Role of Sagittal Oblique Magnetic Resonance Imaging Technique in Injuries of Anterior Cruciate Ligament

Thesis

Submitted for partial fulfilment of the Master degree in Radiology

By Abdullah Jaddo Mohammed Ameen

(M.B.B.,Ch.)
Faculty of Medicine
University of Mosul/Iraq

Under Supervision of

Dr. Sahar Mohammed El Fiky

Professor of Radiodiagnosis Faculty of Medicine – Ain Shams University

Dr. Ahmed Mohamed Bassiouny

Lecturer of Radiodiagnosis Faculty of Medicine – Ain Shams University

Faculty of Medicine
Ain Shams University
2016



Acknowledgments

First, I am thankful to **Allah**, the kindest and the most merciful for blessing all my steps in life.

I wish to express my extreme appreciation and deepest gratitude to **Dr. Sahar Mohammed El Feki**, Professor of Radio-diagnosis, College of Medicine, Ain Shams University, who suggested the subject and helped me to take the first step. Also here guidance, kind encouragement, and supervision throughout this work upgraded its quality.

I am deeply indebted to **Dr. Ahmed Mohamed Bassiouny,** Lecturer of Radio-diagnosis, Faculty of Medicine, Ain Shams University. His faithful encouragement, continuous guidance, valuable advices, and supervision gave me the motive to utilize available resources in order to put the thesis in an acceptable form.

I am also very grateful and thankful for the **patients** who were included in this study, for their great role in bringing out this thesis.

I would like to send special thanks to **Dr. Khudr Ahmed Al-Jubory and Dr. Saadi Salih Dar El-Salamy** for their kind support throughout the work

Last and not least, I would like to dedicate special thanks for my great **Family**, my **Parents** and my wife, for their wonderful support, patience assistance, encouragement and their prayers for me throughout the course of this work.

Candidate

Abdullah Zebari

Contents

Subject	Page No.
List of Abbreviations	i
List of Tables	iii
List of Figures	iv
Abstract	xii
Introduction	1
Aim of the Work	3
Review of Literature	
Anatomy and MRI Anatomy of the Ante	
Types of ACL injuries	23
MRI Technique of the Knee Joint	67
MRI Imaging of ACL	76
Patients and Methods	78
Results	80
Illustrative Cases	90
Discussion	110
Summary and Conclusion	114
References	115
Arabic Summary	······

List of Abbreviations

Abbr. **Full-term ACL** Anterior cruciate ligament \mathbf{AM} Anteromedial art. cart Articular cartilage CTComputed tomography **FCL** Fibular collateral ligament Field of view **FOV** FS Fat suppression **FSE** Fast spin echo **IFP** Infrapatellar fat pad IR Inversion recovery LCL Lateral collateral ligament LFC Lateral femoral condyle LH Lateral head Lat men Lateral meniscus Lateral patellar retinacula Lat. Pat. Retin \mathbf{MH} Medial head \mathbf{M} Muscle

Medial collateral ligament. Middle genicular artery **MGA**

Medial meniscus MM

MCL

Med. Pat. Retin Medial patellar retinacula

MR Magnetic resonance

Magnetic resonance imaging **MRI**

NEX Number of excitation

Patel. tend. Patellar tendon

PCL Posterior cruciate ligament PHLM Posterior horn lateral meniscus
PHMM Posterior horn medial meniscus

PD Proton density
PL Posterolateral
SL Slice thickness

SPIR Selective partial inversion recovery

SPSS Statistical package for the social science

STIR Short time of inversion recovery

T Tesla

TE Time of echo

TR Time of repetitionTSE Turbo spin echo2D Two dimensional

List of Tables

Table N	o. Title	Page	No.
Table (1):	Rates of injury to the anterior ligament based on sports type		24
Table (2):	The injuries in relation to extrin factors		33
Table (3):	Demonstrating MR imaging protocoknee joint		71
Table (4):	Sex distribution of the study group.	•••••	80
Table (5):	Age (years) distribution of the study	y group	82
Table (6):	Sport type distribution of the study	group	83
Table (7):	Side injured distribution of the group.		84
Table (8):	MRI finding of ACL distribution study group.		85
Table (9):	Arthroscopic finding distribution study group.		86
Table (10):	Type of injury distribution of th group	-	87
Table (11):	Comparison between arthroscop MRI finding according to ACL te		88
Table (12):	Sensitivity and specificity of finding in ACL tear		89

