acute inflammation subsides, stimulation of complete movement and muscle strengthening is started. He is asked to slowly weight bear as tolerated with the knee brace till symptoms subside(26).The aim of treatment is ensure the return to full range of movement by 6 weeks .The principles of rehabilitation for patients with partial tears are the same as those for patients with complete tears. This rehabilitation consists of exercises for muscle strengthening and stretching and cardiovascular, proprioceptive and adaptive training. Pujol et al.(33) Demonstrated that partial ACL tears may have the capacity to heal in terms of clinical findings like pain, instability and laxity, but radiological healing may not happen.

Conservative treatment produces good results when indicated correctly, with minimal reduction of activity level and without impairing stability(32). Other authors have suggested that partial tears are functionally equivalent to complete ACL tears and that conservative treatment would imply worse clinical and functional results. Pujol et al(33), described a series in which 25% of the patients with partial ACL tears evolved with functional instability over a medium to long term. Serial assessments would be necessary in order to monitor the rehabilitation and residual laxity, which thus would enable evaluation of whether conservative treatment should be maintained or whether it should be changed over to a surgical approach(34).

Surgical treatment

On a 11 year follow up of patients with 'complete' ACL rupture, non-operative treatment resulted in poor and fair functional outcome scores that prevented a return to pre-injury activities in the majority of patients, as well as an increased incidence of secondary ACL surgery, meniscus surgery and osteoarthritis knee(35).

a. *Aperture and suspensory fixation*
b. *Tunnel widening*
c. *Type of grafts*
d. *Surgical technique*

Anterior cruciate ligament (ACL) reconstruction with hamstring tendon autograft has become a popular choice among orthopedic surgeons(36,37). Previous studies have shown that a hamstring graft is superior or equivalent to a bone–patellar tendon–bone (BPTB) autograft(38,39).Advantages of hamstring grafts include less donor site morbidity, less kneeling pain, less quadriceps weakness and fewer sensory deficits associated with graft harvest(40). Although there is a clear trend toward the increased use of hamstring tendon autograft, the best fixation method for this soft tissue graft is still being debated by orthopedic surgeons worldwide.

In general, soft tissue graft fixation can be classified as suspensory or aperture based on the location of the fixation point and the method of securing the graft. Multiple studies have found no significant difference between suspensory fixation and aperture fixation. In this study we are combining aperture and suspensory fixation.

Graft fixation should be (41)

Strong enough to avoid failure of the graft or the fixation.

Stiff enough to restore load displacement and allow biological incorporation of the graft into the bone tunnels.

Secure enough to resist slippage under cyclic loading (during the first 1 to 2 months when conversion from mechanical to biologic fixation occurs)

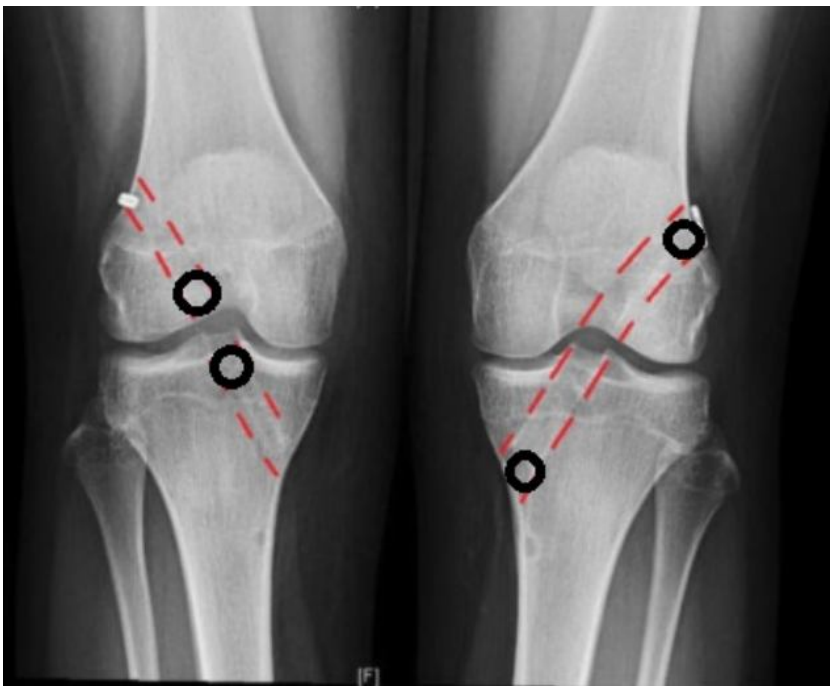


Image shows black circles where grafts are fixed . Left- aperture fixation, Right- Suspensory fixation

If the graft was fixed at the cortex it called suspensory fixation and if was fixed near the joint it is called aperture fixation.

a. **Aperture fixation**

In aperture fixation a headless screw is used to fix the graft, where the threads of the screw engage the graft and the cancellous bone. It is maintained by friction and interference fit between the graft and the tunnel wall (cancellous bone). These screws are called interference screws. Interference screws are commonly used for fixation of both soft tissue (hamstring) and BPTB grafts in ACL reconstruction, but unlike in BPTB grafts in which fixation is applied to the bone, in soft tissue/ hamstring grafts, the threads of the interference screws engage the graft.

Currently, two types of interference screw technologies are used: metallic and bio-absorbable. Metallic screws are used because of their strength, longevity and are used while fixing bone patellar tendon bone grafts(42). But metal screws are not recommended while using hamstring grafts. Bio-absorbable screws are more commonly used as they damage the graft less, and they create fewer artifacts on magnetic resonance imaging (MRI) and computed tomography (CT) than metal screws, allowing clinicians to assess the anterior cruciate ligament (ACL)–reconstructed knee for subsequent injury and to plan revision surgery if required.

One of the common problems with the interference screws was slippage of the graft. It was proposed that metal screws resisted graft slippage than bio-absorbable, but biomechanical studies show that bio-absorbable screws equally prevented graft slippage compared to metal screws(41)

Metals screws were the first generation. Second generation was PLLA (poly- L-lactic acid) bio-absorbable interference screws. Third generation were the HA (hydroxyl-apatite) coated PLLA bio-absorbable screws(43). The fourth generation are the poly-D,L-

lactide-tricalcium phosphate(PLLA-TCP) and calcium sulphate composite or poly-glycolic acid (PGA-TCP and calcium sulphate).

When a bio-absorbable implant is placed into bone, it becomes surrounded by a fibrous layer, followed by a nonspecific response from fibroblasts, macrophages, polymorphonuclear leukocytes and multinucleated giant cells, which resorb bone(43,44). Hydrolysis then breaks down these polymers, resulting in an accumulation of breakdown products (glycolic acid, lactic acid)(45). These breakdown products create a locally acidic environment, lowering the pH around the screw, which inhibits bone formation and stimulates resorption(46). The presence of a fibrous layer may hinder bone in-growth around the screw. The newer screws are coming with a hydroxyl-appetite composite and show better bone formation around the screw(47)

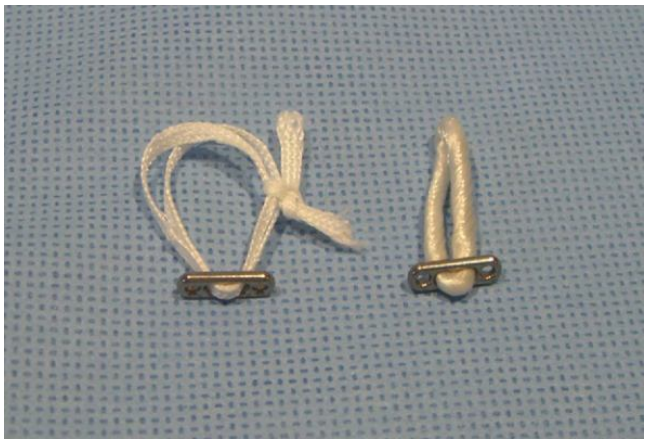
The length of the screw did not affect displacement, load to failure and stiffness (porcine) between interference screws of length 12.5, 15 and 20 mm(48,49). It is preferred to use 9mm diameter screws on both the tibial and femoral sides than a smaller 7mm screws(49).

Thus interference screws are relatively easy to use, provide aperture fixation, excellent stiffness, minimal slippage after cycling.

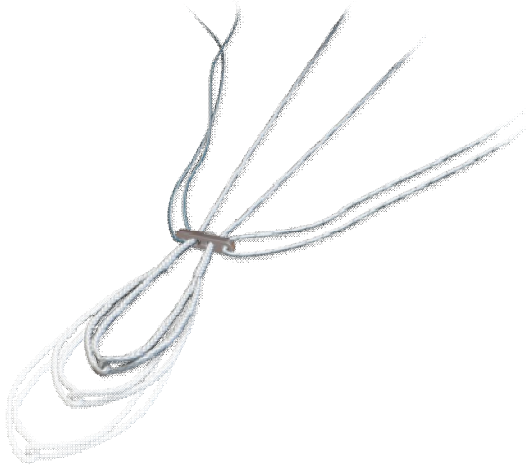
Suspensory fixation

Suspensory fixation can be classified into cortical and cancellous. Cortical fixation includes endobutton, tight rope, rigid loop, staples, screws and washers. Cancellous fixations include transfixation pins.

Endobutton is a first generation type cortical fixation. The initial endobutton technique used a polyester tape that needed to be tied at the desired length before



insertion into the tunnel(50). However, biomechanical studies showed slippage of the polyester tape by 2 to 4 mm so they changed over to closed loop polyester tape(50). The second generation used an adjustable tight rope or a rigid loop in which knot has to be tied after the endobutton is inserted and flipped.



b. Tunnel widening

There are 2 types of graft motion which causes tunnel widening

Bungee effect

Windshield wiper effect

Bungee effect-This phenomenon of the ‘‘bungee cord effect’’(51) leads to secondary to longitudinal graft motion, which may reduce stability and construct stiffness and also lead to tunnel widening.

In the ACL reconstruction surgery, soft tissue grafts are commonly fixed with suspensory devices (a rope with a loop) on the end of the graft that is suspended outside the cortical bone. These devices are less stiff than interference screws, but avoid disruption of the insertion of the ACL graft. However, a micro-motion of the graft inside the bone tunnel in a longitudinal (up and down) fashion causes widening of the tunnel. With "poor fitting" oversized tunnels, there is potential for graft motion or a bungee cord effect along with the seepage of synovial fluid into the tunnel from the sides. This is called “Bungee effect”(52,53).

Wind shield wiper effect- There was tunnel widening around the graft due to far points of fixation of the graft and was noted and reported by L’Insalata et al(54). Tunnel expansion was significantly greater following ACL reconstruction using HS (hamstring) autograft than in those using BPTB (bone patellar tendon bone)autograft. He noted that thought the tunnel in a hamstring tendon fixation was of same size of the graft (as hamstring graft was of uniform diameter) the tunnel widening was more than using a BPTB graft which was not of a uniform diameter. This is because the points of fixation

for the hamstring grafts are at a greater distance from the normal insertion site of the normal ACL and biomechanical point of action of the normal ACL than the points of fixation for BPTB grafts. It is suggested that this greater distance creates a potentially larger force moment during graft cycling which may lead to greater expansion of bone tunnels.

Webster et al stated that the bone tunnel widening stabilized after the first few weeks to months, possibility indicating graft-tunnel incorporation(14). The longer the time for graft-tunnel incorporation resulted in more time available for graft-tunnel micro-motion. Thus Morgan et al claimed that aperture fixation of the tibial and femoral side tunnels may prevent bone tunnel enlargement(55).

c. Types of Grafts

	Patellar tendon	Hamstrings
Advantages	• Higher strength • Lower re-tear rate • Earlier graft remodeling and healing • Better knee stability	• Smaller incision/better cosmesis • Minor functional impairment from graft harvesting • Earlier regeneration of hamstrings
Disadvantages	• Higher incidence of anterior knee pain and kneeling pain • Increased incidence of OA post-ACL reconstruction • Higher rate knee extension deficit due to adhesions	• Higher incidence of tunnel widening • Electromechanical delay in knee flexors/weakness

OA, osteoarthritis; ACL, anterior cruciate ligament

Advantages of the patellar tendon graft

Both patellar tendon and hamstring grafts used in ACL reconstruction exceed the biomechanical strength and stiffness of native ACL and this has been proven to be safe approach in an attempt to eliminate the risk of graft tear(56). The use of multiple stands resulted in doubling of the maximum load and stiffness for both semitendinosus and gracilis tendons.

The graft fixation is also an important aspect of surgical failure. It is suggested that, depending on the graft going to be used, the type of fixation should be adjusted accordingly. Specifically, it was found that interference screw offer the maximum load and stiffness properties for PT grafts, resembling those of native ACL. This is extremely important since PT graft is suggested to promote graft healing and remodeling due to the presence of the bone plug. In a recent long-term RCT with follow- up at 15 years, suggesting that a higher percentage of patients reconstructed with PT graft participated in sports-related activities ($p = 0.05$)(57,58).

Disadvantages of patellar tendon graft

Patellar tendon is associated with a higher incidence of anterior knee pain and kneeling pain. A recent metaanalysis of 12 studies, with data from 850 patients, showed a significantly higher incidence of anterior knee pain and kneeling pain in PT patients(59).The disadvantages with PT grafts include anterior knee pain , pain during

kneeling as well as reported increased incidence of osteoarthritis reported when compared with hamstring grafts (45% *versus* 14% respectively)(60). This was confirmed in a meta-analysis of studies with more than five-year follow-up, where patellar graft was associated with higher incidence of radiographic osteoarthritis(61).

Advantages of hamstring tendon

The main advantage of the hamstring tendon graft is that it has lower donor site morbidity associated with its harvesting. Hamstring harvesting might be a technically challenging technique, but it causes a smaller incision which results in better cosmetic appearance of the wound, an outcome that may be important in young female patients. It causes significantly less anterior knee pain and less incidence of kneeling pain, as described above(62,63). Complications associated with hamstring graft are rather minor (for example, electromechanical delay in knee flexors and weakness) and are not proven to cause any functional impairment(64,65). Interestingly, most reports suggest a regeneration of hamstrings within two years of surgery, while patellar tendon reconstitution may be a more prolonged process.(64)

Disadvantages of hamstring tendon

Tunnel widening is reported more frequently with the use of hamstring grafts. This was against the initial belief that, since hamstring graft fills the drilled tunnels completely, it would be associated with lesser tunnel widening. It was found that tunnel increase was approximately double compared with patellar tendon graft (~20% *versus*~10% and 25% *versus* 15% increase in tibial tunnel increase for anteroposterior and lateral views. Three randomized controlled studies showed a higher percentage of tunnel widening on the femoral side in patients treated with hamstring graft(66,67); however, only one of them reported significantly higher knee laxity in the 402 hamstring group(66). Compaction of an autologous bone dowel into the tibial tunnel was shown to reduce the cross-sectional area of the tibial side tunnel and prevent tunnel expansion in approximately 90% of patients after one to two years post-period(68).

Failure load comparison between grafts

Table 2 Biomechanical data on graft material and fixation devices currently used in ACL reconstruction

	Fixation technique	Ultimate failure load [N]	Stiffness [N/mm]	Reference
Intact ACL		2160±157	242±28	[33]
Quadrupled hamstring tendon graft		4140±n.n.	807±n.n.	[26]
Tibial	Interference screw	776±155	226±56	[96]
	Suture/post	830±187	60±14	[96]
	Washer (20 mm)	930±323	126±28	[96]
Femoral	Interference screw (b)	507±93	58±14	[91]
	Interference screw (b)	621±139	76±20	[104]
	Interference screw (t)	419±77	40±11	[99]
	Interference screw (t)	774±154	80±15	[104]
	Cross-pin	737±140		[108]
	Endobutton	864±164		[108]
	Transfix	746±119		[108]
Patellar tendon-bone graft		2376±151		[94]
Tibial	Interference screw (b)	718±219	46±5	[104]
Femoral	Interference screw (b)	707±169	115±26	[106]
	Interference screw (b)	702±168	190±78	[107]
	Interference screw (t)	681±146	107±25	[106]
	Press-fit	571±109	125±29	[106]
	Cross-pin	639±156	226±63	[107]

Published by Dargel et al(53)

The quadrupled hamstring graft has proven biomechanical advantages as reported and hence being use widely for ACL reconstruction. We have been using the quadrupled graft in our unit for the past 10 years.

d. **Surgical technique**

L'Insalata et al described use of cortical fixation when he used a hamstring graft and aperture fixation when he used patellar tendon bone graft(54).

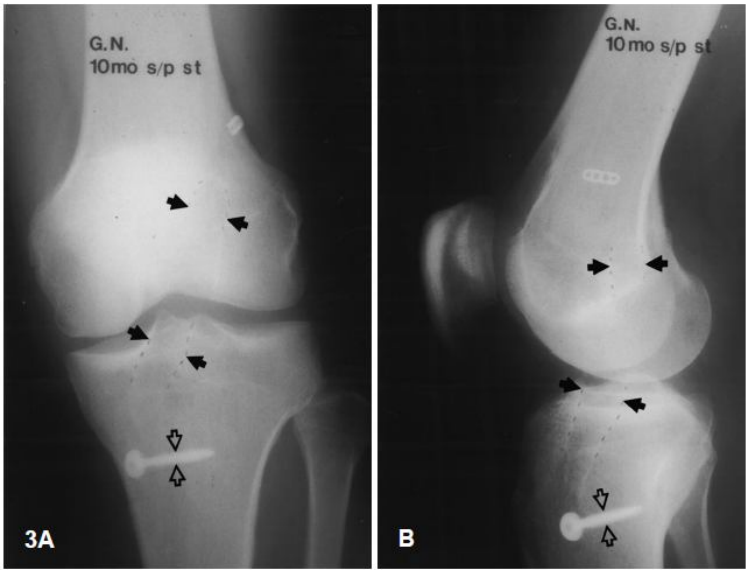


Figure 1: Hamstring graft fixation using cortical fixation

We routinely use quadrupled hamstring grafts for ACL reconstruction. We were using suspensory fixation routinely in our unit for the femoral fixation till early 2017 following which we changed our practice to using aperture fixation to augment the femoral tunnel.

