Sudan University of Science and Technology
College of Graduate Studies

Characterization of Knee Joint Diseases Using Medical Ultrasound and Magnetic Resonance Imaging

توصيف امراض الركبة باستخدام التصويرالطبي بالموجات فوق الصوتية والرنين المغنطيسي

A Research Submitted for the fulfillment of the A ward of Ph. D. Degree in Diagnosis of Medical Ultrasound

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الآية

بسم الله الرحمن الرحيم

(وَعَلَّمَ آَدَمَ الْأَسْمَاءَ كُلَّهَا ثُمَّ عَرَضَهُمْ عَلَى الْمَلائِكَةِ فَقَالَ أَنْبِئُونِي بِأَسْمَاءِ هَؤُلَاءِ إِنْ كُنْتُمْ صَادِقِين(31)

قَالُوا سُبْحَانَكَ لَا عِلْمَ لَنَا إِلَّا مَا عَلَّمْتَنَا إِنَّكَ أَنْتَ الْعَلِيمُ الْحَكِيمُ (32))

سورة البقرة: الايات (31-32)

Dedication

To

My mother,

The soul of my father,

My wife and daughters

Acknowledgement

I thank Allah for granting me the ability to complete this work. Also my thank to my supervisor professor**Dr. BushraHussein**for his assistance and closed guidance throughout this research, I have learnt a lot from him, extend thanks to my co-supervisor **Dr. Alsafi Ahmed Abdella** for his help and support. Also extend my thanks to**Dr. Mohammed Elfadil** and Dr. **CarolinAyad** for their spending plenty oftime and effort to help me.

I'm greatly indebted to many faculty members of the Department of Radiology in King Khalid University, Abha KSA and Aseer Center Hospital.

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Abstract

A great number of people all over the world suffer from knee joint diseases. The benefits of ultrasound (US) when compared to magnetic resonance imaging (MRI) are that the US is non-invasive, simple, rapid, accurate method, freely available, well accepted by patients, cheap and that it has the advantage of dynamic evaluation and real time imaging.

The general objective of this research was to differentiate between the accurate diagnosable findings and characterization of US relative to MRI in knee joint diseases.In this study the researcher establishing criteria for diagnosing knee joint diseases (acute and chronic) with Doppler and conventional US modalities compared to MRI modality which is consider a gold standard in knee joint imaging.

This was an observational cross-sectional study of 300 patients with different complains, attended to the Radiological Center, College of Applied Medical Sciences, King Khalid University, Saudi Arabia, from October 2011 to June 2015G, with knee joint pathology who were referral from different clinics to do US and MRI for comparison. 224 of them, male 192(85.7%) and female32(14.3%) US and MRI revealed variable diseases, the age range was from 12 to 80 yearsand 50 patients with normal knee joint were examined for literatures review and anatomy.The knee joint ultrasound examination has performed with GE-USA Medical System Logic 3 Expert 2007, using linear probes with high frequency range of 7.5 to 12MHz. The technique protocol meets the standard by American Institute of Ultrasound in Medicine (AIUM),

The MRI machine was a GE 1.5 Tesla, field of view (FOV) 14 cm, using knee joint coil and 4/0.2 mm thickness/gap and about20 minutes total time (without Gradient Echo (GRE)). All patients'examinations are done in supine position by using routine examinations, 5 or 6 sequences. These sequences were used: (1) Axial fast spin echo (FSE) T2-Weighted Fat saturation, (2) Coronal FSE T1W, (3) Coronal FSE proton density weighted (PDW) Fatsat, (4) Sagittal spin echo (SE) PDW, (5) Sagittal FSE T2W Fatsat, (6) +/- Sagittal T1*

The commonest presenting symptoms were painful, swelling and inability to move. Effusion was the most frequent 139 cases(62.1%), seen in Ultrasound as anechoic, loose body 4cases(1.8%), seen in Ultrasound as echogenic feature, synovial cyst 8 cases (3.6%), seen in Ultrasound as anechoic feature,quadriceps tendon rupture 3 cases(1.3%), seen in Ultrasound as anechoic feature, meniscus tear 10 cases (4.5%), seen in Ultrasound as anechoic & Hypoechoic feature, tumor 2 cases(.09), seen in Ultrasound as Hyperechoic feature, bursitis 18 cases(8%), seenin Ultrasound as anechoic feature with internal echo, arthritis 8 cases(3.6%), seen in Ultrasound as anechoic feature, baker cyst 8 cases(3.6%), seen in Ultrasound as anechoic feature, and deep vein thrombosis (DVT) 6 cases(2.7%), seen in routine ultrasound as Hyperechoic structure. Medial collateral ligament tear 3 cases (1.3%), seen in Ultrasound as Hypoechoic feature and lateral collateral ligament 2 cases (0.9%), seen in Ultrasound as Hypoechoic feature and Hyperechoic feature in chronic situation,also seen in both US and MRI. Anterior cruciate ligament tear (ACL tear) 9 cases (4%) and posterior cruciate ligament tear (PCL tear) 4 cases (1.8%) seen in MRI only not seen in US, but Doppler Ultrasound show increase vascular flow. US revealed characterization frequency per individual, was: Hyperechoic 8 cases (3.6%), Hypoechoic 6 cases (2.7%) an echoic 193 cases (86.2%), echogenic 4 cases (1.8%) and none seen of other diseases 13 cases (5.8%). MRI characterization frequency perindividuals was: high signal 181cases (80.8%) and low signal 43 cases (19.2%).

Ultrasound is able to evaluate the knee joint diseases especially cystic masses, menisci, ligaments, tendons and muscles tear. The most of the knee joint disorders were effusions due to various diseases , MRI is not wide available in poor country and rural areas and it is expensive, for that I recommend, that ultrasound can contributing to the diagnosis of knee joint pathology in the low resourced countries.

ملخص البحث

هناك عدد كبير من الناس في جميع أنحاء العالم يعانون من أمراض مفاصل الركبة. فوائد الموجات فوق الصوتية (US) بالمقارنة مع التصوير بالرنين المغناطيسي (MRI) هي أن الموجات فوق الصوتية غير تداخلية ، بسيطة ، سريعة ، طريقة دقيقة ، وهي متاحة بحرية، و مقبولة من قبل المرضى ، ورخيصة ، و لديها ميزة التقييم الديناميكي و التصوير في الوقت الحقيقي للفحص .

الهدف العام من هذه الدراسة هوالتشخيص الدقيق وتوصيف امرض مفصل الركبة باستعمال التصوير بالموجات فوق الصوتيةUS والرنين المغنطيسي MRI.في هذه الدراسة اسس الباحث معايير لتشخيص أمراض مفصل الركبة (الحادة و المزمنة) مع دوبلر وطرائق الموجات فوق الصوتية التقليدية مقارنة بالرنين المغنطيسيMRI الطريقة التي تعتبر المعيار الافضل في تشخيص امراض الركبة في الوقت الراهن

هذه دراسة مقطعية الرصد من 300 مريض الذين حضروا إلى مركز الاشعة، كلية العلوم الطبية التطبيقية، جامعة الملك خالد، المملكة العربية السعودية، في الفترة من أكتوبر 2011 إلى ديسمبر 2014م، يعانون من امراض في مفصل الركبة والذين حولوا من عيادات مختلفة.منهم 224 مريض، الذكور 192 (85.7٪) والإناث 32 (14.3٪) الموجات فوق الصوتية و الرنين المغنطيسي MRIاكتشفاامراضا متعددة لهم، والفئة العمرية كانت 12-80 سنة . 50 مرضى ليست لديهم اعراض او شكوى تم فحص مفصل الركبة لهم بغرض الدراسة والتشريح. وقد أجرى الفحص بجهازالموجات فوق الصوتية من نوع GE-USA الطبية نظام Logic 3 Expert 2007، وذلك باستخدLinear probe مع مجموعة عالية التردد من 7.5 إلى MHz12. بروتوكول التقنية كان وفقا ل معيار المعهد الأمريكي للموجات فوق الصوتية في الطب (AIUM)،

جهاز التصوير بالرنين المغناطيسي GE1.5تسلا، مجال الرؤية 14 سم، وذلك باستخدام الملف الخاص بالركبة coilو4 / 0.2 مم سمك/الفجوة وحوالي 20 دقيقة الوقت الإجمالي للفحص(دون التدرج الصدى (GRE)). تتم جميع الفحوصات للمرضى في وضع الإستلقاء علي الظهر باستخدام الفحوصات الروتينية 5 أو 6 اتجاهات متوالية. وقد استخدمت هذه المتتاليات: (1) المحورية تدور بسرعة صدى (FSE) مرجح T2تشبع الدهون fat saturation ، (2)coronal الاكليل FSE T1W، (3)coronal الاكليل FSE كثافة البروتون بالوزن (PDW) Fatsat)، (4) تدور سهمي صدى (SE) PDW)، (5) سهمي FSE T2W Fatsat، (6) T1 -/+ سهمي *

كانت أكثر الأعراض شيوعا هيآلام وتورم وعدم القدرة علي الحركة و كان انصباب السوائل الأكثر تواترا 139حالة (62.1 ٪) وتوصيفه في الموجات فوق الصوتية عديم الصدى ، جسم فضفاض 4حالات (1.8 ٪)وتوصيفه في الموجات فوق الصوتية كامل الصدى ، والكيس الزلالي 8حالات (3.6 ٪) وتوصيفه في الموجات فوق الصوتية عديم الصدى، تمزق اوتار عضلة الفخذ 3حالات (1.3 ٪)وتوصيفه في الموجات فوق الصوتية ناقص وعديم الصدى ، تمزق في الغضروف المفصلي 10حالات (4.5 ٪) وتوصيفة بالموجات فوق الصوتية ناقص وعديم الصدى، ورم 2حالة (0.09)وتوصيفه بالموجات فوق الصوتية مفرط الصدى ، التهاب الجراب 18حالة (8 ٪) وتوصيفه بالموجات فوق الصوتية عديم الصدى، والتهاب المفاصل 8حالات (3.6 ٪)وتوصيفه بالموجات فوق الصوتية عديم الصدى ، والكيس الخباز cystBaker's8حالات (3.6 ٪)وتوصيفه بالموجات فوق الصوتية عديم الصدى و الخثار الوريدي العميق DVT 6(2.7%)وتوصيفه بالموجات فوق الصوتية مفرط الصدى.وتمزق الرباط الجانبي الانسي 3 (1.3 ٪) وتوصيفه بالموجات فوق الصوتية ناقص الصدى،وتمزق الرباط الجانبي الوحشي 2حالة (0.9 ٪)وتوصيفه بالموجات فوق الصوتية ناقص الصدى وجدا أيضا في كل من الموجات فوق الصوتية والتصوير بالرنين المغناطيسي .أماتمزق الرباط الصليبي الأمامي (ACL) 9حالات (4 ٪) وتمزق الرباط الصليبي الخلفي (PCL) 4حالات (1.8 ٪) وجد في التصوير بالرين المغنطيسيMRI فقط بي صورة واضحة ولكن تصوير الموجات فوق الصوتية بالدوبلار اشارة الى زيادة في كمية سريان الدم. كشفت الموجات فوق الصوتية توصيفات مرضية ، كانت كالآتي: مفرط الصدى 8حالات (3.6 ٪) ، ناقص الصدى 6حالات (2.7 ٪) وعديم الصدى 193حالة (86.2٪) ، كامل الصدى4حالات (1.8 ٪)الامراض التي لم تكتشف بالموجات فوق الصوتية13حالة (5.8 ٪) والتصوير بالرنين المغناطيسي اعطى توصيفات مرضية كالآتي : إشارة عالية 181حالة (80.8 ٪) وإشارة منخفضة43حالة (19.2 ٪)
الموجات فوق الصوتية لها المقدرة في توصيف امراض الركبة خاصة امراض التكيسات والسوائل بامتياز، ولان التصوير بالرنين المغنطيسي غير متوفر وباهظ التكلفة نوصي باستعمال ومساهمة التصوير الطبي بالموجات فوق الصوتية لتشخيص امراض الركبة، خاصة في الدول النامية والفقيرة.

List ofAbbreviations

MRI Magnetic Resonance Imaging

US Ultrasound

MUS Musculoskeletal Ultrasound

ACL Anterior Cruciate Ligament

PCL Posterior Cruciate Ligament

BMI Body Mass Index

LCL Lateral Collateral Ligament

MCL Medial Collateral Ligament

Std. Deviation Standard Deviation

AIUM American Institute ofUltrasound inMedicine

DVT Deep Vein Thrombosis

FNA Fine Needle Aspiration

FSE Fat Suppression Echo

RF Radio Frequency

ASUM Australasian Society forUltrasound inMedicine

FAT SAT Fat Saturation

FC Flow Compensation.

FFE Fast Field Echo

FID Free Induction Decay Signal.

FISP Fast Imaging with Steady Precession

FLAG Flow Adjusted Gradients.

FLAIR Fluid Attenuated Inversion Recovery

FMRI Functional MRI

FOV Field of View

FSE Fast Spin Echo.

GFE Gradient Field Echo

GR Gradient Rephasing

GRE Gradient Echo

IR Inversion Recovery

MRA Magnetic Resonance Angiography

NSA Number of Signal Averages

PD Proton Density

PEAR Phase Encoding Artifact Reduction

RF Radiofrequency

SAT Saturation

SE Spin Echo

SNR Signal to Noise Ratio

STIRShort tau Inversion Recovery

TE EchoTime

TSE Turbo Spin Echo

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CHAPTER ONE

1.1 INTRODUCTION

The use of ultrasound US as a clinical investigative tool started in 1950's. US application in imagingremainedunderutilized until 1980's. when compared US to magnetic resonance imaging (MRI) are that the US is non-invasive, simple, rapid, accurate method, freely available, well accepted by patients, cheap, affordable and that it has the advantage of dynamic evaluation in real time imaging (Sharlene,et al 1999).

Recent advances in US system instrumentation and transducer technology allowed better demonstration of musculoskeletal diseases. The most known clinical application is the ability to obtain a clear anatomical overview of the superficial structures around the bones. Soft tissue pathology of the knee represented one of the common uses since the nineties of last century (Iagnocco, et al 2010). The majority of adults, all over the world, complain of knee joint pain that is routinely investigated by conventional x-ray, ultrasound and MRI. The latter provides conclusive diagnosis, but the disadvantage of being an expensive option, well beyond the capabilities of most developing countries. The efficiency of ultrasound has not been studied in comparison with MRI in knee joint disorders like ACL/PCL ruptures (Fig. 1-1), medial and lateral collateral ligament injuries, quadriceps tendon rupture, cellulitis, soft tissue abscesses, septic arthritis, aneurysm, nerve sheath tumor, meniscal tears, joint effusions and other fluid collections such as bursitis and Baker's cysts (Grassi, et al, 1999) US and MRI are the primary modalities currently used for synovium assessment(Guermazi, et al, 2008).

Yet US of the knee joint can yield a lot of more information on the bursae, (Fig. 1-2)Tendons, muscles, ligaments menisci and joint space pathologies (Grassi, et al, 1999).

MRI produces high-quality tomographic images of the body in any plane by portraying the distribution of hydrogen nuclei within the tissue imaged. MRI does not involve ionizing radiation; it uses radiofrequency pulses and a strong magnetic field to create images. When the patient is placed in a strong magnetic field, the hydrogen nuclei (protons) in the body align with the axis of the external magnetic field. Radiofrequency pulses are applied to change the orientation of aligned protons. After the cessation of the radiofrequency pulses, the excited protons relax and return to their initial state by emitting electromagnetic energy. The emitted electromagnetic energy is detected, and ultimately converted into the MR image(Wood, et al, 1999)

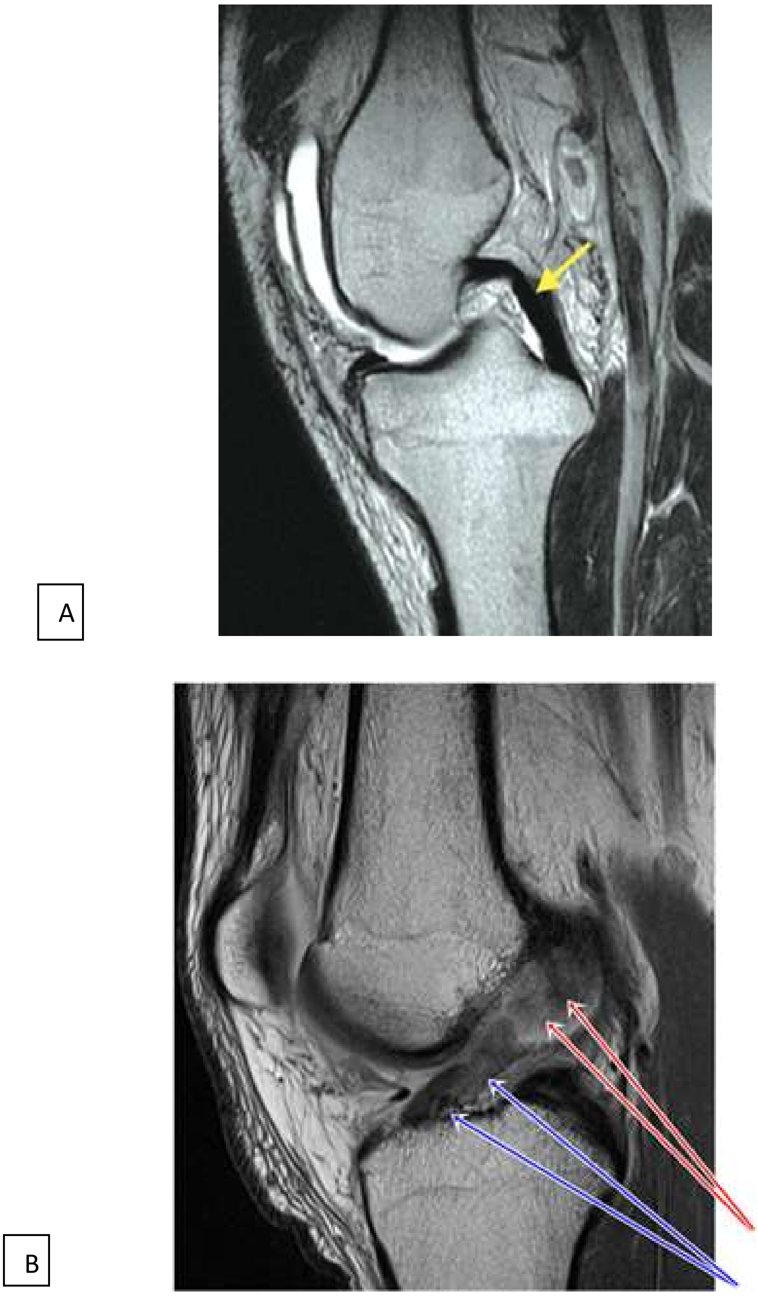


Figure (1-1): MRI A: Effusion, B: Image showsanterior cruciate ligament injury

(Wood, et al 1999)

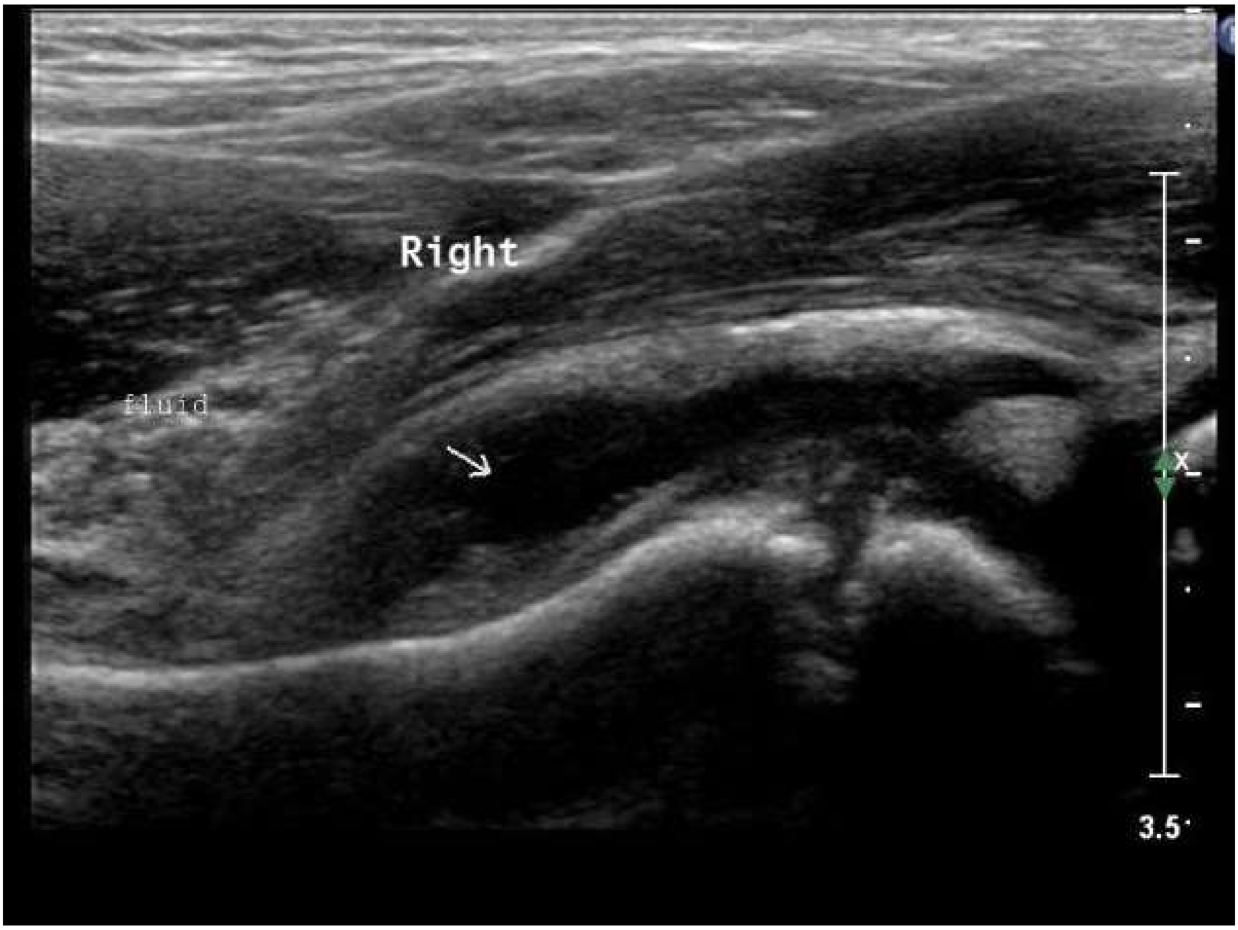
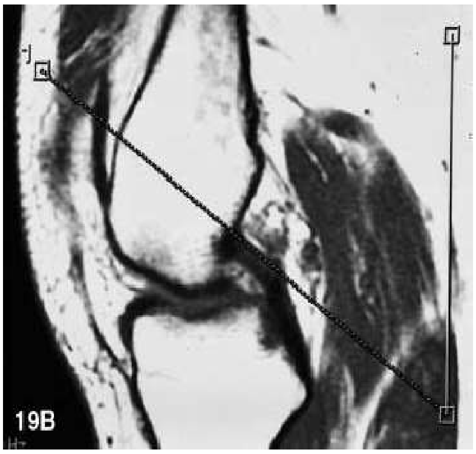
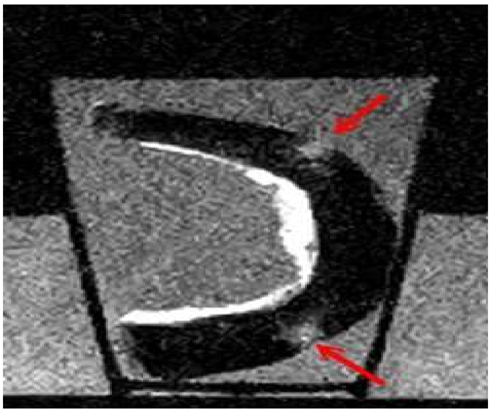


Figure (1-2) Effusion shows anechoic fluid in the suprapatellabursa

1.2Problems of the study

Although MRI has different protocols in diagnosing musculoskeletal system, there were many problems happened during knee joint scanning ,such as magic angle artifact(Fig. 1-3) , flow artifact in the popliteal artery, hazard, motion artifact and claustrophobia , that may obscure the normal anatomy and mimic the visualization and the ability to characterized the diseases, where the patient position was fixed inside the coil, addition to the main drawbacks of MRI are its high cost and limited availability. MRI requires a longer scan time compared with most imaging modalities. Patients have to stay still during the scanning procedure because motion often degrades the image. MRI is contraindicated in patients with cardiac pacemakers, certain types of aneurysm clips, cochlear implants, and intraocular metallic foreign bodies therefore another method like Ultrasound should be tested to have the same diagnostic values in diagnosis diseases obscured by MRI technical Faults,showing all the anatomical structures separately because in ultrasound examinations The patient indicates where he or she feels maximal pain, and the examination is directed to this location.





Figure(1-3) 19A, B Magic angle phenomenon.**A** Sagittal spin-echo T1-weighted image of the knee shows an area of increased signal intensity (arrows) in the upper posterior cruciate ligament. **B** The upper fibers of the posterior cruciate ligament are angled at 55° to the static magnetic field, producing increased artifactual signal due to the magic angle phenomenon

At this TE, magic angle artifacts will become evident. Note the bright signal (arrows) at the edges of the meniscus, where the collagen fibers are close to the magic angle (Fig. 1-4).

Figure (1-4): TE weighted magic angle artifacts

The upsloping posterior horn of the lateral meniscus is often close to 55 degrees to the main magnetic field, and one will often see magic angle artifact in this region (Fig.1-5)

Figure (1-5): upsloping posterior of lateral meniscus

The inner edge of the posterior horn of the lateral meniscus is the classic location for magic angle artifact, due to the upsloping nature of this area of the meniscus in many patients. Although less frequent, the posterior horn of the medial meniscus can also be upsloping, and magic angle can be encountered in medial meniscus as well. In rare cases, magic angle artifact can also be associated with the anterior horns of the menisci.

The expensiveness,lack of MRI and the main strength of knee joint ultrasoundto assess the Para articular diseases have been considered as main problems of the current study.

1.3Objectives

1.3.1GeneralObjectives of the research

The general objective of this research was to differentiate between the accurate diagnosable findings and characterization of US relative to MRI in knee joint diseases.

1.3.2Specifics objectives:

Use Ultrasound and MRI to Characterize the knee joint Anatomy and the following diseases:- (ACL and PCL ruptures, acute collateral ligament injuries , tendon lesions, particularly partial and complete quadriceps rupture , cellulitis , soft tissue abscess , septic arthritis ,osteoarthritis, osteosarcoma ,osteochondroma, meniscus diseases ,aneurysm ,nerve sheath tumor, DVT, joint effusions and other fluid collection such as bursitis, baker cyst and other diseases.

1.4 Significance of study

A great number of people all over the world complain of knee joint diseases, the benefits of ultrasound are that the US is: non-invasive, freely available, well accepted by patients, cheap and that it has technical benefits including dynamic evaluation and real time imaging, it allows contralateral examination and does not pose limitations due to metal artifacts, which can be problematic in magnetic resonance imaging (MRI). The ability to visualize needles and target structures in real time makes it an ideal tool for the guidance procedures used in diagnosis and management [Del Cura, 2008].