List of Figures

Figure No. Title		
	Page No.	
Figure (1):	16-week fetus showing the two bundles of the anterior cruciate ligament with the knee in extension (A, sagittal view with medial femoral condyle removed) and flexion	
Figure (2):	Arthroscopic view of the anterior cruciate ligament in 15 years old female, the anteromedial	
Figure (3):	The two clear bundles of the ACL (AM and PL) are shown in cadaveric specimen	
Figure (4):	Fetal anterior cruciate ligament, sagittal section	
Figure (5):	Anterior view of a Gross specimen of the right knee joint	
Figure (6):	Femoral attachment locations of anteromedial (AM) and posterolateral (PL) bundles of the ACL (Right knee medial femoral condyle is removed)	
Figure (7):	Arthroscopic view: Following dissection and removal of soft tissue residues, insertion site anatomy was identified	
Figure (8):	Tibial attachment locations of AM and PL bundles (tibial plateau of right knee, menisci removed)	
Figure (9):	Sagittal and coronal sections of ACL vascular anatomy	
Figure (10):	Sagittal T1-weighted MRI view demonstrating intercondylar notch. Normal ACL	

Figure (11):	T1-weighted coronal view at mid coronal plane showing normal ACL
Figure (12):	T1-weighted Axial view at inferior patellofemoral compartment displaying normal ACL
Figure (13):	Scheme describing the multi-planar loading mechanism of non-contact injury to the anterior cruciate ligament
Figure (14):	Acute complete tear of anterior cruciate ligament (ACL) in a 25 year old male
Figure (15):	Acute complete tear of anterior cruciate ligament (ACL) midsubstance in a 35 years old female
Figure (16):	Complete acute tear of the anterior cruciate ligament (ACL) at the femoral attachment site in a 35 years old female
Figure (17):	Complete tear of the anterior cruciate ligament (ACL) in a 34 years old male with mechanical block (a) Proton density (PD) sagittal FSE 36
Figure (18):	Bone marrow contusions as a secondary sign of anterior cruciate ligament (ACL) tear in a 26 years old male
Figure (19):	Altered angle (22°) between anterior cruciate ligament (ACL) and lateral tibial plateau (normal value 45° or more) as an indirect sign of complete ACL tear in a 26 years old male 38
Figure (20):	Anterior cruciate ligament (ACL) tear in a 26 years old male
Figure (21):	Buckled course of the posterior cruciate ligament (PCL) as an indirect sign of complete anterior cruciate ligament (ACL) in a 25 years old male

Figure (22):	Abnormal femorotibial relationship in a 36 years old male with complete anterior cruciate ligament tears
Figure (23):	Partial anterior cruciate ligament (ACL) tear in a 28 year oldf emale
Figure (24):	Typical partial tear of anterior cruciate ligament (ACL) involving 50 % of the ligament thickness in a 29 year old female with knee injury
Figure (25):	Partial tear of the anterior cruciate ligament (ACL) involving more than 75 % of the distal ligament thickness in a 19 year old male
Figure (26):	Avulsion fracture type II of the intercondylar eminence of the tibia at the insertion of anterior cruciate ligament (ACL) in a 27 year old male with severe knee injury
Figure (27):	Avulsion fracture type III of the intercondylar eminence of the tibia at the insertion of anterior cruci- ate ligament (ACL) in a 17 year old female with acute trauma
Figure (28):	Chronic distal tear of anterior cruciate ligament (ACL) healed on the notch in a 28 year old male with old knee trauma
Figure (29):	Chronic anterior cruciate ligament (ACL) tear healed on the notch in a 21 year old patient with old knee trauma. Sagittal proton-density (PD) FSE image
Figure (30):	Chronic anterior cruciate ligament (ACL) tear in a 42 year old patient with knee instability and without recent trauma
Figure (31):	Anterior drawer test, note the anterior excursion of the tibia in relationship to the femur

Figure (32):	Lachman test 53
Figure (33):	Pivot shift test
Figure (34):	Avulsion fracture of tibial spine 56
Figure (35):	Segond fracture
Figure (36):	Osteochondral injury lateral femoral condyle 58
Figure (37):	Unilateral congenital absence of anterior cruciate ligament (ACL) in a 13 year old female tennis player with- out trauma or clinical instability
Figure (38):	Ganglion cyst of anterior cruciate ligament (ACL) in a 51 year old male with posterior knee pain. Sagittal proton-density (PD) FSE image
Figure (39):	Mucoid degeneration of anterior cruciate ligament (ACL) in a 24 year old female. Sagittal proton-density (PD) FSE image
Figure (40):	Sagittal oblique Images are performed on an axial scout images 10-15° off a perpendicular to a bicondylar line which is tangent to the posterior borders of the femoral condyles
Figure (41):	Normal MRI anterior cruciate ligament (ACL) in a 34 year old lady
Figure (42):	Pie chart sex distribution of the study group 81
Figure (43):	Pie chart age (years) distribution of the study group
Figure (44):	Pie chart sport type distribution of the study group
Figure (45):	Pie chart side injured distribution of the study group
Figure (46):	Pie chart MRI finding of ACL distribution of the study group