Measuring bone tunnel widening

Tunnel widening is a frequently encountered phenomenon following ACL reconstruction. A variety of different algorithm of measuring the tunnel widening using x-ray, CT scan and MRI has been described. X-ray measurement consist of weight bearing anteroposterior and lateral views of the knee(69,70). In the last decade CT and MRI has been increasingly used for the evaluation of tunnel widening, as these promise higher accuracy and lower inter and intra-observer variability(70,71).

Fauno and Kaalund measured femoral tunnel width 1cm above the femoral tunnel aperture and tibial tunnel 1cm below the joint surface(72). Peyrache at al measured both the tibial and femoral tunnels at 3 different heights(11). Nebelung at al measured both the tunnel width at both ends of the tunnel(73).

Fink et al measured 5 levels of the tunnel on CT scans(74).

A recent 2018 meta-analysis of femoral tunnel widening in ACL reconstruction using antero-medial portal by Ra et al(75)was **3.5 mm, 95% CI 0.8–6.3 mm.** We measured and compared immediate post operative x-rays and x-rays at follow up. We also did a CT at follow up to corroborate the x-ray findings, however there was no immediate post operative CT to compare the findings.

MATERIALS AND METHODS

Study design

Case control study: To investigate the difference in tunnel widening on the femoral side in ACL fixation between two groups, one group with suspensory fixation only and the other with a combination of suspensory fixation and aperture fixation. The other objective was to assess the clinical difference in terms of functional outcome between these groups using Lysholm and IKDC scores. Patients from both the groups were evaluated.

Location

Orthopedic out-patient department (OPD) unit II of Christian Medical College (CMC), Vellore

Recruitment

Patients who underwent ACL surgery from January 2016 to March 2018 were recruited. Both the group of patients were asked to follow up at 6 months but some didn't hence they were contacted by phone, e-mail or registered post. The initial recruitment period was from October 2016 to March 2018 and the period was extended 6 months retrospectively to January 2106 as many patients failed to turn-up after they were asked to come for review. The study was approved by the institutional review board(IRB).

Sample size

Historical data collection and pub-med search was done. The sample size was calculated with statistical input from the following reference article "*Bone Tunnel Enlargement After Anterior Cruciate Ligament Reconstruction With Semitendinosus Tendon Using Endobutton Fixation on the Femoral Side* ". The sample size was calculated using nMaster software version 2.0.

Formula:

$$n = \frac{Z^{2}_{1-\alpha/2}\, p\,(1-p)}{d^{2}}$$

Where,

p : Expected proportion

d : Absolute precision

1- α/2 : Desired Confidence level

With 72% of expected proportion of the femoral tunnel widening, 10 % precision and 95 % desired confidence level, the study requires totally 77 subjects for prospective arm. As we might not be able to get adequate sample size of 77 in 2 years, we expected a minimum of 30, as 30 is required for making a normal distribution curve.

Inclusion criteria

Patients who underwent ACL reconstruction with suspensory fixation (rigid loop or endobutton) only on the femoral side.

Patients who underwent suspensory and aperture fixation on the femoral side.

Patients who had a bioscrew and a screw post for suture anchor on the tibial side.

Patient who consented for the study

Exclusion criteria

Patients who underwent revision ACL reconstruction

Patients who had bone staples on the tibial side instead of screw post were excluded.

Methodology

Informed consent was taken from all the patients. Both the group of patients were asked to follow up 6 months as routine. Patients who did not come for follow up at 6 months in both the groups were contacted by phone, e-mail and through registered post. They underwent plain radiograph, anteroposterior and lateral view of the knee and CT scan of the knee at follow up. X rays were done as a part of their routine follow up and CT scans were done as a part of the study from the fluid grant.

Height and weight of the patient were measured in a standardized fashion. CT scan machine used was General Electronics- Discovery 750 helical CT. Both the patients IKDC scoring and Lysholm scoring was done. A single leg hop test was also performed.

CT scan measurements, for the study was done by an experienced radiologist who was blinded to the different types of ACL graft fixation. The tunnels were measured after reconstruction of the tunnel in the oblique coronal and saggital planes, which was standardized for all patients. X rays were measured by the principal investigator with the radiologist. The initial tunnel diameter was measured from the immediate post operative x-rays. The follow up measurements to look for tunnel widening were done from the follow up x-ray. A CT scan was also done to corroborate the follow up x-ray findings. There was no immediate post operative CT scan.

Tunnel measurements

CT scans were taken with 2.5mm slice cuts. Axial, saggital and coronal images were taken and 3D reconstruction was done. The femoral and tibial tunnels were reconstructed in the axis of the tunnel in the coronal-saggital plane.

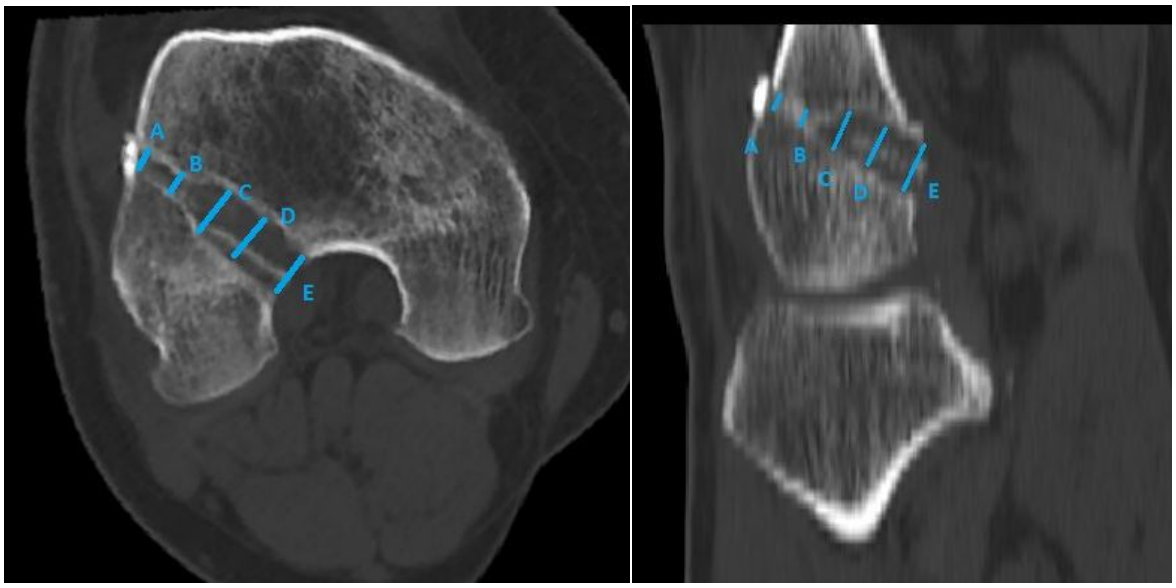


Figure 1: Femur-- Left- anteroposterior reconstruction, right- lateral reconstruction

Femoral side- On the femoral side the diameter of the tunnel was measured at 5 different points; A,B,C,D and E which were equidistant from each other.

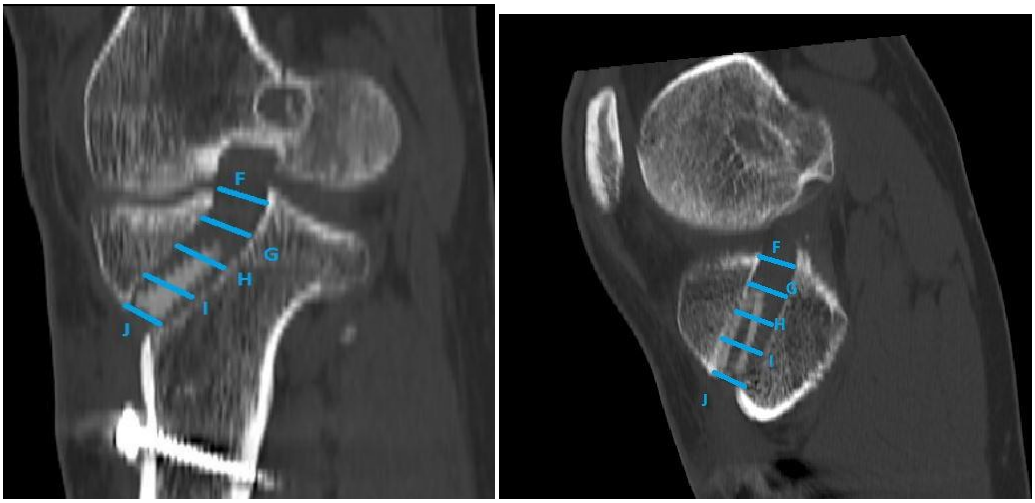
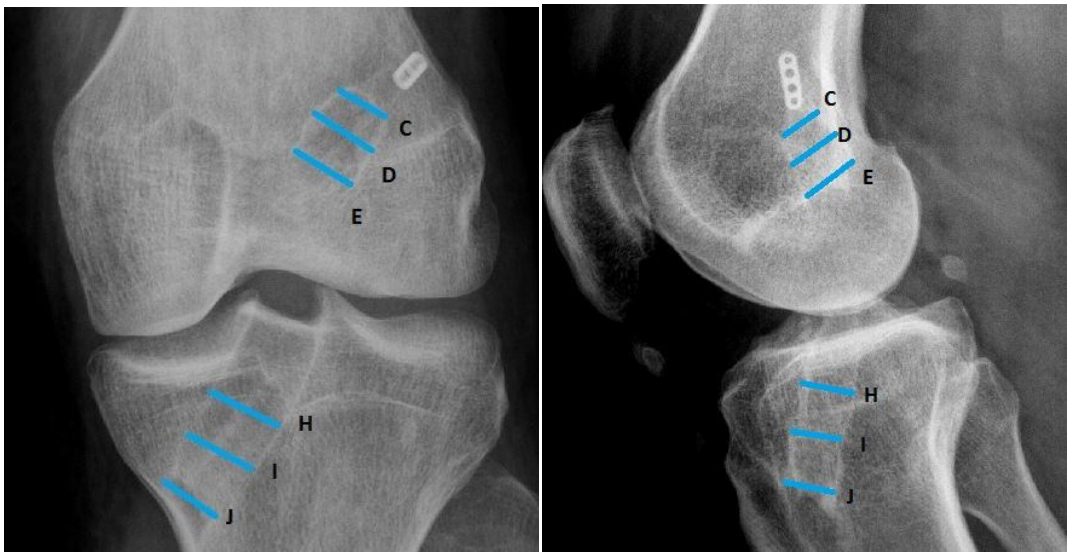


Figure 2: Tibia-- Left- anteroposterior reconstruction, right- lateral reconstruction

Tibial side- On the tibial side the diameter of the tunnel were also measured at 5 different points; F, G, H, I and J which were equidistant from each other(74).



X-ray measurements were also done in the same points but for the study purpose only points D and E were quoted as mentioned by the other authors(75).

Data analysis was done using SPSS 21.0. Mean and standard deviation was used to describe continuous variables, while frequency and percentages were obtained for categorical data. The chi square test and the student t test were employed to study the statistical significance of categorical and continuous variables respectively.

ANALYSIS AND RESULTS

A total of 48 patients were included in the study.

Group 1: On the endobutton only group 15 patients reported.

Group 2: On the endobutton + screw fixation group 33 were taken.

Table 1: Age distribution

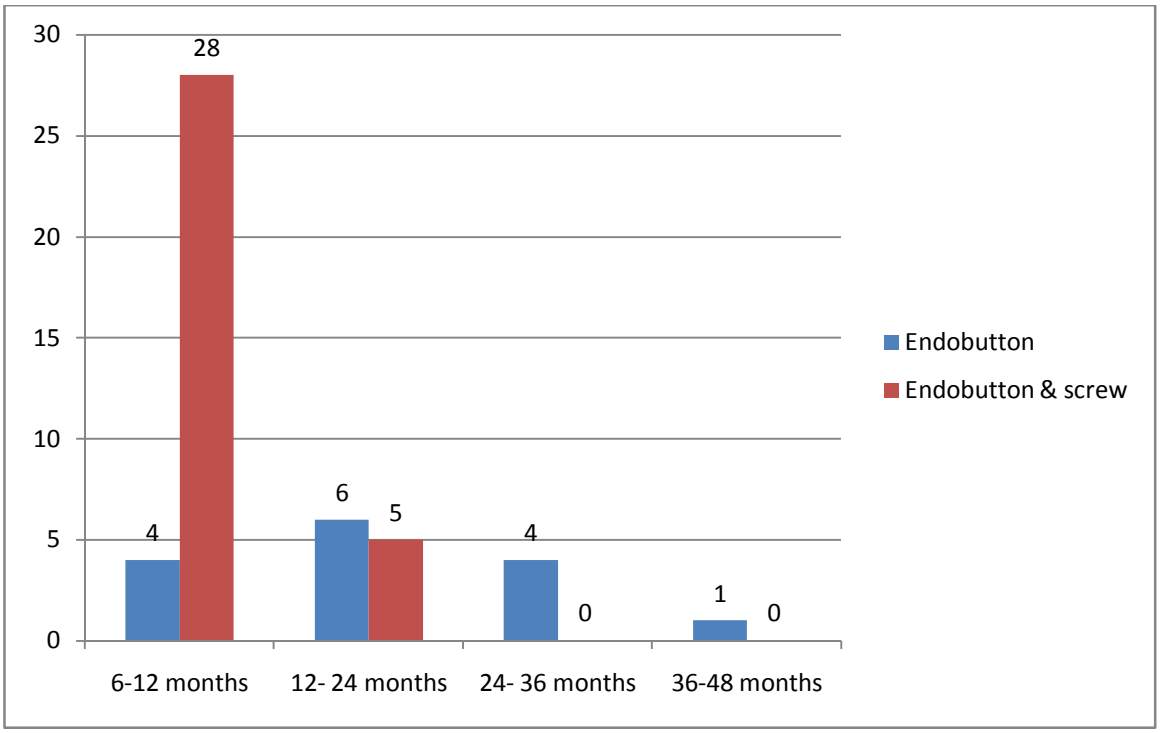
	Frequency	Percent
Male	45	93.8
Female	3	6.3
Total	48	100.0

Out of the 48 injured 3(6.3%) were women and 45(93.8%) were men.

In Endobutton group- there was 1 female

Endobutton & screw group- there were 2 females

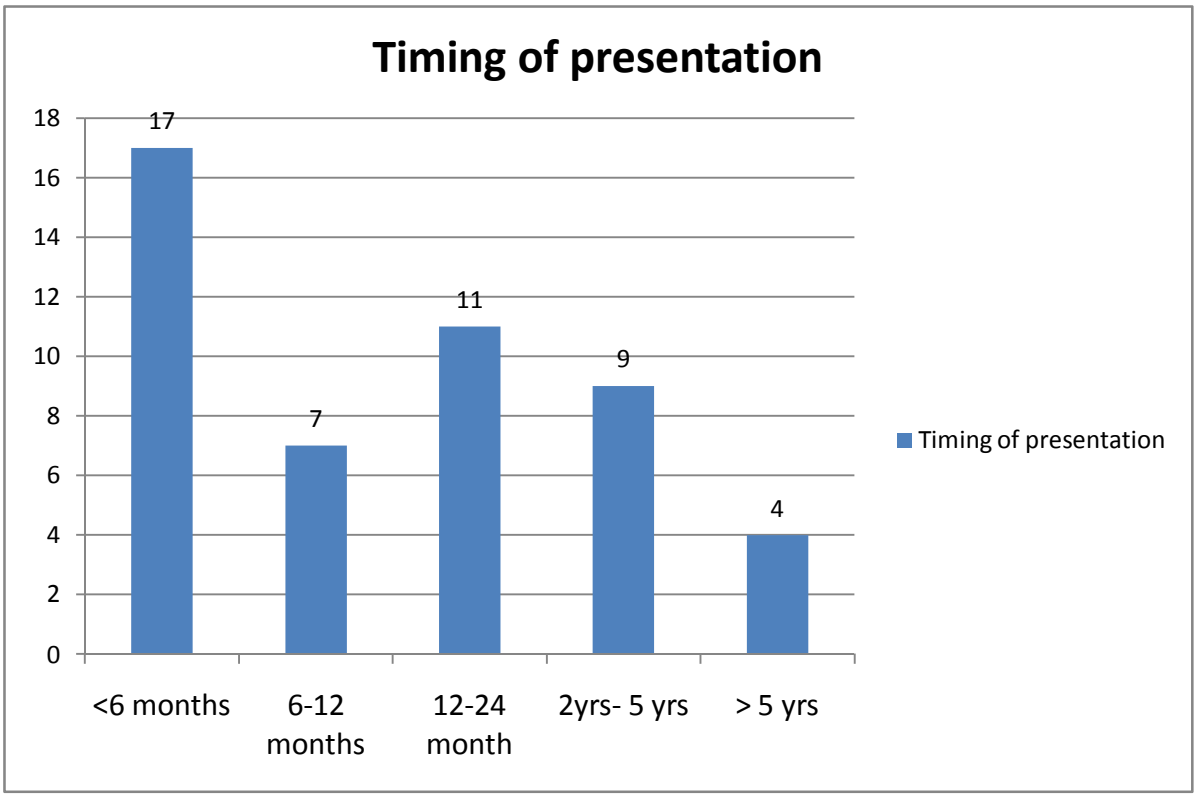
Table 2: Mean follow up after surgery



	In months mean± SD(range in months)
Endobutton group	21.33 ± 11.14 ( )
Endobutton & screw group	9.12 ± 3.83 ()

The interval from surgery to follow up was longer in the endobutton group. This was due to the time of assessment, which was done only when the patient had visited the hospital for follow up.