CHAPTER TWO

LITERATURE REVIEW

2.1 The Knee Joint anatomy

The knee joint is the largest and most complicated joint in the body (Grant, 1999). Basically, it consists of two condylar joints between the medial and lateral condyles of the femur and the corresponding condyles of the tibia, and gliding joint, between the patella and the patella surface of the femur, note that the fibular is not directly involved in the joint. (Canale, et al, 2007) see (Fig. 2-1), (Fig. 2-2) and (Fig. 2-3)

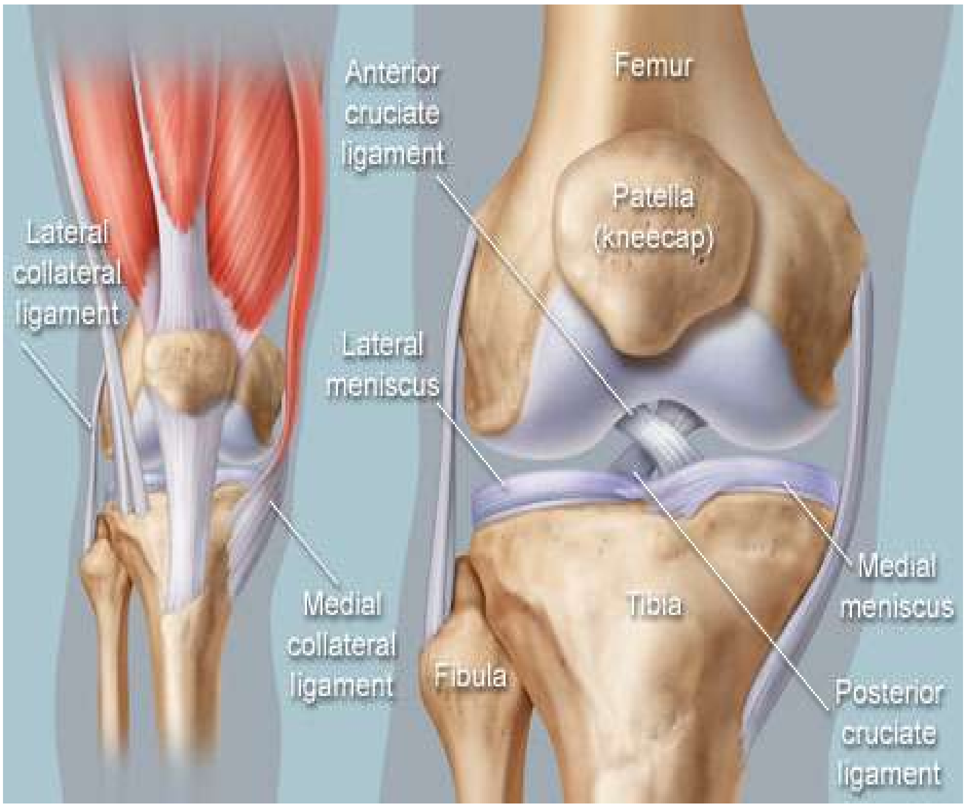


Figure (2-1):knee joint anatomy (Canale, et al, 2007)

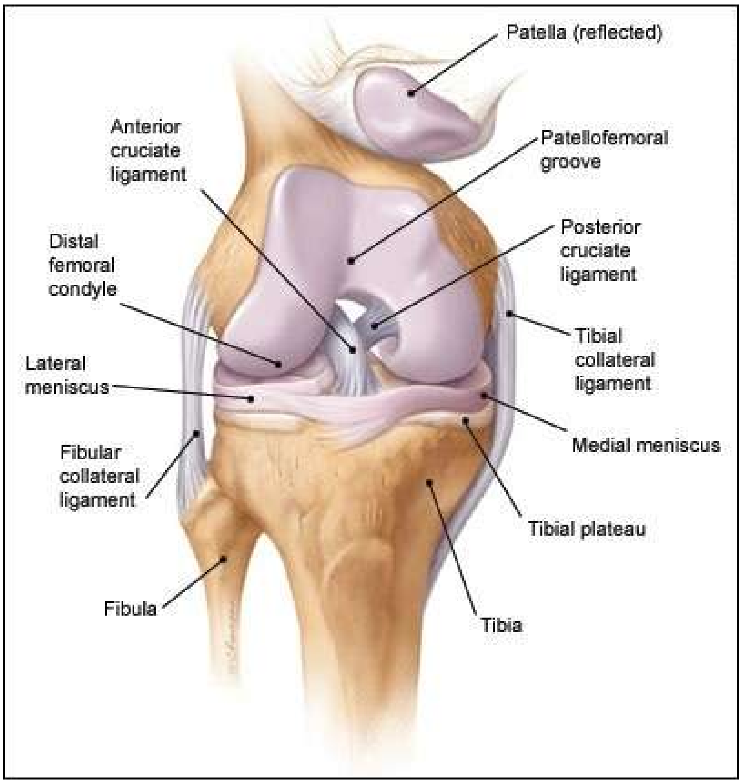


Figure (2-2): knee joint anatomy(grant 1999)

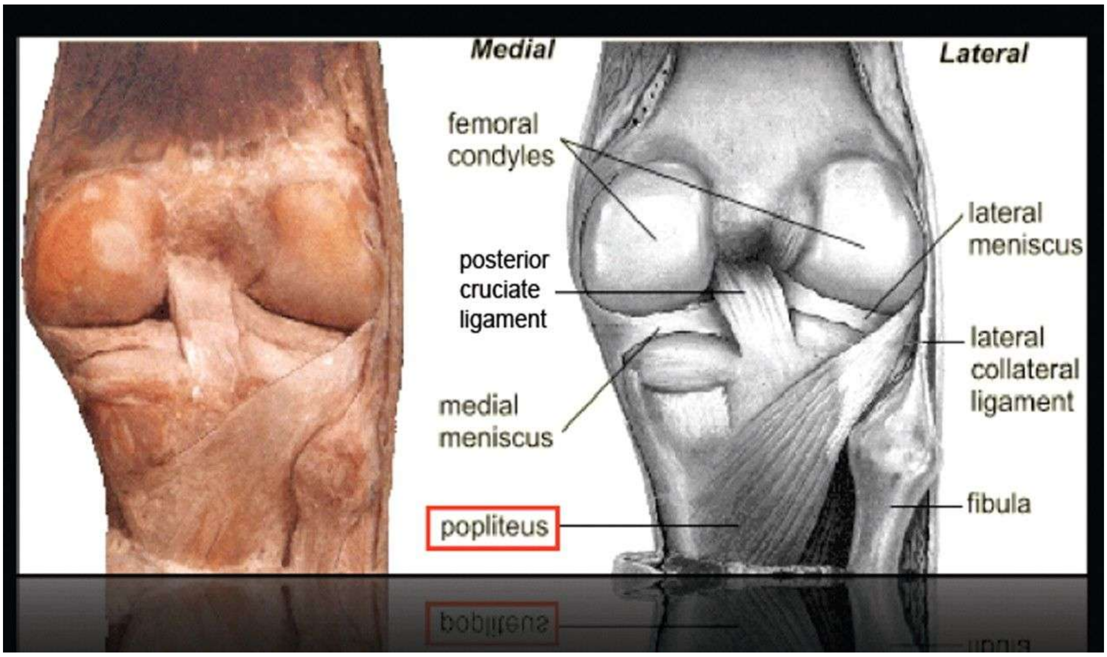


Figure (2-3): knee joint anatomy(grant 1999)

In athletes, it is the joint sustaining themost injuries. As stated earlier, the knee joint consists of the medial and lateral condyles of the distal femur whicharticulate with the medial and lateral condyles of the proximal tibia. In addition to these articulations, the femurarticulates anteriorly with the patella to form a gliding joint (Whittaker, et al, 2006).Many ligaments and the tendons of several muscles serve to strengthen the knee joint. Let's take a look at the ligamentsnow, Please refer to (Figure2-4) below for an illustration of the anterior structures of the knee joint (with the patellaremoved), then turn to (Figure2-5) on the following page, to examine a posterior view(Whittaker, et al 2006).

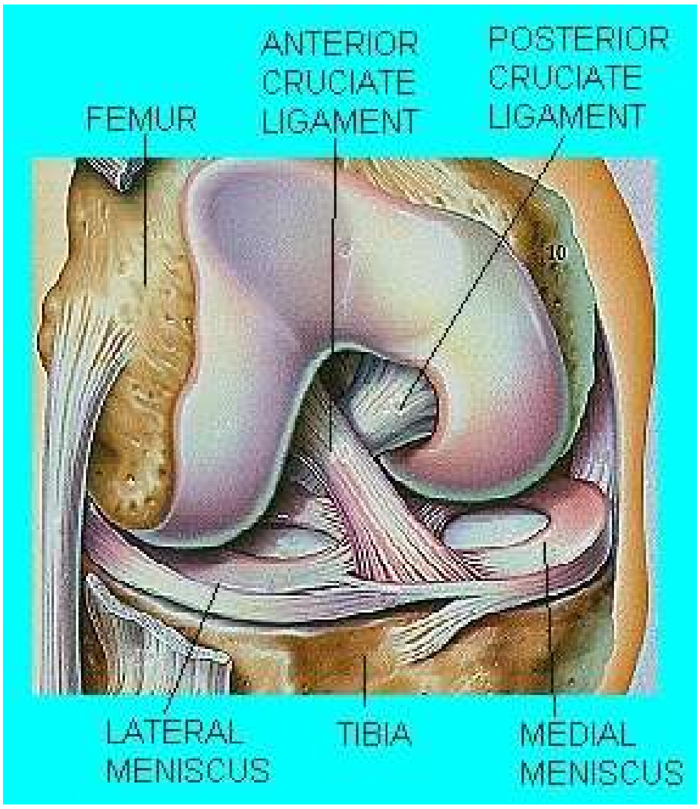


Figure (2- 4): anterior view of the knee joint(Whittaker, et al 2006).

The ligaments associated with the knee joint include; the pateliar, oblique popliteal, arcuate popliteal, tibial collateral,fibular collateral and the anterior and posterior cruciate ligaments. Let's take a few moments to discuss each of theseligaments in a little more detail, beginning with the patellar ligament. (Whittaker, et al, 2003)

2-1-1 Ligaments of the Knee

The ligaments of the knee joint are responsible for keeping the articulating surfaces of the knee together. The first groups ofligaments we shall discuss serve to strengthen the joint capsule, beginning with the patellar ligament, which is in fact acontinuation of the tendon of the quadriceps femoris muscle of the anterior thigh; it extends from the inferior margin of thepatella to the tibial tuberosity.

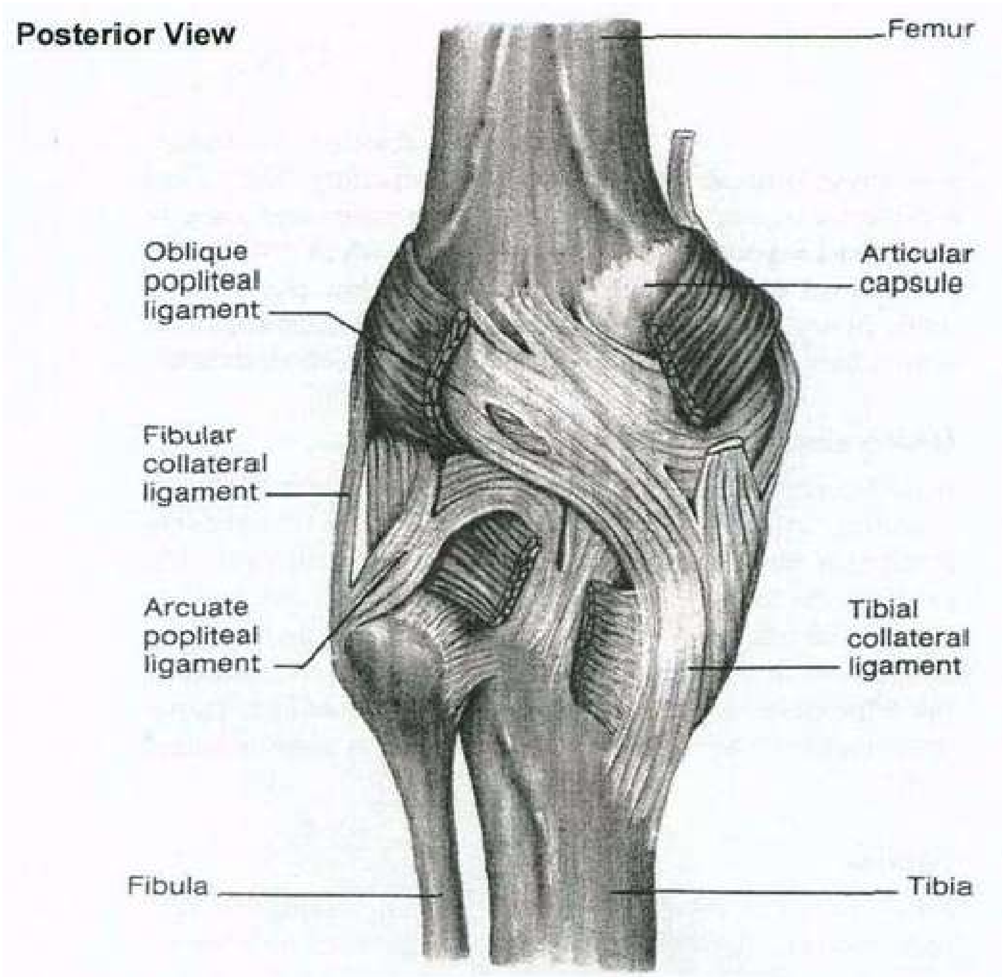
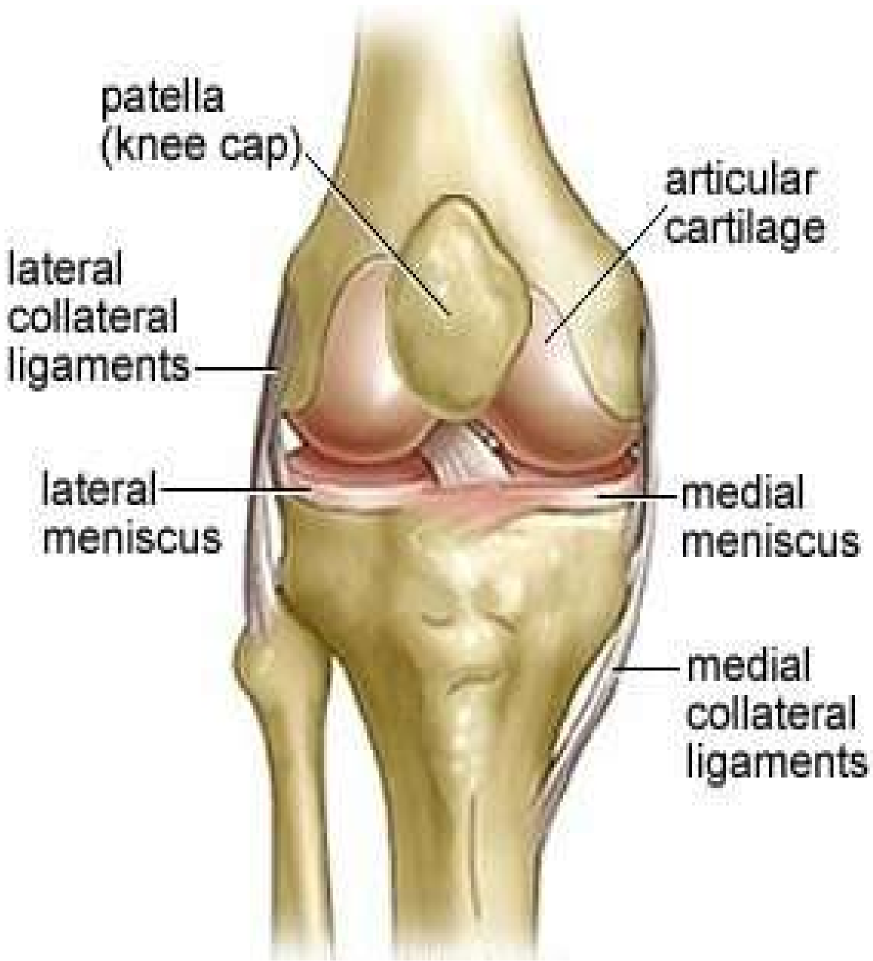


Figure (2- 5): posterior view of the knee joint

The oblique popliteal ligament connects the lateral condyle of the femur to the margin of the head of the tibia. Thearcuate popliteal ligament is Y shaped ligament connecting the lateral condyle of the femur to the head of the fibula.**(**Whittaker, et al, 2003**).**The next two ligaments serve to prevent lateral displacement of the knee. The tibial collateral ligament connects themedial condyle of the femur to the medial condyle of the tibia. The fibular collateral ligament is located between thelateral condyle of the femur and the head of the fibula.Finally, the two cruciate ligaments stretch upward between the tibia and the femur, crossing each other;these ligamentsserve to hold the articulating surfaces of the knee joint in place, or together.

The anterior cruciate ligament originatesfrom the anterior Intercondylar area of the tibia, extending to the lateral condyle of the femur, while the posterior cruciateligament connects the posterior Intercondylar area of the tibia to the medial condyle of the femur.(Thompson, et al, 2006)**.**Before we move on, take a look at (Figure 2 -6) below. This anterior view of the right knee adds the patella and a fewtendons to the structures seen in the previous diagrams.



Figure(2-6): Anterior view of the knee joint

Before we move on to review the muscles that are responsible for moving the upper and lower leg, take a quick look atFigure (2 -4) once again, and note the two menisci separating the articulating surfaces of the femur and the tibia. Thesestructures require a little more discussion.

The medial and lateral menisci are fibro cartilaginous structures that are roughly C-shaped, acting like a gasket to helpdistribute the weight of the upper body from the femur to the tibia, protecting the articular cartilage from excessive force.

Each meniscus is attached to the head of the tibia and is composed of a thick outer rim and a much thinner center,essentially converting the tibial surface into a shallow socket that fits the corresponding condyle of the femur, therebycompensating for any differences in shape between the two articulating surfaces. . **(**Thompson, et al, 2006**)**

2.1.2 Bursae of the knee joint

Also, we mustn't forget that there are several bursae associated with the knee joint, and these can be seen in (Figure 2-7)immediately below (highlighted).

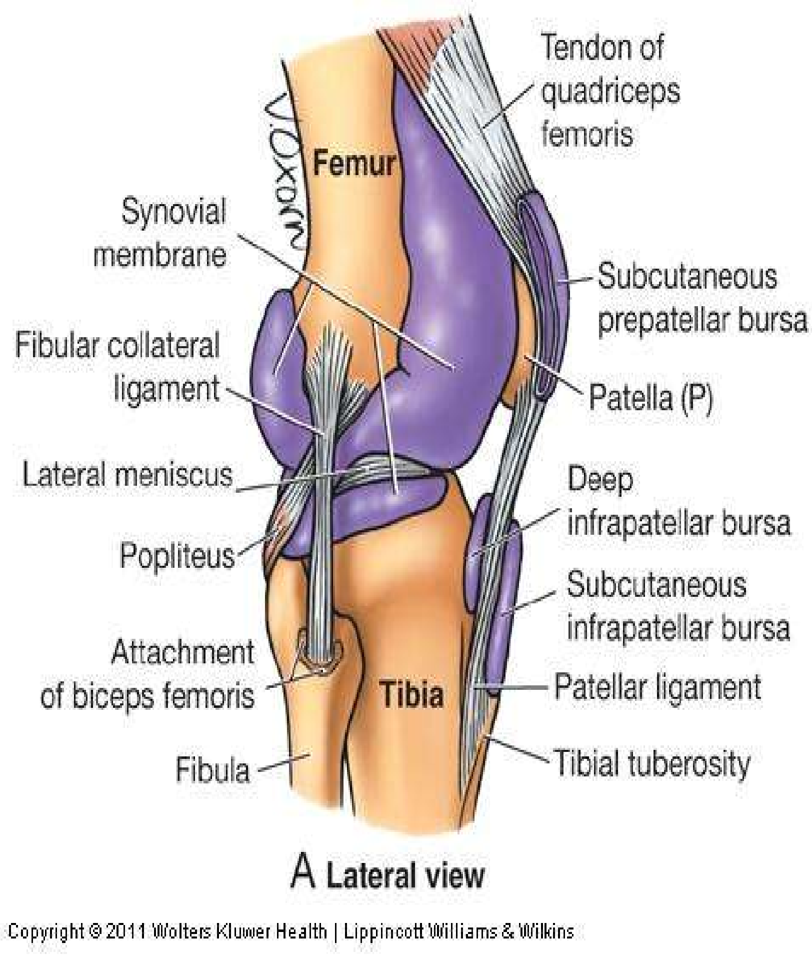
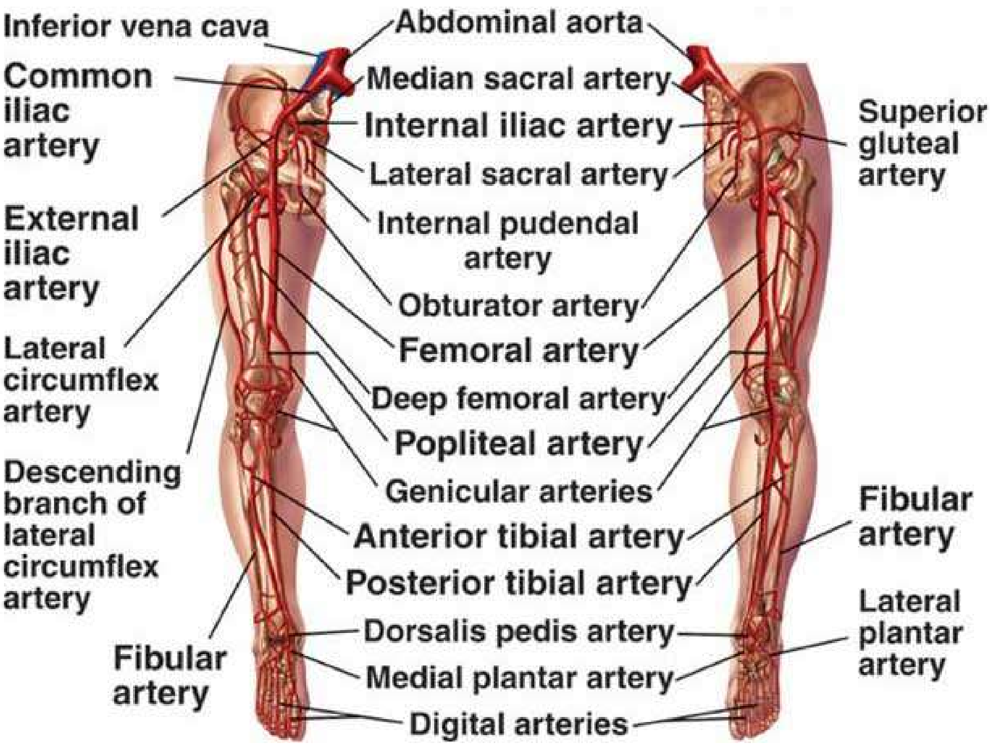


Figure (2- 7): bursae of the knee joint

2.1.3 Blood supply of the knee

The knee joint blood supply is derived from a rich anastomosis of the five major constant arteries, namely, the superior medial and lateral, the middle (posterior), and the inferior medial and lateral genicular arteries. Anastomosis also occurs with descending genicular arteries and the anterior tibial recurrent artery. These branches form anastomoses in and around the knee joint, while each major vessel was noted to provide the respective major blood supply to specific areas. The most obvious difference between vascularization of child and adult knees was the separation of vessels and relative avascularity of epiphyseal plate areas; such persisted until closure of the epiphyseal plate. The regions representing the seals of plate closure had less rich vascularization. A rich intraosseous blood supply was defined in the femoral and tibial condyles and the patella. Similarly, the adjacent and superficial soft tissues, including major ligaments and peripheral parts of the menisci, were richly vascularized. Areas of separated vascularization in children may have relevance to epiphyseal injury, growth deformity, Osgood-Schlatter disease, and hematogenous osteomyelitis. In adults, such information may be relevant to high tibial osteotomy, meniscus and cruciate ligament repair, and surgery utilizing the semitendinosus tendon, fascia lata, or patella tendon grafts (Post, et al 2002), (fig. 2- 8, a, b, c).

A



B

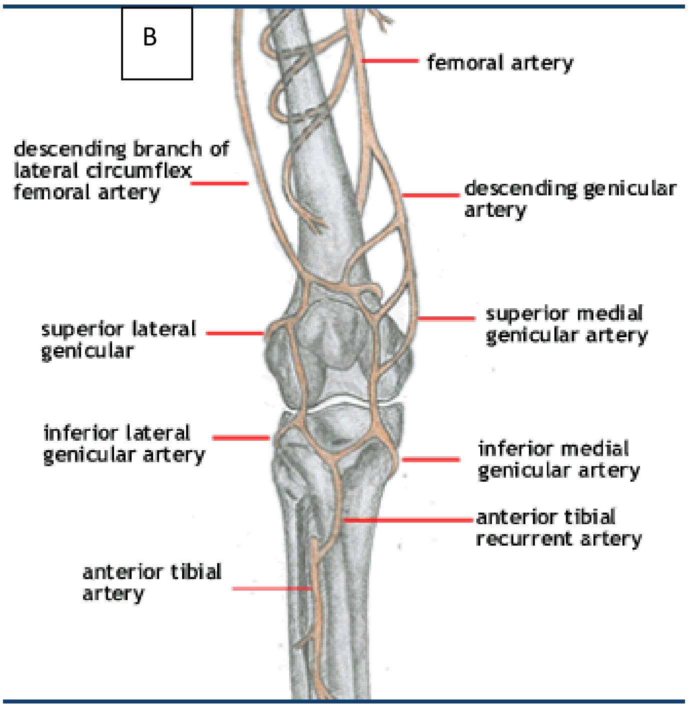


Figure (2-8): Knee joint blood supply A &B

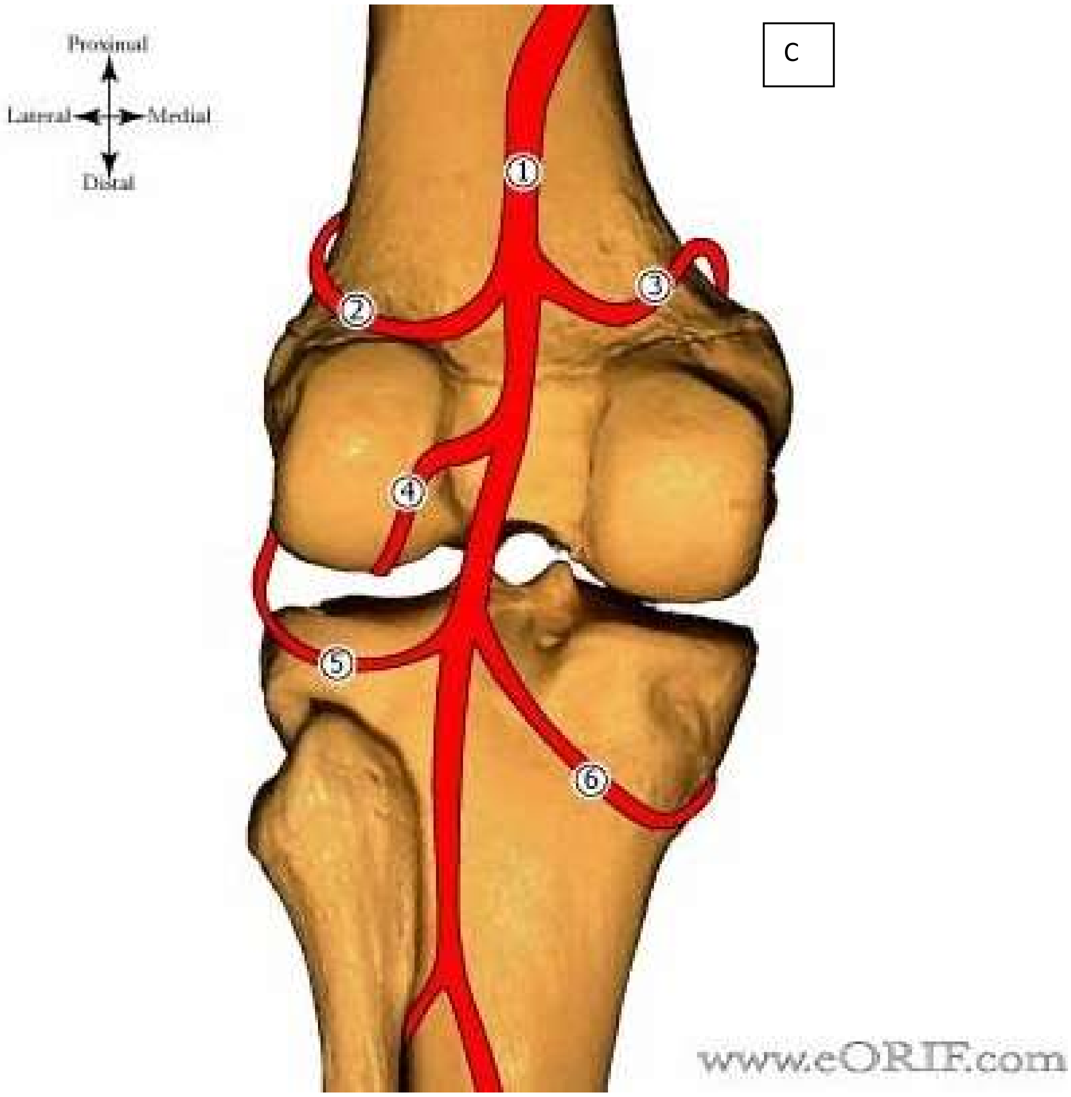


Figure (2-8): Knee joint blood supplyC, shows Posterior view of the knee demonstrating blood supply: (1) Popliteal artery(2) Superior lateral genicular artery (3) Superior medial genicular artery (4) Middle geniculate artery (5) Inferior lateral genicular artery (6) Inferior medial genicular artery

2-2 Physiology of the knee joint

The knee is one of the largest and most complex joints in the body. The knee joins the thigh bone (femur) to the shin bone (tibia). The smaller bone that runs alongside the tibia (fibula) and the kneecap (patella) are the other bones that make the knee joint.

Tendons connect the knee bones to the leg muscles that move the knee joint. Ligaments join the knee bones and provide stability to the knee:

- The anterior cruciate ligament prevents the femur from sliding backward on the tibia (or the tibia sliding forward on the femur).
- The posterior cruciate ligament prevents the femur from sliding forward on the tibia (or the tibia from sliding backward on the femur).
- The medial and lateral collateral ligaments prevent the femur from sliding side to side.

Two C-shaped pieces of cartilage called the medial and lateral menisci act as shock absorbers between the femur and tibia.

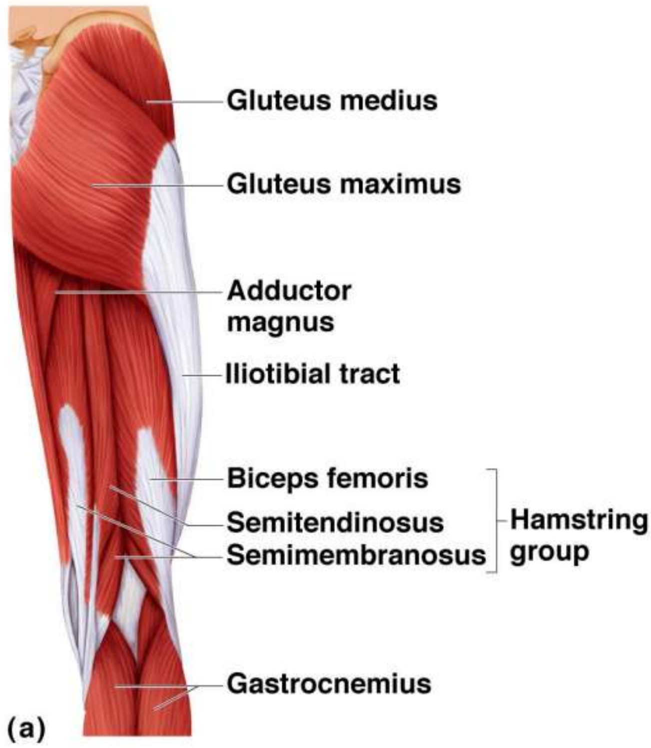
Numerous bursae, or fluid-filled sacs, help the knee move smoothly (web MD, 2015).

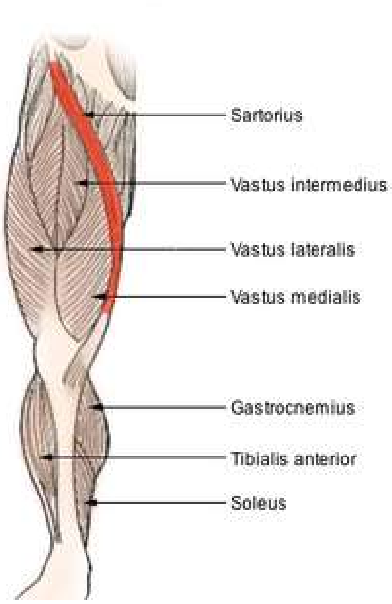
2-2-1Movement of the Lower Leg

Once again, the muscles that move the lower leg are situated proximal to the calf, at the level of the thigh or lowerabdomen. Take a moment to examine the three views in figure (2- 9)which follow, as we discuss the flexorsand extensors responsible for movement below the knee joint. . **(**Thompson, et al, 2006**)**

The lower leg flexors include; the biceps femoris,semitendinosus, semimembranosus and the sartorius muscles. Let'slook at each muscle in more detail now after you've taken a moment to locate them in (Fig. 2-9).

