Sudan University of Science and Technology
College of Graduate Studies

Characterization of Patellar Ligament Using Magnetic Resonance Imaging

توصيف الرباط الرضفي باستخدام التصوير بالرنين المغناطيسي

A Thesis Submitted For Partial Fulfillment Of M.Sc. Degree In Diagnostic Radiological Technology

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الآيه

قال تعالى:

صدق الله العظيم

سورة طه الآيه (114)

Dedication

Dedicated to my parents , who I keep in my heart , who motivated and much supported me.

To brothers , sisters, relatives and friends who supported me through all my life .

To everyone who's also supported me and gave me a push.

Acknowledgement

This research is made through the help and support from everyone , including parents, teachers, family and friends.

Firstly great thanks be to Allah for completion this research.

Second I would like deeply to thank my supervisor Prof. Caroline Edward and also Sudan University of Science and Technology, college of Radiological science for their most support and encouragement for giving this research.

I would also like to thank East Nile Hospital and the Modern Medical Center department for their cooperation in data collections.

Finally Special thanks for all friends, teachers, colleagues.

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List of Abbreviations

MRI	Magnetic Resonance Imaging
CT	Computed Tomography
PCL	Posterior cruciate ligament
ACL	Anterior cruciate ligament
Lat	Lateral
Med	Medial
lCL	Lateral collateral ligament
MCL	Medial collateral ligament
PL	Patellar tendone length
PT	Patellar thickness
BMI	Body Mass Index
KV	KiloVoltage
MA	Milli Ampere
SE	Spin echo
FSE	Fast spin echo
GRE	Gradient echo
Sat	Saturation pulse
T1	Longitudinal relaxation time
T2	Transverse relaxation time
PD	Proton density
FOV	Field of view
3D	Three dimensional view
MPR	Multi Planner Reformation
P	Posterior
A	Anterior
R	Right
L	Left
STIR	Short Time Inversion Recovery
Fig	Figure
NO	Number

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Abstract

The study provides characterization of the patellar ligament and measurment on sagittal sections by using MRI machine. It's a discriptive study mainly to provide the characterization of the ligament length and thickness. To correlate the findings with age, gender, weight, height and BMI. And to compare the results with the literature. The data was collected at Modern Medical Center and East Nile Hospital during the period from November 2017 to February 2018. Closed MRI machine was used, the study included a sample of 50 patients (35 males and 15 females) with age range between (20-70) years old , whose mean age was (39.6±14.53) years old .The mean age of the patellar ligament length was (50.826±5.215mm) and the upper patellar ligament thickness was (4.148±1.015mm), the middle patellar thickness was (4.048±0.66mm) and the lower patellar thickness was (4.342±0.898mm). The mean female patellar length was (48.33 ±3.91mm) ,upper patellar thickness was(4.24±0.86mm) ,middle patellar thickness was (3.88±0.62mm) and lower patellar thickness was (3.72±0.45mm).The mean male patellar length was (51.89±5.38mm) and upper patellar thickness was (4.10±1.08mm), middle patellar thickness was (4.12±0.68mm) and lower patellar thickness was (4.60±0.91mm). The patellar ligament length and lower patellar thickness are significantly different according to gender at (p =0.024) and (p =0.001) respectively. The patellar ligament length have significant relation with the patient height at (p=0.000) and the upper patellar thickness was significant relation with age, weight and BMI at (p= 0.022, 0.033 and 0.021) respectively. As conclusion this study showed that MRI is a noninvasive test and suitable examination for characterizing the patellar ligament length and thickness.