Table 3: Presentation since injury



Majority of the patients (72.9%) presented within 2 years of injury,

17 patients (35.4%) presented within 6 months of injury

7 patients (14.6%) presented between 6 to 12 months

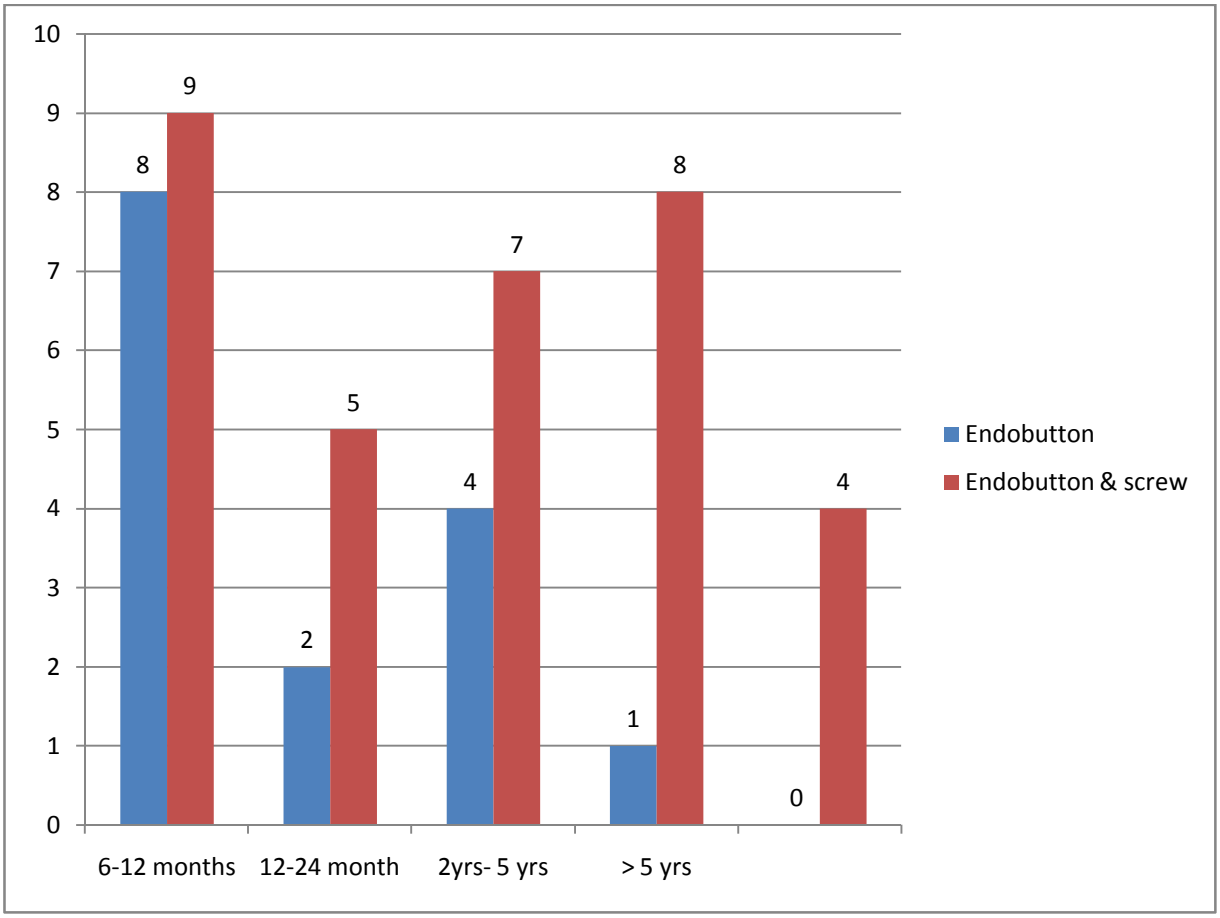
11 patients (22.9%) presented between 12 to 24 months

9 patients (18.8%) presented between 2 yrs to 5 years

Some patients even presented after 5 years (8.4%)

On an average, review since injury in both the groups was (mean 31.23 ± 50.48 SD) months

Table 4: Presentation since injury

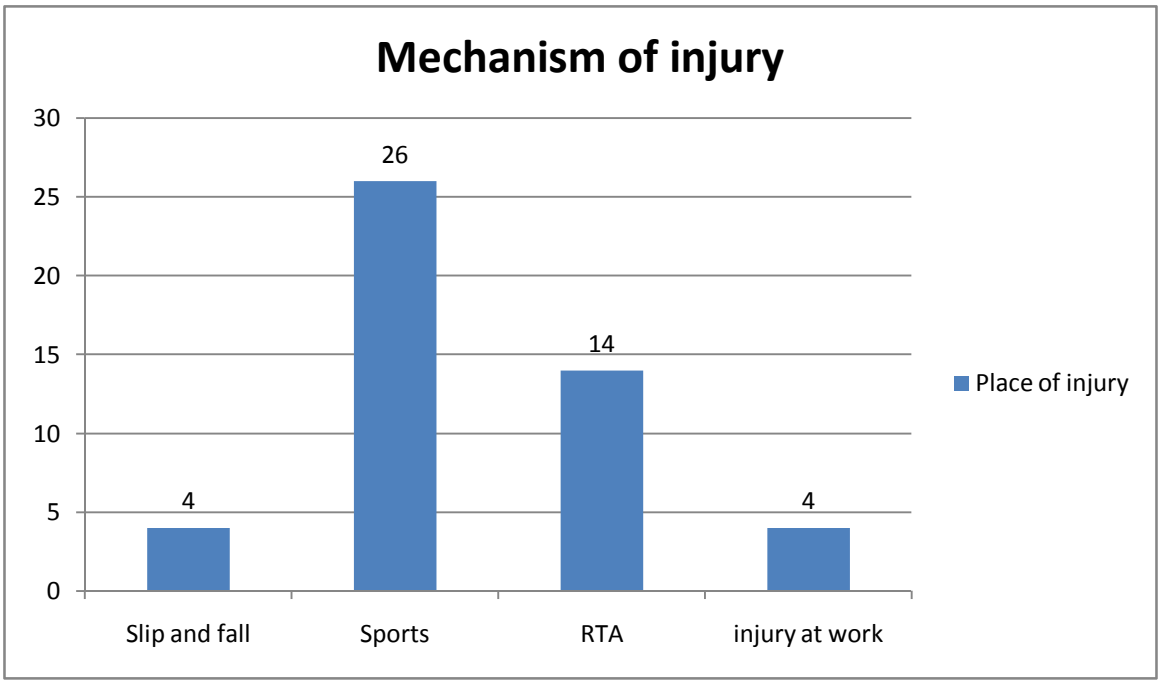


In the Endobutton group8 patients (53%) presented within 6 months of injury

On an average, review since injury was (mean 10.33 ± 9.55 SD) months

Endobutton & screw group mean presentation since injury was 40.73 ± 58.36 months. They presented quite late since the time of injury.

Table 5: Mechanism of injury



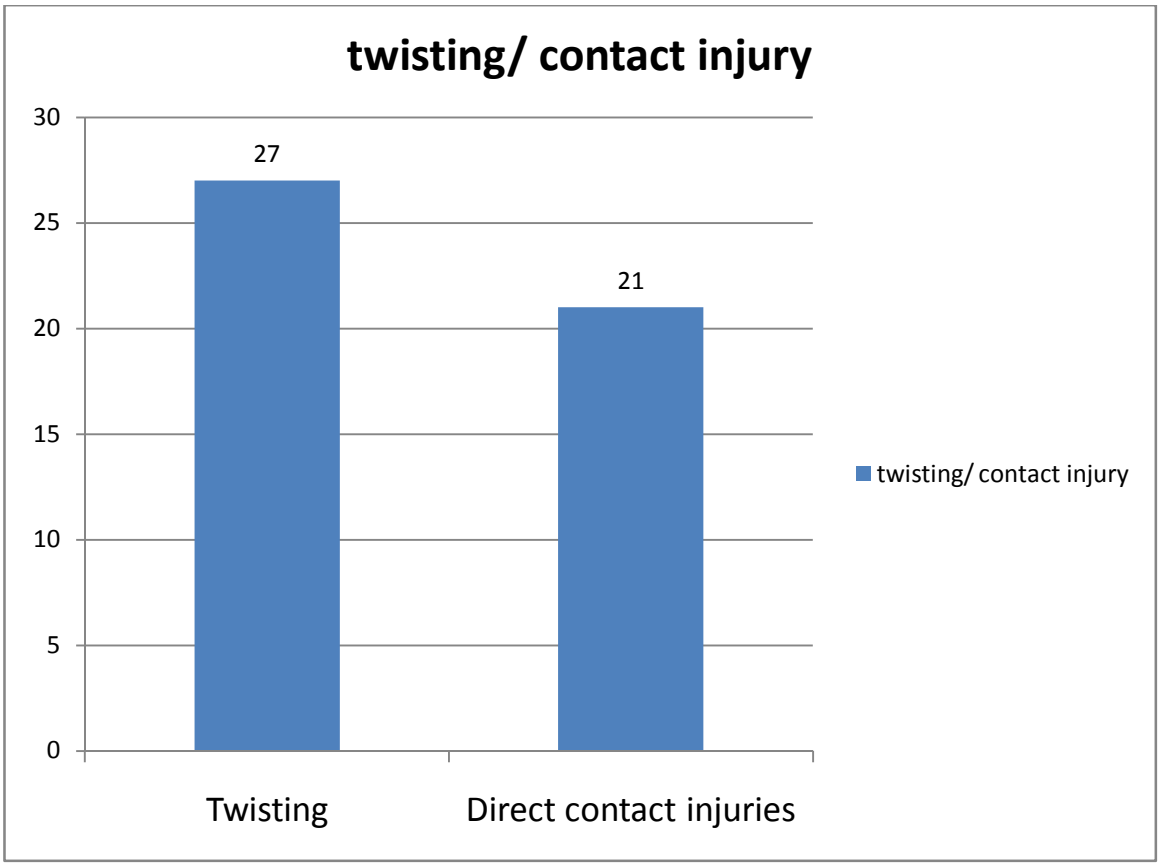
4 patients (8.3%) were slip and fall at home (out of which 2 were females)

26 patients (54.2%) of the injuries were sports related

14 patients (29.2%) were during road traffic accidents

4 patients (8.3%) were injuries at work

Table 6: Type of injury

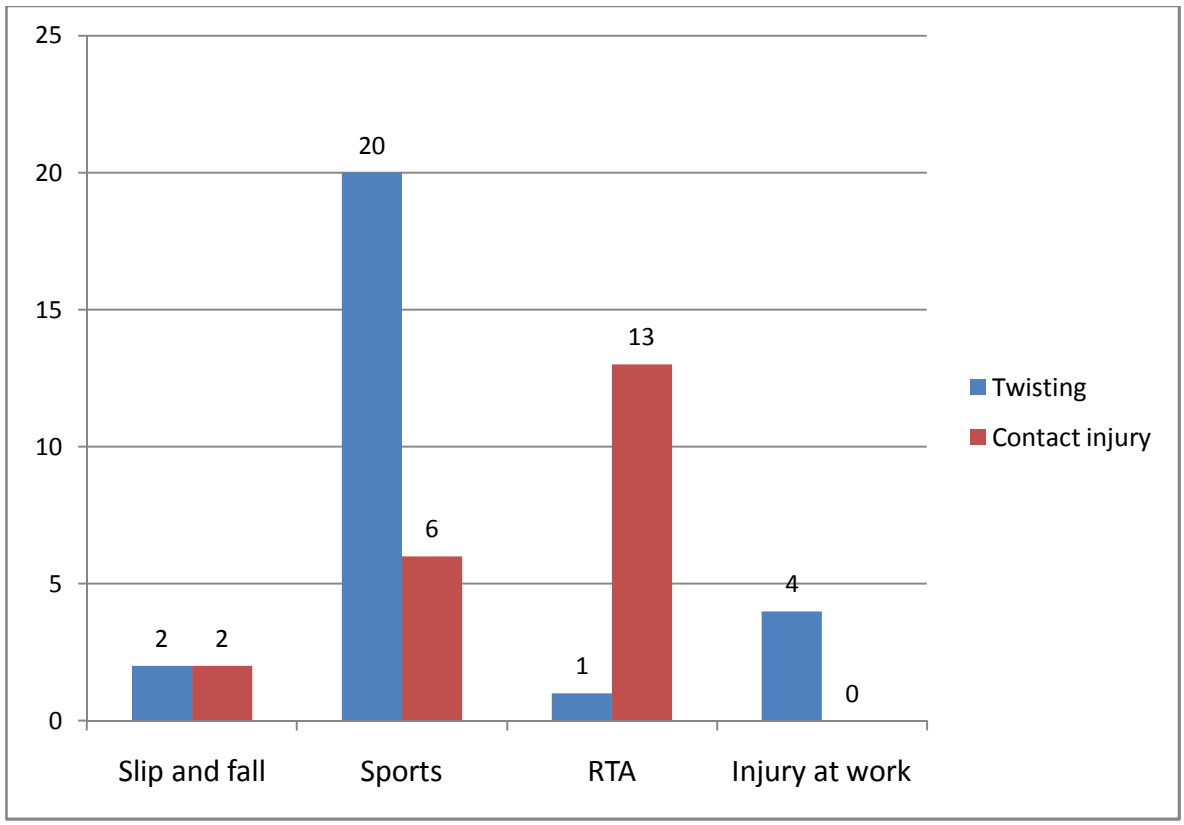


Both twising injury and contact injuries were almost equal in number but twising injury was more commonly associated with ACL injuries

27 patients (56%) of the injuries were due to twisting type

21 patients (44%) of the injuries were due to direct contact

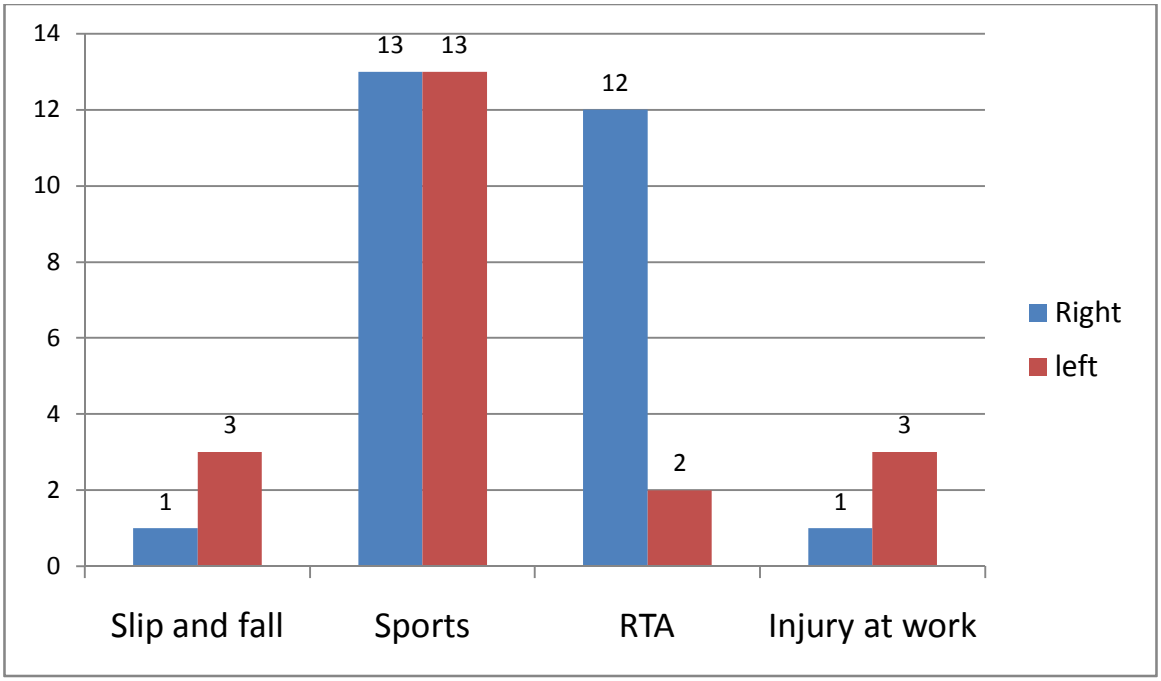
Table 7: Mechanism of injury- Type of injury