The biceps femoris is the first of three hamstring muscles, passing along the posterior aspect of the thigh laterally, arisingfrom two heads (as its name suggests). The first head is attached to the ischium of the pelvis and the second is attached tothe femur. It attaches to the proximal ends of the fibula and the tibia, serving to flex and rotate the lower leg laterally aswell as to extend the thigh. The biceps tendon (white arrow below) can easily be felt as a prominent ridge behind the lateral aspect of the knee**(**Whittaker, et al, 2006**).**





(b)

Figure (2 -9): a, muscle of the lower leg flexors and extensors of the thigh, b Sartorius

The semitendinosus is the second of three hamstring muscles, so named because it becomes tendinous in the middle of thethigh, continuing to its insertion on the tibia as a long, cordlike tendon. Located more medially on the posterior thigh thanthe biceps femoris, this muscle connects the ischium to the proximal end of the tibia, serving to flex and rotate the lowerleg medially as well as extend the thigh (Thompson, et al, 2006). The semimembranosus is the third hamstring muscle located medially on the posterior aspect of the thigh. Connecting theischium to the tibia, it serves to flex and rotate the leg medially as well as extend the thigh (sounds familiar doesn't it).The sartoriusmuscle is the longest muscle in the human body. Passing obliquely across thefront of the thigh, and then descending medially over the knee, the sartorius muscle connects the ilium of the pelvis to the tibia,allowing flexion of the lower leg and the thigh. In addition, it assists in abduction and lateral rotation of the thigh. Quite acapable muscle**(**Whittaker, et al 2006**).**

Well, that's it for the flexors. You know there has to be an extensor, so let's talk about the muscle group that makes up theprimary extensor of the knee; the quadriceps femoris muscle. Take a minute to locate it on the front of the thigh in theanterior view (Figure 2-10). That's because the quadriceps femoris is made up of four separatemuscles (as its name suggests); the rectus femoris, vastuslateralis, vastusmedialis and the vastusintermedius muscles**(**Whittaker, et al 2006**).** Now take another look at (figure 2-11)and identify the components of the quadriceps femoris.

As a group, the quadriceps femoris occupies the entire front and both sides of the thigh, originating on the Ilium and thefemur, the four muscles course distally to become a common patellar tendon which passes over the front of the knee,attaching to the patella. After the inferior aspect of the patella, the patellar tendon continues as the patellar ligament,attaching the patella to the anterior tibia.That's it for the muscles that move the lower leg! Read on to learn about the muscles those move the upper leg or thigh.

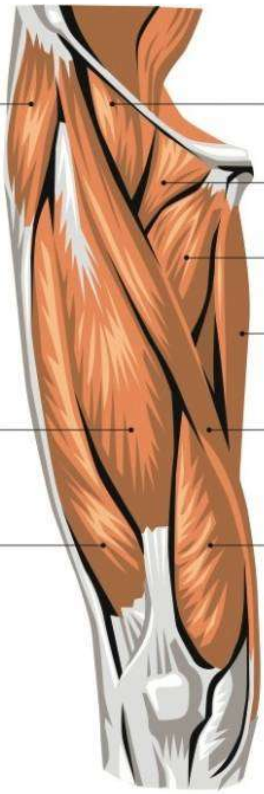


Figure (2- 10): extensor of the knee muscles

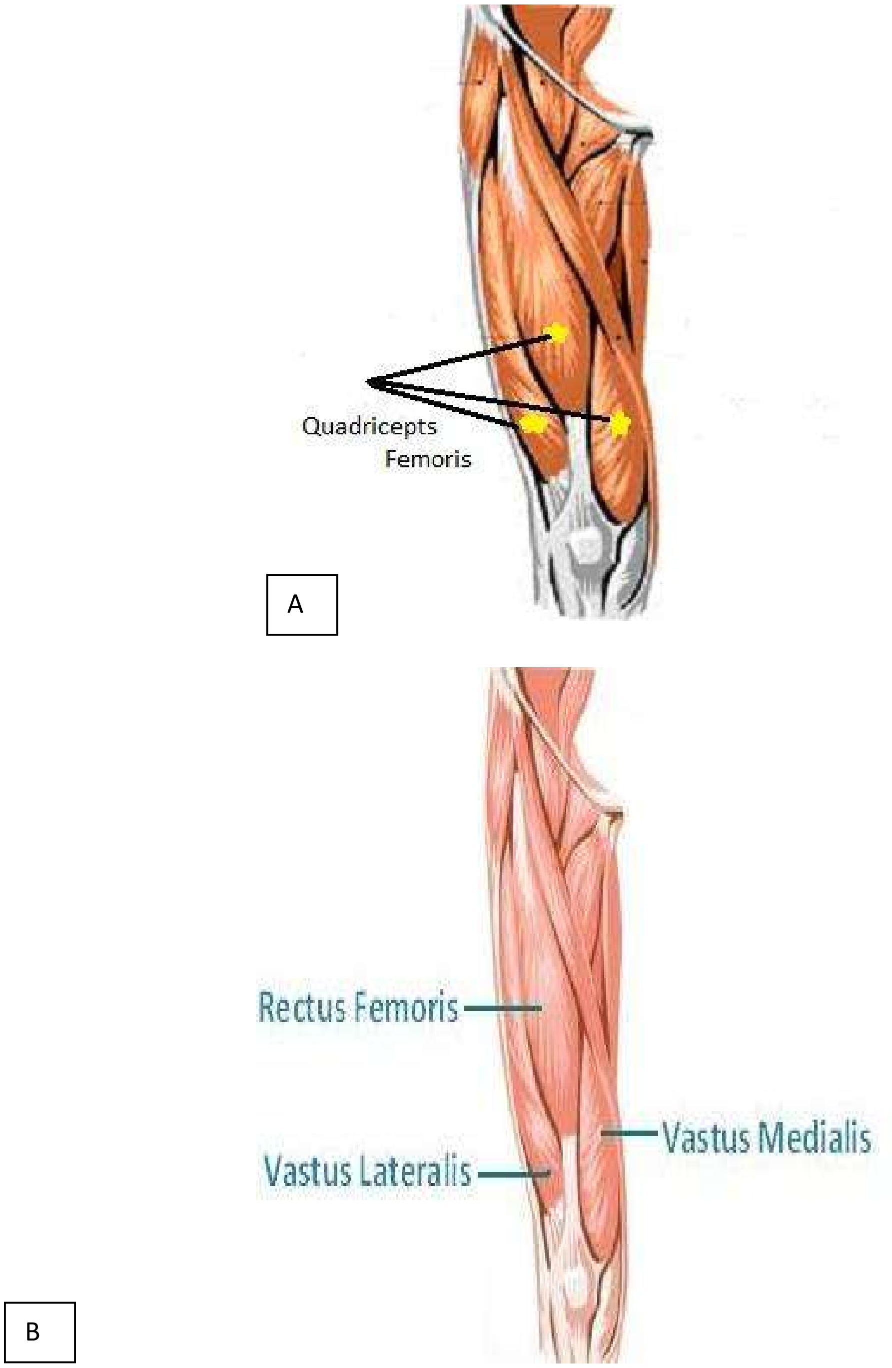


Figure (2- 11): A & B quadriceps femoris

2-2-2Movement of the Upper Leg

Fortunately we can use the same three figures reviewed just a moment ago, figure(2-10) to discuss the musclesthat move the upper leg, or thigh. As always, these muscles are proximal to the body part to be moved, so we will find theirorigins in the pelvic girdle and lower abdomen. These muscles can be separated into anterior and posterior groups, withthe anterior group responsible for flexion of the thigh and the posterior group responsible for extension, abduction androtation of the thigh as well as a third group of muscles responsible for adducting the thigh, named; the thigh adductors.**(**Whittaker, et al, 2006**).**

When discussing the muscles responsible for moving the upper leg, anterior muscles groups are responsible for flexion,while opposing groups located posteriorly are responsible for extension.The anterior group of muscles includes; the psoas major and the iliacusmuscles. The psoas major muscle connects the lumbarvertebrae to the femur, serving to flex the thigh. The iliacus muscle lies lateral to the psoas major, originating on the iliaccrest of the pelvic girdle, also attaching distally to the femur and similarly serves to flex the thigh. Because of their closeproximity and identical function, these two muscles are often referred together as the iliopsoas muscle **(**Whittaker, et al, 2006**).**The posterior group of muscles includes; the gluteus maximus, gluteus medius, gluteus minimus and tensor fasciaelatae muscles. Once again, please take a moment to locate them in figures (2- 9) and (2-10)the gluteus maximus is thelargest muscle in the body, covering the major portion of each buttock. Connecting the ilium, sacrum and coccyx to thefemur utilizing a length of fascia, the gluteus maximus muscle serves to extend the thigh. The gluteus medius muscle islocated behind the gluteus maximus, extending from the ilium to the femur, serving to abduct the thigh and rotate itmedially. The gluteus minimus muscle lies behind the gluteus medius, with identical attachments and function**(**Whittaker, et al,2006**).**This is opposite to the muscles that move the lower leg, where anterior muscle groups are responsible for extension andposterior muscle groups responsible for flexion.

Finally, the tensor fasciae latae muscle connects the ilium to the fascia of the thigh (or iliotibial tract), which extends allthe way down to the lateral tibia, serving to abduct and flex the thigh, as well as rotate it medially.

The final muscle group, known as the thigh adductors, includes; the adductor longus, adductor magnus and the gracilismuscles. The adductor longusmuscle, as its name suggests, is a long muscle connecting the pubic bone to the femur, serving to adduct the thigh andassist in flexing and rotating it laterally. The adductor magnus muscle is the largest adductor of the thigh, as its namesuggests. Originating on the ischium, it also extends to the femur where it adducts the thigh and assists in extending androtating it laterally. Finally, the gracilis muscle connects the pubic bone to the tibia, serving to adduct the thigh as well asflex the leg at the level of the knee.

(Whittaker, et al 2006**)**

That's it for our discussion of muscles which move the upper and lower leg. Now let's continue and learn how and why weperform MSK ultrasound of the knee.

2.3Pathology of the Knee

Your knee joint is made up of bone, cartilage, ligaments and fluid. Muscles and tendons help the knee joint move. When any of these structures is hurt or diseased, you have knee problems. Knee problems can cause pain and difficulty walking.

Knee problems are very common, and they occur in people of all ages. Knee problems can interfere with many things, from participation in sports to simply getting up from a chair and walking. This can have a big impact on your life.

The most common disease affecting the knee is osteoarthritis. The cartilage in the knee gradually wears away, causing pain and swelling.

Injuries to ligaments and tendons also cause knee problems. A common injury is to the anterior cruciate ligament (ACL). You usually injure your ACL by a sudden twisting motion. ACL and other knee injuries are common sports injuries (Medline, 2015)

2.3.1 Acute knee joint diseases:

sprains and strains, anterior knee pain (pain around the kneecap), menisci or cartilage damage, tendonitis, torn ligaments or tendons,bleeding into the joint (www.nhs.uk, 2015).

2.3.1.1 Knee Joint Trauma

Do you remember how many times you scanned your knees while growing up? It always seemed that your knees sufferedmost whenever you fell! Well it's the same for adults. Trauma to the knees is very common secondary to falling, and various other reasons. Since the patella leads the way to the ground, soft tissue injuries and patellar fractures arerelatively common(Whittaker JL.et al 2006)**.**If the patella is spared in a fall, damage to the extensor mechanism of the knee may result, including;

-Muscle tears

-Full or partial thickness tears of the quadriceps or patellar tendons

-Damage to the patellar retinaculum

Partial muscle tears are usually accompanied bya hematoma, which on ultrasound appears as a poorly defined, hypoechoic mass with or without internal echoes, lyingwithin the muscle belly. These hematomas usually resolve spontaneously overtime.Incomplete or partial muscle tears are graded into three separate categories depending on the amount of muscle tissueinvolved and the size of the hematoma. Grade I tears are very small areas of hypoechogenicity representing hematomasless than 1 cm. in size. These tears should heal fairly quickly in about 2-3 weeks. Grade II muscle tears involve less thanone third of the muscle and demonstrate hematomas less than 3 cm. in size. These tears are more serious, requiring 3-6weeks to heal. Finally, Grade III muscle tears are significant injuries involving more than one third of the musclesubstance, with hematomas that are greater than 3-cm. in size. These tears often take several months to heal, but are lesssevere than a complete muscle tear, which requires surgery(Thompson, et al, 2006**).**

2.3.1. 2 Tendon and Ligament Tears

By this point you're probably getting sick of hearing about tendon and ligament tears, so I won't spend a great deal of timeon the subject. As in other areas of the body, tears of the tendons or ligaments of the knee may be partial or full thickness.Ultrasound is useful to differentiate total discontinuity of the tendon which requires surgery, from a focal, full thicknessor partial thickness tear through one side of the tendon. Partial thickness tears may be difficult to differentiate from a focalarea of inflammation, so power Doppler capability is essential for differentiating between the two. If a focal area ofdecreased echogenicity is identified, remember to rock the transducer in a heeltoe fashion to be certain that the anisotropyartifact is not rearing its ugly head! This is especially true of tendon insertion sites, where a hypoechogenic ultrasoundappearance is very common due to anisotropy. Also, whenever a tendon tear is identified, it's important to check out thebursae in the vicinity (especially the suprapatellar and prepatellarbursae) to rule out the presence of blood, secondary totendon trauma (Thompson, et al, 2006**).**Tears of the quadriceps tendon usually occur within one or two centimeters of its insertion into the base of the patella andsimilarly, patellar tendon tears usually occur within one or two centimeters of its insertion into the apex of the patella.Tears of the medial collateral ligament (MCL) are frequently seen in athletes, usually affecting the femoral aspect of theligament. Because this ligament is trilaminar in structure, tears are rarely vertically oriented through the substance of theligament, but are more frequently zig-zag in appearance, coursing through the layers. The deep layer is more frequentlytorn than the superficial layer, and may be associated with a medial meniscus tear and possibly anterior cruciate ligamentrupture.The lateral collateral ligament (LCL) is thicker at its proximal, femoral portion than it is inferiorly; therefore injury to thisligament tends to occur inferiorly near its shared insertion site with the biceps femoris tendon on the head of the fibula.

Similar to muscle injuries, tendon and ligament injuries are also graded based on the degree of discontinuity of the internalfibrillar architecture. Grade I injuries include stretching of the ligament as well as minor tears which demonstrate onlyminimal fiber discontinuity with an internal area of hypoechogenicity secondary to hemorrhage, but normal tendon size (Thompson, et al, 2006**).**Grade II tears represent more significant fiber damage with thickening of the tendon or ligament and a hypoechoic fluidcollection at the site of injury. Grade II tears however, are only partial tears. Finally, Grade III tears demonstratecomplete rupture of the tendon or ligament with fiber discontinuity and a fluid space filling the site of the tear. Thesetears are quite significant, resulting in joint looseness or instability **(**Thompson, et al 2006**).**As mentioned earlier, portions of the anterior and posterior cruciate ligaments can be seen when performing MSKultrasound of the knee joint. Approximately two-thirds of the PCL and the distal one-third of the ACL may be seen, butultrasound is not considered the best imaging modality when injury to these two ligaments is suspected. The visualizedportions of the ACL and PCL are hypoechoic when compared to the extra-articular collateral ligaments, which arehyperechoic compared to surrounding tissues(Thompson JA, et al 2006**).**

2.3.1.3 Anterior Cruciate Ligament tears

The Anterior Cruciate Ligament (ACL) is an important ligament in the knee required for stability. If the ACL is injured, then you may have problems with the knee giving way on you, or with you having feelings of the knee being unstable.

Once the ACL has been injured then there is a high chance or risk that you may damage other structures in the knee such as articular cartilage (the cartilage that forms the lining of the knee joint) which may lead to earlier arthritis, and / or the meniscus(the piece of cartilage that sits between the two bones) see (Fig 2-13).

(www.melbournekneeortho.com.au/services/anterior-cruciate-ligament-injury#sthash.FkuvdhoN.dpuf)

- It is a ligament located in the middle of the knee.
- There are two main ligaments in the middle of the knee, the anterior cruciate ligament and the posterior cruciate ligament. It is called anterior because it is located anterior (in front) of the posterior cruciate ligament.
- A ligament is tissue that runs from one bone across a joint and connects with another bone.

- The purpose of a ligament is to provide stability to a joint.
- For the ACL that stability is to stop the tibia (leg bone) moving in front of the femur (thigh bone). The ACL also functions to limit rotation of the knee joint.

The ACL is most commonly injured whilst playing sports. It occurs when a force is applied to the knee that is greater than the ACL can handle and the ligament then ruptures.

Most commonly occurs with:

- Twisting / turning (Pivoting)
- Contact
- Landing awkwardly from a leap or jump
- When the foot is planted to the ground

In Victoria the most common sports for injury are those that involve mechanisms where the knee is placed under stress. These include:

- Netball
- Basketball
- Soccer ball
- Rugby
- Rugby League
- Martial Arts
- Snow sports

There are other ways that you can injure your ACL and these include:

- Motor vehicle accident
- Work injury

- A direct blow to the side of the knee

Symptoms

- **Swelling** - The most common symptom is swelling. This occurs because when the ACL ruptures, bleeding occurs into the knee joint. Swelling does vary and those that ice the knee straight away will have less swelling. The swelling tends to come up straight away (ie.. Within the first couple of hours).
- **Pain** - The feeling of pain will be all around the knee initially.
- **Sense of disruption -** Patients commonly report that they felt as though “bones had moved” “my knee dislocated” “my knee was at a funny angle or position”.
- Patients will report (or those who were around them) - A snap or a popping sensation.
- Patients generally speaking are not able to put weight on their knee (weight-bear) after an injury.
- If the injury occurs whilst playing sports, nearly everyone cannot continue playing.
- Those who have had an ACL reconstruction already, will report similar symptoms if they rupture their reconstruction.

There may be feelings of:

- **Locking / catching** (the meniscus or menisci could be damaged).
- **Giving way / giving out** episodes (as the ACL is injured the stability of the knee is affected. It could also be a pain response).

Examination / Signs

- **Effusion (swelling)** - This is normally moderate to large when the injury is seen within the first couple of weeks. The swelling is into the knee joint and always contains blood.
- **Limp** - Patients will walk with a painful limp -They may even need crutches initially.
- **Muscle wasting / weakness** -The Quads muscles (muscles at the front of the thigh) will start to lose their muscle bulk within 1 week of injury. This occurs because the knee joint is not being moved in its normal way.
- **Hamstrings tightness** -The Hamstrings (muscles at the back of the thigh) may feel tight as they try to protect the knee. Some patients will not be able to get their knee out straight because of this.

(http://www.melbournekneeortho.com.au/services/anterior-cruciate-ligament-injury#sthash.FkuvdhoN.dpuf)

2.3.1.4 Posterior Cruciate Ligament Tear

Posterior Cruciate Ligament (PCL) is located deep within the knee joint and PCL injuries are quite common knee injuries in sport. The PCL is larger and stronger than the Anterior Cruciate Ligament (ACL). It passes backwards and downwards from the bottom of the thigh bone to the top of the shin bone. Its main purpose is to prevent the shin bone slipping backwards on the thigh bone.

PCL injuries are usually caused by a blow to the front of the upper shin. In motor vehicle accidents, this occurs as the top of the shin strikes the dashboard. In sports, a PCL injury can occur when an athlete falls to the ground on a bent knee, causing the upper shin to strike the ground first. A prominent Tibial Tuberosity (lump just below the knee cap) resulting from previous Osgood Schlatter's disease may enhance the impact when the tibia strikes the ground.

One study estimates that PCL injuries make up as many as 20% of all knee ligament injuries, but the diagnosis is often missed. This is due to the fact that many people can function normally without a PCL. However, detection of PCL injury is important because untreated PCL ruptures will lead to significant degeneration (i.e. osteoarthritis) of the knee and disability in later life.

2.3.1.4.1 PCL Tear Signs & Symptoms

Unlike those with ACL injuries, patients who have PCL injuries do not usually experience much knee pain or swelling. They usually report vague symptoms such as unsteadiness or insecurity of the knee. Patients who have longstanding PCL injuries that have never been diagnosed may report pain around the kneecap.

There are a number of physical tests that can be used to detect a PCL injury. One of the most widely recognised is the posterior drawer test. The test is done with the patient lying on their back, the knee bent to a right-angle, and the foot flat on the table. In this position, the Tibial Plateau should lie 1 cm in front of the Femoral Condyles. The degree of PCL injury is determined by the extent that the tibia can be pushed backwards by the examiner:

No Injury, the Tibial Plateau remains 1 cm in front of the Femoral Condyles.

Grade 1 Injury, the Tibial Plateau moves backwards but stays in front of the Femoral Condyles.

Grade 2 Injury, theTibial Plateau moves backwards to lie level with the Femoral Condyles.

Grade 3 Injury, theTibial Plateau moves backwards to lie behind the Femoral Condyles.

2.3.2 Chronic knee joint disease:

Chondromalacia patella (also called patellofemoral syndrome): Irritation of the cartilage on the underside of the kneecap (patella), causing knee pain. This is a common cause of knee pain in young people.

Knee osteoarthritis: Osteoarthritis is the most common form of arthritis, and often affects the knees. Caused by aging and wear and tear of cartilage, osteoarthritis symptoms may include knee pain, stiffness, and swelling.

Knee effusion: Fluid buildup inside the knee, usually from inflammation. Any form of arthritis or injury may cause a knee effusion.

Meniscal tear: Damage to a meniscus, the cartilage that cushions the knee, often occurs with twisting the knee. Large tears may cause the knee to lock.

ACL (anterior cruciate ligament) strain or tear: The ACL is responsible for a large part of the knee's stability. An ACL tear often leads to the knee "giving out," and may require surgical repair.

PCL (posterior cruciate ligament) strain or tear: PCL tears can cause pain, swelling, and knee instability. These injuries are less common than ACL tears, and physical therapy (rather than surgery) is usually the best option.

MCL (medial collateral ligament) strain or tear: This injury may cause pain and possible instability to the inner side of the knee.

Patellar subluxation: The kneecap slides abnormally or dislocates along the thigh bone during activity. Knee pain around the kneecap results.

Patellar tendonitis: Inflammation of the tendon connecting the kneecap (patella) to the shin bone. This occurs mostly in athletes from repeated jumping.

Knee bursitis: Pain, swelling, and warmth in any of the bursae of the knee. Bursitis often occurs from overuse or injury.

Baker's cyst: Collection of fluid in the back of the knee. Baker's cysts usually develop from a persistent effusion as in conditions such as arthritis.

Rheumatoid arthritis: An autoimmune condition that can cause arthritis in any joint, including the knees. If untreated, rheumatoid arthritis can cause permanent joint damage.

Gout: A form of arthritis caused by buildup of uric acid crystals in a joint. The knees may be affected, causing episodes of severe pain and swelling.

Pseudogout: A form of arthritis similar to gout, caused by calcium pyrophosphate crystals depositing in the knee or other joints.

Septic arthritis: Bacterial infection inside the knee can cause inflammation, pain, swelling, and difficulty moving the knee. Although uncommon, septic arthritis is a serious condition that usually gets worse quickly without treatment (webmd.com, 2015).

2.3.2.1Tendonitis

Similar to the topic of tendon tears, we've rehashed tendonitis almost to death too, so I'll just spend a few momentsreviewing several types of tendonitis related to the knee. Jumper's knee is the most common term applied to anyinflammatory process affecting the patellar tendon (ligament). The site of inflammation usually involves the first fewcentimeters distal to the insertion of the ligament into the apex of the patella. Treatment of this common problem isusually with a combination of R.I.C.E. (Rest, Ice, Compression and Elevation).

When the symptoms of Jumper's knee present in an adolescent, the condition is known as Osgood-Schlatterdisease which describes inflammation of the patellar ligament and its insertion into the immature anterior tibial tuberosity,more frequently in ten to fifteen year old males, especially following sporting activity. Patellar tendon inflammation inthese patients is often accompanied by fluid in the superficial and/or deep infrapatellar bursa.Less frequently, patellar tendonitis may affect the distal segment of the patellar ligament, near its insertion into the tibial tuberosity and rarely, the inflammatory process may affect the entire tendon.

2.3.2.2 Bursitis

Recall that the function of a bursa is to decrease friction between any two anatomical surfaces that are moving in differentdirections, typically where muscles, tendons and ligaments glide over bones. The term bursitis refers to the inflammationof a bursa. Bursal swelling and fluid distension occurs most often as a result of chronic friction, or overuse such as may beseen in someoccupations or in athletes, and also when excessive pressure is put on a bursa for extended periods of time.Let's look at a couple of common forms of bursitis affecting the knee, beginning with an occupational form known asHousemaid's knee (prepatellar bursitis).Housemaid's knee is an inflammation of the prepatellar bursa caused by excessive pressure put on the area due to chronickneeling (hence the name). It occurs in housekeepers, gardeners, tile or flooring layers and roofers or others with similaroccupations. It is easily prevented by wearing good kneepads. Bursitis may also be secondary to disease processes like arthritis or gout, in which case internal echoes may be seenfloating within the bursal fluid. Finally, foreign bodies may also be responsible for bursitis in superficial bursae like theprepatellar bursa (Thompson, et al, 2006).

2.3.2.3Meniscal Pathology

Asmentioned earlier, the extra-articular components of the knee joint are better seen with ultrasound than intra-articularstructures like the menisci. Therefore, MRI remains the best imaging modality when meniscal damage is suspected.However, the external portion of each meniscus, including the base, can be imaged when performing MSK ultrasound ofthe knee, so let's review a little meniscal pathology.A normal meniscus appears like an echogenic, inverted triangle with the base adjacent to the collateral ligaments of theknee and the apex projecting into the knee joint. In general, the bodies and anterior horns of the menisci are better seenthan the posterior horns, which are relatively deeper in the knee. When imaging the menisci, remember to utilize the variable focus capabilities of the ultrasound system. Use multiple focalzones when possible and position the focal zone deeper than when imaging the collateral ligaments. Also, stressing theknee while scanning in real time often optimizes visualization of the menisci. Finally, the posterior horns of the meniscimay be better visualized with a curved array transducer which conforms more naturally to the popliteal fossa (Thompson, et al, 2006).

2.3.2.4Popliteal Artery Aneurysm and DVT

The popliteal artery is located behind the knee. Aneurysms (widening of the artery) can occur in this location. Patients rarely have any symptoms due to the aneurysm. It is usually discovered on routine physical examination by a physician. The cause of these aneurysms is unknown. They tend to occur in older men and women (more common in men) and occur in both legs about 50% of the time, see(fig. 2-12)(2015 http://www.vasculardoc.com/popliteal-aneurym.aspx).

If a physician suspects the presence of a popliteal artery aneurysm, an ultrasound exam is usually ordered to confirm the presence of the aneurysm, determine the size, and look for the presence of clot within the aneurysm. Because of the abnormal swirling of blood within the aneurysm sac, blood clot usually forms along the inside wall of the aneurysm. Most of the time, popliteal artery aneurysms cause problems because the blood clot builds up to the point where it shuts down blood flow completely, or because some of the clot within the aneurysm travels down the artery and into the foot. Either of these two events can lead to the need for amputation of the lower leg and foot. This is what makes popliteal artery aneurysms so dangerous. These types of aneurysms rarely rupture, although this can occasionally occur.

After confirmation of the presence of a popliteal artery aneurysm, a determination is made as to whether repair is necessary at that time. Each case is different and a decision must be made by the patient's physician as to whether repair is necessary or whether close follow up and careful observation is the better course. Many issues must be taken into consideration including the size of the aneurysm, condition of the arteries above and below the aneurysm, presence or absence of blood clot within the aneurysm, and the overall health of the patient who has the aneurysm.

Surgical repair is usually quite successful, durable, and can usually be performed with low risk. The best procedure for repair involves an incision on the leg, removal of the popliteal aneurysm and reconstruction of the blood flow to the foot using either a vein or an artificial artery. In recent years, some physicians have recommended stent grafts to repair popliteal aneurysms, particularly in patients who are "not good risks" for the more standard type of repair due to, for example, cardiac or pulmonary conditions. Most experienced vascular specialists regard stenting as a "second choice procedure" reserved for very high risk patients who may not be suitable candidates for open surgery. Stent graft popliteal aneurysm repair does not have the durability of an open repair and closure of the stent occurs in a substantial number of cases within a year or two after the stent is placed. Many specialists also have concerns about placing a metallic stent behind the knee where it will be subject to flexion of the knee joint.

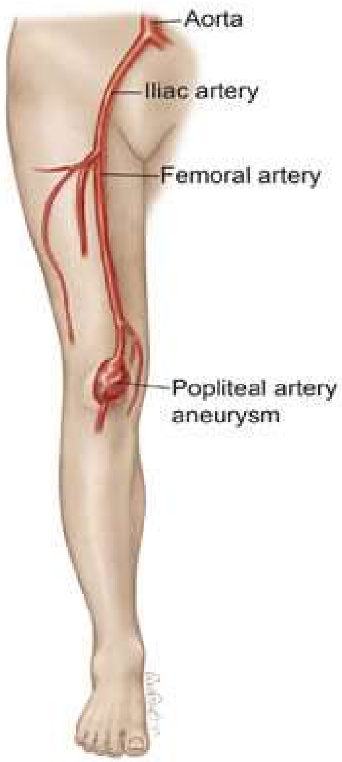


Figure (2-12A) shows Popliteal artery aneurysm (2015 http://www.vasculardoc.com/popliteal-aneurym.aspx)

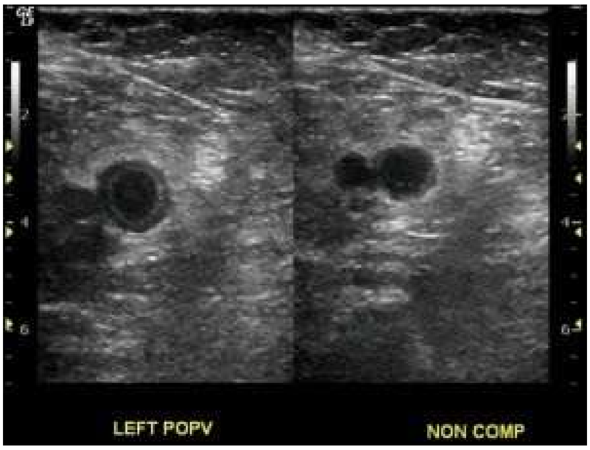


Figure: (2-12B) Popliteal vein DVT

2.3.2.5 Baker's Cyst

Baker's cysts are collections of fluid in the back of the knee which can occasionally be confused with a popliteal artery aneurysm. A Baker's cyst is usually the result of a problem in the knee joint which is causing inflammation of the joint space. Examples are traumatic injuries to the joint or inflammatory conditions such as arthritis. Baker's cysts generally occur in adults over the age of 50, and its treatment consists of correcting the underlying problem in the knee joint which has led to the development of the cyst. Occasionally, the cysts become very large and can press on adjacent structures such as veins resulting in swelling of the entire leg below the knee. In situations such as this, the Baker's cyst is sometimes drained with a needle in order to relieve the pressure created by the cyst. (2015 http://www.vasculardoc.com/popliteal-aneurym.aspx)

2.3.3Knee joint tumors

Soft tissue tumors around the knee joint can be classified as benign and malignant. BenigntumorsInclude lipoma, synovial hemangioma, synovial chondromatosis and pigmented villonodular synovitis.Malignant tumors Include synovial sarcoma and soft tissue sarcoma. Knee joint is the most common site for majority of these soft tissue tumors. These tumors being superficial are usually felt on clinical examination and imaging is necessary to evaluate its morphology, extent, differential diagnosis and post operative follow-up. MRI is the modality of choice as it can characterize the soft tissue better than all other modalities.

