

**EVALUATION OF THE RESULTS OF EARLY
ARTHROSCOPIC ACL RECONSTRUCTION USING THE
ANATOMIC (CENTRAL TO CENTRAL) SINGLE BUNDLE
TECHNIQUE USING THE HAMSTRING GRAFT**

Thesis

**Submitted For Partial Fulfillment
of MD Degree In
ORTHOPEDIC SURGERY**

Presented by

Amr Elias Morsy Mohamed
M.B.B.Ch.,M.Sc.

Under Supervision of

Prof. Dr. Ahmed Ahmed Morrah

Professor of orthopedic surgery.
Faculty of Medicine
Cairo University

Prof. Dr. Nasser M. Othman El Koussy

Professor of orthopedic surgery.
Faculty of Medicine
Cairo University

Prof. Dr. Alaa Mohy Eldin Soliman

Professor of orthopedic surgery.
Faculty of Medicine
Cairo University

Assistant Prof. Molham Mahmood Mohammad

Assistant prof. of orthopedic surgery
Faculty of Medicine
Cairo University

**Cairo University
2015**

ABSTRACT

Anatomic anterior cruciate ligament (ACL) reconstruction has become popular during the last decade. This procedure is designed to reconstruct the anatomic insertion of the ACL footprint. Previous biomechanical basic studies and clinical results have demonstrated the advantages of this procedure compared with conventional ACL reconstruction technique .

The aim of study is to evaluate the results of early arthroscopic ACL reconstructions using single bundle anatomic central to central technique using the semi-tendinosus and gracilis autografts which were fixed by end button on the femoral side and biodegradable interference screws on the tibial side .

thirty patients with a primary diagnosis of acute Anterior Cruciate Ligament tear seen in the clinic were evaluated and prepared for early arthroscopic ACL reconstructions. All the patients had a post operative accelerated rehabilitation program similar to that designed by (K. Donald Shelbourne and Christine Klotz ,2007) was used for the patients.

Evaluation was done by the use of International Knee Documentation Committee (IKDC) evaluation form (subjective and objective).

this study suggests that early arthroscopic ACL reconstructions using single bundle anatomic central to central technique gives good functional results with no increased incidence of ROM loss .

(Key Words: anatomic ACL reconstruction, timing,accelerated rehabilitation,arthrofibrosis)

Acknowledgement

Praise to "Allah", the Most Gracious and the Most Merciful Who Guides Us to the Right Way

*I would like also to express my deep gratitude to **Prof. Dr. Ahmed Ahmed Morrah**, Professor of orthopedic surgery, Faculty of Medicine, Cairo University, who had made a great effort with me in this thesis.*

*It is a great honor to express my deep gratitude and cordial appreciation to **Prof. Dr. Nasser Mohamed Othman**. Professor of orthopedic surgery, Faculty of Medicine, Cairo University, who gave me much of his effort, experience and close supervision throughout the work.*

*I would like to express my deep gratitude to **Prof. Dr. Alaa Mohy Eldin**, Professor of orthopedic surgery, Faculty of Medicine, Cairo University, for his great encouragement, constant support.*

*My appreciation and deepest thanks to **Assistant Prof. Molham Mahmood**, Assistant prof. of orthopedic surgery, Faculty of Medicine, Cairo University, for his great assistance for providing all practical facilities for the study*

My great appreciation is extended to all those who shared either practically . or morally in the accomplishment of this work.

CONTENTS

Title	Page
Introduction	1
Review of literature	
1. Anatomy of ACL	3
2. Biomechanics of ACL	14
3. Diagnosis of ACL Tear	20
4. Anterior Cruciate Ligament Reconstruction	40
5. Rehabilitation of ACL	57
Work	
1. Patient & Methods	67
2. Results	93
3. Discussion	116
4. Summary & Conclusion	125
5. References	128
Arabic summary	