Sports related injuries were majority twisting type 76.92%

In RTA majority of the injury was contact type 92.86%

Table 8: Mechanism of injury - side of injury



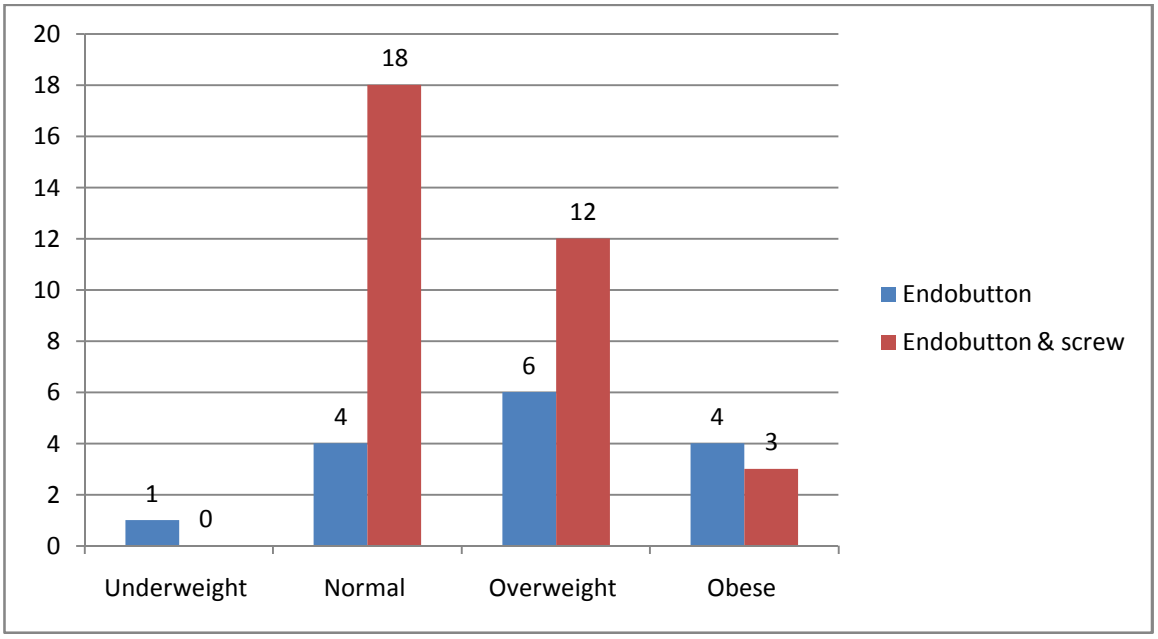
In slip and fall 75% involved the left knee

In sports left and right knees were equally involved (50% on both sides)

In RTA right knee (85.71%) was more involved, as the oncoming vehicle is from the right side

In work related injury 75% injuries were on the left knee

Table 9: BMI comparison at review

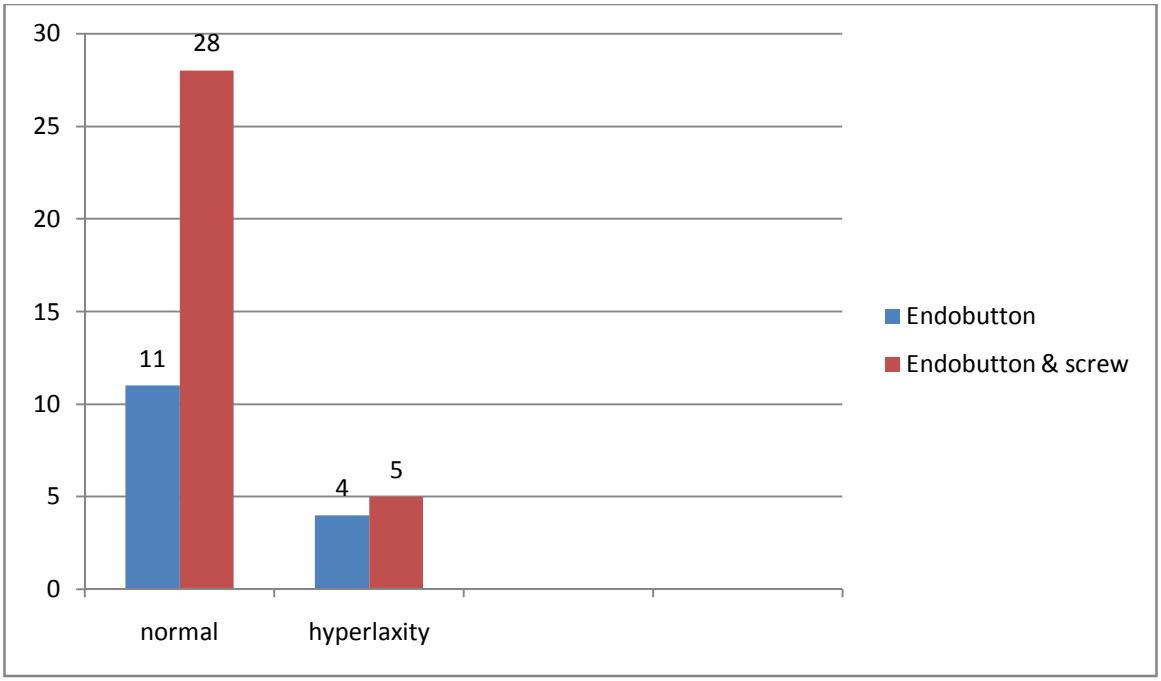


In the endobutton group, 1 patient (6.67%) was underweight, 4 patients (26.6%) were of normal weight,6 patients (40%) were of overweight, and 4 patients(26.6%) were obese, mean BMI was 26.90 ± 4.41 SD

Majority of the Endobutton & screw group were of normal weight 18 patients (54.5%), 12 patients (27.9%) were overweight, 3 patients (9.09%) were obese. Mean BMI was 25.47 ± 2.91 SD

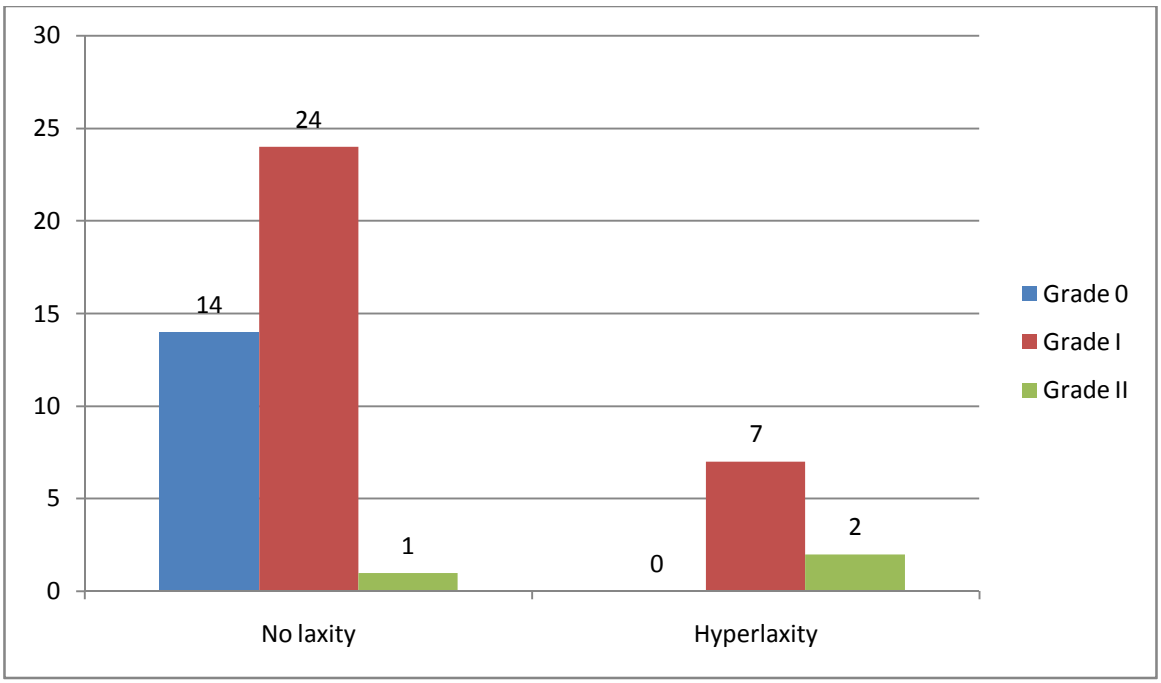
The average BMI between both the groups was 25.92 ± 3.46 (mean ± SD)

Table 10: Generalized ligamentous laxity



There were 4 patients with generalized ligamentous laxity in the endobutton group and 5 patients in the endobutton & screw group.

Table 11: Generalized hyper-laxity and anterior drawer

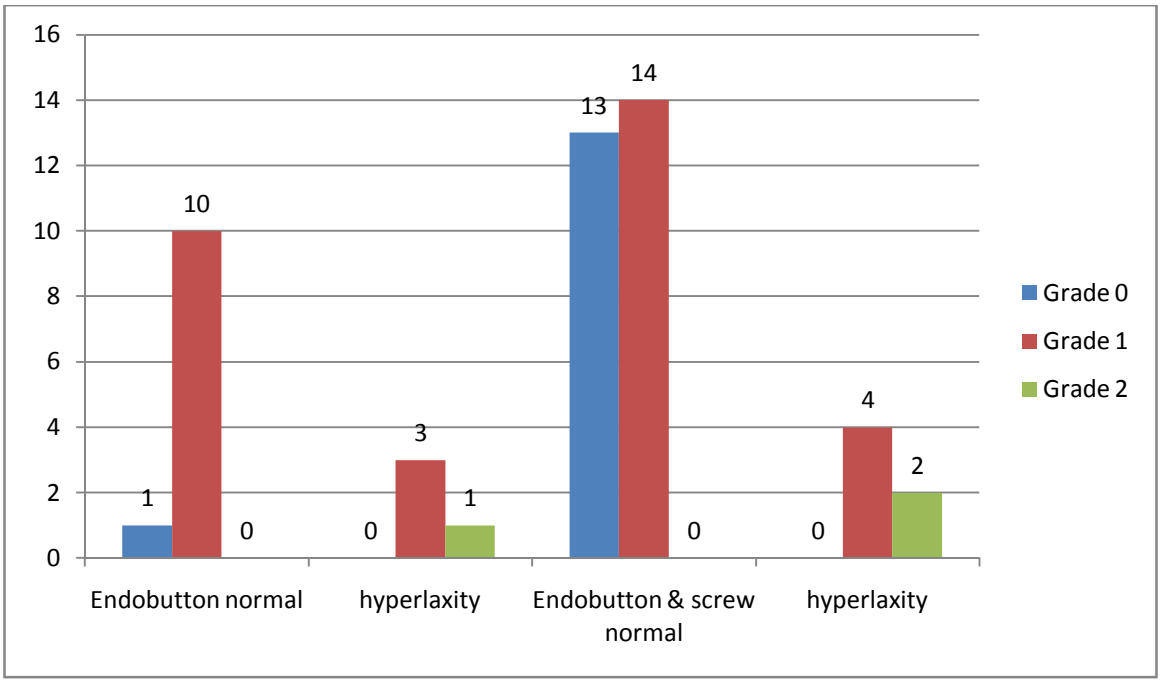


There were totally 9 patients with generalized hyper-laxity

Out of which 7 patients (77.8%) had grade I laxity and 2 patients (22.2%) had grade II laxity, no one had grade III laxity

Out of the patients who had no generalized laxity, 14 patients (35.9%) had grade 0 laxity and 25 patients (61.5%) had grade I laxity and 1 patient (2.6%) had grade II laxity.

Table 12: Generalized laxity and anterior drawer- group wise



In endobutton group among the normal patients majority had grade I anterior drawer – 10 patients (66.7%), 1 patient had grade 0 drawer

Among the endobutton and screw group patients, 13 patients (39.4%) had grade 0 drawer and 14 patients (42.4%) had grade I drawer.

In both endobutton and endobutton & screw group the drawer percentage was equal in the hyper-laxity group

Table 13: Anterior drawer- group wise

Anterior drawer was measured as mentioned in review of literature

In the endobutton & screw group the anterior drawer had reduced compared to the endobutton only group.

Endobutton group- grade 0- 6.7%, grade I- 86.7%, grade II- 6.7%

Endobutton & screw group- grade 0- 39.4%, grade I- 54.5%, grade II- 6.1%

Grade II laxity was found in patients with hyper-laxity

group		Frequency	Percent
Endobutton only	Grade 0	1	6.7
	Grade I	13	86.7
	Grade II	1	6.7
	Total	15	100.0
Endobutton + screw	Grade 0	13	39.4
	Grade I	18	54.5
	Grade II	2	6.1
	Total	33	100.0

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	5.441[a]	2	.066
Likelihood Ratio	6.435	2	.040
Linear-by-Linear Association	3.719	1	.054

Table 14: Lachman - group wise distribution

Lachman was measured as mentioned in review of literature

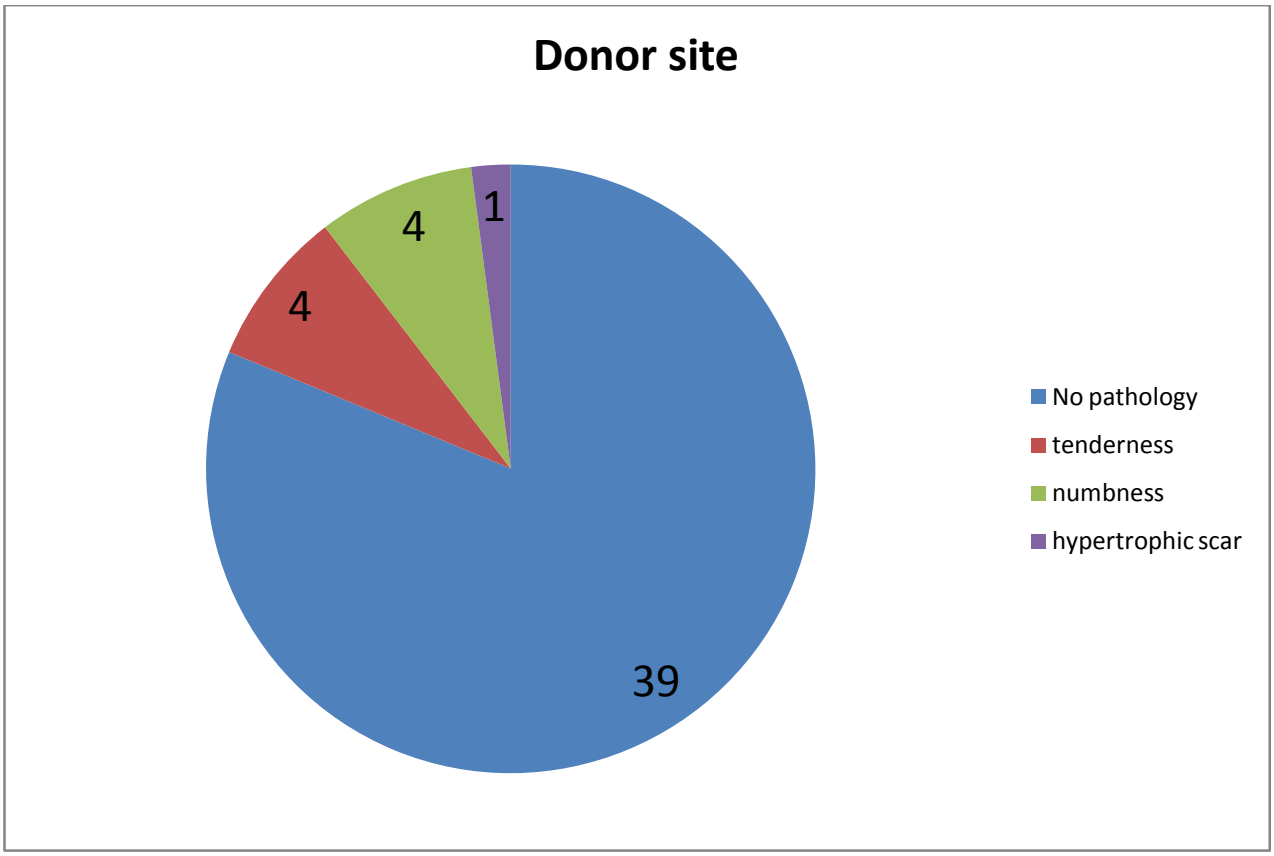
Lachman was reduced in endobutton & screw group – grade 0- 27.3%, grade I- 66.7%, grade II -6.1%

In endobutton group lachman was more pronounced- grade 0- 6.7%, grade I – 80%, grade II- 13.3%

Group		Frequency	Percent	Valid Percent	Cumulative Percent
Endobutton only	Grade 0	1	6.7	6.7	6.7
	Grade I	12	80.0	80.0	86.7
	Grade II	2	13.3	13.3	100.0
	Total	15	100.0	100.0	
Endobutton + screw	Grade 0	9	27.3	27.3	27.3
	Grade I	22	66.7	66.7	93.9
	Grade II	2	6.1	6.1	100.0
	Total	33	100.0	100.0	

	Value	df	Asymptotic Significance (2-sided)
Pearson Chi-Square	3.015[a]	2	.221
Likelihood Ratio	3.429	2	.180
Linear-by-Linear Association	2.843	1	.092
N of Valid Cases	48		

Table 15: Donor site pathology



Out of the 48 patients in the study, 39 patients had no donor site pathology, 4 had tenderness at the screw post, 4 patients had numbness in the harvest site and lateral to the harvest site, 1 patient had a hypertrophic scar.

Lysholm score

Lysholm grading

Poor <64

Fair 65-83

Good 84-94

Excellent 95-100

Endobutton group:

< 7 months- 83.5 ± 0.71 (mean ± SD)

>7 months- 94.69 ± 4.80 (mean ± SD)

7 months was chosen as patients didn't start running nor squatted till after 7 months (till their 1st follow up).

Endobutton & screw group:

< 7 months- 87.86 ± 8.73 (mean ± SD)

>7 months- 92.55 ± 7.11 (mean ± SD)

Endobutton & screw group had a better Lysholm scores while compared to the endobutton only group.