2.3.3. 1 Benign tumors:

Include lipoma, synovial hemangioma, synovial chondromatosis and pigmented villonodular synovitis.

2.3.3.1.1 Lipoma:

It is the most common soft tissue tumor seen in the extremity(Francesca, et al 2007) Lipoma can be classified as cutaneous and deep seated, based on its location. Intra muscular lipoma is a rare deep seated lipoma (Keiji, et al 1999)It can be classified as well circumscribed type and infiltrating type, on histology(Mark, et al, 2002). Intra muscular lipomas may compress the adjacent neurovascular bundle causing symptoms. Lipoma and well-differentiated liposarcoma are difficult to distinguish on imaging. Radiological evaluation is mainly aimed at differentiating lipoma from well-differentiated liposarcoma and also to look for fat plane between it and surrounding structures in cases of compression

2.3.3.1.2 Hemangioma:

Hemangioma is the most frequently encountered vascular soft tissue tumor (Joan, et al, 2004)(fig. 2- 13). Soft tissue hemangioma can be classified as cutaneous, subcutaneous, intra muscular and synovial based on the site of origin. Based on the size & type of predominant vessel; Hemangioma can be classified as cavernous, capillary, venous and arteriovenous (Akgun, et al, 2003). Further based on the anatomical relationship to a joint it can be classified as juxtra-articular, intra-articular and intermediate types. Synovial hemangioma is usually seen in early adolescents. Knee is the most common site. It is also reported in elbow, wrist & ankle (Sanghi, et al, 2007).

(Fig. 2- 13) Synovial Hemangioma: PD fat saturated Sagittal(A) image showing bunch of grapes appearance(arrow). TIRM Sagittal (B) & T2 Coronal(C) images demonstrating hyperintense lesions involving the medial retinaculum and extending into quadriceps muscle. This can be characterized as synovial and intramuscular type and juxtra-articular type of hamangioma. T2 Medic Axial(D) image demonstrating fluid- fluid levels(thick arrow).

2.3.3.2 Malignant tumors:

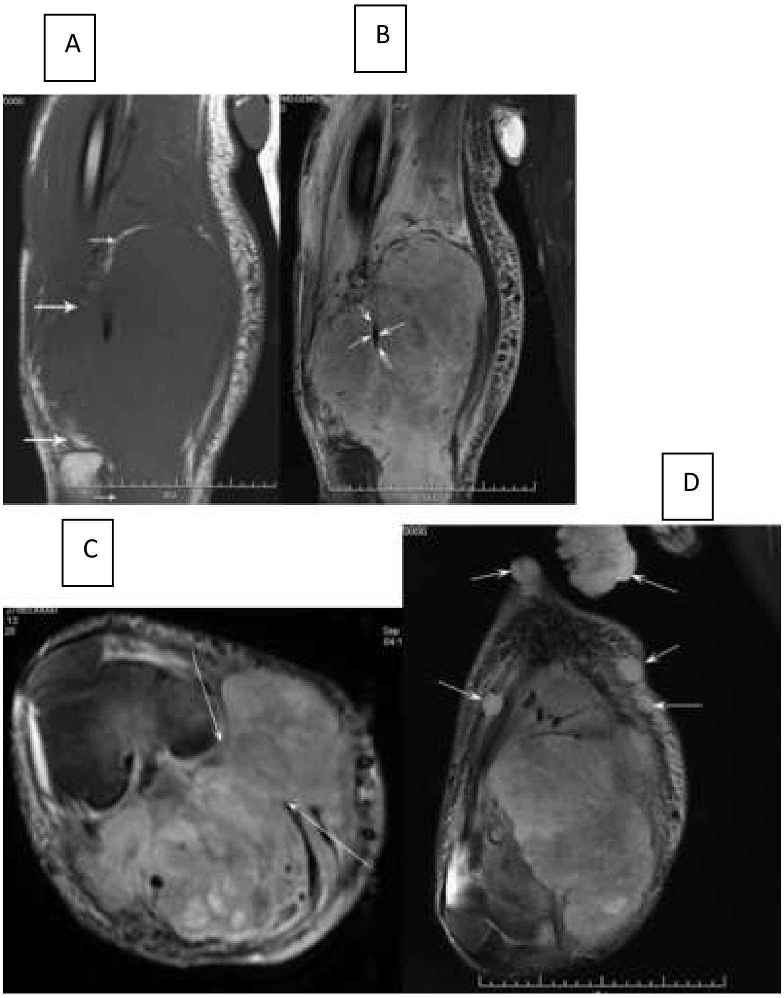
Include synovial sarcoma and soft tissue sarcoma.

2.3.3.2.1 Synovial sarcoma:

Synovial sarcoma is a primary malignant mesenchymal tumor found most commonly in the lower extremities (Trassard, et al, 2001). It is a misnomer as it does not arise from the synovium, but form primitive mesenchymal cells in the extra articular soft tissue close to the synovium. Pathologically synovial sarcoma display dual epithelial and mesenchymal differentiation (Mark, et al, 2006) It has three main histological sub types namely; Biphasic, monophasic and poorly differentiated. It usually affects adolescent and young adults between 5 – 40 yrs. Knee is the most common site followed by foot and ankle (Deshmukh, et al, 2004). Clinically the patient presents with slowly growing palpable mass. Radiological evaluation is mainly aimed at evaluating the extent and staging of tumor besides suggesting a specific diagnosis. MRI is the imaging modality of choice.

2.3.3.2.2 Soft tissue sarcoma:

(Fig. 2-14)these are a histological diverse group of malignant tumors which predominantly arise from soft tissue. There are more than 50 various sub types described in literature(Brennan, et al, 2001). Most common of them are liposarcoma, leiomyosarcoma, malignant fibrous histiocytoma [MFH], fibrosarcoma and synovial sarcoma(Neil, et al, 2003). Synovial sarcoma has been described earlier. Thigh is most common site for soft tissue tumors followed by pelvis, arm or trunk(Henry, et al, 2005). These tumors are usually seen in adults(Hildur, et al, 2004). Imaging in these tumors is mainly indicated to evaluate the extent, staging; morphological characterization and post operative& post chemo- radiotherapy follow up. Specific diagnosis is arrived mostly after Histopathology.



(Fig. 2-14): Soft tissue Sarcoma: T1 Sagittal(A) image showing a large hypointense mass in the posterior aspect of the thigh and extending into the popliteal fossa(multiple arrows). T2 W Sagittal (B) image showing a hetrogenous signal intensity mass encasing the Superficial Femoral Artery (arrows). PD fat saturated Axial(C) image demonstrating extension of mass into the medial compartment of thigh (arrows). T2 W Coronal(D) image demonstrating multiple skin nodules(arrows). Pathologically this was a recurrent spindle cell sarcoma.

2.4 Ultrasound of the Knee

Contrary to the beliefs of many of the structures of the knee joint can be examined quite capably with musculoskeletal ultrasound. As the largest joint in the human body, injury to the knee joint is more common than any other articulation and with its numerous extra-articular structures, there is plenty to examine. Every examination should begin by taking the patient's history. Once the patient's symptoms are known, it is often possible to streamline the ultrasound examination to specific areas of the knee.

2.4.1 Patient HistoryPotential Findings

Pain when rising from a sitting position or during stair climbing

Patellofemoral disease motor vehicle accident (MVA)trauma (dashboard injury)

PCL tear or dislocation

Pain or locking of knee after squatting

Meniscal tear

Popping sound after a pivoting motion during a non-contact injury

ACL tear

Popping sound during contactCollateral ligament, meniscus or patellar dislocation

Acute swelling

ACL, peripheral meniscal tear, osteochondral fracture with or without capsule tear

Knee "gives out"

Ligamentous laxity, patellar subluxation and/or dislocation, meniscal tear, chondromalacia of the patella.

Now that we have an idea what we're looking for, let's take a look at the state of the art of knee ultrasound, beginning with a review of patient positioning and examination technique. Patient Positioning and Examination Technique As we've stated frequently before, high resolution ultrasound imaging of the knee requires a high frequency, linear transducer in the 10-12 MHz range. Curved array transducers with slightly lower frequencies in the 7.5-10 MHz range may be useful to examine the posterior knee with its curved surface and deeper structures. Broad band transducers with variable frequency and extended field of view imaging capabilities are also very useful, but are not absolutely necessary (Thompson, et al 2006).To begin the examination, the patient lies comfortably in either a supine, sitting or semi-reclining position. The knee should be flexed about 15-20 degrees with a small pillow placed behind the knee in order to stabilize and immobilize the leg. The examiner should sit adjacent to the patient, allowing easy access to the knee under investigation. Once positioned, the knee should be imaged from four different approaches, including:

- **Anterior approach**
- **Medial approach**
- **Lateral approach**
- **Posterior approach**

Anterior Approach

Examination of the knee begins from an anterior approach, with the patient in a supine, sitting or semi-reclining position.

The transducer should be positioned in a longitudinal orientation, directly over the suprapatellar region. The knees should be stabilized by placing a small pillow behind them, also causing them to flex slightly. Beginning in the midline, the following structures should be evaluated;

- **patellar and quadriceps tendons**
- **supra-patellar recess, bursa and fat pad**
- **patellar retinacula**
- **cortical surface of the femur and tibia**
- **anterior cruciate ligament (distal segment)**

First, the quadriceps tendon is identified over the distal femur, forming a large portion of the extensor mechanism of the knee (a term you should become familiar with). The extensor mechanism of the knee consists of the quadriceps muscle group, quadriceps tendon, patella, patellar retinaculum, and patellar ligament and is a common site of knee injury.Recall that the quadriceps tendon is the musculotendinous junction of the four anterior thigh muscles; the vastuslateralis, vastusmedialis, vastusintermedius and the rectus femoris, which inserts on the upper border of the patella. Like all tendons, the quadriceps tendon demonstrates a typical fibrillar pattern. It is bordered anteriorly by subcutaneous fat and posteriorly by the suprapatellar fat pad and bursa(Thompson, et al 2006**)**.

Next, the suprapatellar bursa (sometimes referred to as the suprapatellar recess) extending 5-6 cm. above the superior margin of the patella is examined. The bursa lies between the suprapatellar fat pad anteriorly and the prefemoral fat pad posteriorly. Up to 2 mm. of fluid can normally be seen within the suprapatellar bursa. It may be necessary to flex the knee to about 30° in order to identify any fluid that may be present. The patella lies within the intratendinous junction of the quadriceps femoris tendon and the patellar ligament3 (or tendon), extending from the inferior aspect of the patella to the anterior tibial tuberosity. Deep to the patellar tendon, just anterior to the joint space, lies Hoffa's fat pad, whichcontrasts the patellar tendon sandwiched anteriorly between it and the subcutaneous fat. The prepatellar bursa lies between the subcutaneous fat and the patella and is normally not identified during MSK ultrasound examination.**(**Whittaker, et al 2003**).**Before moving on to the next structure, remember to image the superficial and deep infrapatellar bursae at the insertion of the patellar tendon into the tibia. A small amount of fluid is often found within the deep infrapatellar bursa lying between the patellar tendon and the tibia. With all this talk of bursae, , on the next page, which illustrates each of the bursae just mentioned. The medial and lateral patellar retinacula, serving to immobilize the patella, should be imaged before concluding examination from the anterior approach, should assist in identifying some of the structures seen while scanning from the various approaches.

Finally, the hyaline cartilage covering the anterior femoral condyles should be imaged, after flexing the knee maximally to optimize visualization. The cartilage appears as an anechoic space between the bony surface of the femoral condyles and the surrounding tissues. While the knee is in this flexed position, the distal segment of the anterior cruciate ligament or ACL can also be partially visualized, inserting into the anteromedial tibial plateau, using Hoffa's fat pad as an imaging window **(**Whittaker, et al 2003**).**

You will often see the patellar ligament referred to as the patellar tendon, which many consider a misnomer because, like all ligaments, it connects bone to bone. However, some anatomists consider the patella a sesamoid bone living within a tendon, so refer to the patellar ligament as a tendon. Either term is acceptable.

Bursae of the Knee

Most of the major bursae of the knee are illustrated in (Fig. 2-15) below. These include the anterior bursae; including the suprapatellar bursa located between the quadriceps tendon and the femur, the prepatellar bursa located between the patella and the skin, the retropatellar bursa located between the patellar ligament and the proximal tibia and the pretibial bursa located between the tibial tuberosity and the skin. The medial bursae illustrated include; the gastrocnemius bursa located between the medial head of the gastrocnemius and the joint capsule and the pes anserinus bursa located betweenthe tibial collateral ligament and the gracilis, sartorius and semitendinosus tendons. Finally, the popliteal bursa is illustrated posterolaterally, between the popliteus tendon and the lateral femoral condyle **(**Whittaker, et al, 2003**).**The suprapatellar, gastrocnemius and popliteal bursae may communicate with the joint space.

A

B

Figure(2–15):A:-Scanningbursae of the kneeB:-Bursae of the knee joint

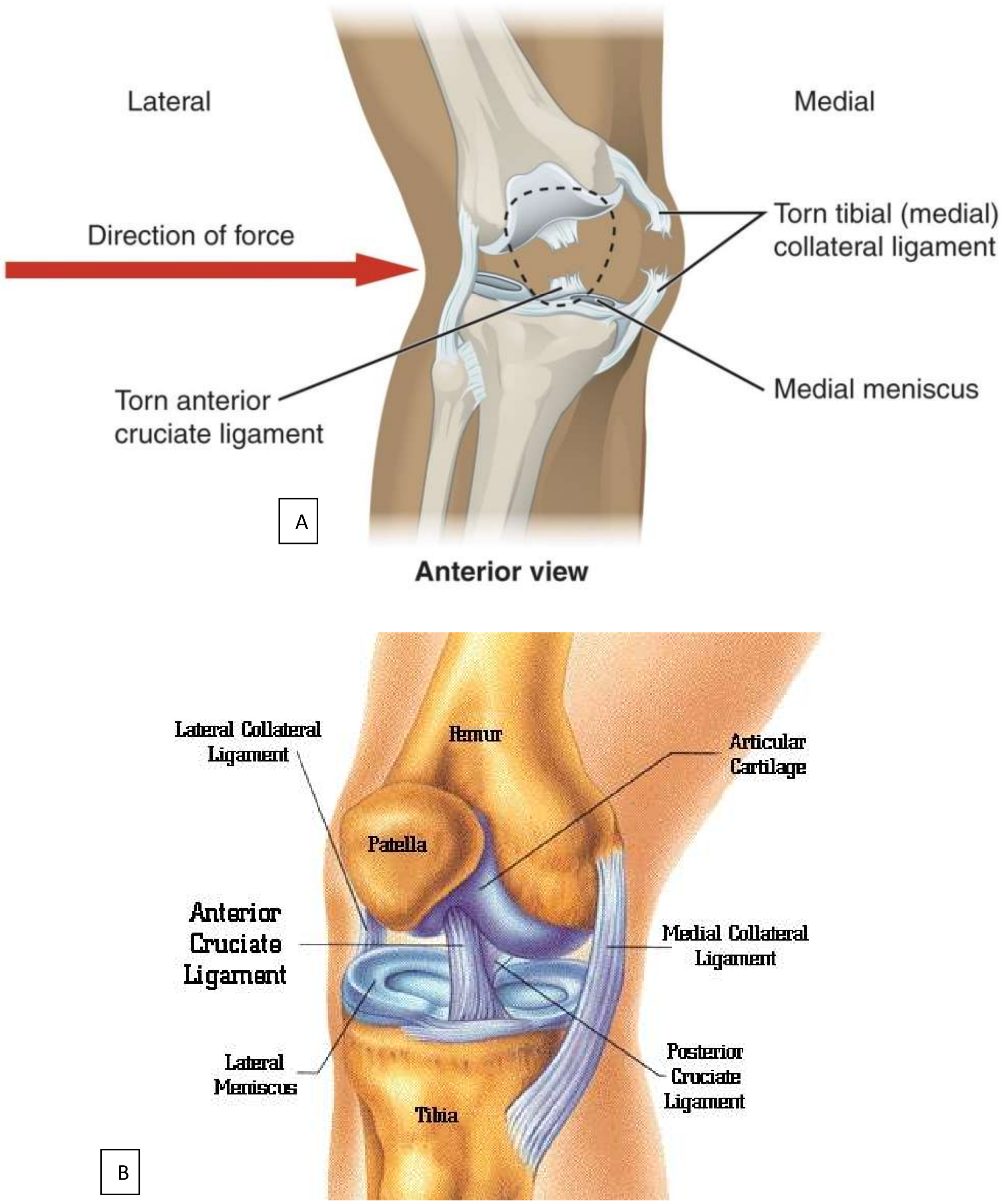
Medial Approach

The medial side of the knee is seen to best advantage with the patient in a semi-decubitus position, with the knee externally rotated and the hip slightly flexed. A soft pillow or foam wedge may be used to support the knee. When imaging the knee from a medial approach, the following structures should be assessed; (fig. 2-16).

(Whittaker, et al, 2003**)**

- **medial collateral ligament (MCL) or tibial collateral ligament**
- **adductormagnus insertion**
- **pesanserinus tendons and bursa**
- **medial meniscus**

The structure of greatest interest on the medial aspect of the knee is the medial collateral ligament or MCL as it is often referred to. Originating on the medial femoral condyle, it inserts distally on the medial tibial condyle. Ultrasonically, the MCL is trilaminar in appearance, with distinct, fibrillar superficial and deep layers, separated by a layer of fibro-adipose tissue.



Figure(2–16): A anterior view B medial side of the knee

(http://philschatz.com/anatomy-book/resources/918_Knee_Injury.jpg)

The superficial layer of the MCL attaches on the femur proximally and the tibia distally. The deep layer of the MCL is continuous with the medial meniscus, aiding in the identification of the meniscus. Also, you should be aware that medial meniscus and MCL pathology often coexists, and the MCL (along with the ACL) is one of the two most commonly torn ligaments of the knee (Fig. 2- 13 A).

Near the origin of the MCL, the adductor tubercle of the femur is an easily identified bony landmark, serving as the site of insertion of the adductor magnus muscle. Also nearby, the next structure of interest is the pes anserinus, an anatomic term used to identify the insertion of three conjoined tendons into the anteromedial, proximal tibia. From anterior to posterior, the pes anserinus is made up of the tendons of the sartorius, gracilis, and semitendinosus muscles. This conjoined tendon lies superficial and anterior to the tibial insertion of the medial collateral ligament (MCL) described above and is a common site of bursitis affecting the pes anserine bursa underlying the conjoined tendons and separatingthem from the head of the tibia. The normal pes anserine bursa is not seen ultrasonically.Finally, before moving on to the next approach, the medial meniscus and medial joint space should be imaged to the extent possible utilizing a coronal plane. In the long axis, the meniscus appears as a triangular, intraarticular structure, with its apex pointing into the joint, while on the transverse view, the meniscus appears crescent shaped. The anterior horn and body of the medial meniscus are best seen from the medial aspect of the knee. We shall review a few high resolution images of the menisci a little later on. Let's move on to the lateral approach next.

Lateral Approach

Examination of the lateral knee is best performed with the patient in a lateral decubitus or semi-decubitus position, with the knee internally rotated and supported as mentioned earlier. The lateral approach to the knee provides optimal visualization of the following structures;

- **bicepsfemoris tendon**
- **lateral collateral ligament (LCL) or fibular collateral ligament**
- **lateral meniscus**
- **iliotibial band**

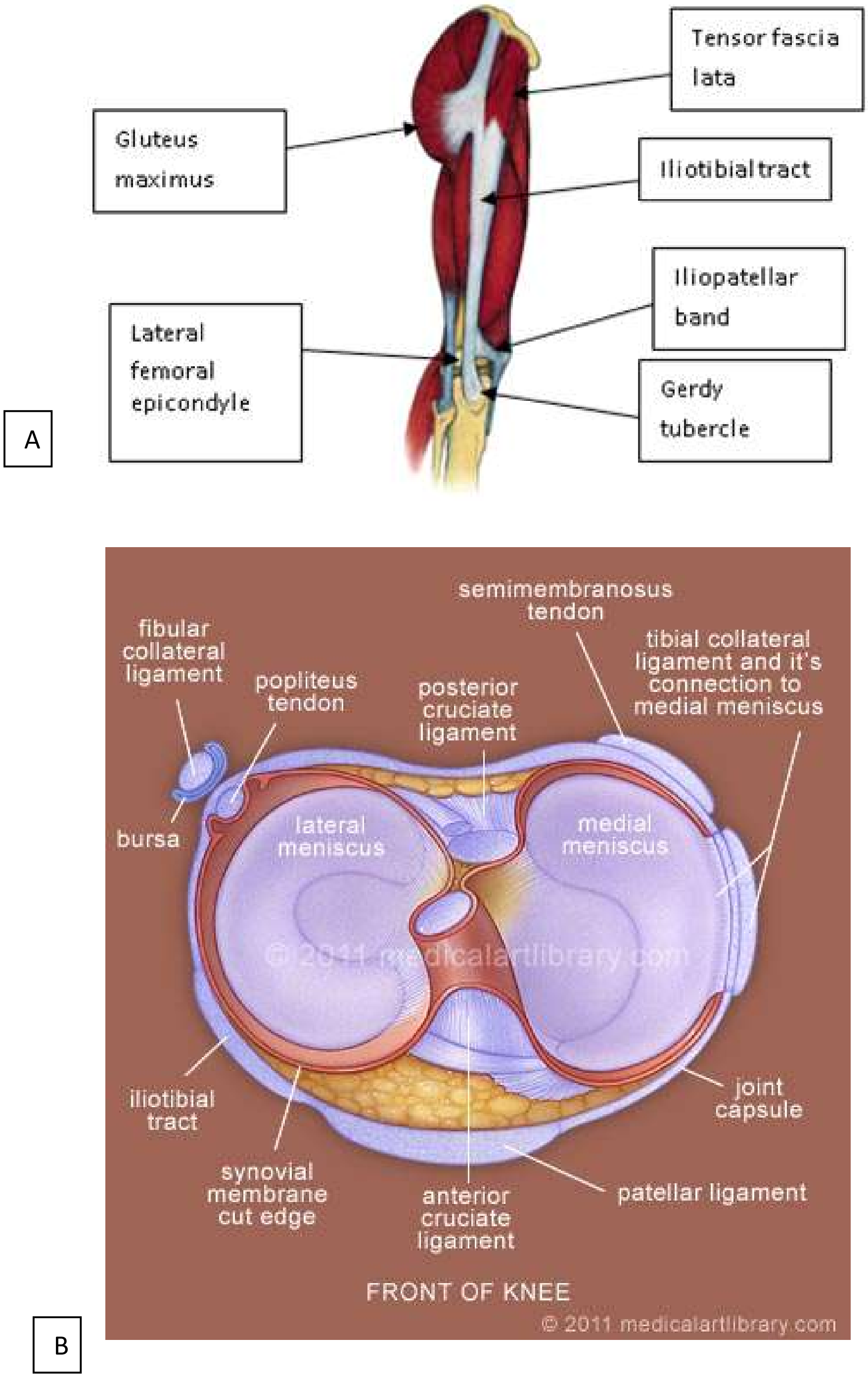
It is helpful to first identify a few bony landmarks on the lateral side of the knee including; the lateral femoral condyle, the head of the fibula and Gerdy's tubercle on the anterolateral surface of the proximal tibia. These structures can be identified with the transducer in a long axis in the coronal plane.

The lateral collateral ligament or LCL and biceps femoris tendon are the structures of greatest interest from this approach and the nearest bony acoustic landmark for locating their insertions is the head of the fibula, which lies inferior and posterior to the joint line defined by the femorotibial articulation. The short and long heads of the biceps femoris muscle combine distally to form a conjoint tendon that inserts onto the styloid process of the proximal fibula along with the lateral collateral ligament. In other words, the biceps tendon and the lateral collateral ligament share a common insertion into the head of the fibula.**(**Whittaker, et al 2003**).**

Similar to its medial counterpart, the anterior horn and body of the lateral meniscus can be imaged from a lateral approach. Unlike its medial counterpart, the lateral meniscus is separated from the LCL by the popliteus tendon which attaches the popliteus muscle to the femur at a point anterior and distal to thefemoral attachment of the LCL. You should also take a moment to evaluate the lateral joint space at this point.

Finally, the insertion of the iliotibia! band or tract (which originates on the iliac crest) can be identified at Gerdy's tubercle, located near the anterolateral margin of the tibial condyle. Take a moment to locate it in (Fig. 2-17) before we move on to discuss the final approach from the posterior aspect of the knee.

After imaging both sides of the knee, the examination concludes by examining the posterior aspect of the knee, or popliteal fossa. It may be useful to change the transducer to a curved linear array at this point, in order to improve contact with the naturally curved skin surface behind the knee. Also, a lower frequency transducer may be more effective, especially in obese patients.



Figure(2–17): A Iliotibial tract end at Gerdy's tubercleB cross sectional anatomy of the knee

Posterior Approach

Obviously, examination of the knee from a posterior approach requires turning the patient to a prone position, although the patient may also be examined while upright. Probably the most common reason for investigating the popliteal fossa is to confirm or rule out the presence of a Baker's (or popliteal) cyst. Also, the following structures can be evaluated from a posterior approach;

- **Semimembranosus gastrocnemius bursa (for Baker's cyst)**
- **Posterior horns of the medial and lateral menisci**
- **Posterior cruciate ligament**
- **Cartilage of the medial and lateral femoral condyles**
- **Popliteal vessels**

Since evaluation of the knee to confirm the presence of a Baker's cyst is so common, we shall discuss the pathology and the procedure used to investigate it in more detail now.

Baker's cysts occur within the medial aspect of the popliteal fossa. Approximately forty percent of patients have a communication between the knee joint and the bursa located between the gastrocnemius and semimembranosus tendons. Any process that causes the knee joint to swell in these individuals (i.e. arthritis, infection or trauma) can lead to fluid being forced into the bursa, causing it to enlarge and become a Baker's cyst. It is extremely important to use color or power Doppler to verify the lack of flow in any structure suspected to be a Baker's cyst in order not to miss a popliteal aneurysm or dilated vein. Finally, small Baker's cysts may only become evident after a series of knee flexion/extension maneuvers (like pumping a bellows), so remember to exercise the knee **(**Whittaker, et al, 2003**).**Similar to the medial approach, the posterior horns and bodies of the medial and lateral menisci are visible from the popliteal fossa. They also appear as triangular, hyperechoic structures within the joint space. The LCL is often better seen with the patient prone with their leg fully extended, so take a moment to image it once again.

Finally, with the knee in full extension, about two thirds of the posterior cruciate ligament (PCL), which is the stronger of the two cruciate ligaments, may be seen as a hypoechoic triangular structure along the downslopingintracondylar area of the tibia. Remember to orient the transducer in the oblique plane of the PCL. We are fortunate that many intraarticular structures are surrounded by fat, which contrasts the structures to some extent, making them more visible ultrasonically. **(**Whittaker, et al, 2003**)**

2- 5 MRI of the knee joint

MRI produces high-quality tomographic images of the body in any plane by portraying the distribution of hydrogen nuclei within the tissue imaged. MRI does not involve ionizing radiation; it uses radiofrequency pulses and a strong magnetic field to create images. When the patient is placed in a strong magnetic field, the hydrogen nuclei (protons) in the body align with the axis of the external magnetic field. Radiofrequency pulses are applied to change the orientation of aligned protons. After the cessation of the radiofrequency pulses, the excited protons relax and return to their initial state by emitting electromagnetic energy. The emitted electromagnetic energy is detected, and ultimately converted into the MR image (Wood, et al, 1999).

The MRI signal intensity (brightness) of a particular tissue depends on the number of the mobile hydrogen nuclei and on two relaxation times: T1 and T2. Tissues or materials with low proton density, such as calcium, air, cortical bone, tendons, menisci, and ligaments, exhibit low or no signal intensity in all pulse sequences. Fat, fluid, and edematous tissues containing high proton density have a variable appearance, depending on the pulse sequence. (Peterfy, et al, 1998) Relaxation time refers to the time required for tissue magnetization to return to equilibrium conditions after the radiofrequency pulse is turned off. T1 relaxation time represents the time the hydrogen protons take to return to the axis of the external magnetic field; T2 relaxation timedepends on the time the protons take to dephase. T1 and T2 values, expressed in milliseconds, are constant for a particular type of tissue. An MR image is said to be T1-weighted if image contrast is based on T1 differences between tissues. Similarly, image contrast on a T2-weighted image is based on different T2 relaxation times of tissues. (Tung, et al, 1997). The type of MRI is determined by altering (1) the repetition time (TR), the time that elapses between applying sequential radiofrequency pulses to the patient, or (2) the echo time (TE), the time interval between the incident radiofrequency pulse and when the signal is recorded. A T1-weighted imaging sequence uses short TR and TE, and T2-weighted images are produced with long TR and TE. A third type of image is a proton density or intermediate- weighted image with long TR and short TE. A typical MRI examination includes series of different types of imaging sequences; T1-weighted and proton density – weighted images provide anatomic information, and T2-weighted and inversion recovery images are sensitive to fluid and to pathologic processes. Although MRI provides great inherent soft tissue contrast, intravenous contrast agents may be used to enhance further the contrast difference between normal and pathologic or vascular tissues. The most widely used agents are gadolinium compounds, which have a T1-shortening effect on nearby water protons. This effect results in increased signal intensity on T1-weighted images. (Paley, et al, 2001) Uptake depends on tissue vascularity and capillary permeability. Gadolinium also is used in dilute solution as an MRI arthrographic contrastagent, although it has not been approved by the U.S. Food and Drug Administration for this use.

Clinical Application

MRI is the best available imaging modality that can directly display the osseous, cartilaginous, and soft tissue components of the joint simultaneously. This uniqueness of MRI derives from its excellent soft tissue contrast. Application of MRI in the assessment of arthritis has increased rapidly in clinical practice and research. Many factors have contributed to this increase, including better access to scanners, improved resolutionof scanners, and development of new MRI sequences for evaluating different tissues(Mc, et al, 2001). MRI offers several distinct advantages over conventional radiography and clinical examination in evaluating early RA. MRI is capable of showing inflammatory synovitis with or without contrast enhancement. MRI detects bone erosions in early RA before they appear on plain radiographs. Bone marrow edema is another important MRI finding associated with inflammatory arthritis and is thought to be a forerunner of erosion. This valuable information provided by MRI may be used to improve diagnostic accuracy, predict prognosis, and monitor the effectiveness of therapies in clinical practice (Savnik, et al,2002), & (Mc, et al, 2000).