List of Figures

Title	Page
Fig. (1): (A) Fetal ACL,10th week after gestation. Note the early organization of the ACL between femur and tibia.(B)Vascular endothelial growth factor (VEGF) immunostaining, fetal ACL 22 weeks after gestation	4
Fig.(2): 16-week fetus demonstrating two bundles of the anterior cruciate ligament with the knee in extension (A, sagittal view with medial femoral condyle removed) and flexion (B, frontal view). AM, Anteromedial; LFC, lateral femoral condyle; PL, posterolateral.	4
Fig. (3): Crossing pattern of anteromedial (AM) and posterolateral (PL) bundles.	7
Fig.(4): The mean length is 32 mm (range22–41 mm) (left picture) and the mean width is 10 mm (range, 7–12 mm). The cross sectional area varies in size and shape from the femur to the tibia (right picture).	8
Fig.(5): Superior view of an anatomical section of a cadaver (tibia).	10
Fig.(6): Close up of the enthesis. The 4 layers can be described as ligament fibers, nonmineralized cartilage zone, mineralized cartilage zone, and subchondral bone plate (left).	11
Fig.(7): Blood supply of the ACL.	12
Fig.(8): A. Ruffini receptors, B. Pacinian corpuscles, C. Free nerve- endings	13
Fig. (9): Magnitude of the in situ force in the intact AM bundle and PL bundle in response to 134 N anterior tibial load.	14
Fig.(10): Load-deformation curve of the ACL bone-ligament complex.	18
Fig. (11): Factors to Consider in ACL Autograft Selection.	18
Fig.(12): Lachman's test is very effective for revealing an ACL rupture. Hold the thigh firmly with one hand. Knee should be slightly flexed. Move tibia anteriorly. I	22
Fig.(13): Lachman test interpretation.	22
Fig.(14): Anterior Drawer test.	23
Fig.(15): The pivot shift test.	24
Fig.(16): The grading of the pivot-shift test.	25
Fig.(17): McMurray test.	25
Fig.(18): Posterior drawer test.	26
Fig.(19): Godfrey test.	27
Fig. (20): Prone external rotation test (Dial test).	28
Fig.(21): Second Fracture	29

Fig. (22): (A) Lateral view of a typical right knee during dissection. With the ITB reflected, the ALL fibers are clearly distinguishable from the thin anterolateral joint capsule anterior to it. (B) Anatomic drawing considering the ALL and its relationship with well-known anatomical landmarks on the lateral aspect of the human knee in full extension & 90° of flexion. (ALL, anterolateral ligament; LCL, lateral collateral ligament; LFE, lateral femoral epicondyle; BFT, biceps femoris tendon; FH, fibular head; JC, joint capsule; GT, Gerdy's tubercle; PT, popliteus tendon).	30
Fig.(23): MRI of a normal ACL and its two bundles:	32
fig.(24): Anterior cruciate ligament (ACL) discontinuity. Sagittal	33
Fig.(25): Sagittal view of an MRI showing A) Normal ACL. (B) Acute ACL tear.	34
Fig. (26): (A) Anterior subluxation of the lateral tibial plateau. Sagittal PD fat-sat: Exposure of the posterior horn of the lateral meniscus indicating subluxation of the lateral tibial plateau.(B) Verticalisation of the PCL. Sagittal PD fat-sat: the distal portion of the PCL is vertical. The PCL is concave inwards (white arrowhead).	34
Fig.(27): Partial tear of the posterolateral bundle of the anterior cruciate ligament (ACL):a:sagittal PD fat-sat: presence of some discontinuous fibres. Partial interruption of the fibres at mid-height can be seen (white arrowhead); b: sagittal PD fat-sat: in the same patient and in the same plane but on a different slice the fibres appear to be continuous (black arrow).	35
Fig.(28): (a) MRI sagittal cut best showing tibial and femoral insertion sites is chosen;(b) tibial insertion site is highlighted; (c) femoral inserion site is highlighted; (d) the distance between the mid-portion of the tibial and femoral insertion sites are connected and measured to know ACL length.	37
Fig. (29): (A) MRI showing absence of PL bundle with AM bundle intact. (B) Arthroscopic picture confirming the absence of the PL bundle. (C) PL bundle augmentation.	39
Fig (30): (a) An anterior view of the intercondylar notch in a cadaver with a clock face superimposed. The native ACL can be seen to attach to the femur between the 1 and 3 o'clock positions.(b) The arthroscopic description of tunnel position on the femur.	46
Fig.(31): (A) cadaveric dissection, knee flexed 90 degree and med. femoral condyle removed showing ACL femoral insertion, lat. Condylar ridge & lat. Bifurcate ridge. (B) The femoral tunnel position being marked with a micro fracture awl, placed through the accessory medial portal.	48
Fig. (32): Algorithm for determining surgical technique based on tibial insertion site length and notch width.	52
Fig. (33): Three categories of notch shape are shown in arthroscopic images of the right knee	54
Fig.(34): (Left) The full hyperextension: The heel is lifted off the table. (Right) Full flexion: Can sit on the heels with no tilt in the hips.	58
Fig.(35): Cascade of events for ACL reconstruction perioperative accelerated rehabilitation protocol.	59
Fig. (36): Perioperative rehabilitation phases.	60