IKDC scores

Endobutton group

< 7 months- 59.2 ± 18.67 (mean ± SD)

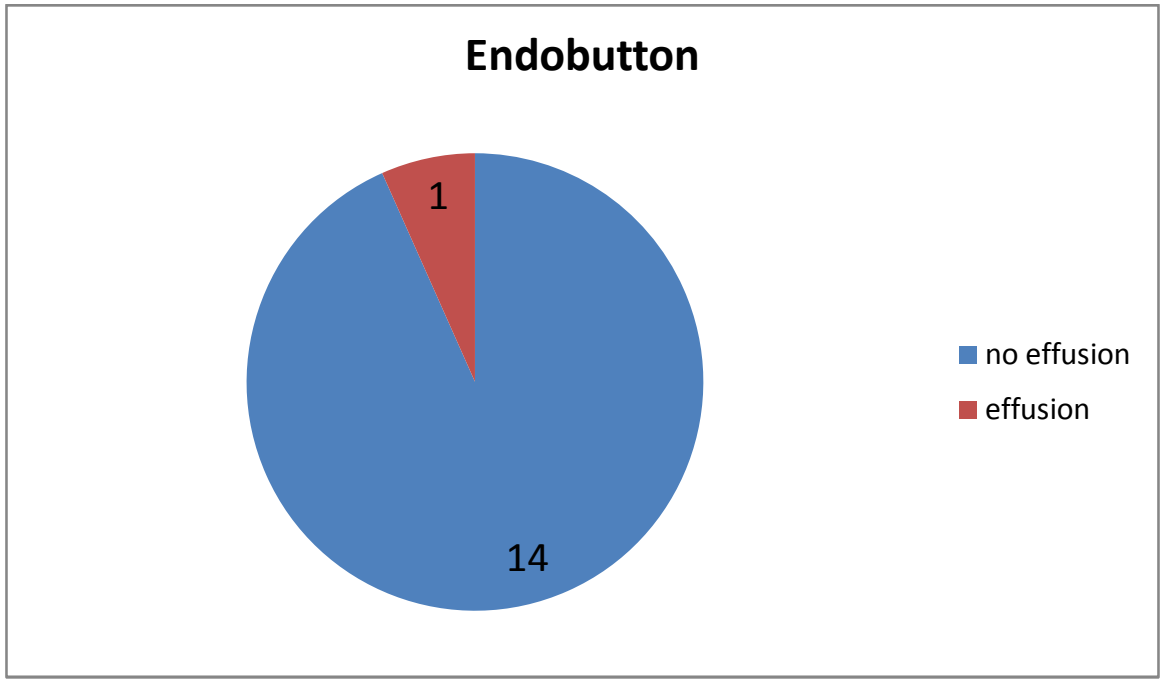
>7 months- 83.39 ± 8.18 (mean ± SD)

In Endobutton & screw group

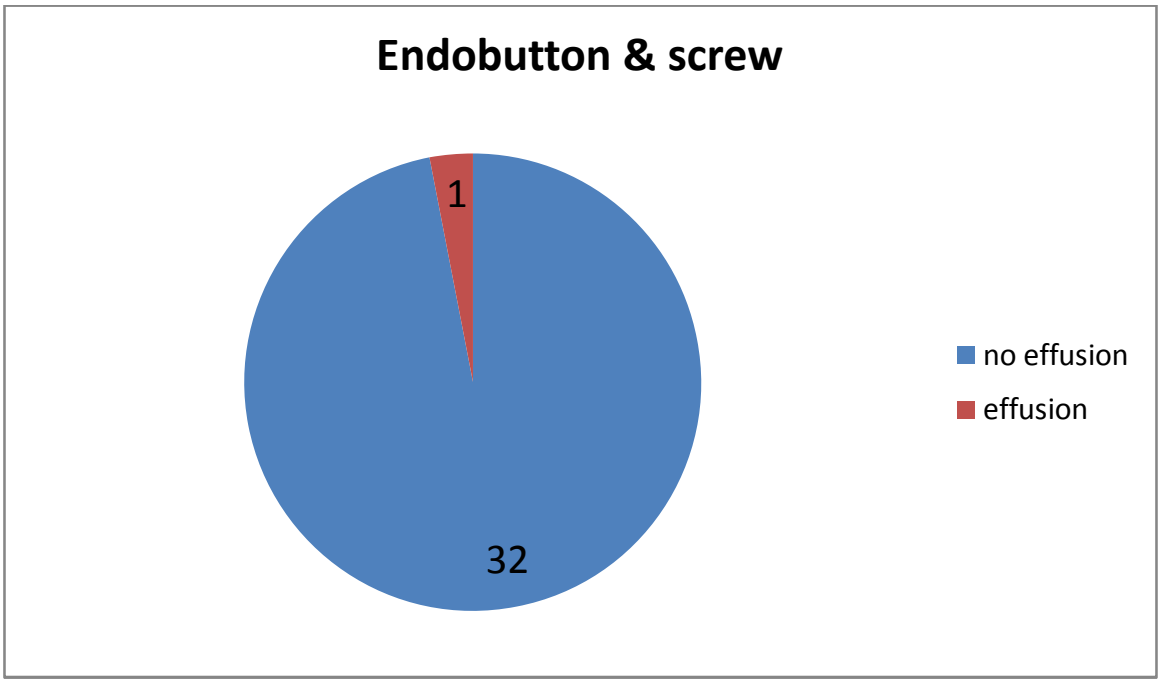
< 7 months- 64.53 ± 14.58 (mean ± SD)

>7 months-75.87 ± 11.16 (mean ± SD)

Table 16: Effusion



There was effusion in 1 patient, patellar tap was positive in the endobutton group



There was effusion in 1 patient, patellar tap was positive in the endobutton &screw group

Table 17: hop test

group		Frequency	Percent	Valid Percent	Cumulative Percent
Endobutton	1 (100-90)	4	26.7	26.7	26.7
	2 (89-76)	8	53.3	53.3	80.0
	3 (75-50)	2	13.3	13.3	93.3
	4 (50-0)	1	6.7	6.7	100.0
	Total	15	100.0	100.0	
Endobutton & screw	1 (100-90)	10	30.3	30.3	30.3
	2 (89-76)	12	36.4	36.4	66.7
	3 (75-50)	7	21.2	21.2	87.9
	4 (50-0)	4	12.1	12.1	100.0
	Total	33	100.0	100.0	

In the single leg hop test both the groups had comparable results. Majority of the patients had grade II – 89-76% in both the groups, probably as they were restricted from running or hopping till the 6 month.

Tunnel widening

Tunnel diameters from CT scan were measured by an experienced radiologist and x-ray diameters were measured by the principal investigator.

Table 18: Endobutton group - Points D, E measurements

Endobutton Group	Immediate post op x-ray measurement (n=15)	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	7.10 ± 0.63 (6.0-8.1)	7.09 ± 0.60 (6.1-8.0)
E	7.16 ± 0.61 (6.2-8.1)	7.17 ± 0.62 (6.2-8.2)

Endobutton Group	X-ray measurement at review (n=15)	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	8.64 ± 1.46 (6.0-11.7)	8.88 ± 1.45 (6.4-12.0)
E	8.69 ± 1.21 (6.5-11.0)	8.81 ± 1.19 (6.5-11.0)

Endobutton Group	CT measurement at review (n=15)	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	8.65 ± 1.55 (5.8-12)	8.41 ± 1.40 (5.7-11.4)
E	8.60 ± 1.32 (6.0-11.0)	8.33 ± 1.22 (6.0-10.7)

The initial tunnel diameter was measured from the immediate post operative x-ray, the follow up measurements to look for tunnel widening were done from the follow up x-ray and CT scan

Table 19: Endobutton & screw group - points D, E measurements

Endobutton & screw	Immediate post op x-ray measurement (n= 33)	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	9.01 ± 0.51 (7.5-9.8)	8.83 ± 0.55 (7.5-9.8)
E	9.17 ± 0.49 (8.0-9.7)	9.11 ± 0.54 (8.0-10.0)

Endobutton & screw	X-ray measurement at review (n= 33)	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	9.75 ± 0.98 (9.8-11.0)	9.83 ± 0.97 (9.6-11.2)
E	10.42 ± 1.02 (9.7-11.0)	10.21 ± 1.07 (9.4-11.2)

Endobutton & screw	CT measurement at review (n= 33)	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	9.27 ± 1.06 (7.2-11.4)	9.37 ± 1.04 (7.5-11.5)
E	10.08 ± 1.04 (8.0-12.0)	9.95 ± 1.09 (8.0-11.7)

Table 20: Tunnel widening

Endobutton	X-ray	
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	1.54 ± 1.48	1.79 ± 1.47
E	1.53 ±1.30	1.65 ± 1.29

Endobutton & screw		X-ray
	AP (mean ± SD) mm, range	Lateral(mean ± SD) mm, range
D	0.74 ± 1.05	1.01 ± 1.04
E	1.25 ± 1.10	1.09 ± 0.98

Tunnel widening was measured as difference between immediate post op x-ray and x-ray at follow up both in the anteroposterior and lateral views. Follow up CT scan measurements were similar to the follow up x-ray measurements. There was no CT at post op period to compare the follow up CT measurements.

P-value: measured by t-test

	AP- xray	Lateral- xray
D	P – 0.038	P – 0.038
E	P- 0.453	P- 0.107

DISCUSSION

Tunnel widening in ACL reconstruction is a common problem noted(72). It is seen mostly in suspensory fixation with hamstring grafts more than aperture fixation in bone patellar tendon bone graft(50). Our hypothesis was that anterior cruciate ligament reconstruction with hamstring graft by suspensory fixation causes femoral tunnel widening, but augmentation with an interference screw does not cause tunnel widening at follow up.

There are recent similar studies, published by Porter and Shadbolt in 2016(76), where they did an in vivo study with computer navigation, they added an aperture interference screw fixation to the femoral side in addition to the suspensory endobutton. Their results showed reduced anterior drawer and pivot shift post addition of the interference screw but they did not evaluate the tunnel widening.

The aim in both the studies was to reduce the distance between the fixation points so that graft motion causing ‘bungee cord effect’ and ‘windshield’ effect would be reduced. The addition of the interference screw was also to improve the stiffness of the fixation.

The patients in this study were operated by 2 primary surgeons, who work in the same orthopedic unit. They both use the same technique for ACL reconstruction. There was no discrepancy in the type of graft harvesting, tunnel position, graft fixation devices or rehabilitation protocol. In both the groups, patients were admitted 2 days

preoperatively, counseled on ACL surgery and rehabilitation protocol. Both the groups underwent preoperative MRI scan to look for any associated meniscal or other intra-articular/ juxta-articular ligament injuries. All the patients were advised to come for an assessment at 6 months after surgery. The time of assessment varied in each group because of the difference in the timing of their follow up visit to this hospital. X-rays were done at their follow up and a CT scan assessment was also done at the time of follow up, but there was no immediate post op CT to compare the findings. There was no difference in rehab protocol between the two groups.

The endobutton with the graft is threaded through the tunnel and appropriate sutures are pulled to ensure flipping of the endobutton after the graft reaches the point marked, and is verified by scopy visualization. The tension on the graft is maintained by pulling the distal strands during cycling of the knee so that the endobutton is flush on the femoral cortex, following which the femoral interference screw is added. The tibial interference screw was inserted while applying a posterior drawer, then the suture screw post was fixed. The interference screw (aperture fixation) was added on the femoral side with the endobutton (suspensory fixation) to add rigidity to the construct and possibly negate the 'windshield wiper effect'. This technique has been performed in our orthopedic unit for the past 2 years.

The Lachman and Drawer test were performed immediately after fixation intra operatively. The study done by Porter et al showed improvement in anterior drawer and pivot shift but tunnel widening was not studied(76).

This study consisted of 45 males and 3 females. Other Indian studies published also shows male predominance(18). This is because Indian women participate in lesser pivoting sports like basketball compared to the western population(15).

The follow up of the patient in the Endobutton group was between 8-41month (mean 21.33 ± 11.14 SD), but the endobutton& screw group was between 6-20 months (mean 9.12 ± 3.83 SD).

ACL injuries related to pivoting sports were double compared to the road traffic accidents in the study. 26 patients (54.2%) of the injuries were sports related and 14 patients (29.2%) were during road traffic accidents. These findings are comparable to the Indian data published in 2012 which had sports related ACL injuries double as that of road traffic accidents(18).

Our Lysholm and IKDC scores were dependent on our regular rehabilitation protocol. Our rehabilitation protocol consisted of wearing a knee brace while walking for 4 weeks in a normal patient and up to 6 weeks in a patient with generalized ligamentous laxity. They were ambulated with crutch support during this period of 4-6 weeks. They were started on quadriceps and hamstring strengthening, active range of movement exercises during this period. Squatting, cycling, jogging and running were delayed till 6 months. Hence patient's who came for their 6 month review, had low Lysholm and IKDC scores. The Lysholm and IKDC scores were comparable between the two groups.

Anterior drawer had reduced in the endobutton & screw group 0- 39.4%, grade I- 54.5%, grade II- 6.1% as compared to endobutton group who had more of grade I laxity. Endobutton group- grade 0- 6.7%, grade I- 86.7%, grade II- 6.7%. P-value was not significant which could be due to difference in sample size. Lachman had also reduced in the endobutton & screw group but was not statistically significant which also may be attributed to the difference in sample size.

Femoral tunnel widening measured by x-ray in the augmentation group measured at a standard point 'D' in the middle of the tunnel was 0.74 ± 1.05 (AP), 1.01 ± 1.04 (lateral) and in the endobutton only group was 1.54 ± 1.48 (AP) and 1.79 ± 1.47(lateral), both of which were statistically significant(p-0.038, p-0.038). Tunnel widening at the point 'E' (aperture) in the augmentation group was 1.25 ± 1.10 (AP), 1.09 ± 0.98 (lateral) and in the endobutton only group was 1.53 ±1.30 (AP), 1.65 ± 1.29 (lateral). This was not statistically significant. The follow up x- ray measurements were similar to the follow up CT measurements.

Tunnel widening on x-ray in the endobutton & screw group at points D and E (aperture) on the femoral side was lesser compared to the endobutton-only group. Tunnel widening was measured as difference between immediate post op x-ray and x-ray at follow up. The CT scan measurements at follow up were similar to the follow up x-ray measurements that were done. There was no CT done at the immediate post op period to compare the follow up CT measurements.

This is possibly due to negation of the ‘windshield wiper’ and the ‘bungee cord effect’ as the fixation points are brought nearer.

The tunnels were measured at points D and E as quoted in the other similar studies which measured distal femur tunnel widening(77,78).

The advantages of the study were that the patients were operated and were followed up by the same surgeons. The limitations of the studies were that the subjects were not well matched on the follow up period. The x-ray measurements were done by the principal investigator and the radiologist together, CT scan measurements were done independently by radiologist.

CONCLUSION

Our hypothesis which assumed that tunnel widening would be reduced by the addition of the interference screw on the femoral side in addition to the suspensory fixation contributed to decrease in tunnel widening as well as better functional outcome true. In addition to the radiological improvement, there was also clinical improvement noted in the patients both during immediate post operative period and during their follow up.

BIBLIOGRAPHY

1. Chechik O, Amar E, Khashan M, Lador R, Eyal G, Gold A. An international survey on anterior cruciate ligament reconstruction practices. Int Orthop. 2013 Feb;37(2):201–6.

2. Nebelung W, Becker R, Merkel M, Röpke M. Bone tunnel enlargement after anterior cruciate ligament reconstruction with semitendinosus tendon using Endobutton fixation on the femoral side. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 1998 Dec;14(8):810–5.

3. Fink C, Zapp M, Benedetto KP, Hackl W, Hoser C, Rieger M. Tibial tunnel enlargement following anterior cruciate ligament reconstruction with patellar tendon autograft. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2001 Feb;17(2):138–43.

4. Fauno P, Kaalund S. Tunnel widening after hamstring anterior cruciate ligament reconstruction is influenced by the type of graft fixation used: a prospective randomized study. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2005 Nov;21(11):1337–41.

5. Parkar AP, Adriaensen MEAPM, Fischer-Bredenbeck C, Inderhaug E, Strand T, Assmus J, et al. Measurements of tunnel placements after anterior cruciate ligament reconstruction--A comparison between CT, radiographs and MRI. The Knee. 2015 Dec;22(6):574–9.

6. Clatworthy MG, Annear P, Bulow JU, Bartlett RJ. Tunnel widening in anterior cruciate ligament reconstruction: a prospective evaluation of hamstring and patella tendon grafts. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 1999;7(3):138–45.

7. Höher J, Möller HD, Fu FH. Bone tunnel enlargement after anterior cruciate ligament reconstruction: fact or fiction? Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 1998;6(4):231–40.

8. Jo H, Jun DS, Lee DY, Lee SH, Seong SC, Lee MC. Tibial tunnel area changes following arthroscopic anterior cruciate ligament reconstructions with autogenous patellar tendon graft. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2004 Jul;12(4):311–6.

9. Nebelung W, Becker R, Merkel M, Röpke M. Bone tunnel enlargement after anterior cruciate ligament reconstruction with semitendinosus tendon using Endobutton fixation on the femoral side. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 1998 Dec;14(8):810–5.

10. Hantes ME, Mastrokalos DS, Yu J, Paessler HH. The effect of early motion on tibial tunnel widening after anterior cruciate ligament replacement using hamstring tendon grafts. Arthrosc J Arthrosc Relat Surg. 2004 Jul;20(6):572–80.

11. Peyrache MD, Djian P, Christel P, Witvoet J. Tibial tunnel enlargement after anterior cruciate ligament reconstruction by autogenous bone-patellar tendon-bone graft. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 1996;4(1):2–8.

12. Iorio R, Vadalà A, Argento G, Di Sanzo V, Ferretti A. Bone tunnel enlargement after ACL reconstruction using autologous hamstring tendons: a CT study. Int Orthop. 2007 Feb;31(1):49–55.