Figure (47):	Pie chart Arthroscopic finding distribution of the study group
Figure (48):	Pie chart Type of injury distribution of the study group
Figure (49):	Bar chart between arthroscopic and MRI finding according to ACL tear
Figure (50):	Sensitivity and specificity of MRI finding in ACL tear
Figure (51):	Sagittal T2 and PD SPIR MRI images displaying a severe ACL partial tear at middle part with a thin hairline of intact fibers, which is proved by arthroscopy90
Figure (52):	Sagittal PD SPIR MRI image demonstrating a slightly depressed lateral notch sign at the distal lateral femoral condyle91
Figure (53):	Sagittal PD SPIR demonstrating an intermediate/ high signal linear band crossing the posterior horn of the medial meniscus extending to capsular and inferior articular surfaces in suggesting grade III meniscal tear92
Figure (54):	Sagittal PD WI and PD SPIR MRI demonstrating a high signal intensity in the ACL with swollen and completely torn fibers at their femoral insertion which is proved by arthroscopy
Figure (55):	Sagittal PD SPIR image displaying a patch of increased signal intensity affecting the posterior part of the lateral tibia condyle denoting a patch of marrow contusion, which is a secondary sign of ACL tear.

Figure (56):	Sagittal PD SPIR MRI image exhibiting a linear band of high signal crossing the posterior horn of the medial meniscus extending to capsular and inferior articular surfaces denoting Grade III meniscal tear
Figure (57):	Sagittal PD SPIR MRI image demonstrating a thick, and edematous ACL with an abnormal bright signal and discontinuity of the superior fibers suggesting a sever partial tear (Arthroscopy demonstrate a complete injury)96
Figure (58):	Sagittal T2 WI and PD WI images displaying the defect at the superior ACL fibers in keeping with a sever partial tear and associated PCL buckling which is a secondary sign of ACL tear 97
Figure (59):	Coronal PD SPIR MRI showing empty lateral femoral notch sign consistent with ACL tear. The PHLM tear is also seen, The MCL shows periligamentous bright signal suggestive of a grade I sprain
Figure (60):	Sagittal T2 WI and PD SPIR MRI images reveal torn upper ACL fibers associated with oval cystic fluid signal. Mild joint effusion is also noted in the form of bright fluid signal within the joint space which is proved by arthroscopy 99
Figure (61):	Coronal PDW SPIR showing an empty lateral femoral notch sign consistent with a torn ACL, the MCL shows peri-ligamentous bright signal in keeping with a grade I sprain; intact fibers and there is a patch of marrow contusion at the lateral tibial condyle. Collectively these post trauma sequalae are suggestive of a vulgus stress type of injury

Figure (62):	Sagittal T2W and PDW SPIR images showing partially torn ACL namely its superior fibers with fuzzy edematous appearance the ACL fibers caudal to the tear best appreciated on fat suppressed image. Arthroscope demonstrate a complete tear	01
Figure (63):	Sagittal PDW SPIR showing a patch of marrow contusion at the posterior aspect of the lateral tibial condyle, fibular head and a focal zone of bright marrow contusion also seen at the lateral femoral condyle	02
Figure (64):	Sagittal PDW SPIR showing a faint linear band of bright signal within the PHMM suggestive of an intra-substance tear with no disrupted confines. A bright patch of marrow contusion is also seen at the posterior aspect of the medial tibial condyle	03
Figure (65):	Sagittal PD WI and PD SPIR images showing a complete tear of the ACL at upper part. The fibers appear bulky, fuzzy and edematous with abnormal inhomogenous bright signal best appreciated on fat suppressed image. (Which is proved by arthroscopy)	04
Figure (66):	Sagittal PDW SPIR showing a PHLM horizontal tear extending to the body appearing as a linear band of abnormal bright signal with a defect seen at its capsular surface, the abnormal intra-meniscal bright signal is seen extending to a well defined more or less rounded bright cystic lesion seen related to the posterior aspect of the affected meniscal horn denoting meniscal cyst, rendering it a grade III tear. 10	05

	List	of	Fig	ures
--	------	----	-----	------

Figure (67):	Coronal PDW SPIR showing peri-ligamentous bright signal around the MCL in keeping with a grade I sprain. No definite tears
Figure (68):	PD STIR and PD WI MRI images show markedly swollen ACL fibers an increase in their signal intensity denoting partial thickness tear (Arthroscopy demonstrated an intact ACL) 107
Figure (69):	Sagittal PD SPIR MRI showing a PHLM multidirectional tear extending to superior, inferior and capsular surfaces with fragmentation denoting grade IV tear associated with posterior meniscal cyst
Figure (70):	Axial T2W image showing corrugated wrinkled medial patellar retinaculum suggesting a sprain 109