Fig.(37): Criteria for return to athletic activity	66
Fig.(38): IKDC knee examination form	73
Fig.(39): Position of the patient	78
Fig.(40): Examination under anesthesia	79
Fig.(41): Skin incision and the exposed under surface of Sartorius fascia showing the tendons	80
Fig (42): (A) Separation of the tendon from the undersurface of the sartorius fascial flap. (B) Graft harvesting by closed tripper	81
Fig.(43): Tripled Semi.T tendon	82
Fig.(44): Graft tentioning	83
Fig.(45): Marking of femoral tunnel seen from med. Portal	84
Fig.(46): Measuring the femoral tunnel	85
Fig.(47): Femoral tunnel	85
Fig.(48): (A) Marking of tibial tunnel. (B) Full extention to check the accuracy.	87
Fig.(49) (A) Tibial guide position. (B) Full extention to check the accuracy.	87
Fig.(50): Graft passage	88
Fig.(51): Graft fixation	88
Fig.(52): Wound closure and Dressing	90
Fig.(53): Partial weight bearing	
Fig. (54): 2 scopic views during surgery showing residual post traumatic hematoma (left) and inflammed syvovium (right)	93
Fig. (55): MRI showing tear ACL & Scopic view during surgery showing tear ACL	113
Fig.(56): Scopic view during surgery showing ACL graft after reconstruction (left) and postop. X-ray (right)	113
Fig. (57): 2 Scopic views during surgery showing : Torn ACL (left) & ACL graft after reconstruction(right)	115
Fig. (58): Postoperative X- rays	115

List of Graph

Title	Page
Graph (1): Distribution of effusion pre- and post-treatment among the study sample	96
Graph (2): Distribution of manual Lachman pre- and post-treatment among the study sample	98
Graph (3): Distribution of anterior drawer pre- and post-treatment among the study sample	99
Graph (4): Distribution of pivot shift pre- and post-treatment among the study sample	100
Graph (5): Distribution of single leg hop test results pre- and post-treatment among the study sample	102
Graph(6): Distribution of final objective score results pre- and post-treatment among the study sample.	103
Graph (7): Mean highest level of activity without pain pre- and post-treatment among the study sample	105
Graph (8): Mean highest level of activity without giving way pre- and post-treatment among the study sample	105
Graph (9): Mean rate of knee function pre- and post-treatment among the study sample	107
Graph (10): Mean total subjective score pre- and post-treatment among the study sample	108
Graph (11): Correlation between time from injury to surgery and the total subjective score.	110

List of Tables

Title	Page
Table (1) : Sex distribution	67
Table (2) : Side of the injured knees	67
Table (3) : Age and injury – surgery time	68
Table (4) : The pre and post. op effusion among the studied patients	96
Table (5): Lack of extension pre and post operative.	97
Table (6): Lack of flexion pre and post operative.	97
Table (7): Manual lachamman pre and post operative.	98
Table (8): Anterior drawer pre and post operative.	99
Table (9): Pivot shift pre and post operative.	100
Table (10): Graft site pre and post operative.	101
Table (11): Single leg hop test pre and post operative	102
Table (12): Final score pre and post operative	103
Table (13): pre and post op subjective score results regarding the symptoms in the study group.	104
Table (14) : pre and post op subjective score results regarding the sport activities in the study group.	106
Table (15) : pre and post op. function of the knee	107
Table (16): pre and post op. final subjective IKDC score	108
Table (17): Relation between side affected and final score.	109
Table (18): Relation between aspiration and final score.	109
Table (19): Relation between time from injury and the final score.	110
Table (20): Correlation between time from injury to surgery and the total subjective score.	111

List of Abbreviation

ACL	:	Anterior cruciate ligament
ALL	:	Anterolateral ligament
AMB	:	Anteromedial bundle
BFT	:	Biceps femoris tendon
BPTB	:	Bone patellar tendon bone
CkC	:	Closed kinetic chain
DVT	:	Deep vein thrombosis
FH	:	Fibular head
GT	:	Gerdy's tubercle
IKDC	:	International Knee Documentation Committee
IMB	:	Intermediate bundle
ITB	:	Iliotibial Band
JC	:	Joint capsule
KOOS	:	Knee Osteoarthritis Outcome Score
LCL	:	Lateral collateral ligament
LFC	:	lateral femoral condyle
LFE	:	Lateral femoral epicondyle
MFG	:	Medial femoral condyle
MRI	:	Magnetic Resonance Imaging
OKC	:	Open kinetic chain
PCL	:	Posterior cruciate ligament
PLB	:	Posterolateral bundle
PT	:	popliteus tendon
ROM	:	Range-of-motion
SLR	:	Straight leg raising
VEGF	:	Vascular endothelial growth factor

INTRODUCTION

Currently, a large number of ACL reconstructions are performed each year around the world, therefore, the ACL has been one of the most frequently studied structures of the musculoskeletal system during the last decades.