ملخص البحث

توفر الدراسة توصيف الرباط الرضفي وقياسه على الأقسام السهمية باستخدام آلة التصوير بالرنين المغناطيسي. هي غالبا دراسه وصفيه تقيس وتوصف طول الرباط الرضفي وسمكه وتربط النتائج بالمتغيرات وتقارنها بالدراسات السابقه.جمعت البيانات و أجريت الدراسة في المركز الطبي الحديث ومستشفى شرق النيل خلال الفترة من نوفمبر 2017 إلى فبراير 2018. وشملت الدراسة عينة من 50 مريضا (35 ذكر و 15 أنثى) . تتراوح أعمارهم بين (20-70) عمر الوسط (39.6 ± 14.539) سنة. بلغ متوسط طول الرضفة للإناث (48.33 ± 3.91) وسماكة الرضفة العليا (4.24 ± 0.86) وسماكة الرضفة الوسطى (3.88 ± 0.62) وسماكة الرضفة السفليه كانت (3.72 ± 0.45) وكان متوسط طول الرضفة للذكور (51.89 ± 5.38) وسماكة الرضفة العليا كانت (4.10 ± 1.08) ، وكانت سماكة الرضفة المتوسطة (4.12 ± 0.68) وسماكة الرضفة السفليه كانت (4.60 ± 0.91). معدل الوسط لطول الرباط الرضفي اعلى عند الذكور من الاناث. يختلف طول رباط الرضفة وسماكة الرضفة بشكل معنوي باختلاف النوعين (0.024) و (0.001) على التوالي. طول الرباط الرضفي له علاقة مع الطول عند (0.00) وسماكة الرضفة العليا لها علاقة مع العمر والوزن ومؤشر كتلة الجسم عند (0.022 و 0.033 و 0.021) على التوالي. كما استنتجت هذه الدراسة ، فإن التصوير بالرنين المغناطيسي هو اختبارآمن وفحص مناسب لطول الرباط وسماكة الرضفي.

CHAPTER ONE
(Introduction)

1-1Background:

Anatomically the patella ligament origin from apex ofknee and insertion to tibialtuberosity , physiology machineof the knee is composed of the quadriceps muscles and patellar ligament , detailed morphological data of them are the fundament basis to understand the pathogenesis of disorder around knee.(RISHARD S.SNEELL,2000).

This study provides the patellar ligament of knee measureson Magnetic Resonance Imaging(MRI) ,it's best to visualize and have good tissue resolution and high spatial resolutionwhich allows the clear imaging of bones including thepatella, femur and tibia , as well as the ligament structure of the patellar ligament .The characterize of patellar ligament is black in T1w and T2w more accurate in sagittal imaging , measurementinclude longitudinal length of the patellar ligament and thickness any change insignal intensity.Anthropometry including weight, age genderand BMI inaddition we compared the data between male and femalesubject .The morphometry of patellar ligament is becomingincreasingly important in diagnosis tear.
(Http://Radiologyinfo.Org,2014).

1-2 Problems :-

Patellar ligament is well demonstrated by MRI as low signal intensity with equal semantically thickenss , some times tearing may happen leaving the tendon to be wider , so the measurement should be studied i to avoid miss diagnosis , and compare the normal measurement of patellar ligament with abnormal measurement as the tendon measure may be larger than normal in case of tearing ligament.

1-3 Objectives: -

1-3-1General objectives :-

To characterize the patellar ligament using MRI.

1-3-2Specific objectives :-

1-To measure the thickess and length of patellar ligament.

2- To correlate the findings with age , gender , weight , height and BMI.

3- To compare the measurement with what was found in the literature.

1-4 Thesis overview:-

To make the aims of the project stated above true thesis falls into five chapters . Chapter one which is an introduction ,deals with theoretical from work of the study, it present thestatement of the study problem and objective of the study ,and thesis outcome chapter two, deals with theoreticalbackground of knee joint (anatomy, physiology andpathology), review of the instrumentations and techniqueswhich include knee assessment by clinical examinations ,conventional X-ray ,CT computed tomography, MRI magneticreasons imaging and literature review (previous study), while chapter three discuses the material and method and chapterfour include presentation of the results and finally chapterfive deals with the discussion , recommendation, conclusionof the study perfumed as well as future work.