In the near future, MRI is likely to play a major role as a prognostic marker and as an outcome measure in the management of RA. To achieve these goals, further development
is required in terms of longitudinal studies and standardization of MRI scanning protocols, nomenclature, and scoring systems to make them reproducible and reliable (Taouli, et al 2002). In addition to the potential applications of MRI mentioned previously, the most widely accepted, practical application of MRI in inflammatory arthritis is in evaluation of some of the complications that may arise because of the disease or its treatment, such as tendon tears, insufficiency fractures, osteonecrosis, and brainstem and spinal cord compression . At present, the main drawbacks of MRI are its high cost and limited availability. MRI requires a longer scan time compared

with most imaging modalities. Patients have to stay still during the scanning procedure because motion often degrades the image. MRI is contraindicated in patients with cardiac pacemakers, certain types of aneurysm clips, cochlear implants, and intraocular metallic foreign bodies.

Table (2-1): Examples of tissue appearance on common MRI imaging sequences

	T1 weighted	T2 weighted	STIR
Bone cortex and calcification	Very low signal	Very low signal	Very low signal
Bone marrow	High signal	High signal	Low signal
Cartilage	Iso signal to the tissue	Slightly low signal	Iso signal
Joint effusion	Iso signal to the tissue	High signal	High signal
Acute hemorrhage	Low to iso signal	Low to iso signal	Low to iso signal
Sub acute hemorrhage	High signal	High signal	Various signal
Hemosiderin	Very low signal	Very low signal	Very low signal
fat	High signal	High signal if FSE	Low signal

(HIROSHI, et al 2004)

2.6 Previous studies:

Study done by (E. Wakamuke, et al 2005) titled: Experience with Ultrasound of the Knee Joint at Mulago Hospital, Uganda:A cross sectional descriptive study of the sonographic pattern of knee joint pathology was performed at Mulago Hospital from July 2004 –February 2005. A total of 107 consecutive patients referred to the Radiology department with knee joint pathology were studied. The patients' socio-demographic data, clinical history and physical examination were recorded.

The sonographic appearance of joint fluid, synovitis , loose bodies, bursae and cysts, tendon, mensci and ligament pathology were recorded. The mean age was 38.0 and median 36 years. The commonest presenting symptoms were painful swelling of the knee 55(51.4%), pain 39 (36.4%), swelling and inability to move were 6 (5.6%). Sonographic features revealed osteoarthrosis was the most frequent 22(59.5%), loose bodies were 7 (18.9%) and fractures 2(5.4%).

Study done by (Catherine, et al 2003) titled:Periarticular Lesions Detected on Magnetic Resonance Imaging Prevalence in Knees With and Without Symptoms shows :

Peripatellar lesions (prepatellar or superficial infrapatellar) were present in 12.1% of the patients with knee pain and ROA, in 20.5% of the patients with ROA and no knee pain, and in 0% of subjects with neither ROA nor knee pain (P _ 0.116). However, other periarticular

lesions were present in 14.9% of patients with both ROA and knee pain, in only 3.9% of patients with ROA but no knee pain, and in 0% of the group with no

knee pain and no ROA (P _ 0.004).

study done by (Cüneyt, et al ,2008) Titled Ultrasonographic Assessment of Knee in Patients with Rheumatoid Arthritis

In the comparisons of the results of US and MRI examinations, both modalities were mostly concordant. A significant rate of concordance was found between US and MRI results, for joint effusion ($k=0.683$, $p<0.001$) synovial proliferation ($k=0.595$, $p<0.001$), popliteal cysts ($k=0.865$, $p<0.001$) and tendonitis ($k=0.889$, $p<0.001$). On the US, the mean medial and lateral femoral condylar cartilage thickness was calculated as 2.1 mm on both sides, whereas the MRI revealed 1.8 mm on the medial and 1.9 mm on the lateral part. In the statistical analysis, the condylar cartilage was significantly thicker on the US than on the MRI ($p<0.001$). On the other hand, there was a significant correlation between two modalities regarding the cartilage morphology, both on the medial ($k=0.658$, $p<0.001$) and the lateral part ($k=0.851$, $p<0.001$).

Study done by (Paul, 2008) titled:Advances and utility of diagnostic ultrasound in musculoskeletal medicine says : Musculoskeletal ultrasound (US) can serve as an excellent imaging modality for the musculoskeletal clinician. Although MRI is more commonly ordered in the United States for musculoskeletal problems, both of these imaging modalities have advantages and disadvantages and can be viewed as complementary rather than adversarial. For diagnostic US, relative recent advances in technology have improved ultrasound's ability to diagnose a myriad of musculoskeletal problems with enhanced resolution. The structures most commonly imaged with diagnostic musculoskeletal US; include tendon, muscle, nerve, joint, and some osseous pathology. This brief review article will discuss the role of US in imaging various common musculoskeletal disorders and will highlight, where appropriate, how recent technological advances have improved this imaging modality in musculoskeletal medicine. Additionally, clinicians practicing musculoskeletal medicine should be aware of the ability as well as limitations of this unique imaging modality and become familiar with conditions where US may be more advantageous than MRI.

Study done by (Lento, et al 2010) titled: The use of ultrasound in guiding musculoskeletal interventional procedures

There has been an increase in the use of ultrasound (US) to help guide interventional procedures involving the musculoskeletal system. To perform these procedures safely and accurately, two steps must occur. First, the appropriate structure must be localized using diagnostic US imaging. Second, a needle must be guided under constant visualization toward the targeted tissue. Although US imaging can help place the needle and, hence, therapeutic medication more accurately, there is still debate about whether or not image-guided procedures result in improved outcomes. This article discusses the advantages and disadvantages of performing US-guided injections and describes injection principles and techniques. Studies examining the efficacy of US-guided procedures are reviewed.

Studydone by: (Ann, et al, 2004); titled: Weight changes and the risk of knee osteoarthritis requiring arthroplasty

To examine the effect of weight changes between 20 and 50 years of age on the risk of severe knee osteoarthritis (OA) requiring arthroplasty. After adjustment for age, sex, history of physical workload, recreational physical activity, and previous knee injury, weight gain resulting to a shift from normal body mass index (BMI $\leqslant 25$ kg/m^2) to overweight (BMI >25 kg/m^2) was associated with a higher relative risk of knee OA requiring arthroplasty than persistent overweight from 20−50 years of age, compared with those with normal relative weight during the corresponding age period. The odds ratios (OR) were 3.07 (95% confidence interval 1.87 to 5.05) for those with normal weight at the age of 20 years and overweight at two or three of the ages 30, 40 or 50 years, 3.15 (1.85 to 5.36) for those with overweight from the age of

30 years, and 2.37 (1.21 to 4.62) for those with overweight from the age of 20 years, respectively.

Study done by:(Lento, et al 2008) Titled: Advances and utility of diagnostic ultrasound in musculoskeletal medicine.

Musculoskeletal ultrasound (US) can serve as an excellent imaging modality for the musculoskeletal clinician. Although MRI is more commonly ordered in the United States for musculoskeletal problems, both of these imaging modalities have advantages and disadvantages and can be viewed as complementary rather than adversarial. For diagnostic US, relative recent advances in technology have improved ultrasound's ability to diagnose a myriad of musculoskeletal problems with enhanced resolution. The structures most commonly imaged with diagnostic musculoskeletal US, include tendon, muscle, nerve, joint, and some osseous pathology. This brief review article will discuss the role of US in imaging various common musculoskeletal disorders and will highlight, where appropriate, how recent technological advances have improved this imaging modality in musculoskeletal medicine. Additionally, clinicians practicing musculoskeletal medicine should be aware of the ability as well as limitations of this unique imaging modality and become familiar with conditions where US may be more advantageous than MRI.

Study done by: (I. Möller,ea al 2008)

This review addresses the use of ultrasound (US) as an imaging technique for the evaluation and monitoring of the osteoarthritic joint. US complements both the clinical examination and radiological imaging by allowing the rheumatologist to recognize not only the bony profile but also to visualize the soft tissues. Systematic US scanning following established guidelines can demonstrate even minimal abnormalities of articular cartilage, bony cortex and synovial tissue. US is also extremely sensitive in the detection of soft tissue changes in the involved joints including the proliferation of the synovium and changes in the amount of fluid present within the joint. Monitoring the amount of fluid in the hip and knee joint with osteoarthritis may be a potentially useful finding in the selection of patients for clinical investigation and for assessing their response to therapeutic interventions.

Study done by: (B. Frediani, et al, 2002) titled: Ultrasound and Clinical Evaluation of Quadricipital Tendon Enthesitis in Patients with Psoriatic Arthritis and Rheumatoid Arthritis, ClinRheumatol (2002) 21:203–206, shown mean age was; 51.7 years;
Abstract: Enthesitis is an inflammatory lesion of thetendon, ligament and capsular insertions into the bone,and it is a fundamental element in the diagnosis ofspondyloarthropathies. Sonography is the method of

choice for studying periarticular soft tissues because it iscapable of detecting both the early (oedema, thickening) and the late alterations (erosions and enthesophytes); it isalso an inexpensive, biologically harmless and easilyrepeatable technique. The aim of this study was tocompare the prevalence of quadricipitalenthesitis in psoriatic arthritis (PsA) and rheumatoid arthritis (RA)patients, and to document any clinical and echostructuraldifferences in this lesion between the two diseases. Theresults show that enthesitis is more frequent in PsApatients, more than half of whom are asymptomatic.Knee inflammation was found in the PsA patients withenthesitis regardless of the concomitant presence of jointeffusion; none of the RA patients suffered fromenthesitis alone. Quadricipitalenthesitis is more frequentin male patients. There was no significant correlationbetween the presence of peripatellar psoriatic lesions andenthesitis. Sonographic examinations of patients withenthesitis revealed that those with RA had dominantlyinflammatory lesions, whereas PsA patients also showedmajor new bone deposition.

CHAPTER THREE

3Methodology of the study

3.1 Material

3.1.1 Patient:

This was a descriptive quantitative an observational cross-sectional study of 300 patients, with an aim to characterize the knee joint diseases using Medical Ultrasound (US) and Magnetic Resonance Imaging (MRI). 224 of them, US and MRI revealed variable diseases, male 192(85.7%) and female 32(14.3%) the age range from 12 to 80 years and 50 patientswith normal knee joint were examined for literatures review and anatomy.

3-1-2Research Area and Site:-

The Study was take place in south Saudi Arabia in Abha area(Aseer region),KKU, College of Applied Medical Sciences, Radiological Center (Department).

3-1-3The Period of Research:-

The duration of the research was commencing from October 2011 to June 2015

3.2 Equipment

3.2.1 Ultrasound Machine

The knee joint ultrasound examinations were performed with appropriate instrumentation including the following tools and equipments (fig 3-1)which used effectively and accurately:-

1- Ultrasound system general electric (GE) USA medical system logic3expert2007

2- Ultrasound transducer linear probe with high frequency 7.5 to 12MHz.

3- Ultrasound gel to make probe movement easy and more close contact probe –skin

4- Ultrasound printer

5- Thermal paper

Figure (3-1): Ultrasound Machine

3-2-2**MRI machine**

The MRI machine was a GE 1.5 Tesla, field of view (FOV) 14 cm, using 4/0.2 mm thickness/gap and about20 minutes total time (without Gradient Echo (GRE))(fig. 3-2).

Figure (3-2): MRI Machine

Figure (3-3): MRI Machine 2

3-3 Technique

3-3-1 Ultrasound

An examination or the technique protocol meetsthe standard by American institute of ultrasound in medicine (AIUM)

3.3.1.1 Patient preparation:

Patient preparation for the US exam, do not take any anti-inflammatory drugs (advil, ibuprophen, motrin, etc.) For 12 hours prior to your scheduled exam. Patient limit his caffeine intake on the day of testing. You may eat and drink and take other medications as you would normally. Patient do not use or be treated with hot or cold packs, lotions, physical therapy, tens, electrical stimulation, chiropractic adjustments or osteopathic manipulations in the 24 hours prior to your exam. To avoid the necessity to change into a gown for the testing; Patients scheduled for knee scans should bring or wear shorts or loose fitting pants that can be rolled above the knee.

3.3.1.2 Technique &Patient position: sitting,supine and prone with flexion or extension knee joint.

Transducer position: - several transducer position should be used longitudinal,posterolateral,antrolateral,transverse, anterior or posterior approach**.**

Patient Positioning and Examination Technique As we've stated frequently before, high resolution ultrasound imaging of the knee requires a high frequency, linear transducer in the 10-12 MHz range. Curved array transducers with slightly lower frequencies in the 7.5-10 MHz range may be useful to examine the posterior knee with its curved surface and deeper structures. Broad band transducers with variable frequency and extended field of view imaging capabilities are also very useful, but are not absolutely necessary. To begin the examination, the patient lies comfortably in either a supine, sitting or semi-reclining position. The knee should be flexed about 15-20 degrees with a small pillow placed behind the knee in order to stabilize and immobilize the leg. The examiner should sit adjacent to the patient, allowing easy access to the knee under investigation. Once positioned, the knee should be imaged from four different approaches, including:

- **Anterior approach**
- **Medial approach**
- **Lateral approach**
- **Posterior approach**

3.3.1.2.1 Anterior approach

Patient lies supine on bed with knee flexed 20 - 30 degrees. Alternatively patient may sit on the side of a raised bed with foot resting on Sonographer's knee for support. Identify the normal anatomy, including: Quadriceps tendon (tears, M/T junction, tendonitis) Suprapatella bursa (bursitis-simple/complex, synovial thickening, loose bodies) Patella (gross changes eg erosion, bipartite, fracture) Patella tendon (tears, tendonitis, insertion enthesopathy) Infrapatella bursa (tendonosis, tears, bursitis, fat pad changes) Infero-Medial - Pes anserine bursa.

(2015, http://www.ultrasoundpaedia.com/normal-knee/)

Figure (3-4):A anterior view scan, B Ultrasound image of the knee – anterior view, supra patella

Figure (3-5): A, Infrapatella scan Longitudinalplane B, Ultrasound image

3.3.1.2.2 Posterior approach

Patient prone on bed, knee flexed slightly with a pad under the ankle for support. Survey the entire fossa to identify the normal anatomy, including; Popliteal artery and vein (patency. aneurysm, thrombosis) Posterior joint (joint effusion) Medial popliteal fossa [bursa between semi-membranosis tendon and medial gastrocnemius muscle] (Baker's cyst) Document the normal anatomy and any pathology found, including measurements and vascularity if indicated.

Figure (3-6):Scanning posterior fossa of the knee

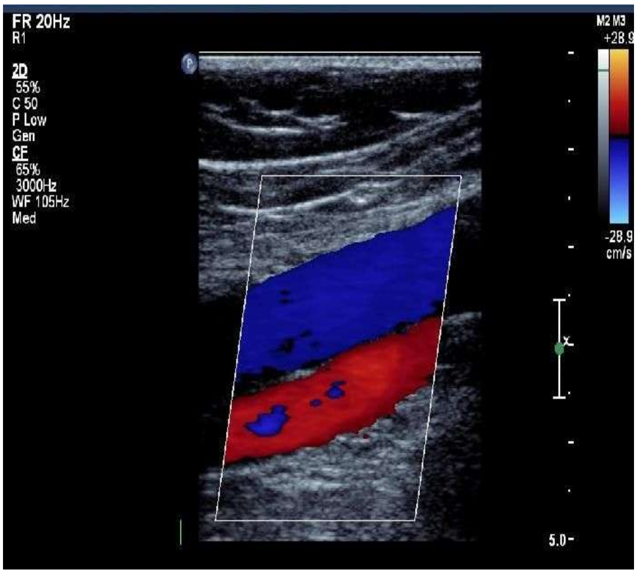


Figure (3-7): Confirm both arterial and venous flow and exclude a popliteal artery aneurysm

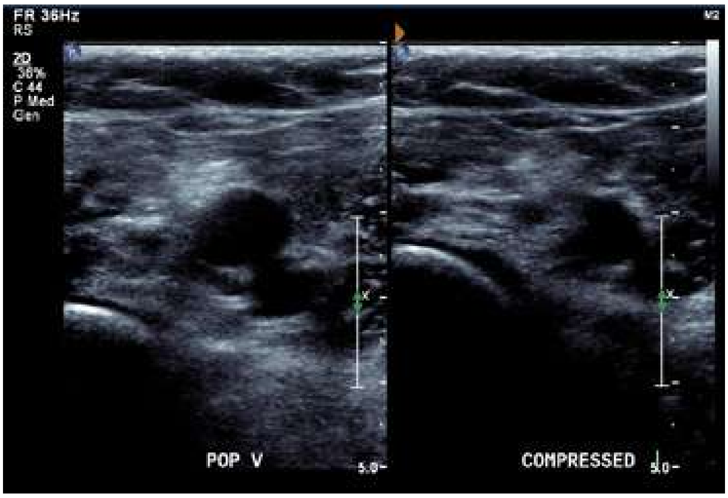


Figure (3-8): Ultrasound image of the popliteal vein and artery in transverse,

Without and with compression to exclude DVT.

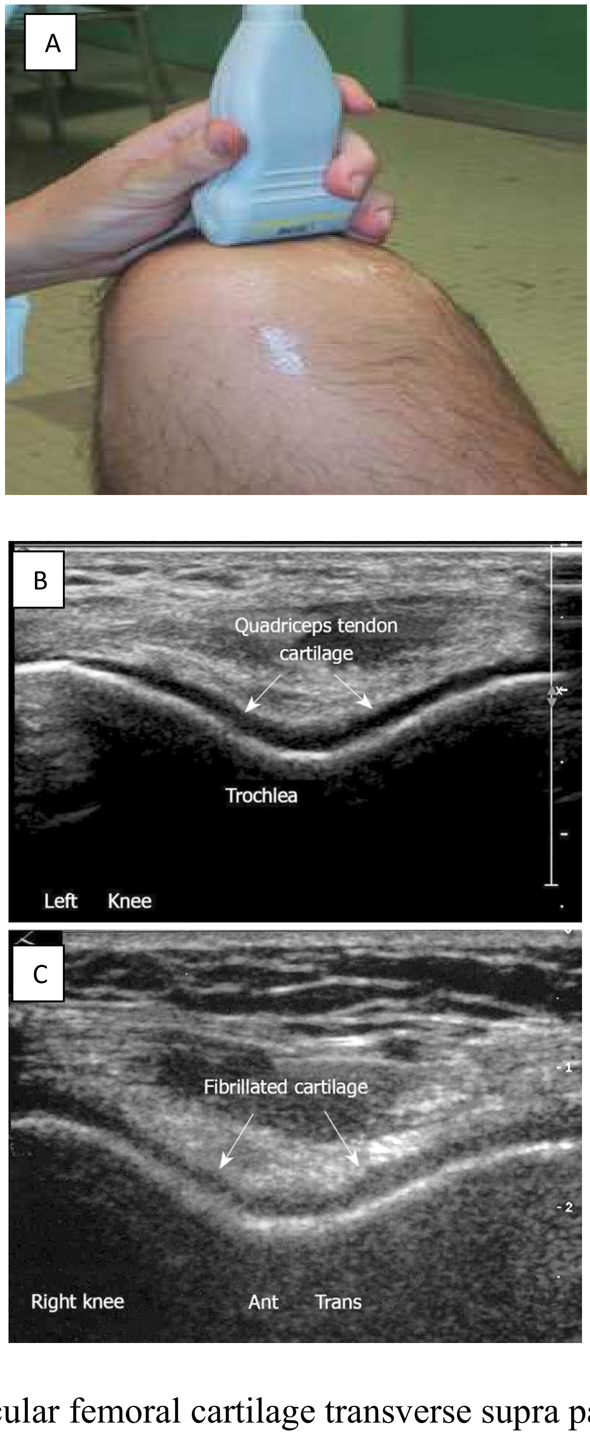


Figure (3-9): A, Articular femoral cartilage transverse supra patella scanning, B&C ultrasound image

(world congress on osteoarthritis 2008)

3.3.1.2.3 Medial approach:

Show medial collateral ligament and medial meniscus

Figure (3-10): LongitudinalMedial knee joint scan, where the meniscus is acting as a spacer between the tibia and the femur bone.

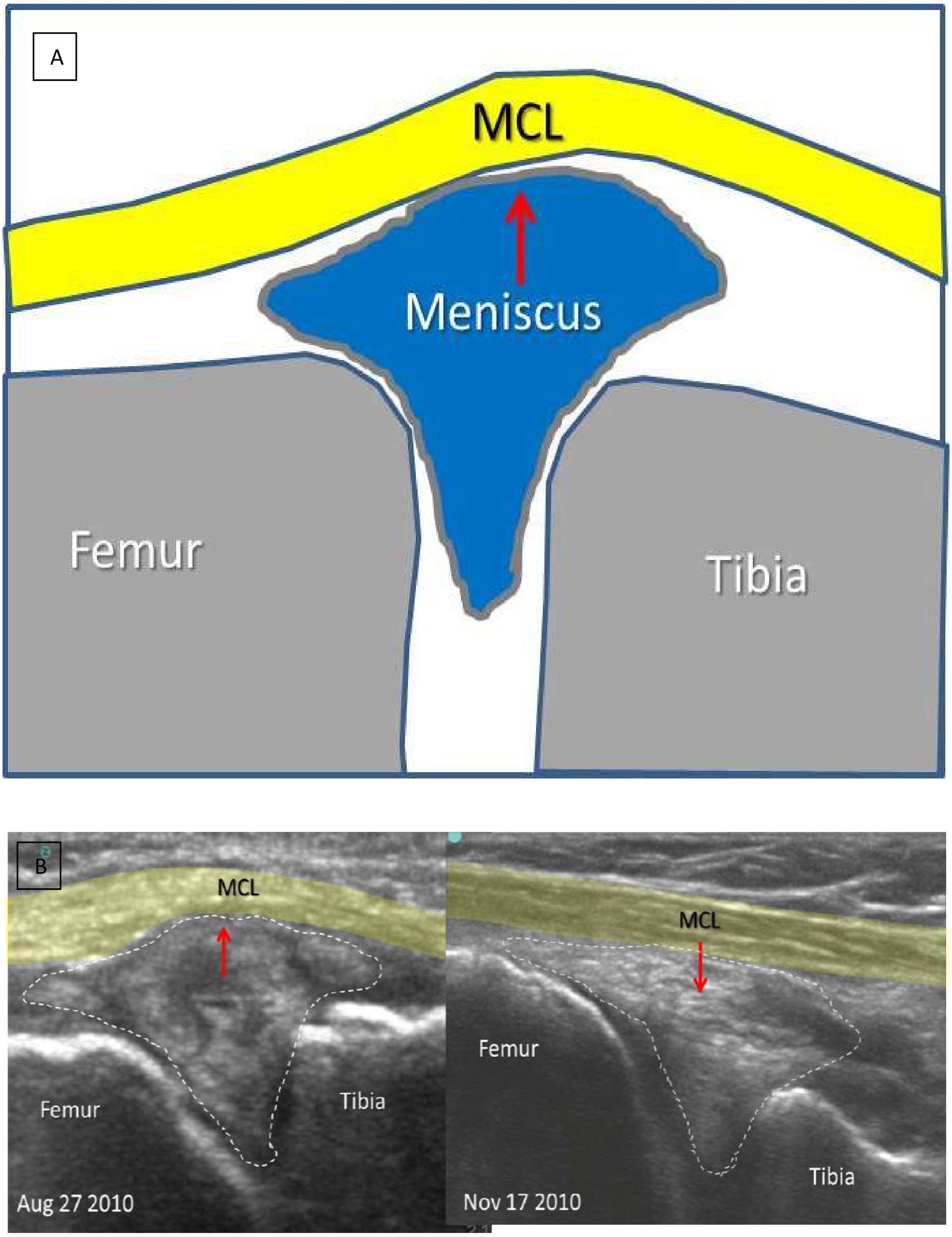


Figure (3-11): medial approach, A diagram, B Ultrasound image

3.3.1.2.4 Lateral approach

Assess the Lateral collateral ligament, Ilio-Tibial band insertion and peripheral margins of the lateral meniscus. Unlike the medial side, the LCL is separated from the meniscus by a thin issue plane(fig. 3-12).

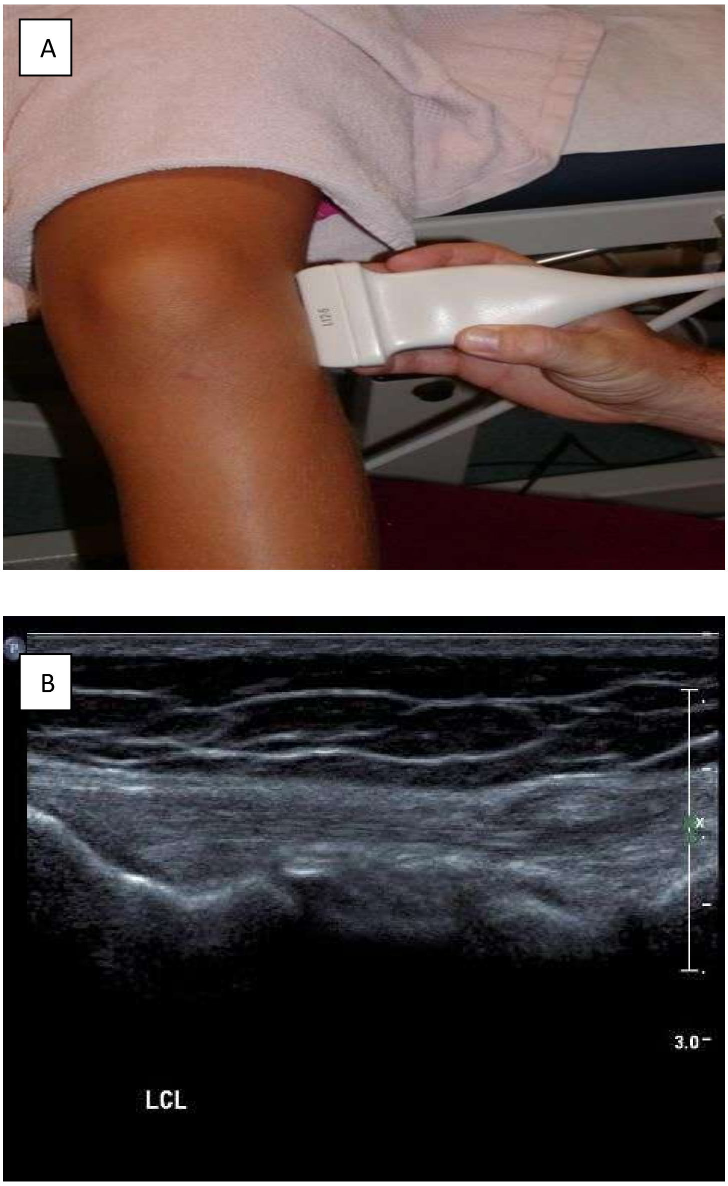


Figure (3-12): A lateral knee joint scanning, B lateral knee joint ultrasound image

3.3.2 MRI

3.3.2.1 Patient Preparation:

All patients were prepared to remove all ferromagnetic material from body and check pregnancy, and all patients ask for menstrual cycle. Most of female patients especially postmenopausal woman were prepared that examination done in 10 day role menstruation , and patients are asking for having drug , or chemotherapy and radiotherapy , few patients have radiotherapy are asked to come after 12 month.

3.3.2.2 MRI Protocol

All patients were examined in supine position, Sagittal, coronal and axial position. All examinations are done by using special knee joint coil and routine, 5 or 6 sequences. The sequences were used are : (1) Axial fast spin echo (FSE) T2-Weighted Fat saturation, (2) Coronal FSE T1W, (3) Coronal FSE proton density weighted (PDW) Fatsat, (4) Sagittal spin echo (SE) PDW, (5) Sagittal FSE T2W Fatsat, (6) +/- Sagittal T2*

3.4 Ultrasound and MRI Characterization

The sonographic appearance of fluid, synovitis, loose bodies, bursae, and cysts, was record addition to menisci and ligament pathology. Joint effusions were anechoic near joint capsule simple effusion was anechoic also, if there was haemoarthrosis or infection diffuse increased in echogenicity is suggested (case (1) and case (3)). There was bursal thickening in chronic bursitis and internal echo seen in the fluid in case of hemorrhage and infection (case (9)). Synovitis was demonstrated as diffuse nodular thickening of the joint bursal margin and flow was detected in Doppler sonography (case (9). loose bodies was Echogenic structures completely separated from other structures lying within joint space(case (12)) , Meniscal cysts were shown as anechoic fluid collections characteristically lying at the margin of the knee joint underlying the meniscus (case (2) and (19)). Meniscal tears were recorded as discrete hypoechoic clefts coursing in the oblique fashion through a hyperechoic triangular meniscus. Meniscitis were seen as hypoechoic triangular menisci.

Baker's cysts were seen in posterior knee joint arised from simimembranosus bursa and protrude posteriorly to overlie to gastrocnemius muscle, the simple cysts were uniformly anechoic while the internal echo seen in complex cysts. in rupture baker's cysts there was irregular hypoechoic or anechoic area distal the cyst, the double wall also was noted , ruptured baker's cysts were differentiate from deep venous thrombosis by Doppler ultrasound . Tendon tears appeared echo poor focal defect in the fiber bundles. Tendon calcification was shown as hyperechoic area with posterior shadowing. Tenosynovitis was shown as thickening of the tendon sheath or a hypoechoic rim around the tendon due to fluid or synovitis. The sonographic appearance of ligaments of the knee is similar to tendons characterized by parallel Echogenic fiber bundles. Ligament tears seen as Echogenic fibrillar pattern by hypoechoic granular tissue when completely torn. Medial collateral ligament injury also seen thickening with hyper and hypo echoic (heterogeneous echogenicity) .muscle tears seen as Hypoechoic area as discontinuity in the pinnate pattern. Lipomas were shown as hyperechoic masses with posterior attenuation. We have used color Doppler to differentiate mass from hematomas from tumor. All sonographic features demonstrated by at least 2 radiologists .

The MRI appearance of fluid, synovitis, loose bodies, bursae, and cysts, was record addition to menisci and ligament pathology, The MRI signal intensity (brightness) of a particular tissue depends on the number of the mobile hydrogen nuclei and on two relaxation times: T1 and T2. Tissues or materials with low proton density, such as calcium, air, cortical bone, tendons, menisci, and ligaments, exhibit low or no signal intensity in all pulse sequences. Fat, fluid, and edematous tissues containing high proton density have a variable appearance, depending on the pulse sequence. (Peterfy, et al, 1998)

All MRI features demonstrated by at least 2 radiologists .

US allow contralateral examination and do not pose limitations due to metal artifacts, patients with cardiac pacemakers, certain types of aneurysm clips, cochlear implants, and intraocular metallic foreign bodies, which can be problematic in magnetic resonance imaging (MRI). The ability to visualize needles and target structures in US real time imaging makes it an ideal tool for the guidance procedures used in diagnosis and management [Del Cura, 2008]

Limitations: Despite of these advantages, there are some limitations of this technology. US is considered to be an operator-dependent technology. However, it is reassuring to see that recent studies have established moderate to good interobserver reliability [Scheel,*et al*, 2005); (Schmidt, et al, 2005) and (Naredo,*et al*. 2006). Also this study It is recognised that ultrasound offers little or no diagnostic information for internal structures such as the cruciate ligaments. If this is suspected, MRI is the technique of choice. Ultrasound is complementary to MRI.