Biomechanics of the intact and ACL replacement graft, different types of grafts, mechanism of failure, treatment, surgical techniques, and postoperative rehabilitation protocols have been intensively studied.⁽¹⁾

Since 1895 when Mayo Robson of Leeds Royal Infirmary performed the first ACL repair, the treatment of ACL injuries has occupied many orthopaedic minds, with debates raging between extraarticular versus intra-articular reconstruction, open versus arthroscopic technique and more recently, anatomical reconstruction.⁽²⁾

Fu and Karlsson⁽³⁾ described anatomic ACL reconstruction as ‘the functional restoration of the ACL to its native dimensions, collagen orientation and insertion sites’. It is a detailed and meticulous procedure that involves visualization of the native ACL insertion site, measuring ACL and knee dimensions, appropriate graft tensioning and evaluation of graft and tunnel position. It encompasses single and double bundle reconstruction and can be applied to primary, revision and augmentation surgery. The development of the anatomic technique has made us take a closer look at the ACL anatomy.⁽³⁾

Early surgical intervention during the initial 6 weeks post-injury weeks have suggested that restoring tibiofemoral stability may minimise the risk of further meniscal and chondral injury which may be associated

with degenerative joint changes. Early surgery may also facilitates rapid return to sporting and occupational pursuits with considerable economic consequences.⁽⁴⁾

Delayed ACL reconstruction may be associated with increase in muscle atrophy and reduced strength which may delay early rehabilitation. Conversely, delaying surgical intervention allows optimisation of pre-operative knee range of motion and recovery of surrounding soft tissues from the initial injury and potentially reducing the incidence of post-operative arthrofibrosis and wound complications.⁽⁴⁾

The aim of this study is to evaluate the clinical outcome of early single bundle ACL reconstruction using anatomic central to central technique using the quadrupled hamstring tendon.

ANATOMY OF ACL

The knee joint starts its formation from vascular mesenchyme between femur and tibia in the fourth week of gestation between the blastoma of femur and tibia. A distinct amount of ACL fibers appear in approximately the 8th week after gestation. At this time, the fibroblasts within the ligament are already aligned to the axis of strain of the ACL.⁽⁵⁾

By 9 weeks, the cruciate ligaments are composed of numerous immature fibroblasts having scanty cytoplasm and fusiform nuclei. Over the next weeks, the major change in addition to growth, is the increase in vascularity. During this time the fusiform fibroblasts express high amounts of the angiogenic vascular endothelial growth factor.⁽⁶⁾ (Fig. 1)

The expression of vascular endothelial growth factor is largely downregulated after birth, but this factor is strongly re-expressed during the remodeling of autologous tendon grafts used for ACL reconstruction. After week 20, the remaining development consists of marked growth with little change in form.⁽⁶⁾ Two distinct bundles of the ACL are present at 16 weeks of gestation.⁽⁷⁾ (Fig. 2)

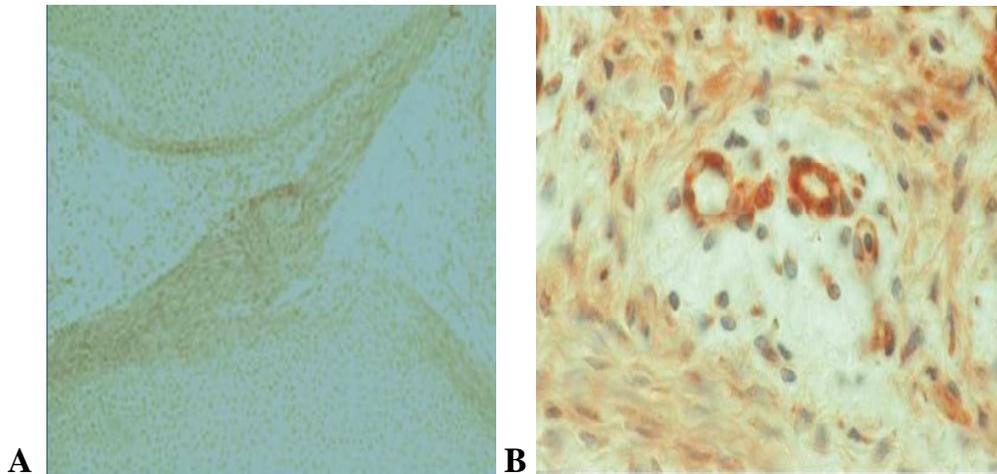


Fig. (1): (A) Fetal ACL, 10th week after gestation. Note the early organization of the ACL between femur and tibia. (B) Vascular endothelial immunostaining, fetal ACL 22 weeks after gestation⁽¹⁾.