CHAPTER TWO
(Theoretical background)
Anatomy, Physiology and Pathology

2-1Anatomy:-

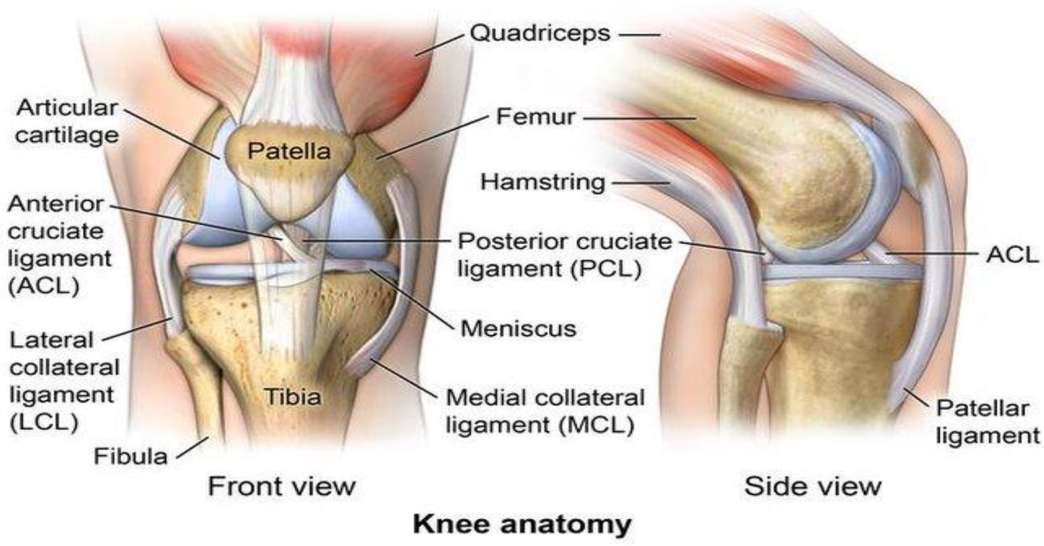
The knee joint the knee is a modified hinge joint and this synovial joint is the largest in the body. Although contained within a single joint cavity, the knee effectively comprises two condylar joints between the femoral and corresponding tibial condyles and a saddle joint between the patella and the femur. The tibiofemoral compartments are each divided by a fibrocartilaginous meniscus.(Paul Butler et al ,2007).

2-1-1Bones:-

The bones that contribute to the knee joint and lower leg arethe femur, tibia, patella and fibula.Cartilage covers the articular surfaces of the femur, tibia andpatella and helps to provide smooth movement within theknee joint.(Lorrie L. Kelley et al, ed2, 2007).

2-1-2 Menisci and Ligaments:-

Menisci located between the femoral condyles and tibial plateaus are the paired menisci these C-shaped menisci, composed of fibrous connectivetissue, cushion the articulation between the femoral condyles and tibial plateaus and are commonly divided into anteriorand posterior horns. On cross section they appear wedgeshaped, with a thickened outer margin that flattens medially. Their outer margins fuse with thejoint capsule and their anterior and posterior horns attach tothe intercondylar eminence of the tibia. The menisci differ insize and shape. The medial meniscus is crescent shaped, withthe posterior horn being wider than the anterior horn. Themedial meniscus is attached to the medial collateral ligament,making it far less mobile than the lateral meniscus. The lateralmeniscus almost forms a closed ring with anterior and posteriorhorns of approximately the same width.Two ligamentsarise from the posterior horn of the lateral meniscus. Theposterior meniscofemoral ligament (ligament of Wrisberg)passes behind the posterior cruciate ligament to attach to themedial femoral condyle. The anterior meniscofemoral ligament(ligament of Humphry) connects the posterior horn tothe medial condyle, passing in front of the posterior cruciateligament. The two menisci are connected anteriorly by thetransverse ligament**.**



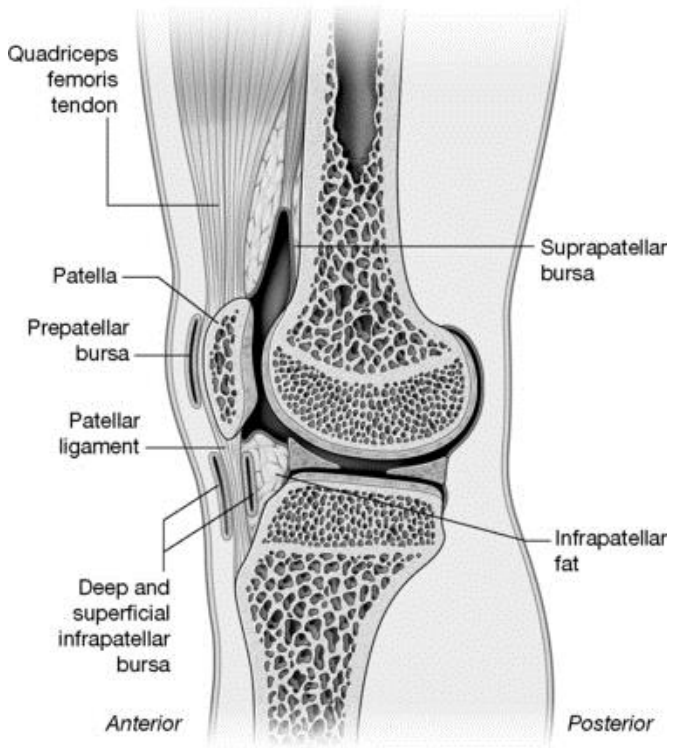
Figure(2-1)shows knee anatomy.
(Http://comportho2016/07/328031.jpg)