3.4 Data collection andsheets:-

The Data was collected in the tabulated database sheet and analyzed by SPSS

The table for data collection

No	Age	Gender	Mass index	Diseases	US finding	MRI finding	US characterization	MRI Characterization

CHAPTER FOUR

4. Results

4.1 Tables and figures:

Table(4-1):Shows Gender Frequency Distribution

Gender	Frequency	Percent	Normal	Abnormal
male	266	88.6	74	192
female	34	11.4	2	32
Total	300	100.0	76	224

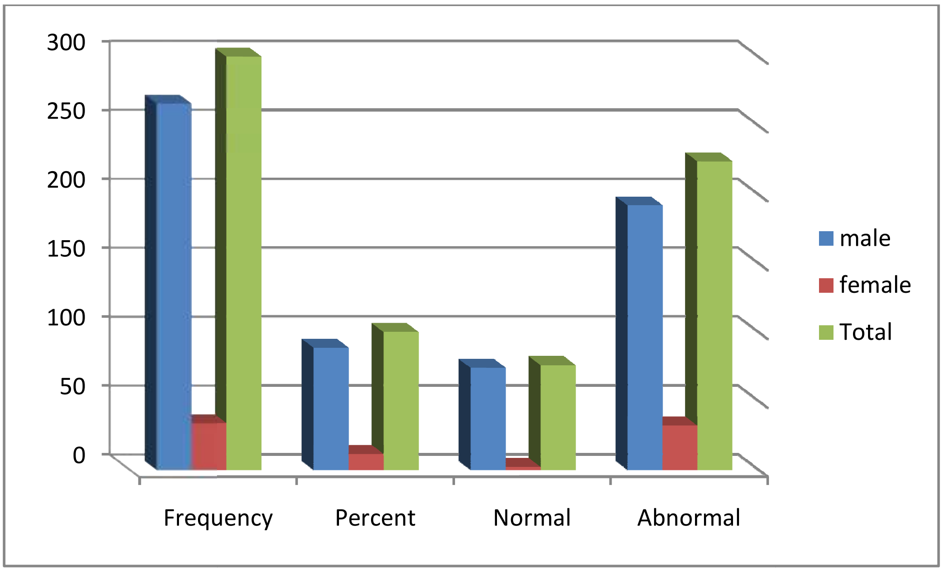


Figure (4-1): Shows Gender Frequency Distribution

Table (4-2): Shows age group frequency distribution

Age group	Frequency	Percent
12-20	9	4.0
21-29	58	25.9
30-38	37	16.5
39-47	42	18.8
48-56	43	19.2
57-65	21	9.4
66-74	14	6.3
Total	224	100.0

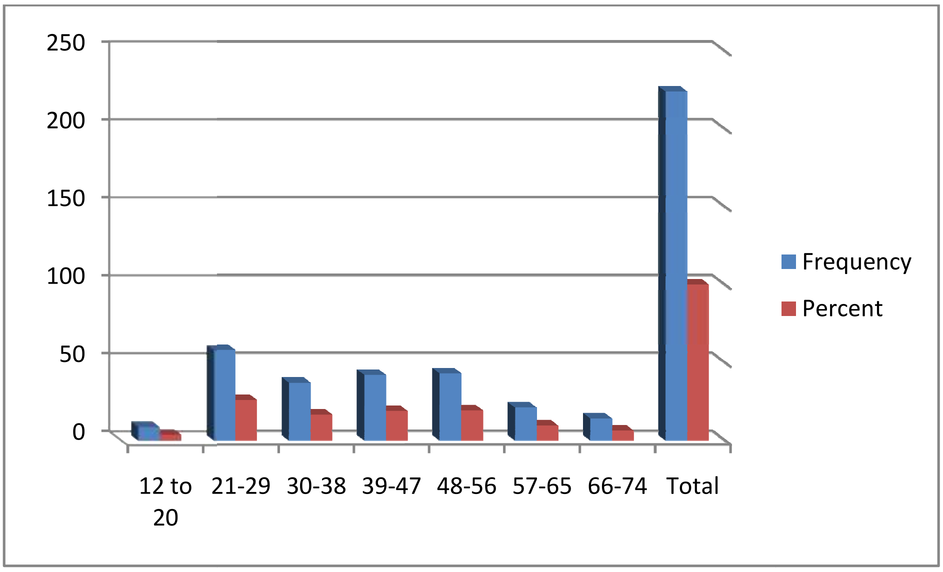


Figure (4-2): Shows age group frequency distribution

Table(4-3): Shows positive cases Vs negative on Ultrasound

US status	Frequency	Percent
No Findings	13	5.8
Finding	211	94.2
Total	224	100.0

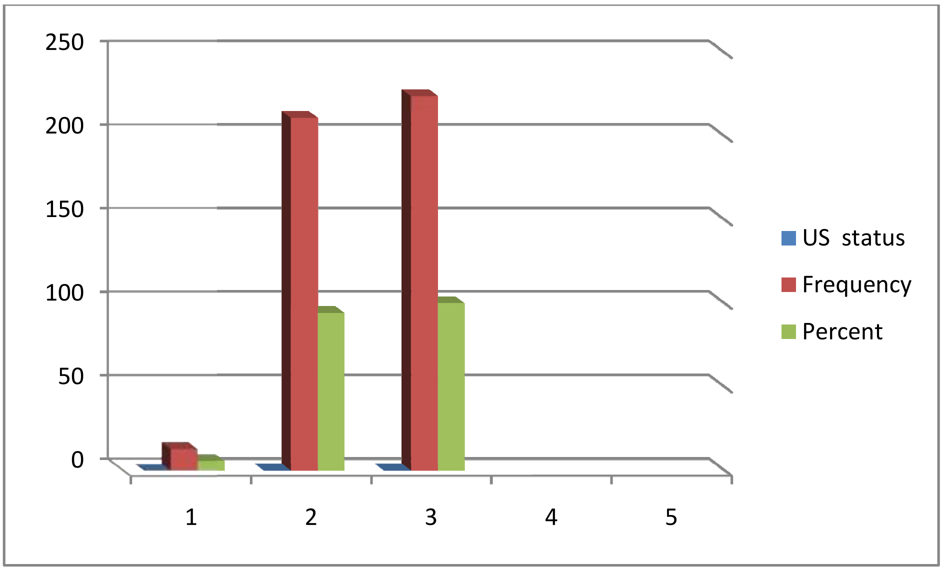


Figure (4-3): Shows positive cases Vs negative on Ultrasound

Table(4-4): Shows Ultrasound Characterization Frequency of Diseases

US	Frequency	Percent
Nofindings	13	5.8
Hyperechoic	8	3.6
Hypoechoic	6	2.7
echogenic	4	1.8
anechoic	193	86.2
Total	224	100.0

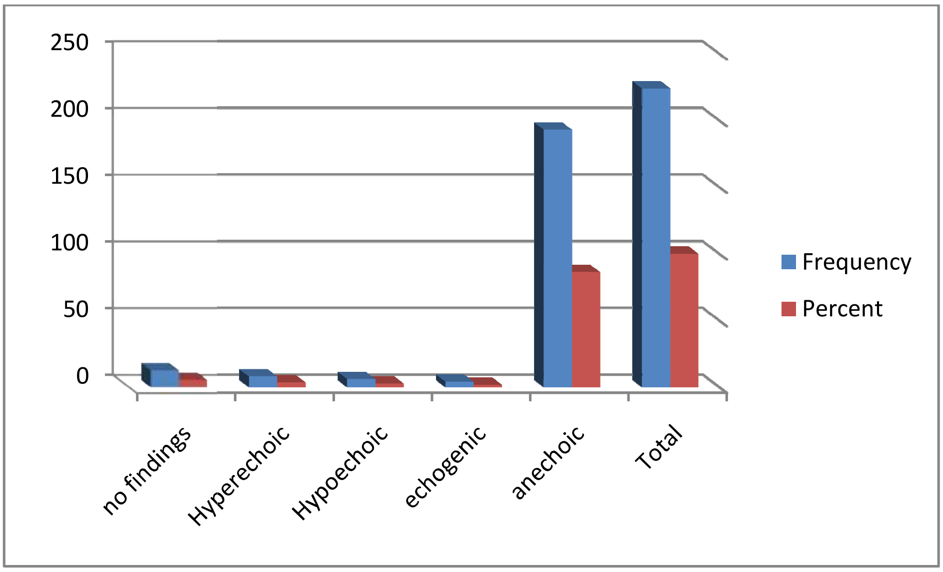


Figure (4-4): Shows Ultrasound Characterization Frequency of Diseases

Table(4-5): Shows BMI Frequency

BMI	Frequency	Percent
17-21	5	2.2
22-26	93	41.5
27-31	97	43.3
32-36	28	12.5
37-41	1	0.4
Total	224	100.0

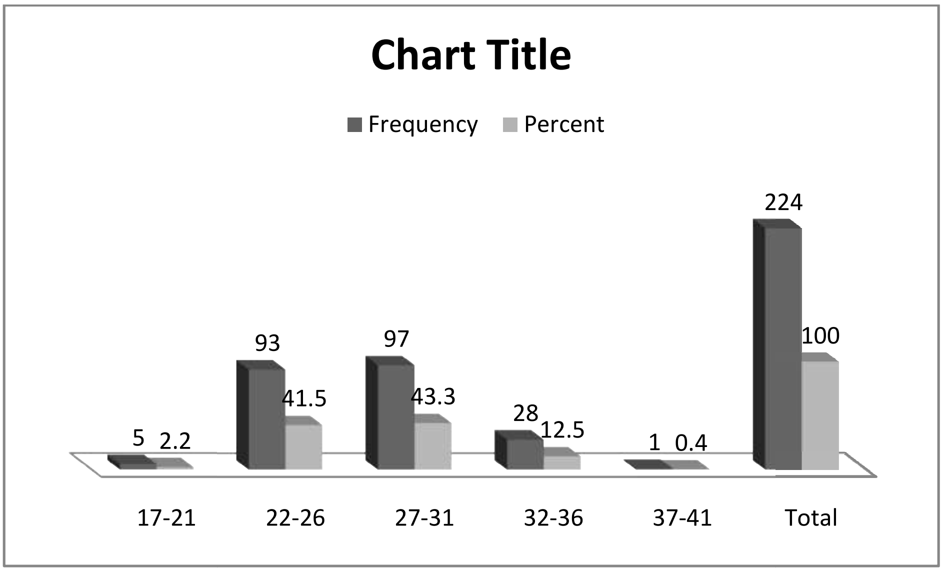


Figure (4-5): Shows BMI Frequency

Table (4-6): Shows variable mean age

variables	Mean	Std. Deviation
age	40.52	14.808
Height	164.92	11.990
BMI	27.42	3.415

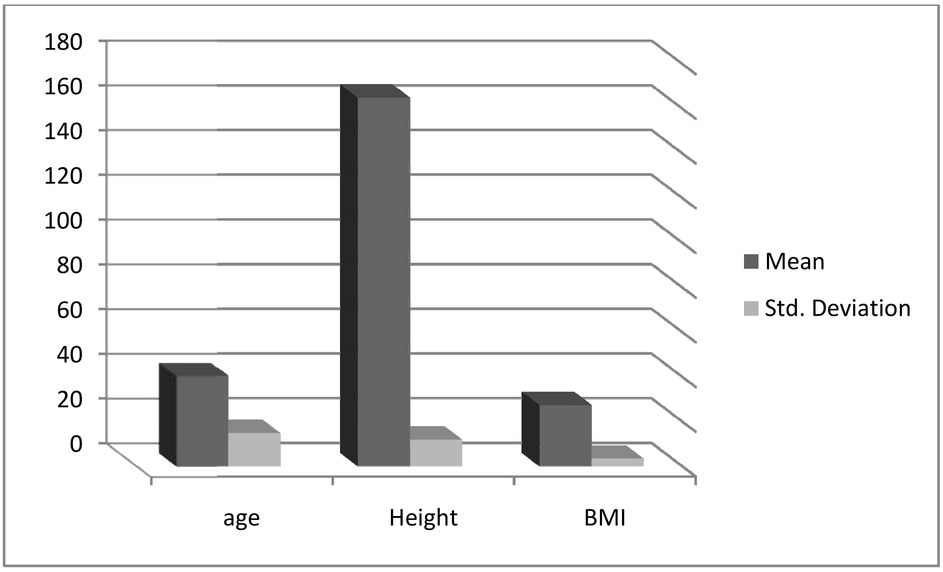


Figure (4-6): Shows variable mean age

Table (4-7): ShowsKnee joint disorders findings by ultrasound and MRI

Total patients scanned 300			**Variable diseases were reveal by US and MRI 224**	
Pathology finding	frequency	percent	Seen in ultrasound	Seen in MRI
Effusion	139	62.1	√	√
Bursitis	18	8.0	√	√
Meniscus tear	10	4.5	√	√
Loose body	4	1.8	√	√
Baker cyst	8	3.6	√	√
Synovial cyst	8	3.6	√	√
Quadriceps Tendon Rupture	3	1.3	√	√
Arthritis	8	3.6	√	√
DVT	6	2.7	×	√
Tumor	2	0.9	×	√
ACL tear	9	4.0	×	√
PCL tear	4	1.8	×	√
Medial Collateral Ligament Tear	3	1.3	√	√
Lateral Collateral Ligament Tear	2	0.9	√	√
Total	224	100.0	√	√

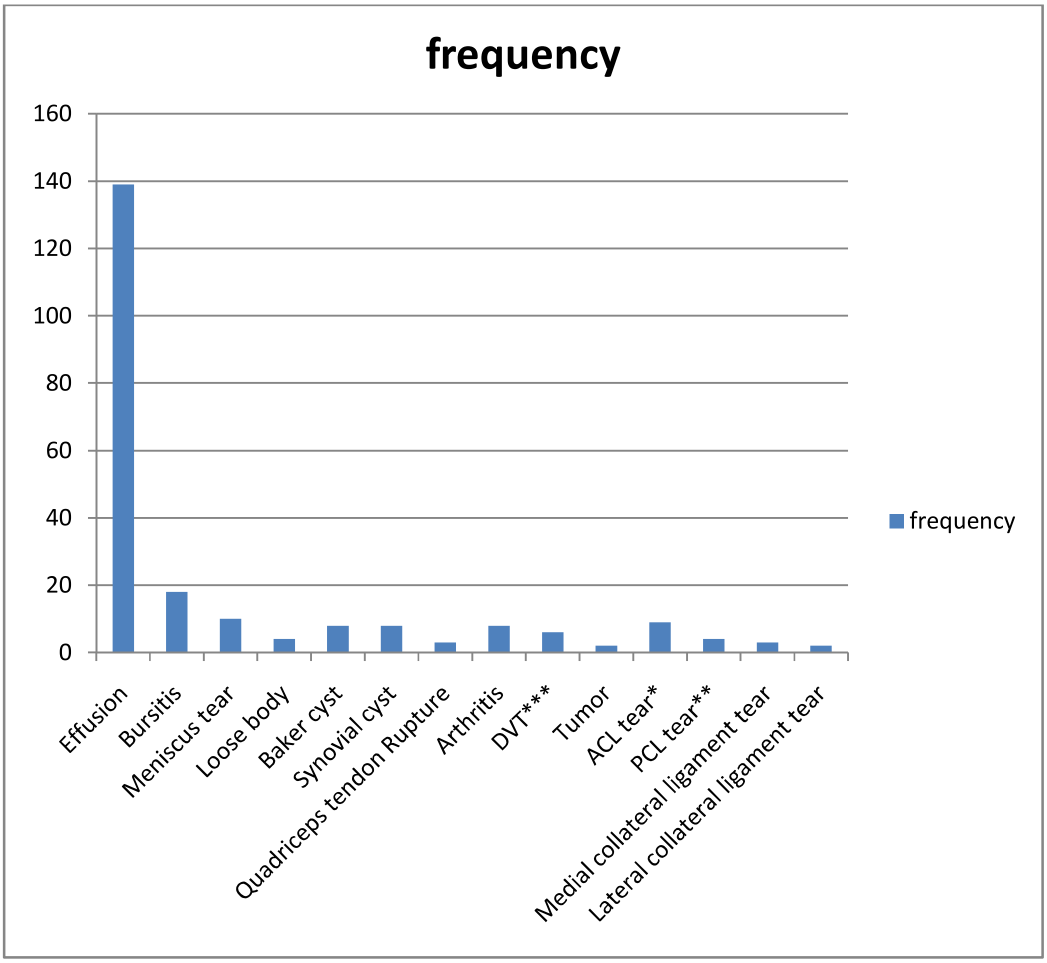


Figure (4-7): Shows all finding diseases distribution

Table (4-8): Shows traumatic injury diseases distribution

Diseases	Frequency	Percent
Effusion	139	62.1
Meniscus tear	10	4.5
Loose body	4	1.8
Quadriceps tendon Rupture	3	1.3
ACL tear	9	4.0
PCL tear	4	1.8
Medial Collateral Ligament Tear	3	1.3
Lateral Collateral Ligament Tear	2	0.9
Total	174	77.7

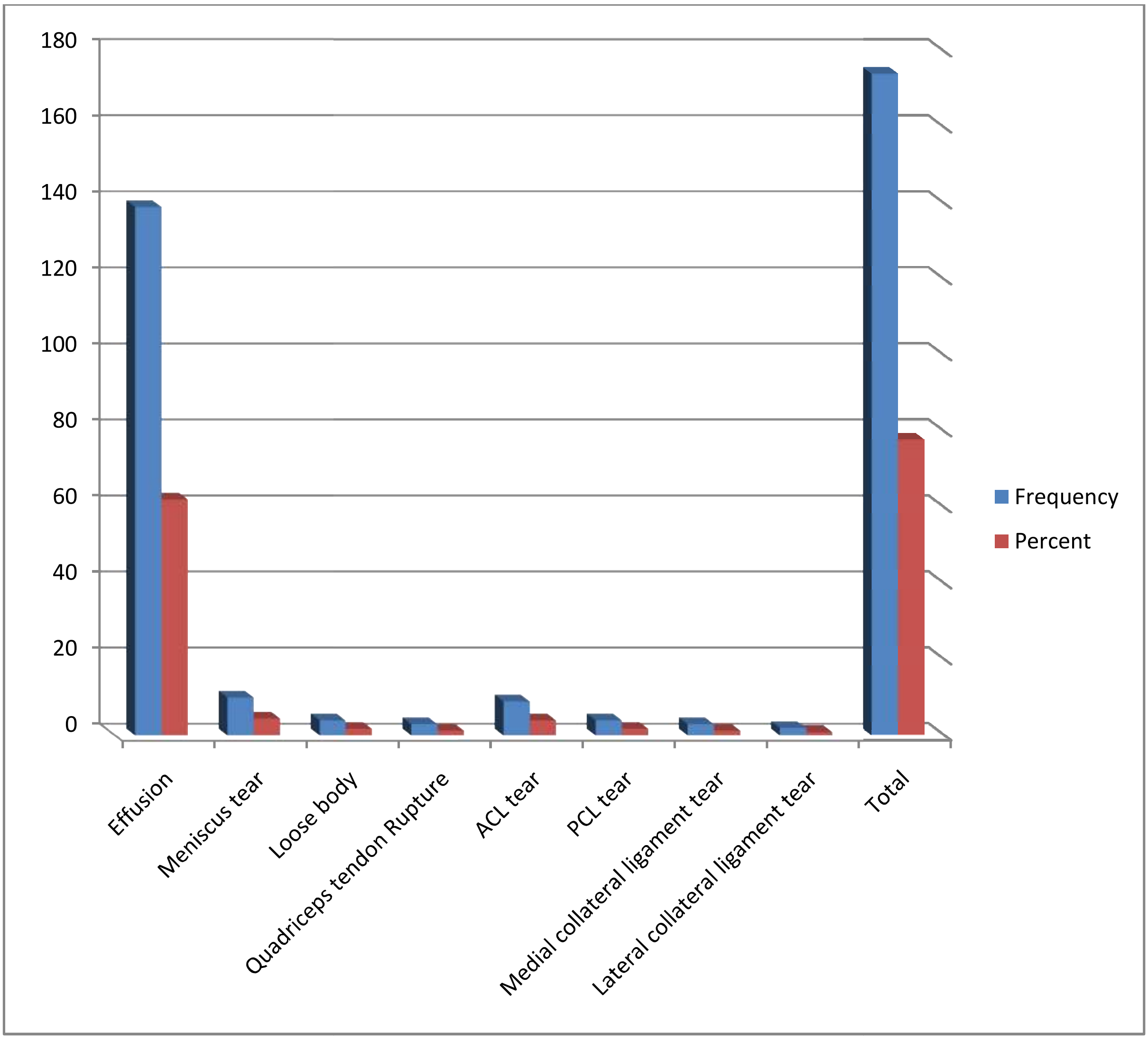


Figure (4-8): Shows traumatic injury diseases distribution

Table(4-9): Shows relationship between diseases and US characterization

Diseases	**US characterization**					**Active Doppler√**
	No Findings	Hyperechoic	Hypoechoic	echogenic	anechoic	
Effusion	0	0	0	0	139	√
Bursitis	0	0	0	0	18	×
Meniscus Tear	0	0	6	0	4	√
Loose body	0	0	0	4	0	×
Baker Cyst	0	0	0	0	8	×
Synovial cyst	0	0	0	0	8	×
Quadriceps Tendon Rupture	0	0	0	0	3	√
Arthritis	0	0	0	0	8	√
DVT	0	6	0	0	0	×
Tumor	0	2	0	0	0	×
ACL Tear	9	0	0	0	0	√
PCL Tear	4	0	0	0	0	√
Medial Collateral Ligament Tear	0	0	0	0	3	√
Lateral Collateral Ligament Tear	0	0	0	0	2	√

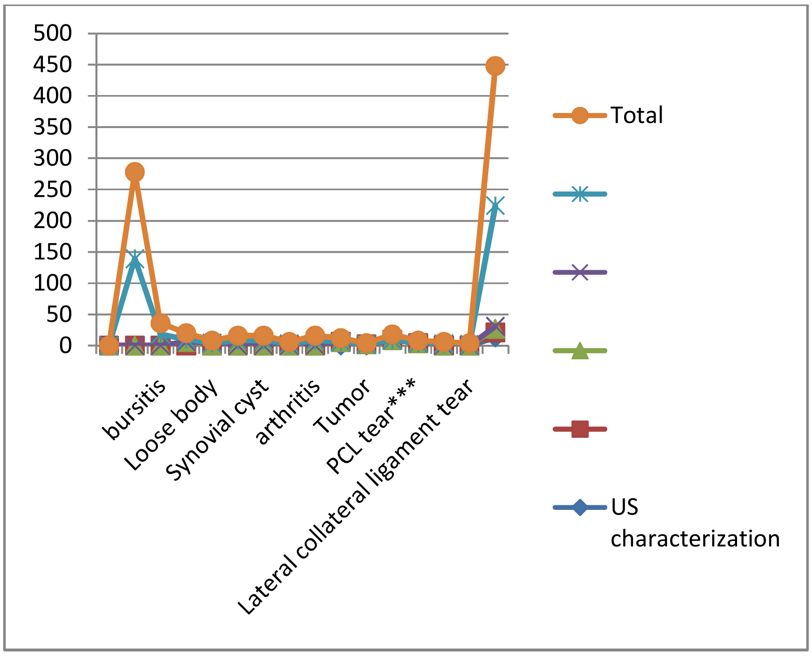


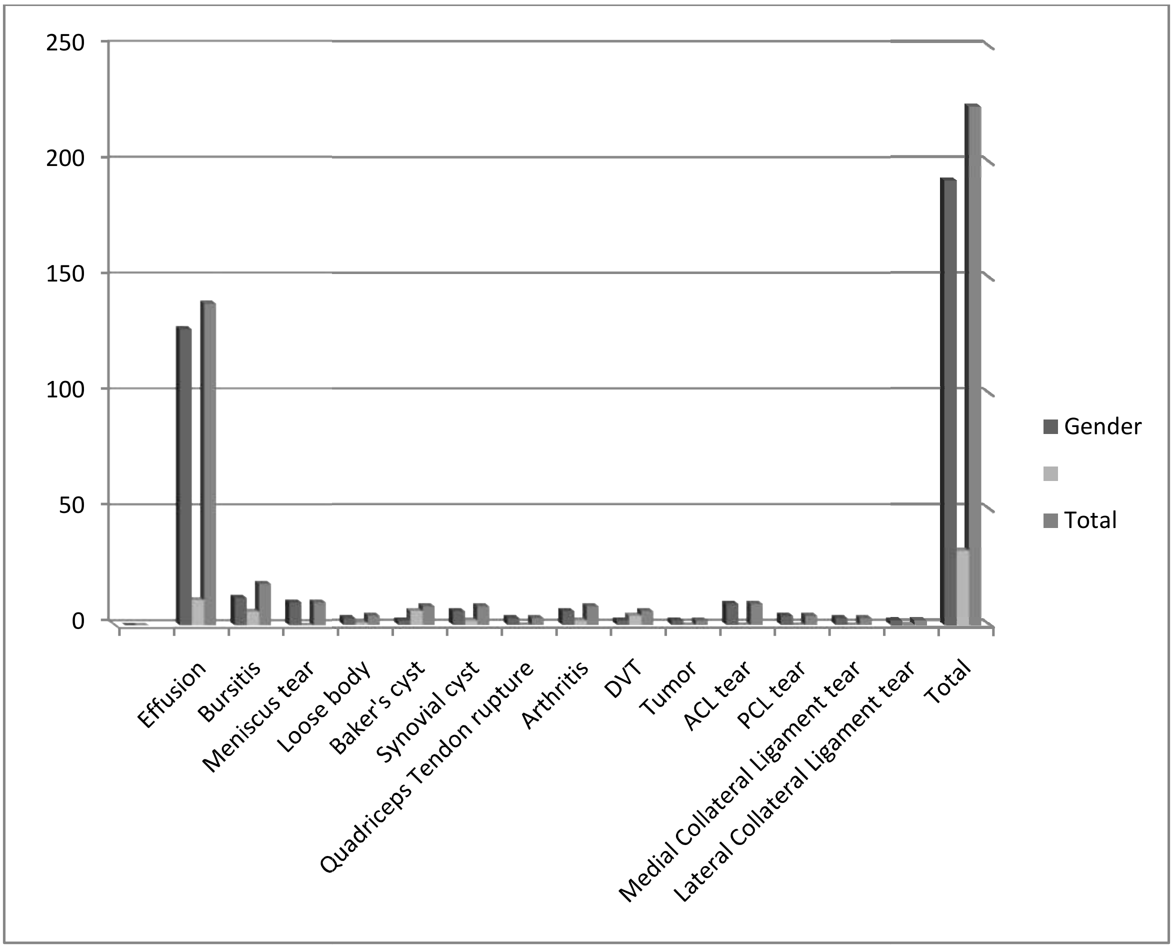
Figure (4-9): Shows relationship between diseases and US characterization

Table(4-10): shows cross tabulation between US &MRI characterization

US* Characterization	MRI* Characterization		Total
	High signal	Low signal	
No findings	0	13	13
Hyperechoic	0	8	8
Hypoechoic	0	6	6
Echogenic	0	4	4
Anechoic	181	12	193
Total	181	43	224

Table (4-11): Shows relationship between all finding diseases and gender

Diseases	Gender		Total
	Male	Female	
Effusion	128	11	139
Bursitis	12	6	18
Meniscus tear	10	0	10
Loose body	3	1	4
Baker's cyst	2	6	8
Synovial cyst	6	2	8
Quadriceps Tendon rupture	3	0	3
Arthritis	6	2	8
DVT	2	4	6
Tumor	2	0	2
ACL tear	9	0	9
PCL tear	4	0	4
Medial Collateral Ligament tear	3	0	3
Lateral Collateral Ligament tear	2	0	2
Total	192	32	224



Figure(4-11): Shows relationship between all finding diseases and gender

Table (4-12): Shows relationship between traumatic finding diseases and gender

Diseases	**Gender**		**Total**
	Male	Female	
Effusion	128	11	139
Meniscus tear	10	0	10
Loose body	3	1	4
Quadriceps Tendon rupture	3	0	3
ACL tear	9	0	9
PCL tear	4	0	4
Medial Collateral Ligament tear	3	0	3
Lateral Collateral Ligament tear	2	0	2
Total	162	12	174

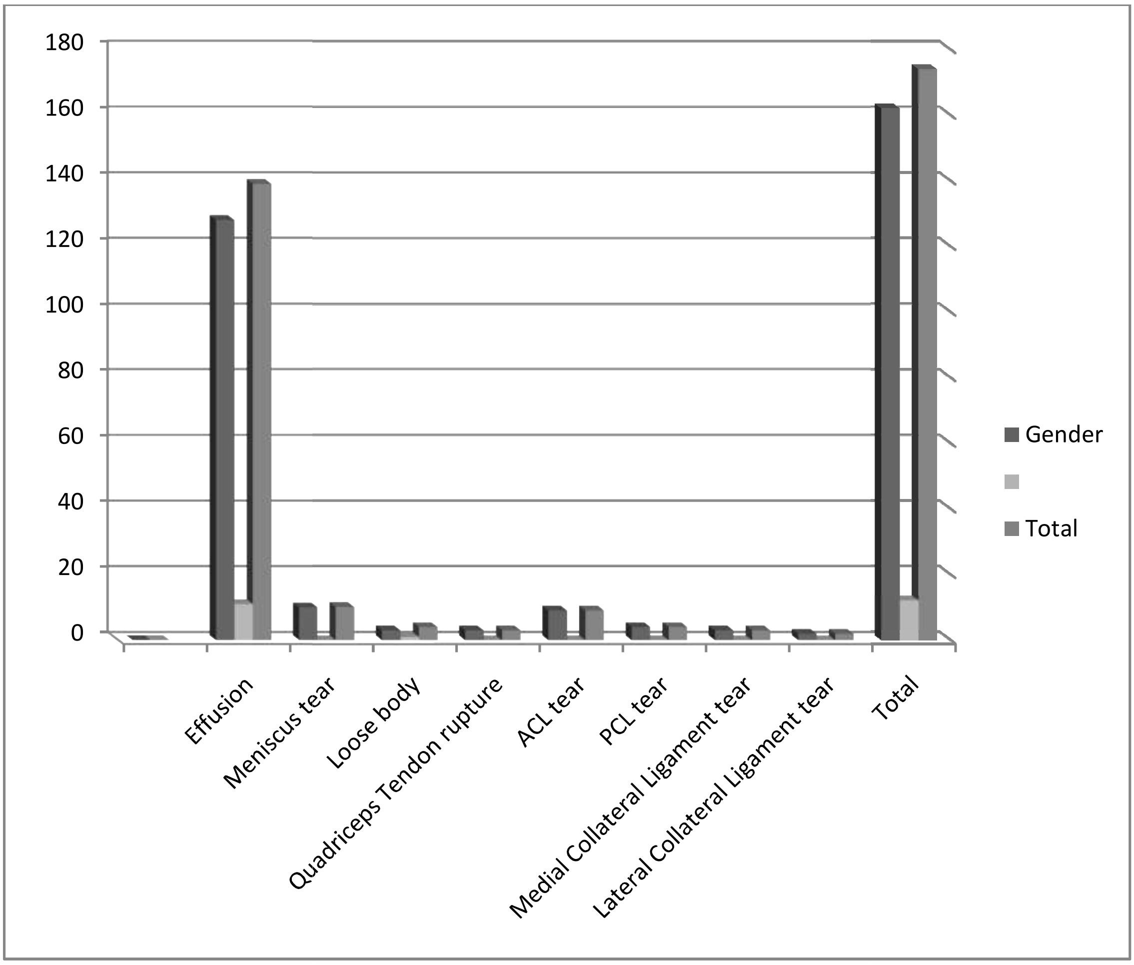


Figure (4-12): Shows relationship between traumatic finding diseases and gender

Table (4-13): Shows relationship between all finding diseases and age group

Diseases	Age groups							Total
	12-20	21-29	30-38	39-47	48-56	57-65	66-74	
Effusion	9	37	23	33	19	10	8	139
Bursitis	0	4	3	1	9	0	1	18
Meniscus tear	0	6	3	1	0	0	0	10
Loose body	0	0	2	0	2	0	0	4
Baker's cyst	0	0	0	0	3	5	0	8
Synovial cyst	0	1	0	2	2	3	0	8
Quadriceps Tendon Rupture	0	2	1	0	0	0	0	3
Arthritis	0	0	0	0	3	2	3	8
DVT	0	0	0	2	1	1	2	6
Tumor	0	0	0	1	1	0	0	2
ACL tear	0	5	2	1	1	0	0	9
PCL tear	0	2	2	0	0	0	0	4
Medial Collateral Ligament tear	0	1	1	0	1	0	0	3
Lateral Collateral Ligament tear	0	0	0	1	1	0	0	2
total	9	58	37	42	43	21	14	224