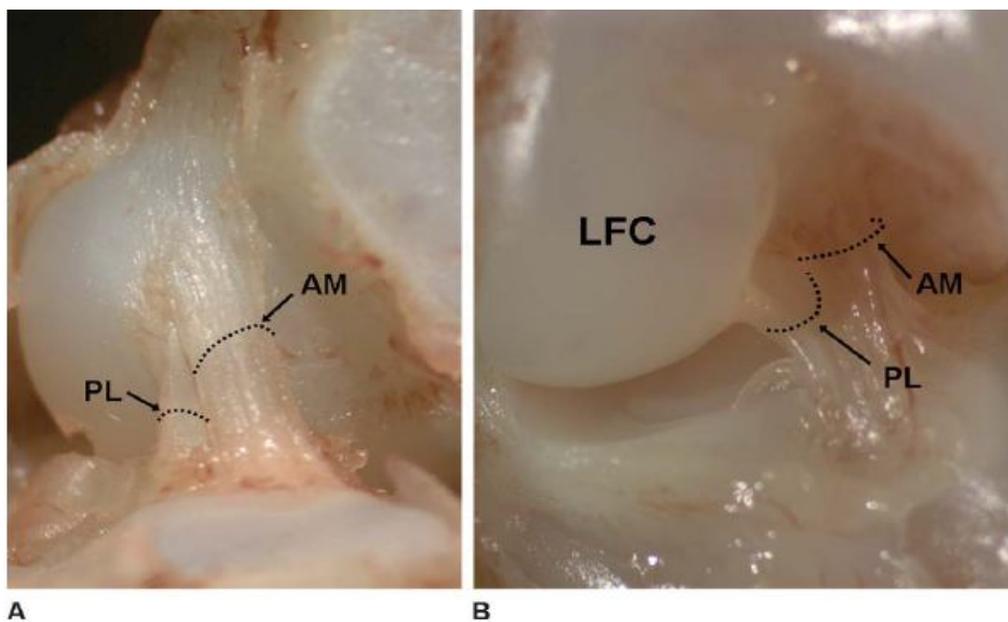


Fig.(2): 16-week fetus demonstrating two bundles of the anterior cruciate ligament with the knee in extension (A, sagittal view with medial femoral condyle removed) and flexion (B, frontal view). AM, Anteromedial; LFC, lateral femoral condyle; PL, posterolateral⁽⁷⁾.

Gross Anatomy:

The ACL is a band of dense connective tissue that connects the femur and the tibia. It is enveloped into the synovial membrane of the human knee joint, which by definition places the ligament intraarticular but extra-synovial. However, from a surgical standpoint, the ACL must be regarded only as an intraarticular structure because it can be reconstructed only intraarticularly and cannot be exteriorized from the articular space. ⁽⁵⁾

The ligament originates at the medial side of the lateral femoral condyle and runs an oblique course through the intercondylar fossa distal–anterior–medial to the insertion at the medial tibial eminence. The axis of the long diameter of the ACL is tilted $26^{\circ} \pm 6^{\circ}$ forward from the vertical. When the knee is flexed, as during surgery, the ligament seems to turn itself in a lateral spiral. ⁽⁵⁾

This external rotation is approximately 90° as the fibers approach the tibial surface. The twist of the fibers of the ACL is a result of the orientation of its bony attachments. The femoral attachment is oriented primarily in the longitudinal axis of the femur, whereas the tibial attachment is in the anteroposterior axis of the tibia. ⁽⁵⁾ (Fig. 3)

The ACL length ranges from 22 to 41 mm (mean, 32 mm) and its width from 7 to 12 mm, mean length of the AM bundle is 33 mm and is 18 mm for the PL bundle. ^(8,9)

The narrowest diameter of the ACL occurs in the midsubstance which is oval in shape with an area of 36 mm^2 and 44 mm^2 for females and males, respectively. The insertion areas of the ACL (tibial and femoral