LigamentsThe ligaments of the knee are divided intoexternal (extracapsular) and internal (intracapsular) ligaments.The external ligaments are arranged around the knee and serveto strengthen and support the joint capsule. The internal ligamentsare found within the joint capsule and serve to providestability to the tibia and femur.**Externalligaments** of the knee include the collateral,patellar, and patellar retinaculum; oblique popliteal; and arcuatepopliteal ligaments. The collateral ligamentsprovide support for the knee by reinforcing the joint capsuleon the medial and lateral sides . Themedial collateral (tibial collateral) ligament is a flattenedtriangular ligament that originates from the medial femoralepicondyle and extends to the medial tibial condyle, continuingto the medial shaft of the tibia. Along its path it fuses withthe medial meniscus. The shorter, lateral collateral (fibularcollateral) ligament is more of a rounded cord arising fromthe lateral femoral epicondyle and attaching to the head ofthe fibula. The anterior joint capsule is strengthened by thepatellar ligament and patellar retinaculum. The patellarligament is the strong thick band representing the continuationof the quadriceps tendon and extends from the patella tothe tibialtuberosity . Thepatellar retinaculum is formed mainly by fibrous extensionsand fascia of various muscles about the knee . The medial patellar retinaculum isformed mainly by fibers from the vastusmedialis muscle andruns distally to attach to the tibia anterior to the medialcollateral ligament. The lateral patellar retinaculum consistsof fibers from the vastuslateralis and rectus femoris muscles aswell as the iliotibial tract and attaches distally to the lateralmargin of the tibial tuberosity to increase stability of the lateraljoint capsule. The oblique and arcuate popliteal ligaments helpreinforce the dorsal surface of the joint capsule. The obliquepopliteal ligament is an expansion of the semimembranosustendon that reinforces the central region of the posterior jointcapsule. It extends laterally to attach to the intercondylar lineof the femur. The inferolateralportion of the posterior capsule is strengthened by thearcuate popliteal ligament as it passes superiorly from theapex of the fibular head to spread out over the posteriorcapsule with fibers continuing to the posterior intercondylararea and to the posterior surface of the lateral femoral condyle.

InternalLigaments Cruciate ligamentsare strong bands of fibers that provide anterior and posteriorstability to the knee. The cruciate ligaments are located withinthe joint capsule but outside the synovial membrane.The anterior cruciate ligament arises fromthe anterior part of the tibial spine and extends to attach to theposterior part of the medial surface of the lateral femoralcondyle . It helps prevent hyperextension andanterior displacement of the tibia. The posterior cruciateligament is the stronger of the two and extends from theposterior tibial spine to the anterior portion of the medialsurface of the medial femoral condyle . It functionsto prevent hyperflexion and posterior displacement of thetibia. (Lorrie L. Kelley et al, ed2, 2007).

2-1-3Bursa:-

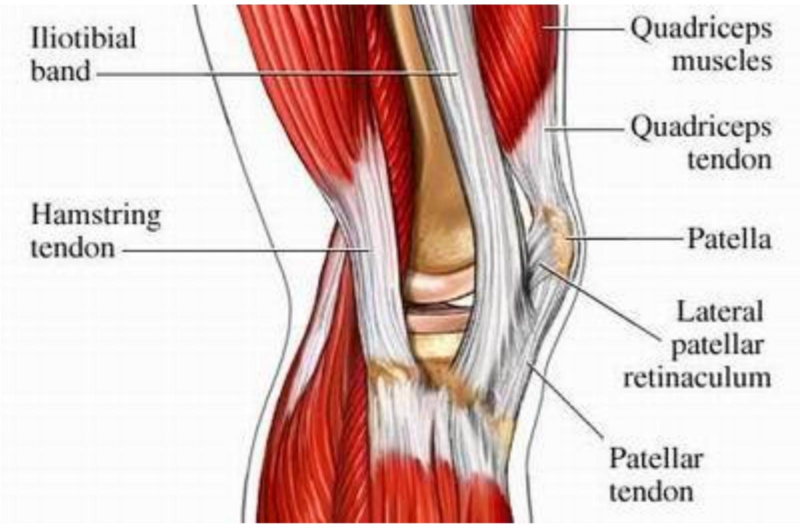
Synovial fluid surround the knee , reduce the friction from movement of tendons across the surface of the joint. There are more than 10 bursae located around the knee joint owing to the number of muscles associated with the knee. The major bursa include the suprapatellar, prepatellar, infrapatellar (superficial and deep), gastrocnemius (medial and lateral), semimembranosus, and popliteusbursae.(Lorrie L. Kelley et al, ed2, 2007).