Table (4-14): Shows relationship between traumatic finding diseases and age group

Diseases	**Age groups**							**Total**
	12-20	21-29	30-38	39-47	48-56	57-65	66-74	
Effusion	9	37	23	33	19	10	8	139
Meniscus tear	0	6	3	1	0	0	0	10
Loose Body	0	0	2	0	2	0	0	4
Quadriceps Tendon Rupture	0	2	1	0	0	0	0	3
ACL tear	0	5	2	1	1	0	0	9
PCL tear	0	2	2	0	0	0	0	4
Medial Collateral Ligament ear	0	1	1	0	1	0	0	3
Lateral Collateral Ligament tear	0	0	0	1	1	0	0	2
Total	9	53	34	36	24	10	8	174

Table(4-15): Shows relationship between all finding diseases and BMI group

Diseases	BMI group					Total
	17-21	22-26	27-31	32-36	37-41	
Effusion	5	53	60	21	0	139
Bursitis	0	7	7	4	0	18
Meniscus tear	0	7	3	0	0	10
Loose body	0	2	1	1	0	4
Baker's cyst	0	1	4	2	1	8
Synovial cyst	0	5	3	0	0	8
Quadriceps Tendon Rupture	0	1	2	0	0	3
Arthritis	0	2	6	0	0	8
DVT	0	2	4	0	0	6
Tumor	0	1	1	0	0	2
ACL tear	0	7	2	0	0	9
PCL tear	0	2	2	0	0	4
Medial Collateral Ligament tear	0	1	2	0	0	3
Lateral Collateral Ligament tear	0	2	0	0	0	2
Total	5	93	97	28	1	224

Table (4-16): Shows relationship between traumatic finding diseases and BMI group

Diseases	BMI group					Total
	17-21	22-26	27-31	32-36	37-41	
Effusion	5	53	60	21	0	139
Meniscus tear	0	7	3	0	0	10
Loose body	0	2	1	1	0	4
Quadriceps Tendon Rupture	0	1	2	0	0	3
ACL tear	0	7	2	0	0	9
PCL tear	0	2	2	0	0	4
Medial Collateral Ligament tear	0	1	2	0	0	3
Lateral Collateral Ligament tear	0	2	0	0	0	2
Total	5	75	72	22	0	174

CHAPTER FIVE

5.1 DISCUSSIONS

Regarding to (table 4-1) and (figure 4-1), distribution of gender for 300 patients presenting with knee joint symptoms who had Ultrasound and Magnetic Resonance Investigation, were: 76 patients normal 74 male, 2 female and 224 US and MRI reveal variable findings, male192 patients (85.7%) and female 32 patients (14.3%), though male higher in this study because male are more active and sport than female in Saudi Arabia, so study contrary and opposite with Study done by (E. Wakamuke, et al 2005),107 patients whohad US of their knees, female presented for US of the knee more than males. This explained bythe statistics of the Uganda population and housing census of September 2002; number of female is higher than male.

Table (4-2) and Figure (4-2) shows age group frequency of knee joint diseases: (12-20) 9 patients (4%), (21-29) 54patients (25.9%), (30-38) 37patients (16.5%), (39-47) 42patients (18.8%), (48-56) 43patients (19.2), (57-65) 21patients (9.4%), (66-74) 14patients (6.3), in this table and figure we observed that: high frequency of incidence diseases range between age (21-29) years, because in this age younger people used to play football the common sport in Saudi Arabia , so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency, and low frequency of incidence diseases in elder individuals patients, range between (66-74) years, different to study done by (B. Frediani, et al, 2002), shown mean age was; 51.7 years; they found more incidence in elder patients.

Regarding to table (4-3) and figure (4-3) shows the diseases finding by ultrasound were: 211 cases (94.2%), no finding diseases were 13 cases (5.8%) from total 224 cases (100%), because US offer little or no diagnostic information for deep internal structures such as the cruciate ligaments.

Regarding to table (4-4) and figure (4-4) ultrasound characterization frequency was: Hyperechoic 8 cases (3.6%), Hypoechoic 6 cases (2.7%), anechoic 193 cases (86.2%), echogenic 4 cases (1.8%) and no finding of other diseases 13 cases (5.8%), this is the same finding shared by previous study done by (Wakefield, et al,2005).

Regarding to table (4-5) and figure (4-5) body mass index frequency was: from (17-21) 5patients (2.2%), (22-26) 93patients (41.5%), (27-31) 97patients (43.3%), (32-36) 28patients (12.5%), (37-41) 1patients (0.4%), we have observed the high incidence of diseases range between (27-31) body mass index, the range between obese and overweight individuals, it is agree with study done by (Ann, et al, 2004) titled: Weight changes and the risk of knee osteoarthritis requiring arthroplasty, overweight (BMI >25 kg/m^2) was associated with a higher relative risk of knee OA compared with those with normal relative weight.

Table (4-6) and figure (4-6) show variable mean age,height and body mass index incidence was: 40.52, 164.52 and 27.42 respectively, this indicate Saudi populations are more obese; this also prevalence in the study done by (Ann, et al, 2004).

Regarding to table (4-7) and figure (4-7) relation between all finding diseases and frequency were: effusion was: 139 cases (62.1%) very high incidence because all traumatic diseases contribute in collection of fluid around the knee joint, it is agree with study done by: (Esen et al., in 2013) found effusion by US to be 55% of consecutive patients presenting with painful knee joint.

Bursitis incidence was 18 cases (8%) the inflammation of bursa is also common due to high incidence of chronic traumatic diseases, and meniscus tears incidence was: 10 cases (4.5%), Because meniscal injury is associated with sporting activities especially football, (a common sport in Saudi Arabia).

Loose body incidence was: 4 cases (1.8%), this also due to traumatic diseases.

Baker's cyst incidence was: 8 cases (3.6%), this met study done by (Ward, et al, 2001) have shown that identification of fluid between the semimembranosus and medial gastrocnemius tendons in communication with a posterior knee cyst, indicates Baker's cyst with 100% accuracy.

Synovial cyst incidence was: 8 cases (3.6%) and Quadriceps tendon Rupture was 3(1.3%), the percentage of tendon rupture is also rare due to the cold nature of the cases presented, same study done by: (Swamy, et al, 2012) ruptures of the patellar and quadriceps tendon are rare injuries requiring immediate repair to allow extensor movement.

Arthritis 8 cases (3.6%); this is the same to (Harry, et al, 1999) report.

Deep Vein Thrombosis (DVT) 6 cases (2.6%), Tumor 2 cases (0.9) , Anterior Cruciate Ligament tears 9 cases (4%), Posterior Cruciate Ligament tears 4 cases (1.8), Medial Collateral Ligament 3 cases (1.3%) and Lateral Collateral ligament 2 cases (0.9%) it is not agree with study done by (Mustafa, et al 2012) in their study female and elder patients were higher.

Regarding to table (4-8) and figure (4-8), relation between traumatic finding diseases and frequency was: effusion was: 139 cases (62.1%) very high incidence because all traumatic diseases contribute in collection of fluid around the knee joint, this near the same with: (Esen, et al, in 2013) found effusion by US to be 55% of consecutive patients presenting with painful knee joint.

Meniscus tears incidence was: 10 cases (4.5%), because meniscal injury is associated with sporting activities especially football, a common sport in Saudi Arabia, 10 individuals (4.5%) of cases showed meniscal degeneration and tear.

Loose body incidence was: 4 cases (1.8%) this also due to traumatic diseases. Quadriceps tendon Rupture was 3 cases (1.3%), the percentage of tendon rupture was also rare due to the cold nature of the cases presented, same study done by: (Swamy, et al, 2012) ruptures of the patellar and quadriceps tendon are rare injuries requiring immediate repair to allow extensor movement. Anterior Cruciate Ligament tears 9 cases (4%), Posterior Cruciate Ligament tears 4 cases (1.8), only seen in MRI, US did not reveal inner structures obscure by patella. Medial Collateral Ligament tears 3 cases (1.3%) and Lateral Collateral ligament tears 2 cases (0.9%).

Regarding to table (4-9): and figure (4-9) Cross-tabulation between finding diseases and Ultrasound characterization of: effusion, bursitis, synovial cysts, arthritis, Quadriceps rupture and baker cyst characterized as anechoic structures in all above diseases, Tumor giving Hyperechoic feature, Meniscus tear appear as anechoic & Hypoechoic feature, loose body appear as echogenic structure, Lateral and Medial Collateral Ligaments tear were Hypoechoic texture in acute injured patients in ultrasound ACL and PCL tear no finding in conventional Ultrasound but in Doppler Ultrasound giving high vascularity in acute injured patients.

Regarding to table (4-10): and figure (4-10): cross tabulation between Ultrasound and MRI characterization was: no finding in ultrasound 13 cases, which was found in MRI T2 W. as low signal, Hyperechoic in Ultrasound 8 cases which were shown as low signal in MRI T2 W., Hypoechoic 6 cases in ultrasound which was seen as low signal MRI, Echogenic structures 4 cases in Ultrasound and seen in MRI T2 W as low signal, Anechoic structures 181 cases in Ultrasound and high signal in MRI T2 W.

Regarding to table (4-11) and figure (4-11): Relationship between all finding Diseases and Gender incidence were: Effusion 128 Male and 11Female, Bursitis 12 Male and 6 Female, Meniscus tear 10 Male no Female was found, Loose body 3 Male and 1 Female, Baker's cyst 2 Male and 6 Female, Synovial cyst 6 Male and 2 Female, Quadriceps Tendon rupture 3 Male and no Female finding, Arthritis 6 Male and 2 Female, DVT 2 Male and 4 Female, Tumor 2 Male and no finding in Female patients, ACL tear 9 Male no finding in Female patients, PCL tears 4 Male and no finding in Female patients, Medial Collateral Ligament tear 3Male and no finding in female patients, Lateral Collateral Ligament tear 2 Male and no finding in Female patients, it is not agree with study done by (Mustafa, et al, 2012).

Regarding to table (4-12) and figure (4-12): Relationship between traumatic finding Diseases and Gender incidence were: Effusion 128 Male and 11Female, Meniscus tear 10 Male no Female was found, Loose body 3 Male and 1 Female, Quadriceps Tendon rupture 3 Male and no Female finding, ACL tear 9 Male no finding in Female patients, PCL tears 4 Male and no finding in Female patients, Medial Collateral Ligament tear 3Male and no finding in Female patients, Lateral Collateral Ligament tear 2 Male and no finding in Female patients, so study contrary and opposite with Study done by (E. Wakamuke, et al 2005) titled: Experience with Ultrasound of the Knee Joint at Mulago Hospital, Uganda. 107 patients whohad US for their knee joint, more female more than male. This may explain bythe statistics of the Uganda population and housing census of September 2002; number of female is higher than male.

Regarding to table (4-13) and figure (4-13): Relationship between all finding diseases and age group were:

Effusion: age group from (12-20) years the frequency was 9 cases, age group from (21-29) years the frequency was 37 cases, age group from (30-38) years the frequency was 23 cases, age group from (39-47) years the frequency was 33 cases, age group from (48-56) years the frequency was 19 cases, age group from (57-65) years the frequency was 10 cases, age group from (66-74) years the frequency was 8 cases. It is agreed with studies done by (Esenet al., in 2013) and (Mustafa, et al, 2012).

The commonest age group frequency range from (21-29) years, about 37 individuals (26.6%), from the total were: 139, because in this age the common sport in Saudi Arabia is the football, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency.

Bursitis incidence was common in age group from (48-56) years, because in this age the patient is exposed to osteoarthritis and other inflammatory diseases.

Meniscus tear was common in age group from (21-29) years, because in this age the common sport in Saudi Arabia is the football, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency.

Loose body incidence was common in age group from (48-56) years, because in this age the patient is exposed to osteoarthritis and other inflammatory diseases.

Baker's cyst and Synovial cyst, Arthritis and DVT incidence were common in age group from (48-65), because in this age the patients elder and more obese and female stand more time in the kitchen than male.

It is agree with study done by (Harry, et al, 1999) who reported that it is usually uncommon in the age group 41-50 years for osteoarthritis. Baker's cyst incidence agree with study done by (Ward et al 2001) have shown that identification of fluid between the semimembranosus and medial gastrocnemius tendons in communication with a posterior knee cyst, indicates Baker's cyst with 100% accuracy.The incidence of Baker's cyst were: female 6 cases (75%) more than male 2 cases (25%) It is agree with study done by (Naredo, et al., 2006).

Studies done by (Teefey, et al, 2001) and (Ward, et al, 2001) had shown that identification of fluid between the semimembranosus and medial gastrocnemius tendons in communication with a posterior knee cyst indicates Baker's cyst with 100% accuracy. These features have been demonstrated in all cases where the Baker's cysts were found. The gender distribution is the same females (75%) and male (25%). This has been attributed to the fact that females stand more than male in the kitchen, and they are more obese.

Quadriceps Tendon rupture, ACL tear, Medial Collateral Ligament tear and Lateral Collateral Ligament tear, incidence were common in age group from (21-29) years, because in this age younger people play football,(the common sport in Saudi Arabia is the football), so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency in age group from (21-29). It is agree with study by (Tung, et al, 1997).

Regarding to table (4-14): Relationship between traumatic finding diseases and age group were:

Effusion: age group from (12-20) years the frequency was 9 cases, age group from (21-29) years the frequency was 37 cases, age group from (30-38) years the frequency was 23 cases, age group from (39-47) years the frequency was 33 cases, age group from (48-56) years the frequency was 19 cases, age group from (57-65) years the frequency was 10 cases, age group from (66-74) years the frequency was 8 cases.

Age group frequency commonest was (21-29) years about 37 individuals (26.6%), from the total were: 139.It is agree with study done by (Verna, et al, 2001) said.

Meniscus tear was common in age group from (21-29) years.

Loose body incidence was common in age group from (48-56) years, because in this age the patient is exposed to osteoarthritis and other inflammatory diseases.

Quadriceps Tendon rupture, ACL tear, Medial Collateral Ligament tear and Lateral Collateral Ligament tear, incidence were common in age group from (21-29) years younger and active age, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency in age group from (21-29) years.

Regarding to table (4-15): Relationship between all finding diseases and Body mass index group was:

Effusion: Body Mass Index group from (17-21) BMI the frequency was 5 cases, Body Mass Index group from (22-26) BMI the frequency was 53 cases, Body Mass Index group from (27-31) BMI the frequency was 60 cases, Body Mass Index group from (32-36) BMI the frequency was 21 cases, Body Mass Index group from (36-40) BMI the frequency was 0,

I have observed that the high incidence of diseases relation to Body Mass Index group was:from(22-26) BMI, because this consider slim and active, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency. Also high incidence of disease was: from (27-31) BMI, because over weight and obese patients they are more exposed to inflammatory diseases than other. It is agree with study done by(Ann, et al, 2004) said titled: Weight changes and the risk of knee osteoarthritis requiring arthroplasty,overweight (BMI >25 kg/m^2) was associated with a higher relative risk of knee OA requiring arthroplasty.

Bursitis was common from (27-31) BMI, because over weight and obese patients they are more exposed to inflammatory diseases than other.

Meniscus tear, Loose body, and Synovial cyst, were common in Body Mass Index group from: (22-26) BMI, because this consider slim and active, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency.

Baker's cyst, DVT, Tumor, Arthritis and Quadriceps Tendon rupture, Body Mass Index group from (27-31) BMI, this has been attributed to the fact that obese people more frequency incidence than slim.

Medial Collateral Ligament tear, Lateral Collateral Ligament tear, ACL tear and PCL tear Body Mass Index group from (22-26) BMI, because this consider slim and active, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency. It is agree with study done by (Frediani, et al, 2002).

Regarding to table (4-16): Relationship between traumatic finding diseases and Body Mass Index group was:

Effusion: Body Mass Index group from (17-21) BMI the frequency was 5 cases, Body Mass Index group from (22-26) BMI the frequency was 53 cases, Body Mass Index group from (27-31) BMI the frequency was 60 cases, Body Mass Index group from (32-36) BMI the frequency was 21 cases, Body Mass Index group from (36-40) BMI the frequency was 0,

I have observed that the high incidence of diseases relation to Body Mass Index group was:from (22-26) BMI and from (27-31) BMI, from (22-26) because in this BMI patient having normal weight, this consider slim and active, so high frequency of traumatic knee joint diseases is very common that increase knee joint diseases frequency.

From (27-31), because over weight and obese patients they are more exposed to inflammatory diseases than other.

Meniscus tear, Loose body,Medial Collateral Ligament tear, Lateral Collateral Ligament tear, ACL tear and PCL tear were common in Body Mass Index group from: (22-26) BMI.

Quadriceps Tendon rupture, Body Mass Index group from (27-31), this has been attributed to the fact that obese people more frequency incidence than slim.

It is agree with study done by (Court‑Payen M., 2004).

5.2 Conclusion:

- In this study total patients scanned was 300, normal was 76 patients abnormal was 224 patients. It is found that Males constituted 192 (85.7%) and Female 32 (14.3%) in abnormal patients.High frequency of knee joint diseases range between age (21-29) years, the low frequency of knee joint diseases, range between (12-20) years.High frequency of traumatic knee joint diseases is very common.

- Knee joint Diseases findings by ultrasound were: 211(94.2%) cases, Knee joint diseases no finding by ultrasound were 13(5.8%).
- High incidence of diseases range between (22-31) body mass indexes.
- All finding diseases and were: effusion, Bursitis, Meniscus tears,Loose body, Baker's cyst, Synovial cyst,Quadriceps tendon Rupture, Arthritis, Deep Vein Thrombosis (DVT), Tumor, Anterior Cruciate Ligament tears, Posterior Cruciate Ligament tears, Medial Collateral Ligament and Lateral Collateral ligament.
- Traumatic finding diseases were: effusion, Meniscus tears, loose body, Quadriceps tendon Rupture, Anterior Cruciate Ligament tear, and Posterior Cruciate Ligament tears, Medial Collateral Ligament and Lateral Collateral ligament.
- Ultrasound characterization of the following knee joint diseases: effusion, bursitis, synovial cysts, arthritis, Quadriceps rupture and baker cyst was: anechoic structures.
- Tumor appear as Hyperechoic and Meniscus tear appear as Hypoechoic feature, loose body appear as echogenic structure, Lateral and Medial Collateral Ligaments tear appear as Hypoechoic texture in acute injured patients in ultrasound ACL and PCL tear no finding in conventional Ultrasound but in Doppler Ultrasound giving high vascularity in acute injured patients.
- Ultrasound in this study is able to detect all the knee joint diseases except ACL and PCL tears.

- Ultrasound can evaluate the knee joint diseases especially cystic masses, menisci, ligaments, tendons and muscles tear.
- Ultrasound allows contralateral examination and does not pose limitations due to metal artifacts, which can be contraindicated in magnetic resonance imaging (MRI).
- Ultrasound able to visualize needles and target structures on real time imaging makes it an ideal tool for the guidance procedures used in diagnosis and manage foreign body and biopsy.
- Doppler ultrasound is very important in case of differentiating baker's cysts from aneurysm.
- Ultrasound is very good in evaluating DVT aging and determine the blood flow across the DVT site.
- Combination of high-frequency probes and improved power Doppler technology provides a great opportunity to study image aspects of inflammatory conditions such as tenosynovitis of knee joint diseases.

5.3 Recommendations:

- Orthopedic surgeon to request ultrasound in routine clinical practice in knee joint investigations.
- Ultrasound examination as the primary image modality in initial evaluation of knee joint and MSK diseases in big Central Hospital.

- MRI is not wide available, expensive and poses limitations due to metal artifacts, so it is recommended that ultrasound to be use contributing to the diagnoses of knee joint pathology in the low resourced services.
- Combinations of different ultrasound frequency and Doppler for MSK diseases were recommended.
- Recent advances in technology such as three-dimensional ultrasound and contrast agents have potential to play a major role in early detection and monitoring of inflammatory arthritis of knee joint diseases in the future, so more practical MSK US for Sonographer is recommended.

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APPENDICES

Appendix A

Data collection and sheet

Sudan University of Science and Technology
Collage of Graduate studies
Ph.D. of Medical Diagnostic Ultrasound
Characterization of Knee Joint Diseases Using Medical Ultrasound and Magnetic Resonance Imaging

Patient data:

Patient name ……………………………………

Patient sex Male ☐ Female ☐

Patient age in years ……………………………………

Patient weight ……………………………………

Patient occupation ……………………………………

Marital status ……………………………………

Athletic practice Yes ☐ No ☐

Previous Medical history ……………………………………

US finding …………………………………

MRI finding:

T1 finding ………………………………………

T2 finding ………………………………………………………

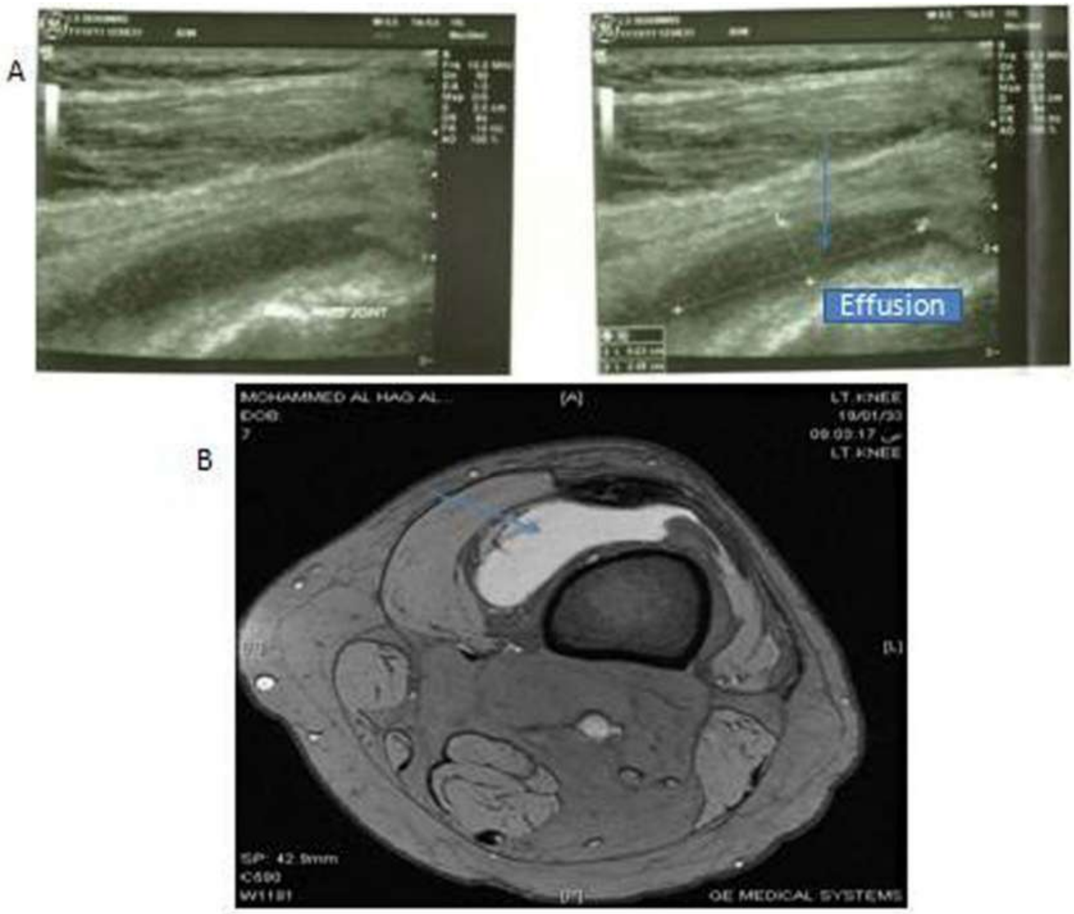
Comment ………………………………………

Appendix B

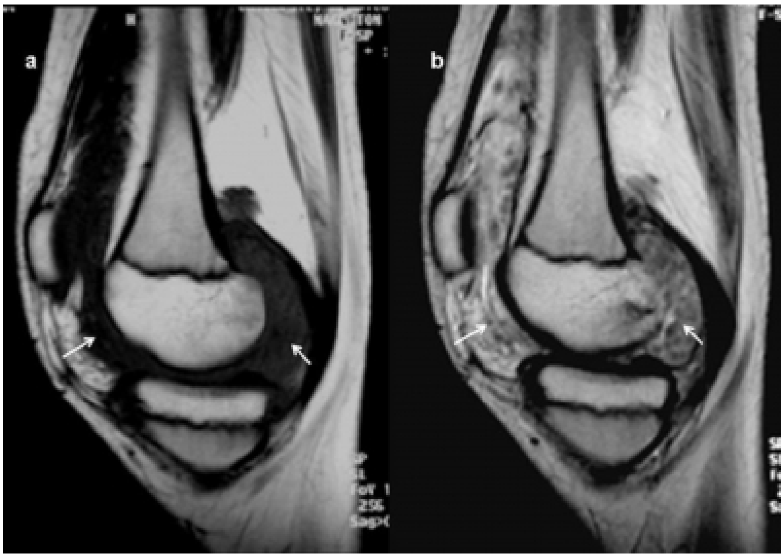
MRI findings and protocol used from the patients data

diseases	MRI* characterization		
	T1 weighted	T2 weighted	STIR
effusion	Iso signal to the tissue	High signal	High signal
bursitis	Iso signal to the tissue	High signal	High signal
meniscus tear	Low signal	High signal	High signal
loose body	Very low signal	Very low signal	Very low signal
baker's cyst	Iso signal to the tissue	High signal	High signal
synovial cyst	Iso signal to the tissue	High signal	High signal
Quadriceps tendon rupture	Iso signal to the tissue	High signal	High signal
arthritis	Low signal	High signal	High signal
DVT****	low signal	low signal	low signal
Tumor	low signal	low signal	low signal
ACL tear**	Low signal	High signal	High signal
PCL tear***	Low signal	High signal	High signal
Medial collateral ligament tear	Low signal	High signal	High signal
Lateral collateral ligament tear	Low signal	High signal	High signal

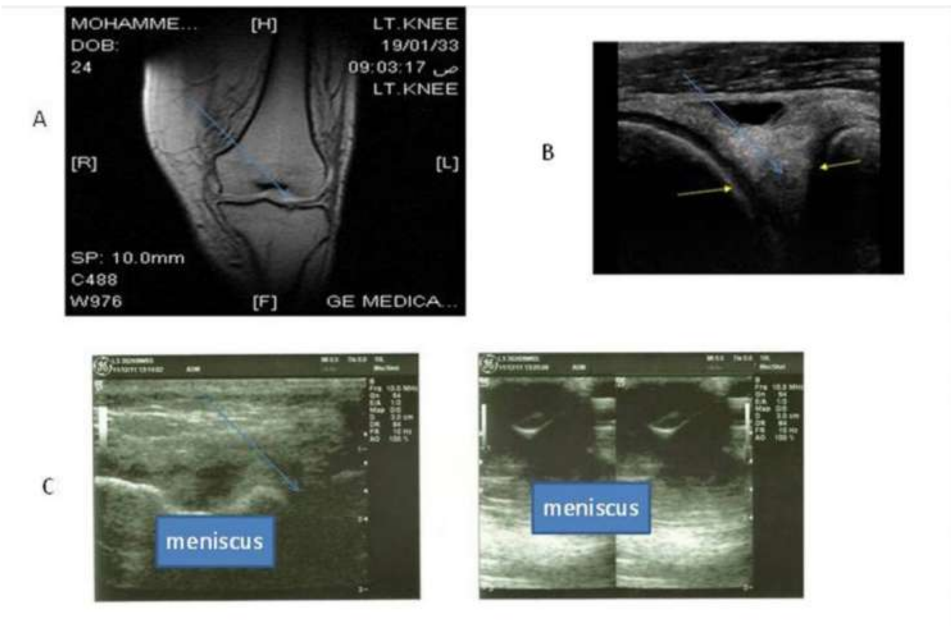
Appendix C: Cases



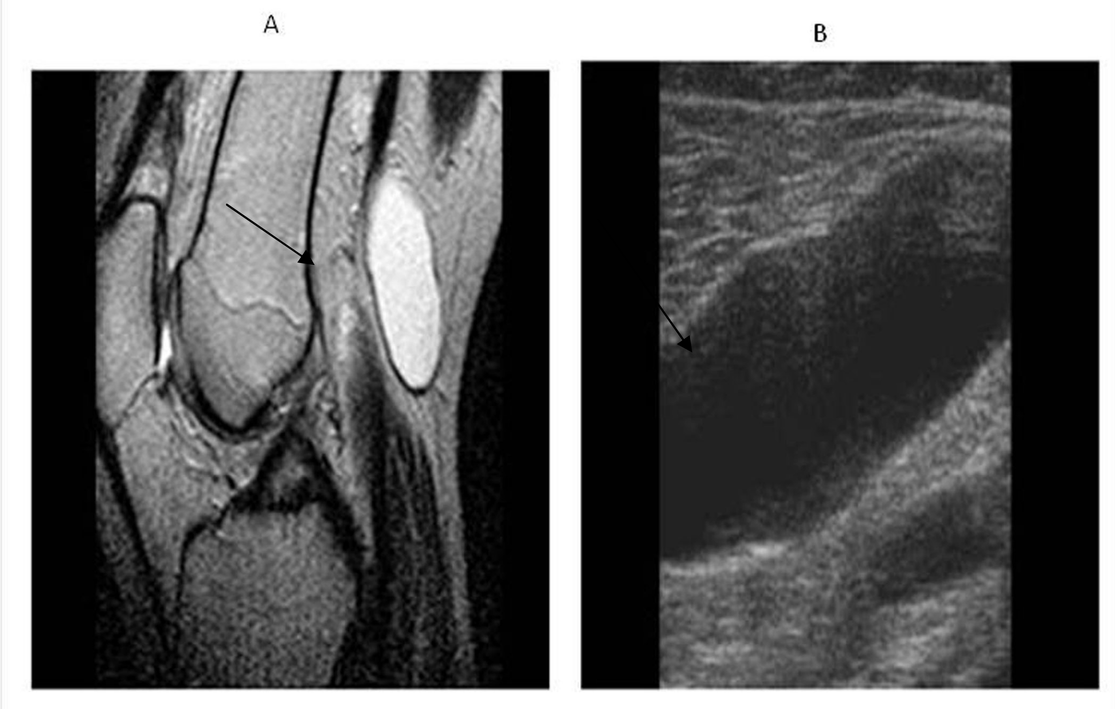
Case (1):Knee joint Effusion, male 58 years, Ultrasound: A, MRI: B



Case(2) Male 55years, A Sagittal T1-W MRI shows thickened synovium which is hypointense (white arrows). b. Sagittal T2-W image shows the corresponding lesion to be inhomogeneouslyhyperintense (black arrows).