13. Kawaguchi Y, Kondo E, Kitamura N, Kai S, Inoue M, Yasuda K. Comparisons of femoral tunnel enlargement in 169 patients between single-bundle and anatomic double-bundle anterior cruciate ligament reconstructions with hamstring tendon grafts. Knee Surg Sports Traumatol Arthrosc. 2011 Aug;19(8):1249–57.

14. Webster KE, Feller JA, Hameister KA. Bone tunnel enlargement following anterior cruciate ligament reconstruction: a randomised comparison of hamstring and patellar tendon grafts with 2-year follow-up. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2001;9(2):86–91.

15. Griffin LY, Agel J, Albohm MJ, Arendt EA, Dick RW, Garrett WE, et al. Noncontact Anterior Cruciate Ligament Injuries: Risk Factors and Prevention Strategies: J Am Acad Orthop Surg. 2000 May;8(3):141–50.

16. Mall NA, Chalmers PN, Moric M, Tanaka MJ, Cole BJ, Bach BR, et al. Incidence and Trends of Anterior Cruciate Ligament Reconstruction in the United States. Am J Sports Med. 2014 Oct;42(10):2363–70.

17. Gianotti SM, Marshall SW, Hume PA, Bunt L. Incidence of anterior cruciate ligament injury and other knee ligament injuries: a national population-based study. J Sci Med Sport. 2009 Nov;12(6):622–7.

18. Jacob K, Oommen A. A retrospective analysis of risk factors for meniscal co-morbidities in anterior cruciate ligament injuries. Indian J Orthop. 2012;46(5):566.

19. Palmer I. The Classic: On the Injuries to the Ligaments of the Knee Joint: A Clinical Study. Clin Orthop. 2007 Jan;454:17–22.

20. Prins M. The Lachman test is the most sensitive and the pivot shift the most specific test for the diagnosis of ACL rupture. Aust J Physiother. 2006;52(1):66.

21. Makhmalbaf H, Moradi A, Ganji S, Omidi-Kashani F. Accuracy of Lachman and Anterior Drawer Tests for Anterior Cruciate Ligament Injuries. Arch Bone Jt Surg. 2013 Dec;1(2):94–7.

22. Butler DL, Noyes FR, Grood ES. Ligamentous restraints to anterior-posterior drawer in the human knee. A biomechanical study. J Bone Joint Surg Am. 1980 Mar;62(2):259–70.

23. van Eck CF, van den Bekerom MPJ, Fu FH, Poolman RW, Kerkhoffs GMMJ. Methods to diagnose acute anterior cruciate ligament rupture: a meta-analysis of physical examinations with and without anaesthesia. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2013 Aug;21(8):1895–903.

24. Jakob RP, Stäubli HU, Deland JT. Grading the pivot shift. Objective tests with implications for treatment. J Bone Joint Surg Br. 1987 Mar;69(2):294–9.

25. Logerstedt D, Grindem H, Lynch A, Eitzen I, Engebretsen L, Risberg MA, et al. Single-legged Hop Tests as Predictors of Self-reported Knee Function After Anterior Cruciate Ligament Reconstruction. Am J Sports Med. 2012 Oct;40(10):2348–56.

26. Colombet P, Dejour D, Panisset J-C, Siebold R. Current concept of partial anterior cruciate ligament ruptures. Orthop Traumatol Surg Res. 2010 Dec;96(8):S109–18.

27. Arneja SS, Furey MJ, Alvarez CM, Reilly CW. Segond Fractures: Not Necessarily Pathognemonic of Anterior Cruciate Ligament Injury in the Pediatric Population. Sports Health Multidiscip Approach. 2010 Sep;2(5):437–9.

28. Claes S, Luyckx T, Vereecke E, Bellemans J. The Segond Fracture: A Bony Injury of the Anterolateral Ligament of the Knee. Arthrosc J Arthrosc Relat Surg. 2014 Nov;30(11):1475–82.

29. Van Dyck P, Vanhoenacker FM, Gielen JL, Dossche L, Van Gestel J, Wouters K, et al. Three tesla magnetic resonance imaging of the anterior cruciate ligament of the knee: can we differentiate complete from partial tears? Skeletal Radiol. 2011 Jun;40(6):701–7.

30. Lefevre N, Naouri JF, Bohu Y, Klouche S, Herman S. Sensitivity and specificity of bell-hammer tear as an indirect sign of partial anterior cruciate ligament rupture on magnetic resonance imaging. Knee Surg Sports Traumatol Arthrosc. 2014 May;22(5):1112–8.

31. Van Dyck P, Gielen JL, Vanhoenacker FM, Wouters K, Dossche L, Parizel PM. Stable or unstable tear of the anterior cruciate ligament of the knee: an MR diagnosis? Skeletal Radiol. 2012 Mar;41(3):273–80.

32. Tjoumakaris FP, Donegan DJ, Sekiya JK. Partial tears of the anterior cruciate ligament: diagnosis and treatment. Am J Orthop Belle Mead NJ. 2011 Feb;40(2):92–7.

33. Pujol N, Colombet P, Cucurulo T, Graveleau N, Hulet C, Panisset J-C, et al. Natural history of partial anterior cruciate ligament tears: A systematic literature review. Orthop Traumatol Surg Res. 2012 Dec;98(8):S160–4.

34. Lorenz S, Imhoff AB. [Reconstruction of partial anterior cruciate ligament tears]. Oper Orthopadie Traumatol. 2014 Feb;26(1):56–62.

35. Kessler MA, Behrend H, Henz S, Stutz G, Rukavina A, Kuster MS. Function, osteoarthritis and activity after ACL-rupture: 11 years follow-up results of conservative versus reconstructive treatment. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2008 May;16(5):442–8.

36. Magnussen RA, Granan L-P, Dunn WR, Amendola A, Andrish JT, Brophy R, et al. Cross-cultural comparison of patients undergoing ACL reconstruction in the United States and Norway. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2010 Jan;18(1):98–105.

37. Duquin TR, Wind WM, Fineberg MS, Smolinski RJ, Buyea CM. Current trends in anterior cruciate ligament reconstruction. J Knee Surg. 2009 Jan;22(1):7–12.

38. Maletis GB, Cameron SL, Tengan JJ, Burchette RJ. A prospective randomized study of anterior cruciate ligament reconstruction: a comparison of patellar tendon and quadruple-strand semitendinosus/gracilis tendons fixed with bioabsorbable interference screws. Am J Sports Med. 2007 Mar;35(3):384–94.

39. Wagner M, Kääb MJ, Schallock J, Haas NP, Weiler A. Hamstring tendon versus patellar tendon anterior cruciate ligament reconstruction using biodegradable interference fit fixation: a prospective matched-group analysis. Am J Sports Med. 2005 Sep;33(9):1327–36.

40. Maletis GB, Cameron SL, Tengan JJ, Burchette RJ. A Prospective Randomized Study of Anterior Cruciate Ligament Reconstruction: A Comparison of Patellar Tendon and Quadruple-Strand Semitendinosus/Gracilis Tendons Fixed with Bioabsorbable Interference Screws. Am J Sports Med. 2007 Mar;35(3):384–94.

41. Moré ADO, Pizzolatti ALA, Fancello EA, Salmoria GV, Roesler CR de M, Moré ADO, et al. Graft tendon slippage with metallic and bioabsorbable interference screws under cyclic load: a biomechanical study in a porcine model. Res Biomed Eng. 2015 Mar;31(1):56–61.

42. Barber FA. Flipped patellar tendon autograft anterior cruciate ligament reconstruction. Arthrosc J Arthrosc Relat Surg. 2000 Jul;16(5):483–90.

43. Hunt JA, Callaghan JT. Polymer-hydroxyapatite composite versus polymer interference screws in anterior cruciate ligament reconstruction in a large animal model. Knee Surg Sports Traumatol Arthrosc. 2008 Jul;16(7):655–60.

44. Weiler A, Hoffmann RFG, Stähelin AC, Helling H-J, Südkamp NP. Biodegradable Implants in Sports Medicine: The Biological Base. Arthrosc J Arthrosc Relat Surg. 2000 Apr;16(3):305–21.

45. Middleton JC, Tipton AJ. Synthetic biodegradable polymers as orthopedic devices. Biomaterials. 2000 Dec;21(23):2335–46.

46. Petricca SE, Marra KG, Kumta PN. Chemical synthesis of poly(lactic-co-glycolic acid)/hydroxyapatite composites for orthopaedic applications. Acta Biomater. 2006 May;2(3):277–86.

47. Hunt JA, Callaghan JT. Polymer-hydroxyapatite composite versus polymer interference screws in anterior cruciate ligament reconstruction in a large animal model. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2008 Jul;16(7):655–60.

48. Black KP, Saunders MM, Stube KC, Moulton MJ, Jacobs CR. Effects of interference fit screw length on tibial tunnel fixation for anterior cruciate ligament reconstruction. Am J Sports Med. 2000 Dec;28(6):846–9.

49. Kohn D, Rose C. Primary stability of interference screw fixation. Influence of screw diameter and insertion torque. Am J Sports Med. 1994 Jun;22(3):334–8.

50. Lind M, Feller J, Webster KE. Bone Tunnel Widening After Anterior Cruciate Ligament Reconstruction Using EndoButton or EndoButton Continuous Loop. Arthrosc J Arthrosc Relat Surg. 2009 Nov;25(11):1275–80.

51. Rork PE. “Bungee cord” effect in hamstring tendon ACL reconstruction. Orthopedics. 2000 Mar;23(3):184.

52. Ishibashi Y, Rudy TW, Livesay GA, Stone JD, Fu FH, Woo SL-Y. The effect of anterior cruciate ligament graft fixation site at the tibia on knee stability: Evaluation using a robotic testing system. Arthrosc J Arthrosc Relat Surg. 1997 Apr;13(2):177–82.

53. Dargel J, Gotter M, Mader K, Pennig D, Koebke J, Schmidt-Wiethoff R. Biomechanics of the anterior cruciate ligament and implications for surgical reconstruction. Strateg Trauma Limb Reconstr. 2007 Apr;2(1):1–12.

54. L’Insalata JC, Klatt B, Fu FH, Harner CD. Tunnel expansion following anterior cruciate ligament reconstruction: a comparison of hamstring and patellar tendon autografts. Knee Surg Sports Traumatol Arthrosc. 1997 Oct 21;5(4):234–8.

55. Morgan CD, Stein DA, Leitman EH, Kalman VR. Anatomic tibial graft fixation using a retrograde bio-interference screw for endoscopic anterior cruciate ligament reconstruction. Arthrosc J Arthrosc Relat Surg. 2002 Sep;18(7):1–8.

56. Noyes FR, Butler DL, Grood ES, Zernicke RF, Hefzy MS. Biomechanical analysis of human ligament grafts used in knee-ligament repairs and reconstructions. J Bone Joint Surg Am. 1984 Mar;66(3):344–52.

57. Li S, Chen Y, Lin Z, Cui W, Zhao J, Su W. A systematic review of randomized controlled clinical trials comparing hamstring autografts versus bone-patellar tendon-bone autografts for the reconstruction of the anterior cruciate ligament. Arch Orthop Trauma Surg. 2012 Sep;132(9):1287–97.

58. Mohtadi NG, Chan DS, Dainty KN, Whelan DB. Patellar tendon versus hamstring tendon autograft for anterior cruciate ligament rupture in adults. Cochrane Bone, Joint and Muscle Trauma Group, editor. Cochrane Database Syst Rev. 2011 Sep 7

59. Xie X, Liu X, Chen Z, Yu Y, Peng S, Li Q. A meta-analysis of bone-patellar tendon-bone autograft versus four-strand hamstring tendon autograft for anterior cruciate ligament reconstruction. The Knee. 2015 Mar;22(2):100–10.

60. Roe J, Pinczewski LA, Russell VJ, Salmon LJ, Kawamata T, Chew M. A 7-Year Follow-up of Patellar Tendon and Hamstring Tendon Grafts for Arthroscopic Anterior Cruciate Ligament Reconstruction: Differences and Similarities. Am J Sports Med. 2005 Sep;33(9):1337–45.

61. Xie X, Xiao Z, Li Q, Zhu B, Chen J, Chen H, et al. Increased incidence of osteoarthritis of knee joint after ACL reconstruction with bone-patellar tendon-bone autografts than hamstring autografts: a meta-

analysis of 1,443 patients at a minimum of 5 years. Eur J Orthop Surg Traumatol Orthop Traumatol. 2015 Jan;25(1):149–59.

62. Freedman KB, D'Amato MJ, Nedeff DD, Kaz A, Bach BR. Arthroscopic Anterior Cruciate Ligament Reconstruction: A Metaanalysis Comparing Patellar Tendon and Hamstring Tendon Autografts. Am J Sports Med. 2003 Jan;31(1):2–11.

63. Xie X, Liu X, Chen Z, Yu Y, Peng S, Li Q. A meta-analysis of bone–patellar tendon–bone autograft versus four-strand hamstring tendon autograft for anterior cruciate ligament reconstruction. The Knee. 2015 Mar;22(2):100–10.

64. Kartus J, Movin T, Karlsson J. Donor-site morbidity and anterior knee problems after anterior cruciate ligament reconstruction using autografts. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2001 Dec;17(9):971–80.

65. Ristanis S, Tsepis E, Giotis D, Stergiou N, Cerulli G, Georgoulis AD. Electromechanical delay of the knee flexor muscles is impaired after harvesting hamstring tendons for anterior cruciate ligament reconstruction. Am J Sports Med. 2009 Nov;37(11):2179–86.

66. Feller JA, Webster KE. A randomized comparison of patellar tendon and hamstring tendon anterior cruciate ligament reconstruction. Am J Sports Med. 2003 Aug;31(4):564–73.

67. Aglietti P, Giron F, Buzzi R, Biddau F, Sasso F. Anterior cruciate ligament reconstruction: bone-patellar tendon-bone compared with double semitendinosus and gracilis tendon grafts. A prospective, randomized clinical trial. J Bone Joint Surg Am. 2004 Oct;86-A(10):2143–55.

68. Matsumoto A, Howell SM, Liu-Barba D. Time-related changes in the cross-sectional area of the tibial tunnel after compaction of an autograft bone dowel alongside a hamstring graft. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2006 Aug;22(8):855–60.

69. Ito MM, Tanaka S. Evaluation of tibial bone-tunnel changes with X-ray and computed tomography after ACL reconstruction using a bone-patella tendon-bone autograft. Int Orthop. 2006 Apr;30(2):99–103.

70. Webster KE, Chiu JJ, Feller JA. Impact of Measurement Error in the Analysis of Bone Tunnel Enlargement after Anterior Cruciate Ligament Reconstruction. Am J Sports Med. 2005 Nov;33(11):1680–7.

71. Järvelä T, Moisala A-S, Paakkala T, Paakkala A. Tunnel enlargement after double-bundle anterior cruciate ligament reconstruction: a prospective, randomized study. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2008 Dec;24(12):1349–57.

72. Fauno P, Kaalund S. Tunnel widening after hamstring anterior cruciate ligament reconstruction is influenced by the type of graft fixation used: a prospective randomized study. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2005 Nov;21(11):1337–41.

73. Nebelung W. Bone tunnel enlargement after anterior cruciate ligament reconstruction with semitendinosus tendon using Endobutton fixation on the femoral side. Arthrosc J Arthrosc Relat Surg. 1998 Nov;14(8):810–5.

74. Fink C, Zapp M, Benedetto KP, Hackl W, Hoser C, Rieger M. Tibial tunnel enlargement following anterior cruciate ligament reconstruction with patellar tendon autograft. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2001 Feb;17(2):138–43.

75. Ra HJ, Celik H, Kim H-J, Lee D-H. Femoral tunnel widening is similar between anteromedial portal and transtibial techniques following single-bundle anterior cruciate ligament reconstruction: a systematic review and meta-analysis. Knee Surg Sports Traumatol Arthrosc. 2018 Oct 10

76. Porter MD, Shadbolt B. Femoral Aperture Fixation Improves Anterior Cruciate Ligament Graft Function When Added to Cortical Suspensory Fixation. Orthop J Sports Med. 2016 Sep 7 ;4(9).

77. Aga C, Wilson KJ, Johansen S, Dornan G, La Prade RF, Engebretsen L. Tunnel widening in single- versus double-bundle anterior cruciate ligament reconstructed knees. Knee Surg Sports Traumatol Arthrosc Off J ESSKA. 2017 Apr;25(4):1316–27.

78. Sabat D, Kundu K, Arora S, Kumar V. Tunnel widening after anterior cruciate ligament reconstruction: a prospective randomized computed tomography--based study comparing 2 different femoral fixation methods for hamstring graft. Arthrosc J Arthrosc Relat Surg Off Publ Arthrosc Assoc N Am Int Arthrosc Assoc. 2011 Jun;27(6):776–83.