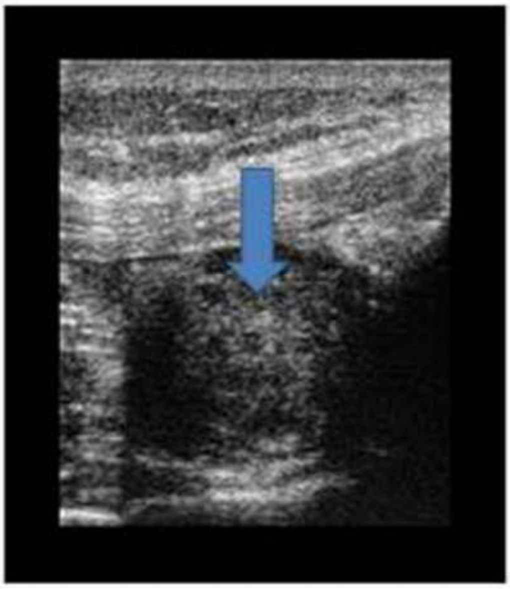
Case (3): Knee joint Meniscus tear, male 58 years, MRI: A, Ultrasound: B &C



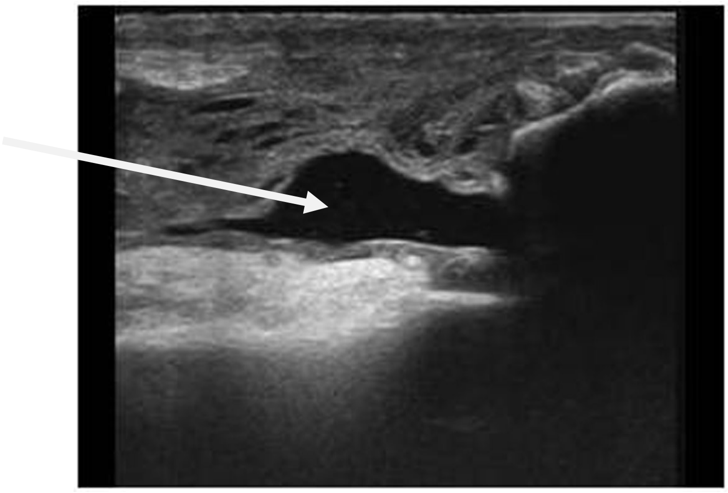
Case (4): Male 55years, Knee joint, Arthrosynovial cyst, coronal T2 weighted Magnetic Resonance Imaging (MRI):A, longitudinal view Ultrasound: B

A

B

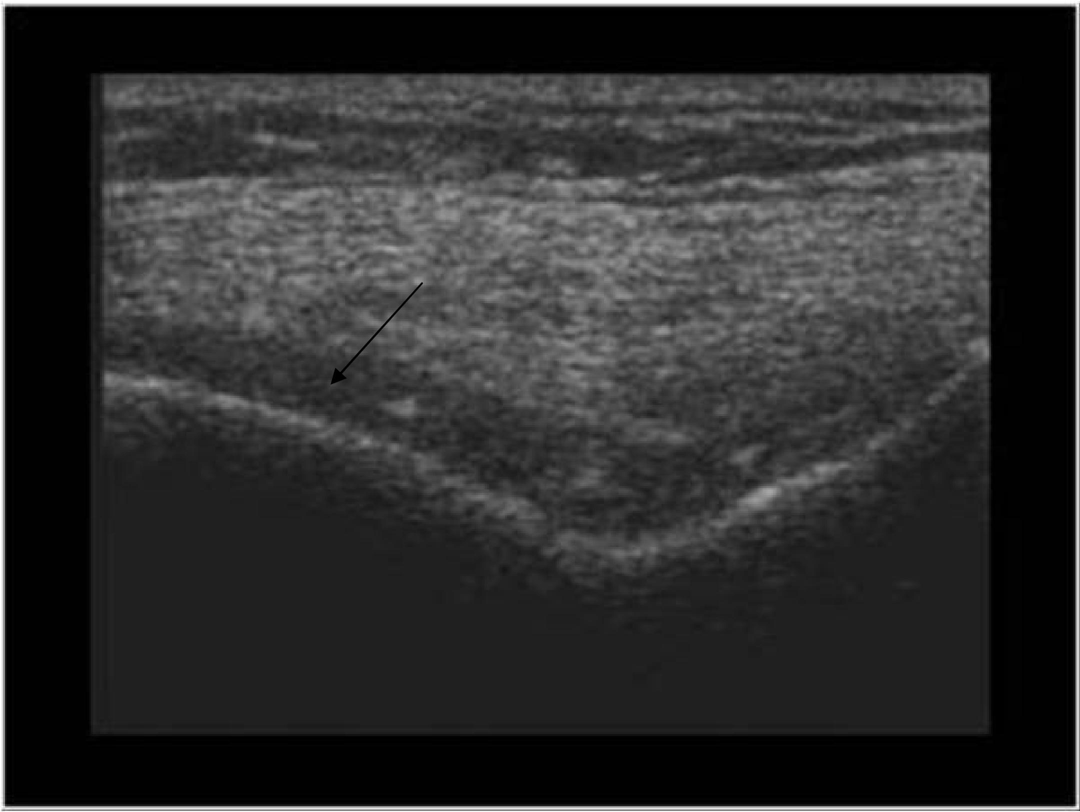


Case(5): Male 39 years Knee joint Soft tissue mass in continuation with the suprapatellar recess, Sagittal T1 weighted Magnetic Resonance Imaging (MRI):A, without effusion and synovial thickening in Ultrasound: B



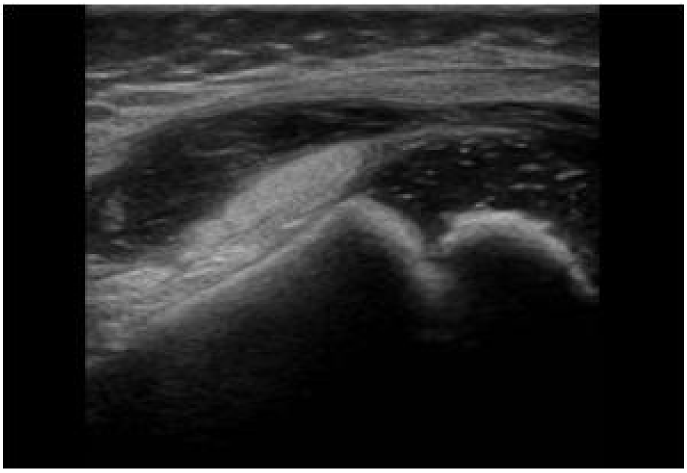
Case (5): Male 23years, Knee joint Quadriceps tendon rupture, Ultrasound longitudinal view.

Case (6): Male 55years, Knee joint Synovial cyst, Sagittal T2 weighted Magnetic Resonance Imaging (MRI).

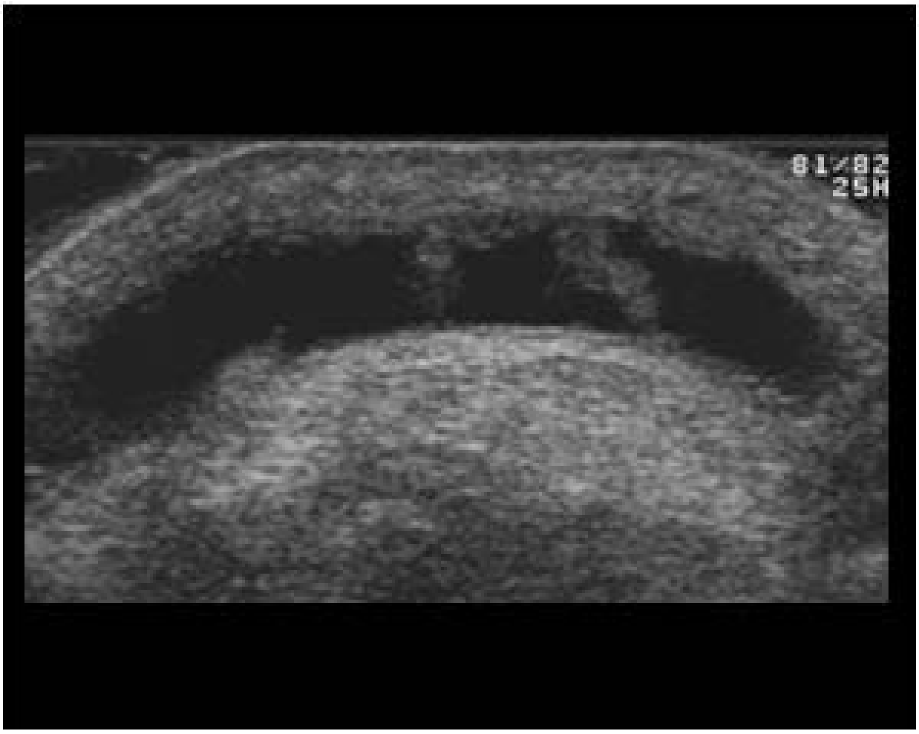


Case(7): Male 62 years, Knee joint Cartilage calcifications Ultrasound

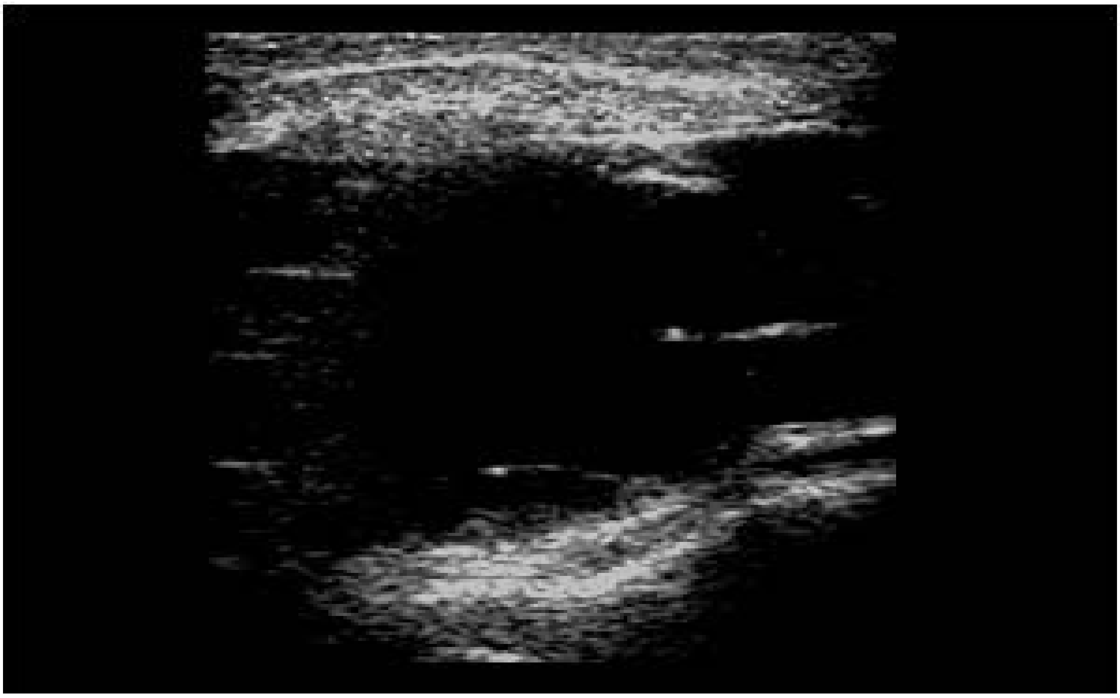
Case (8): Female 48 years, Show Knee joint forBaker's cyst, Ultrasound Transverse view.



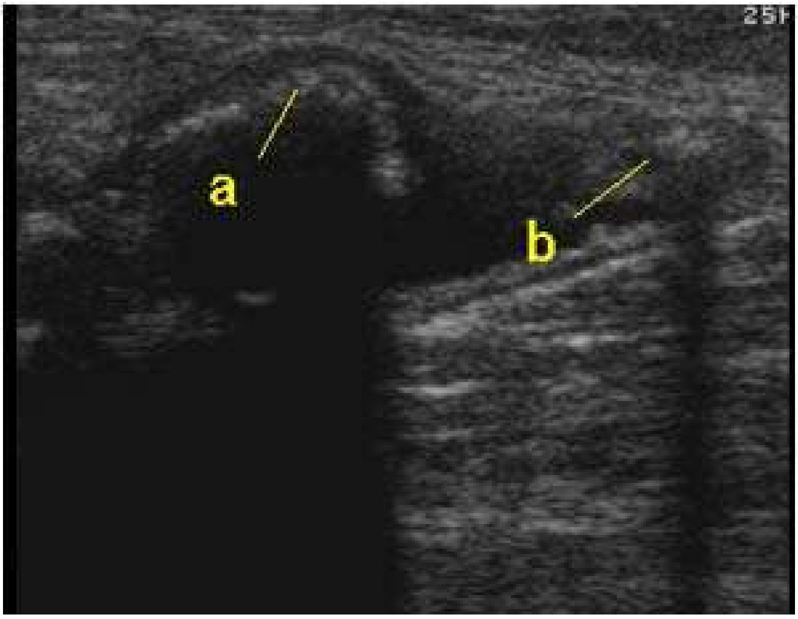
Case (9): Male 58years,Arthritis of the knee with an effusion and synovial thickening Effusion and synovial thickening in the suprapatellar recess longitudinal



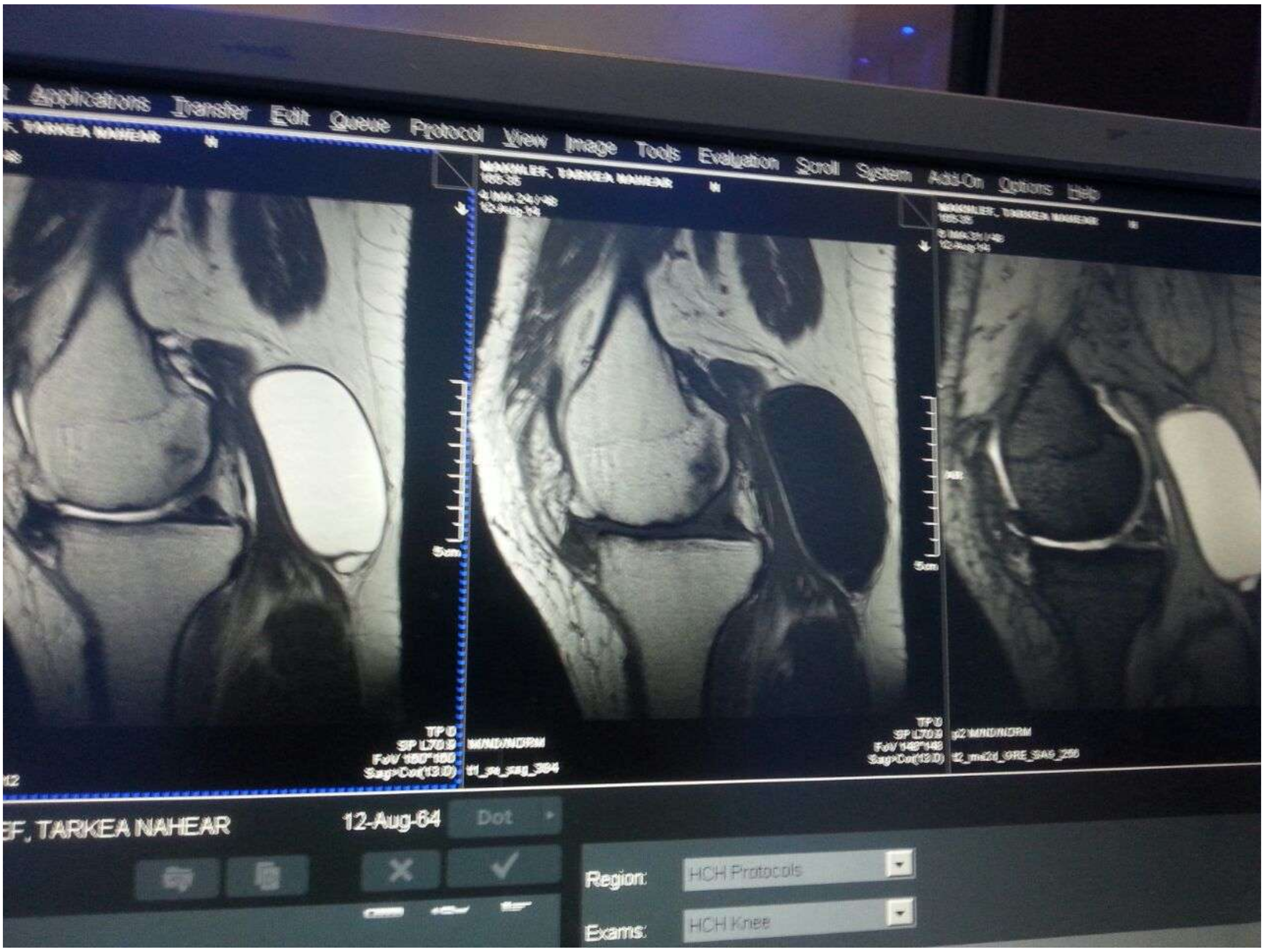
Case (10): Male 66 years, Ultrasound shows Bursitis transverse



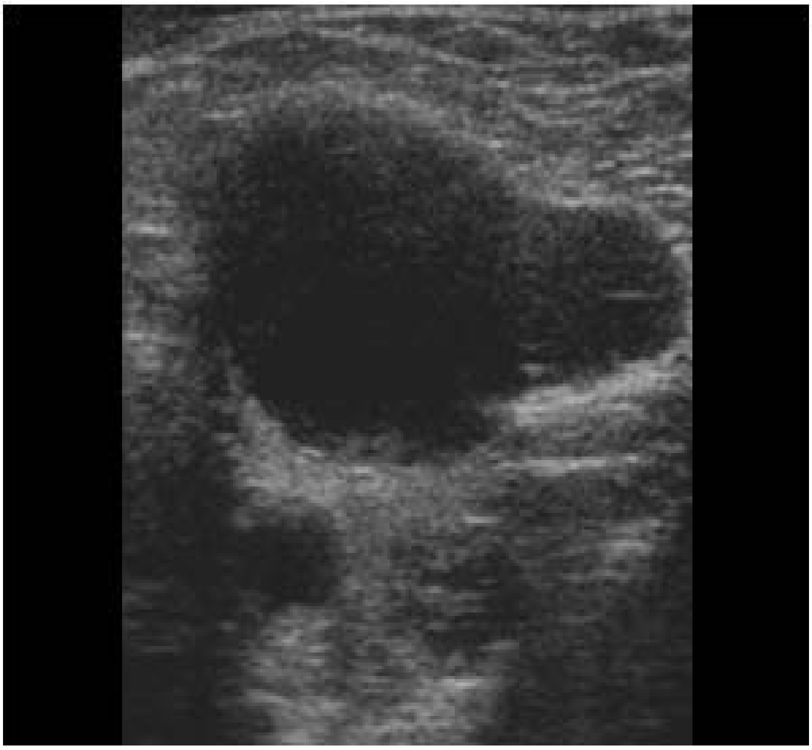
Case (11): Male 65 years, Ultrasound shows synovial cyst behind patella tendon



Case (12): Female 56 years, Ultrasound shows Baker´s cyst with loose bodies longitudinal

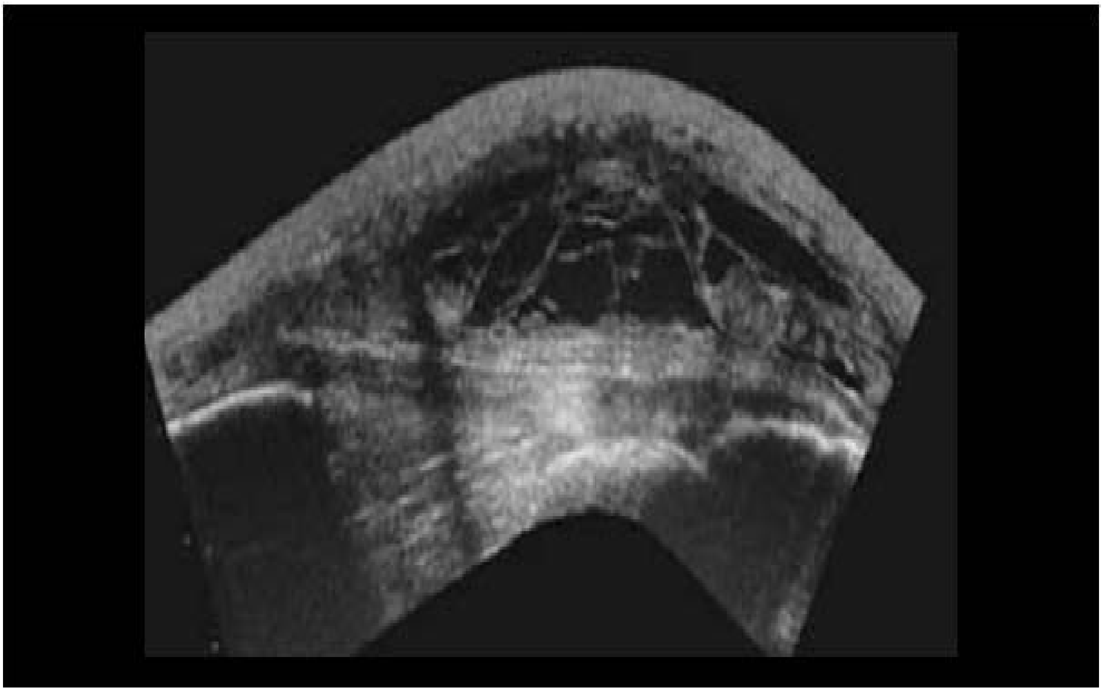


Case (13): Female 58 years, MRI shows baker's cyst T1, T2



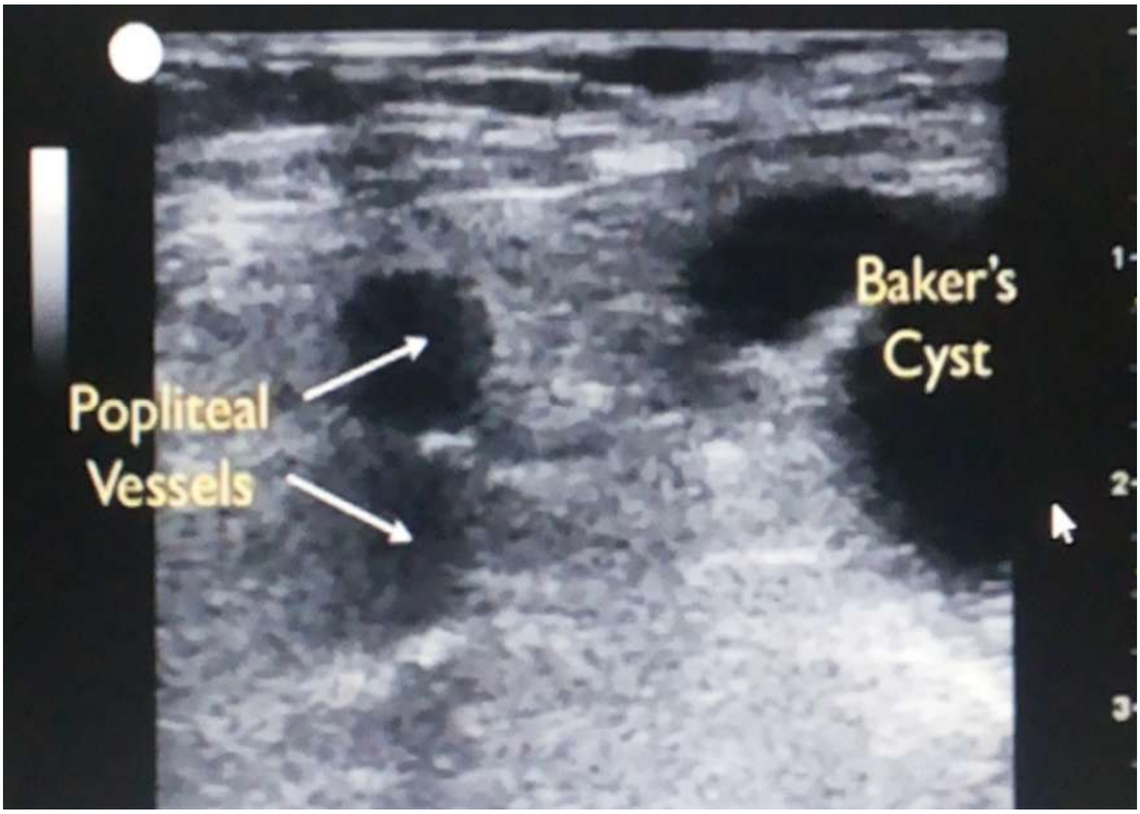
Case (14): Male 62 years,Arthrosynovial cyst transverse in Ultrasound

Case (15): Male 62 years,Arthrosynovial cyst, MRI T2

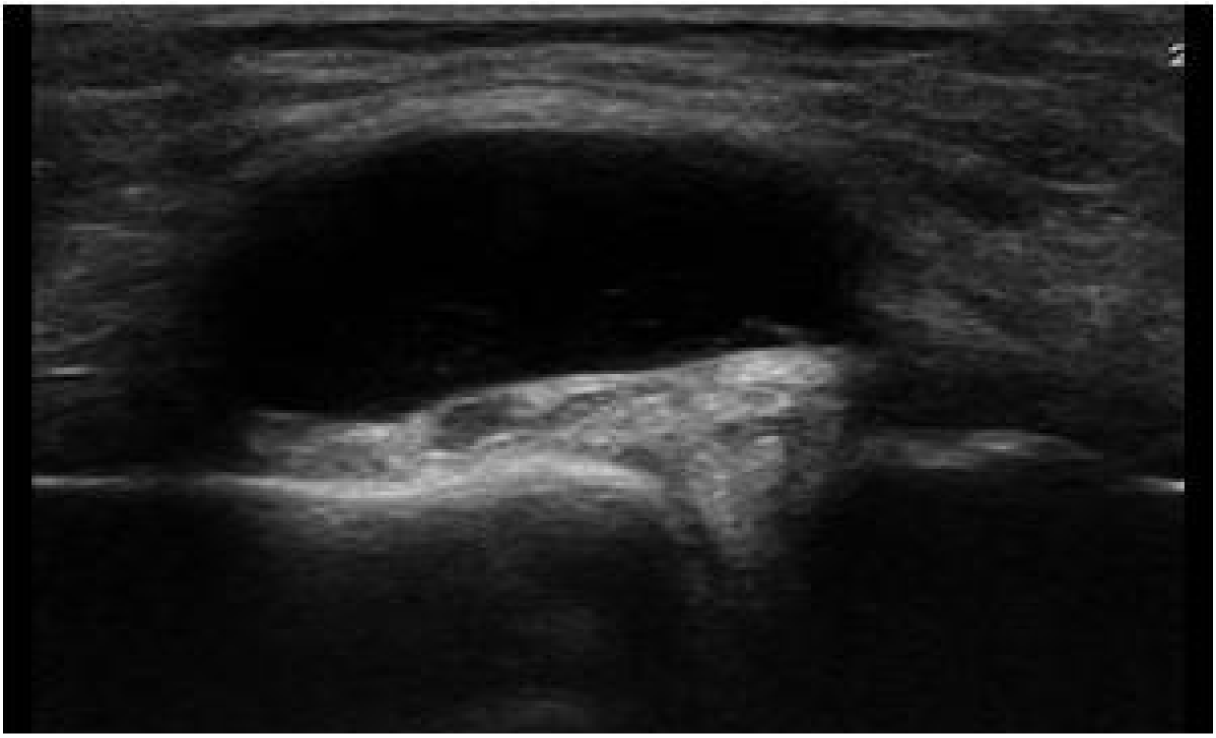


Case (16): Male 23 years, Bursitis of the prepatellar bursa with a septated fluid collection bursitis

Case (17): Male 39 years, Soft tissue mass in the knee in continuation with the suprapatellar recess without effusion and synovial thickening, MRI T1 W.



Case (18): Male 58 years, Ultrasound shows Baker's cyst relation to popliteal vessels



Case (19) Male 39 years, Ultrasound shows meniscal cyst

Case (20): Male 26 years, LongitudinalUltrasound shows medial collateral ligament rupture

Thesis outcome

Two papers were published:

1. **Elgeili Adam Yousif,BushraHussienAhmed,Alsafi Ahmed Abdella,Qurashi Mohammed Ali, Knee joint diseases diagnosed by ultrasound and magnetic resonance imaging Sudan Medical Monitor , Jan-Mar 2014 ,Vol 9 ,Issue 1**

1. **Bushra H. Ahmed, Elgeili Adam A. Yousif, Alsafi A. Abdella, Characterization of Knee Joint Diseases Using Medical Ultrasound and Magnetic Resonance Imaging, International Journal of Science and Research (IJSR), Volume 4 Issue 4, April 2015**