ANNEXURES

Questionnaire

TUNNEL WIDENING IN POST-OP ACL RECONSTRUCTION SURGERY

Hospital number:
Name: Age: Date of Birth:__/___/_____ Sex: M/F
Occupation:
Place:
Height: Weight: BMI:

Details of Injury
Date of Injury:
Mode of Injury: a.❑ADL ❑Sports❑Road Traffic❑Work
b. ❑Non-traumatic gradual onset ❑Traumatic non-contact onset
❑ Non-traumatic sudden onset ❑Traumatic contact onset
Side: Right/ Left
Duration of symptoms: in months_____
Pre-op IKDC score:
Range of motion:

Details of Surgery
Date of Surgery:
Surgery:

Ligament Surgery

❑ACL Repair ❑Intraarticular ACL reconstruction

Graft

❑Ipsilateral ❑Contralateral

❑Single hamstring graft ❑ 2 Bundle hamstring graft ❑ 4 Bundle hamstring graft

Femoral tunnel location:
Femoral tunnel size: length:
Graft length:
Endo-button size:
Femoral screw size:
Tibial screw size:
Screw post:
X-ray/ CT:
Femoral tunnel measurements:

LYSHOLM KNEE SCORING SCALE

I. LIMP:

___ I have no limp when I walk. (5)
___ I have a slight or periodical limp when I walk. (3)
___ I have a severe and constant limp when I walk. (0)

II. USING CANE OR CRUTCHES:

___ I do not use a cane or crutches. (5)
___ I use a cane or crutches with some weight-bearing. (2)
___ Putting weight on my hurt leg is impossible. (0)

III. LOCKING SENSATION IN THE KNEE:

___ I have no locking and no catching sensations in my knee. (15)
___ I have catching sensations but no locking sensations in my knee. (10)
___ My knee locks occasionally. (6)
___ My knee locks frequently. (2)
___ My knee feels locked at this moment. (0)

IV. GIVING WAY SENSATION FROM THE KNEE:

___ My knee never gives way. (25)
___ My knee rarely gives way only during athletics or other vigorous activities. (20)
___ My knee frequently gives way during athletics or other vigorous activities and in turn, I am unable to participate in these activities. (15)
___ My knee often gives way during daily activities. (5)
___ My knee gives way every step I take. (0)

V. PAIN:

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

VI. SWELLING:

___ I have no swelling in my knee. (10)
___ I have swelling in my knee only after vigorous activities. (6)
___ I have swelling in my knee after ordinary activities. (2)
___ I have swelling constantly in my knee. (0)

VII. CLIMBING STAIRS:

___ I have no problems climbing stairs. (10)
___ I have slight problems climbing stairs. (6)
___ I can climb stairs only one at a time. (2)
___ Climbing stairs is impossible for me. (0)

VIII. SQUATTING:

___ I have no problems squatting. (5)
___ I have slight problems squatting. (4)
___ I cannot squat beyond a 90 degree bend in my knee. (2)
___ Squatting is impossible because of my knee(s). (0)

2000 IKDC SUBJECTIVE KNEE EVALUATION FORM

Your Full Name_____

Hospital Number:

Today's Date: _____/_____/_____ Date of Injury: _____/_____/_____

Day Month Year Day Month Year

SYMPTOMS*:

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

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

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

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

0 1 2 3 4 5 6 7 8 9 10

Never ❑❑❑❑❑❑❑❑❑❑❑ Constant

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

0 1 2 3 4 5 6 7 8 9 10

No pain ❑❑❑❑❑❑❑❑❑❑❑ Worst pain

Imaginable

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

❑Not at all

❑Mildly

❑Moderately

❑Very

❑Extremely

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

❑Very strenuous activities like jumping or pivoting as in basketball or soccer

❑Strenuous activities like heavy physical work, skiing or tennis

❑Moderate activities like moderate physical work, running or jogging

❑Light activities like walking, housework, or yard work

❑Unable to perform any of the above activities due to knee swelling

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

❑Yes ❑No

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

❑Very strenuous activities like jumping or pivoting as in basketball or soccer

❑Strenuous activities like heavy physical work, skiing or tennis

❑Moderate activities like moderate physical work, running or jogging

❑Light activities like walking, housework or yard work

❑Unable to perform any of the above activities due to giving way of the knee

SPORTS ACTIVITIES:

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

❑Very strenuous activities like jumping or pivoting as in basketball or soccer

❑Strenuous activities like heavy physical work, skiing or tennis

❑Moderate activities like moderate physical work, running or jogging

❑Light activities like walking, housework or yard work

❑Unable to perform any of the above activities due to knee

9. How does your knee affect your ability to:

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

FUNCTION:

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

FUNCTION PRIOR TO YOUR KNEE INJURY:

Cannot perform 0 1 2 3 4 5 6 7 8 9 10 No limitation

daily activities ❑❑❑❑❑❑❑❑❑❑❑ in daily activities

CURRENT FUNCTION OF YOUR KNEE:

Cannot perform 0 1 2 3 4 5 6 7 8 9 10 No limitation

daily activities ❑❑❑❑❑❑❑❑❑❑❑ in daily activities

2000
IKDC KNEE EXAMINATION FORM

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

Gender: : F : M **Age:**_____ **Date of Examination:**_____/_____/_____ (Day / Month / Year)

Generalized Laxity:	: tight	: normal	: lax	
Alignment:	**A** obvious varus	**A** normal	**A** obvious valgus	
Patella Position:	**P** obvious baja	**P** normal	**P** 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	**E** None	**E** Mild	**E** Moderate	**E** Severe	E	E	E	E
2. Passive Motion Deficit								
ΔLack of extension	L <3°	° 3 to 5°	° 6 to 10°	° >10°				
ΔLack of flexion	L 0 to 5°	° 6 to 15°	° 16 to 25°	° >25°	°	°	°	°
3. Ligament Examination (manual, instrumented, x-ray)								
ΔLachman (25° flex) (134N)	-1 to 2mm	3 to 5mm(1°)) <-1 to –3	6 to 10mm(2°)) <-3 stiff	>10mm(3°)				
ΔLachman (25° flex) manual max	-1 to 2mm	3 to 5mm	6 to 10mm	>10mm				
Anterior endpoint:	A firm		A soft					
ΔTotal AP Translation (25° flex)	0 to 2mm	3 to 5mm	6 to 10mm	>10mm				
ΔTotal AP Translation (70° flex)	0 to 2mm	3 to 5mm	6 to 10mm	>10mm				
ΔPosterior Drawer Test (70° flex)	0 to 2mm	3 to 5mm	6 to 10mm	>10mm				
ΔMed Joint Opening (20° flex/valgus rot)	0 to 2mm	3 to 5mm	6 to 10mm	>10mm				
ΔLat Joint Opening (20° flex/varus rot)	0 to 2mm	3 to 5mm	6 to 10mm	>10mm				
ΔExternal Rotation Test (30° flex prone)	<5°	° 6 to 10°	° 11 to 19°	° >20°				
ΔExternal Rotation Test (90° flex prone)	<5°	° 6 to 10°	° 11 to 19°	° >20°				
ΔPivot Shift	P equal	P +glide	P ++(clunk)	P +++(gross)				
ΔReverse Pivot Shift	R equal	R glide	R gross	R marked				
					R	R	R	R
4. Compartment Findings			crepitation with					
ΔCrepitus Ant. Compartment	C none	C moderate	C mild pain	C >mild pain				
ΔCrepitus Med. Compartment	C none	C moderate	C mild pain	C >mild pain				
ΔCrepitus Lat. Compartment	C none	C moderate	C mild pain	C >mild pain				
5. Harvest Site Pathology	**H** none	**H** mild	**H** moderate	**H** severe				
6. X-ray Findings								
Med. Joint Space	M none	M mild	M moderate	M severe				
Lat. Joint Space	L none	L mild	L moderate	L severe				
Patellofemoral	P none	P mild	P moderate	P severe				
Ant. Joint Space (sagittal)	A none	A mild	A moderate	A severe				
Post. Joint Space (sagittal)	P none	P mild	P moderate	P severe				
7. Functional Test								
One Leg Hop (% of opposite side)	O ≥90%	9 89 to 76%	9 75 to 50%	9 <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. Δ Difference in involved knee compared to normal or what is assumed to be normal.

IKDC COMMITTEE AOSSM: Anderson, A., Bergfeld, J., Boland, A. Dye, S., Feagin, J., Harner, C. Mohtadi, N. Richmond, J. Shelbourne, D., Terry, G. ESSKA: Staubli, H., Hefti, F., Hoher, J., Jacob, R., Mueller, W., Neyret, P. APOSSM: Chan, K., Kurosaka, M.

Patient information sheet

CHRISTIAN MEDICAL COLLEGE VELLORE

COMPARISON OF TUNNEL WIDENING AND FUNCTIONAL OUTCOME BETWEEN SUSPENSORY FIXATION AND SUSPENSORY FIXATION AUGMENTED WITH INTERFERENCE SCREW FOR ANTERIOR CRUCIATE LIGAMENT RECONSTRUCTION WITH HAMSTRING GRAFT

We request you to join the study on the comparison of tunnel widening in 2 different types of anterior cruciate ligament reconstruction, being conducted at Christian Medical College, Vellore.

1. This study is being conducted in the Department of Orthopaedics - Unit II. The study is being done by Dr. Sam J Daniel, a post graduate student in Orthopaedics, under the guidance of Dr. Anil Oommen, Professor, Department of Orthopaedics-II

2. What is the need for this study?

The study aims to find out the result of surgery done for anterior cruciate ligament reconstruction. Since you had undergone surgery here, we invite you to join this study.

3. Can I refuse to participate in this study or withdraw from participating in this study?

You have the full freedom to decide whether or not to participate in this study. If you decide not to participate in this study, it will not affect your treatment at this hospital by any means.

Any new information obtained from this study will be informed to you as and when the study progresses. You have the full freedom to withdraw from participating in this study at any point of time.

The duration of this study is two years. You are required to sign a consent form to be part of this study. You will be undergoing the same physical examination as

being done on all the other patients who underwent the same anterior cruciate ligament reconstruction with an additional X-ray and CT scan in the study.

The doctors conducting this study will have the right to review your medical records at this hospital, as part of this study.

All the expenses of this study will be borne by Christian Medical College, Vellore.

There are no risks to you in being part of this study.

What is the usefulness of conducting this study?

This study aims to assess the result of putting an extra interference screw along with an Endobutton for fixation of the hamstring graft. This may help in improving the treatment for this in the future.

You will not have any extra financial burdens by being part of this study.

The identity and the details of the patients taking part in this study will be kept confidential among the doctors conducting this study. The identity of the participants will not be revealed when this study is published. The patient can continue to access treatment at this hospital even after the completion of this study.

For any doubts and clarifications regarding this study, contact

Dr. Sam J Daniel
P.G. Registrar,
Department of Orthopaedics
Ph: 8870803937
sam.jd47@gmail.com

Dr. Anil Oommen,
Professor,
Department of Orthopaedics- II.
ortho2@cmcvellore.ac.in

Informed consent

Study Title: Tunnel widening in distal femur after ACL reconstruction

Study Number: _____

Subject's Initials: _____ Subject's Name: _____

Date of Birth / Age: _____

(i) I confirm that I have read and understood the information sheet dated _____ for the above study and have had the opportunity to ask questions.

(ii) I understand that my participation in the study is voluntary and that I am free to withdraw at any time, without giving any reason, without my medical care or legal rights being affected.

(iii) I understand that, the Ethics Committee and the regulatory authorities will not need my permission to look at my health records both in respect of the current study and any further research that may be conducted in relation to it, even if I withdraw from the trial. I agree to this access. However, I understand that my identity will not be revealed in any information released to third parties or published.

(iv) I agree not to restrict the use of any data or results that arise from this study provided such a use is only for scientific purpose(s).

(v) I agree to take part in the above study.

Signature (or Thumb impression) of the Subject/Legally Acceptable signatory:

Date: _____/_____/_____Signatory's Name: _____ Signature:

Or 

Representative: _____

Date: _____/_____/_____

Signatory's Name: _____

Signature of the Investigator: _____

Date: _____/_____/_____

Study Investigator's Name: _____

Signature or thumb impression of the Witness: _____

Date: _____/_____/_____

Name & Address of the Witness: _____

Master sheet

group	name	[illegible]	age	sex	occup	state	height	weight	bmi	dx	[illegible]	[illegible]	[illegible]	size	systolic	position	[illegible]	[illegible]	[illegible]
1	Madhab Das	6436829G	33	1	Business	Assam	176	94	30.30	3	6	3	2	1	120	120	120	5	#NULL!
1	Samir Saha	8125713G	34	1	Student	Calcutta	155	78	35.50	5	6	2	1	2	150	190	150	5	#NULL!
1	Rajesh Ghosh	4135846	33	1	Business	Tripura	172	80	27.00	3	1	3	2	2	140	140	140	5	#NULL!
1	Md. Sohel Rana	4864796	47	1	Office work	Bangladesh	172	100	33.80	7	1	3	2	1	140	140	140	5	#NULL!
1	Abhijit Roy	4100530	47	1	Business	West Bengal	164	94	34.80	3	16	3	2	1	130	130	130	5	#NULL!
1	Suresh Kumar	4175044	46	1	Office work	Vellore	172	70	23.70	3	11	3	2	1	140	140	140	5	#NULL!
1	Aatir	4629796	16	1	Student	Kollam	198	100	38.10	4	11	3	2	1	190	190	190	5	#NULL!
1	Alok Kumar	8625086	30	1	Teacher	West Bengal	160	71	26.70	15	11	2	1	1	140	140	140	5	#NULL!
1	Jiten Das	4045596	36	1	Business	West Bengal	156	45	15.00	3	33	2	1	2	140	140	140	5	#NULL!
1	Yuvraj	9082296	23	1	Business	Vellore	172	72	24.30	5	33	3	1	1	140	140	140	5	#NULL!
1	Sanjiban	8575416	42	1	Business	West Bengal	164	70	25.00	4	36	3	2	1	130	130	130	5	#NULL!
1	Shankar	2315714G	34	1	Student	Vellore	163	78	23.30	23	36	2	1	1	130	120	130	5	#NULL!
1	Nagma	4110380	33	1	Business	Vellore	174	97	32.00	13	36	3	2	1	190	120	190	5	#NULL!
1	Mahboor Beg	4215467	23	1	Student	West Bengal	172	77	25.03	15	41	2	1	2	140	135	140	5	#NULL!
1	Manisha Pal	2073466	44	2	House Wife	West Bengal	153	56	23.90	33	34	2	1	1	140	140	140	5	#NULL!
2	Md. Shafiq	9005596	37	1	Business	Bangladesh	176	74	23.90	20	6	2	2	2	140	140	140	'	6
2	Md Gesan	9153950	33	1	Business	Bangladesh	168	73	25.60	22	6	2	1	2	140	130	140	'	6
2	Ashish Giri	6311506	34	1	Business	West Bengal	155	80	36.10	33	6	4	1	2	140	130	140	'	6
2	Vasant Kumar	6625366	32	1	Driver	Assam	166	65	23.60	37	6	3	2	1	140	140	140	'	3
2	Bishu Debnath	7564496	37	1	Driver	West Bengal	176	74	23.90	63	6	2	1	2	140	140	140	'	6
2	Anand Kumar	7864237	34	1	Office work	Bihar	174	80	25.40	103	6	2	1	2	140	130	140	'	6
2	Jagjit Singh	6453013	33	1	Police	West Bengal	183	81	24.20	3	6	2	1	1	140	130	140	'	6
2	Birendra Yadav	6169506	38	1	Police	Jharkhand	176	70	25.60	3	6	4	1	2	140	120	140	'	6
2	Krishna Singh	7786856	32	1	Student	Bihar	182	78	23.50	7	6	2	1	1	140	140	140	'	3
2	Md Rasid	8144023	32	1	Student	Bangladesh	166	66	24.00	33	6	2	1	1	140	140	140	'	6
2	Abdul Ali	8957863	30	1	Student	Bangladesh	171	80	27.40	3	6	2	2	2	140	140	140	'	6
2	Asgar Ali	6162003	33	1	Teacher	Bangladesh	160	63	27.00	73	6	2	1	1	140	130	140	'	6
2	Sumit Chatterjee	6107313	11	1	Student	Jharkhand	175	74	24.20	5	1	2	1	1	140	130	140	'	6
2	Biswajit Dey	7529353	38	1	Technician	Calcutta	169	70	24.50	3	1	2	1	1	140	130	140	'	6
2	Md Mamunul	4534313	36	1	Business	Bangladesh	177	75	23.90	35	8	2	1	1	140	130	140	'	6
2	Jonathan Paul	0024586	25	1	Doctor	Vellore	182	81	24.50	13	8	2	2	2	140	140	140	'	6
2	Farhad Gazi	6047286	32	1	Farmer	West Bengal	172	89	30.10	153	8	2	2	2	140	120	140	'	6
2	Ariful Islam	7115166	40	1	Office work	Bangladesh	176	74	23.90	10	8	3	2	1	140	140	140	'	6
2	Sourav Das	4303063	27	1	Student	West Bengal	157	57	23.40	4	8	2	1	1	120	120	120	'	6
2	Mozammel	7564450	30	1	Business	Bangladesh	176	86	27.80	5	9	4	1	1	140	140	140	'	6
2	Sabbir	4959863	30	1	Teacher	Bangladesh	164	67	24.90	11	10	2	2	2	140	130	140	'	6
2	Subhankar Karmakar	4114560	41	1	Business	West Bengal	165	67	24.60	33	12	1	1	2	150	190	150	'	1
2	Md. Nasir Ullah	9601223	33	1	Business	Bangladesh	172	75	25.40	103	12	3	2	2	150	190	150	'	6
2	Md. Fazal	2524303	33	1	Office work	Bangladesh	155	88	36.60	13	12	2	2	1	150	190	150	'	6
2	Subash	6E7143	46	1	Office work	Vellore	155	74	27.20	1	12	1	2	2	140	140	140	'	6
2	Alok Mitra	6457043	42	1	Pastor	West Bengal	162	66	25.10	35	12	3	2	1	140	140	140	'	6
2	Kazi Sanaul Islam	6451656	23	1	Business	Bangladesh	161	69	25.60	3	13	2	1	1	140	140	140	'	6
2	Lakshman Sharat Singh	1575110	53	1	Business	Meghalaya	180	84	25.90	264	13	3	2	1	150	190	150	'	1
2	Mithilesh Rai	4815303	16	1	Student	Jharkhand	178	75	23.70	7	11	2	1	2	140	140	140	'	6
2	Ashutosh	4936953	33	1	Student	Jharkhand	176	65	21.00	3	13	2	1	2	130	130	130	'	6
2	Buddhadeb	3457306	37	1	Office work	Calcutta	165	66	24.20	14	50	4	1	2	150	190	150	'	1
2	Bablu Dey	2838139F	41	2	House Wife	West Bengal	158	75	30.00	13	1	1	1	2	130	120	130	'	6
2	Bishwajit Adhikari	6056013	31	2	Teacher	Vellore	159	63	25.90	3	6	1	2	1	190	190	190	'	6

group	name	hnc	C-AP	D-AP	E-AP	C-LA	D-LA	E-LA	indxcc2s	findxcc2s	indxcc2l	findxcc2la	findxccdss	findxccosp	findxcctla	findxcctlb	diffeCX_a	diffeCX_c	diffeCX_b	diffeCX_l	diffeCT_	diffeCT_a	diffdCT_	diffeCT_b
1	Madhab Das	642525G	7.1	7.0	7.1	7.2	7.1	7.0	7.6	8.1	9.0	9.6	8.6	8.7	7.6	7.5	0.6	1.5	1.9	2.5	1.6	1.6	0.5	0.5
1	Samir Saha	3182[illegible]G	7.1	7.1	7.1	7.1	7.1	7.1	9.3	9.2	9.2	9.2	9.1	9.0	9.1	8.5	2.2	2.1	2.1	2.1	2.0	1.9	2.0	1.6
1	Rajan Ghosh	412554G	5.2	5.1	6.2	6.1	6.2	6.2	9.8	9.0	9.8	9.0	9.7	8.5	9.2	7.3	2.1	2.3	2.6	2.3	2.6	2.0	2.0	1.7
1	Md. Sohel Rana	488473G	7.0	7.0	7.0	7.0	7.1	7.2	11.7	11.0	12.0	11.0	12.0	11.0	11.4	10.1	4.1	4.0	4.9	3.3	5.0	4.0	4.3	3.5
1	Abhijit Roy	4100532	8.0	8.0	8.1	8.0	8.0	8.1	10.0	9.3	10.6	9.1	10.0	9.0	10.0	8.5	2.0	1.2	2.6	1.0	2.0	0.9	2.0	0.6
1	Suresh Kumar	741804	7.1	7.1	7.0	7.0	7.0	7.0	9.2	7.6	9.4	7.8	8.2	7.9	9.0	7.5	1.1	0.5	1.4	0.8	1.1	0.8	1.0	0.5
1	Ashik	460973G	8.0	8.0	8.1	8.0	8.0	8.2	6.9	7.5	7.2	7.7	6.8	7.4	7.0	7.4	-1.1	-0.5	-0.8	-0.5	-1.2	-0.7	-1.0	-0.8
1	Aloke Kumar	360503G	6.0	6.0	6.2	6.0	6.1	6.2	6.0	6.5	6.4	6.5	5.8	6.0	5.7	6.0	0.0	0.3	0.3	0.3	-0.2	-0.2	-0.4	-0.2
1	Utan Das	404539G	7.0	7.1	7.2	7.0	7.1	7.0	9.9	9.5	9.1	9.7	9.0	9.5	8.7	9.5	1.8	2.3	2.0	2.7	1.9	2.4	1.5	2.5
1	Yuvraj	309225G	7.1	7.1	7.2	7.1	7.1	7.2	8.6	8.5	8.8	8.5	8.2	8.7	8.2	8.1	1.5	1.3	1.7	1.3	1.1	1.5	1.1	0.9
1	Sanjiber	351947[illegible]	7.2	7.2	7.3	7.1	7.1	7.3	9.8	8.8	9.9	8.8	10.4	9.5	9.5	8.5	2.6	1.5	2.8	1.5	3.2	2.0	2.4	1.2
1	Shanker	[illegible]	7.2	7.2	7.3	7.2	7.2	7.3	7.5	8.5	7.7	8.7	7.0	7.0	7.8	8.5	0.3	1.2	0.5	1.4	-0.2	-0.3	0.1	1.2
1	Naguraj	411358D	7.2	7.2	7.2	7.0	7.0	7.1	10.4	10.8	10.5	10.8	10.0	10.4	9.8	10.4	3.2	3.5	3.5	3.7	2.8	3.2	2.3	3.3
1	Mahadev Bose	42[illegible]243F	8.3	8.1	8.0	8.0	8.0	8.0	8.0	7.6	7.7	7.8	7.8	7.4	7.8	7.6	-0.1	-0.4	-0.3	-0.2	-0.3	-0.6	-0.2	-0.4
1	Manohar Pal	20[illegible]346G	6.2	6.3	6.3	6.3	6.2	6.4	7.9	7.8	7.9	7.9	8.2	8.9	7.8	7.6	1.6	1.5	1.7	1.5	1.9	2.6	1.5	1.2
2	Md Shafiul	800533G	7.8	8.6	8.3	7.9	8.3	8.9	8.6	9.0	8.7	8.9	8.6	9.0	8.5	8.8	0.0	0.2	-0.1	0.0	0.0	0.2	-0.3	0.0
2	Md Golam	8153923	7.9	8.8	8.4	7.6	8.5	9.0	9.0	9.6	9.1	9.6	8.8	9.5	9.9	9.5	0.1	0.2	0.6	0.5	-0.1	0.2	0.4	0.5
2	Ashim Giri	691150G	8.0	8.1	8.3	7.9	8.2	9.2	11.5	12.5	11.1	12.4	11.0	12.0	10.9	11.1	2.4	3.2	1.9	3.2	1.9	2.7	1.7	2.5
2	vasanthakumar	660536G	7.3	8.4	8.5	7.0	8.1	8.2	9.4	10.0	9.6	10.3	9.2	10.0	9.4	10.0	1.0	1.4	1.5	2.1	0.8	1.4	1.3	1.6
2	Bishu Debnath	756145G	7.9	9.2	9.5	7.5	8.5	9.0	10.9	11.0	10.9	10.7	10.8	11.0	10.7	10.6	1.1	1.5	2.4	1.7	1.6	1.5	2.2	1.6
2	Anand Kumar	196423F	7.7	9.2	8.9	7.7	8.5	8.8	8.5	11.1	10.6	10.0	9.2	10.0	9.2	9.5	0.3	2.2	2.0	1.2	0.0	1.1	0.5	1.1
2	Jangusingh	648301G	7.6	8.6	8.3	7.6	9.1	9.2	10.9	11.6	10.9	11.5	9.2	10.7	9.1	10.5	2.1	2.3	1.8	2.3	0.4	1.9	0.0	1.7
2	Surahinder Yadav	676930G	9.1	9.6	9.7	8.8	9.3	10.0	10.5	11.5	10.5	11.5	10.4	11.0	10.4	11.0	0.7	2.2	0.7	1.5	0.6	1.9	0.5	1.9
2	Krishna Singh	7758883	8.9	9.1	8.3	8.8	8.9	8.9	8.9	9.6	9.2	9.3	8.4	8.4	8.8	8.1	-0.6	-0.2	-0.6	-0.5	-1.3	-0.4	-1.5	-0.8
2	Md Rasel	614093G	7.6	8.4	8.3	7.7	8.5	8.9	9.1	9.5	9.2	9.0	8.8	9.2	8.7	8.5	0.1	0.7	0.6	0.1	0.4	0.4	0.1	-0.4
2	Abdullah	835785G	7.7	8.6	8.9	7.9	8.4	8.9	8.5	8.1	8.6	8.5	8.4	8.5	8.5	8.5	-0.3	-0.2	0.2	-0.4	-0.4	-0.3	0.1	-0.4
2	Asgar Ali	616003G	7.7	8.5	8.0	7.5	8.5	9.0	10.4	11.5	10.5	10.3	10.0	11.0	10.5	10.5	1.5	2.5	1.7	1.9	1.1	2.0	1.7	1.3
2	Sumit Chaurasia	61[illegible]G	8.3	9.6	8.5	7.6	8.5	9.0	7.9	8.5	8.5	8.5	7.2	8.0	7.5	8.0	-1.1	-1.1	-0.1	-0.5	-2.4	-1.6	-1.1	-1.0
2	Dibakar Dey	752359G	8.2	9.3	8.4	8.5	8.4	9.5	9.3	11.0	10.2	11.1	9.1	10.5	9.5	10.1	0.6	1.5	0.8	1.5	-0.2	1.1	0.1	0.6
2	Md Nurunnabi	403451G	7.0	9.1	9.5	7.7	8.7	9.3	10.9	11.6	10.9	11.5	10.0	11.0	10.2	10.5	1.8	2.1	2.2	2.2	0.9	1.5	1.5	1.6
2	Jonathan Paul	C30458B	8.7	10.0	10.4	8.9	10.1	10.1	9.8	10.5	9.7	10.9	9.8	10.7	9.6	10.5	-0.2	0.1	-0.4	0.5	-0.2	0.3	-0.5	0.4
2	Parimal Gol	604706G	7.8	9.1	9.2	7.8	8.3	9.2	10.5	10.5	10.5	10.5	10.0	10.0	10.7	10.6	1.4	1.3	1.7	1.3	0.9	0.8	1.9	1.6
2	Ariful Islam	7112163	7.6	9.2	9.2	7.9	9.2	9.3	11.0	11.0	11.2	11.2	10.8	10.3	10.4	10.4	1.8	1.5	2.0	1.9	1.6	1.6	1.2	1.1
2	Sourav Das	490392G	6.7	7.5	8.0	5.7	7.5	8.0	8.9	10.0	7.8	8.4	8.0	9.0	7.6	8.6	1.4	2.0	0.3	0.4	0.5	1.0	0.1	0.6
2	Masumul	786142[illegible]	7.6	8.6	8.3	7.7	8.7	9.0	11.3	11.4	11.2	11.3	11.4	11.5	11.5	11.5	2.1	2.5	2.5	2.3	2.8	2.8	2.3	2.5
2	Shishir	496919G	8.5	9.8	10.0	8.0	8.5	10.3	10.1	10.6	10.9	11.8	10.0	11.5	10.2	11.5	0.3	0.5	2.4	1.5	0.2	1.5	1.7	1.2
2	Sucheta Karmakar	411486D	7.9	8.4	8.5	7.5	8.5	8.5	8.8	9.5	10.6	10.6	7.2	8.2	8.8	8.2	0.4	0.9	2.1	2.1	-1.2	-0.4	-0.2	-0.2
2	Md [illegible] Ullah	360123G	7.7	8.4	8.3	7.6	8.5	8.5	9.0	9.1	9.1	9.0	8.1	10.7	9.1	10.6	0.6	0.3	0.6	0.5	0.7	1.9	0.5	2.3
2	Md Faisal	252450G	7.7	9.0	8.7	7.6	8.3	8.8	10.2	10.1	9.8	10.2	8.4	10.0	9.2	9.2	1.2	2.0	1.0	1.4	-0.6	1.9	0.4	0.5
2	Subash	615749	7.6	9.0	8.9	7.7	8.4	8.7	10.1	10.6	10.2	10.5	10.0	11.0	10.2	11.4	1.1	1.9	1.8	1.3	1.0	2.1	1.3	2.1
2	Alok Mridha	645[illegible]04G	7.7	8.8	8.0	7.5	8.5	9.1	8.5	10.6	9.6	10.9	8.8	10.0	9.9	10.0	0.1	1.3	1.1	1.3	0.0	1.0	0.4	0.9
2	Kazi Zahed Iqbal	6461653	7.5	8.8	8.0	7.7	8.5	8.8	9.8	10.6	9.8	9.9	9.0	10.0	9.2	9.5	0.5	1.3	1.2	1.1	0.1	1.0	0.5	1.1
2	Lachman Sharat Singh	172751D	8.6	9.2	8.4	8.6	8.5	9.9	10.7	11.1	9.2	10.7	9.1	10.7	9.1	10.6	1.5	1.7	-0.4	0.3	-0.1	1.9	-0.5	0.9
2	Hrithik Rai	481880G	8.7	9.6	8.3	8.0	8.5	9.8	9.8	9.7	9.6	9.4	9.8	9.5	9.6	9.4	0.2	-0.1	0.0	-0.4	0.2	-0.2	0.0	-0.4
2	Ashutosh	493568G	8.6	9.1	8.3	8.6	8.4	9.6	9.0	10.0	9.1	9.9	8.8	10.0	8.7	9.5	-0.1	0.2	-0.3	0.3	-0.3	0.2	-0.7	0.3
2	Buddadeb	348730G	7.9	9.2	8.3	7.7	8.3	9.2	7.9	8.6	7.8	8.6	7.6	8.0	7.5	8.1	-1.3	-0.7	-1.0	-0.5	-1.6	-1.3	-1.3	-1.1
2	Sabita Dev	283375F	7.6	9.0	8.3	7.7	8.5	8.8	8.7	10.2	9.0	9.9	8.4	9.0	8.5	8.5	-0.6	1.4	0.4	1.1	-0.3	0.2	-0.1	0.1
2	Sabiyashahn	608501G	7.7	8.5	8.3	7.6	8.3	8.4	10.9	11.6	10.9	9.6	10.6	11.0	10.8	9.2	2.4	2.3	2.6	1.2	2.1	2.2	2.5	0.8

lysrcore	ikccscr	hoptest	hyplax	align	patellap	patellac	effusion	antdrw	lach	joiopm	joiopl	pivot	pivotr	crepsa	crepsm	crepsl	sitepath	xjom	xjol	xjop
83	46.0	4	2	2	2	1	1	2	2	.	1	1	1	2	1	1	0	2	1	1
84	72.4	2	2	2	2	1	1	2	2	.	1	1	1	1	1	1	1	1	1	1
100	86.2	3	2	2	2	1	1	2	2	.	1	1	1	1	1	1	0	2	1	1
87	70.1	1	2	2	2	1	2	2	2	.	1	2	1	1	1	2	1	2	1	1
86	81.6	3	2	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
95	75.9	2	2	2	2	1	1	2	2	.	1	2	1	1	1	1	1	1	1	1
100	98.9	2	3	2	2	1	1	2	2	.	1	2	1	2	1	1	2	1	1	1
100	88.5	1	2	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
95	75.9	1	3	2	2	1	1	3	3	.	1	3	1	1	1	1	0	1	1	1
95	85.1	2	3	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
91	85.1	2	2	2	2	1	1	2	3	.	1	2	1	2	2	2	2	2	1	1
91	83.9	2	2	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
100	87.4	1	3	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
96	93.1	2	2	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
85	72.4	2	2	2	2	1	1	1	1	.	1	1	1	1	1	1	0	1	1	1
91	67.8	1	2	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
86	73.6	2	2	2	2	1	1	2	2	.	1	1	1	2	1	1	3	1	1	1
91	73.6	1	2	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
90	64.4	3	2	2	2	1	1	2	2	.	1	2	1	1	1	2	0	1	1	1
99	86.2	1	3	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
90	70.1	4	2	2	2	1	1	1	1	.	1	1	1	1	1	1	0	1	1	1
91	75.9	2	2	2	2	1	1	2	2	.	1	2	1	2	1	1	0	1	1	1
87	57.5	2	2	2	2	1	2	1	1	.	1	1	1	1	1	2	0	1	1	1
90	64.4	4	2	2	2	1	1	2	2	.	1	1	1	2	1	1	0	1	1	1
94	72.4	2	2	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
90	74.7	2	3	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
81	54.0	2	2	2	2	1	1	1	1	.	1	1	1	1	1	1	0	1	1	1
82	39.1	3	2	2	2	1	1	1	2	.	1	1	1	1	1	1	0	1	1	1
85	64.4	1	2	2	2	1	1	1	1	.	1	1	1	1	1	1	0	1	1	1
94	72.4	2	2	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
92	86.2	1	2	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
90	60.9	2	2	2	2	1	1	1	1	.	1	1	1	3	1	1	0	1	1	1
95	83.9	1	2	2	2	1	1	1	1	.	1	1	1	1	1	1	0	1	1	1
100	75.9	2	2	2	2	1	1	1	1	.	1	1	1	1	1	1	0	1	1	1
91	72.4	4	3	2	2	1	1	3	3	.	1	3	1	3	1	1	0	1	1	1
100	88.5	1	2	2	2	1	1	1	2	.	1	1	1	1	1	1	0	1	1	1
71	64.4	3	2	2	2	1	1	3	3	.	1	2	1	1	1	1	0	1	1	1
84	51.7	4	2	2	2	1	1	2	2	.	1	1	1	1	1	1	1	1	1	1
91	78.2	3	2	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
100	80.5	2	2	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
90	64.4	3	2	2	2	1	1	2	2	.	1	1	1	1	1	2	2	1	1	1
95	78.2	1	2	2	2	1	1	1	2	.	1	1	1	1	1	1	2	1	1	1
80	67.8	2	2	2	2	1	1	2	2	.	1	1	1	2	1	1	0	2	1	1
99	95.4	1	2	2	2	1	1	1	1	.	1	1	1	2	1	1	0	1	1	1
85	80.5	2	3	2	2	1	1	2	2	.	1	2	1	1	1	1	0	1	1	1
95	74.7	1	3	2	2	1	1	2	2	.	1	1	1	1	1	1	0	1	1	1
61	29.9	3	2	2	2	1	1	1	1	.	1	1	1	2	1	1	0	1	1	1
100	89.7	3	2	2	2	1	1	1	2	.	1	1	1	1	1	1	0	1	1	1