Figure(2-2) shows knee joint Bursae (Https://neupsykey./2016.jpg).

2-1-4Muscels:-

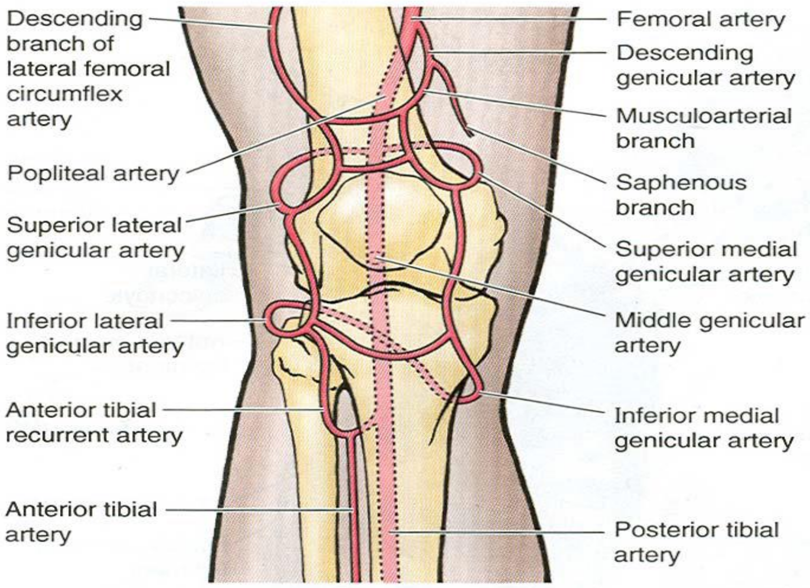
The knee muscles which go across the knee joint arequadriceps and the hamstring ,the quadriceps muscles areone the front of the knee and the Hamstring are one theback of the knee ,plus tendon connect the knee bones tothe leg muscles that move the knee joint (Platzer ,
2004**).**



Figure(2-3) shows muscles of knee joint on lateralaspect(hamstring group& quadricepsmuscles)Http://.days-eye/2016.

2-1-5Blood supply of the knee:-

The vascular supply to the knee consists of a network of many arteries. The genicular branches of the femoral, popliteal arteries and veins in the popliteal fossa, the circumflex fibular arteries, and the recurrent branches of the anterior tibial artery. The great saphenous vein medial to the thight and leg which drains into the femoral vein.(Hirschmann Müller,et al,2015).



Figure(2-4) shows knee blood supply (Https://pbs.twimg.49.jpg)

2-1-6 Physiology:-

The knee is a complex modified hinge joint with the greatest range of movement in flexion and extension about the sagittal plane, as well as varus and valgus rotation about the frontal plane. Also, it facilitates the medial rotation at the end of the knee flexion and the lateral rotation at the terminal extension of the knee both at the transverse plane. The knee maintains stability and control during a variety of loading situations. It consists of two bony articulations; the articulation between the femur and tibia bears most of the body weight, while the articulation between the patella and femur creates a frictionless transfer over the knee of the forces generated by contraction of the quadriceps femoris muscle. The knee consists of two main joints: the femorotibial joint and the patellofemoral joint, which allow the knee to move in three different planes (sagittal, transverse, and frontal). This offers a six degrees of freedom range of motion, including flexion, extension (sagittal planes), internal, external rotation (transverse plane), varus, and valgus stress (frontal plane). (Joseph A .et al, 2000).

Figure (2-5) Shows function of knee joint(Http://yoursurgery.2016.jpg)

2-1-7Pathology :-

Anatomically tendon attach muscles to bones , the patellartendon attach the bottom of the knee cap (patella) to thetop of the shine bone (tibia) , it is actually alignment thatconnect to two different bones ,pathological the patellartendon works with the muscles in the front of your thigh.Tears are common among middle –aged people who playrunning or jumping ,patellar tendon tear can be eitherpartial or complete. (Http://American Acadmy of Orthopidicsurgn ,2014).

2-1-7-1 Partial tear:-

A partial patellar tendon tear means that the soft tissue will not be completely disrupted. Some fibers are torn.(R. Wilkerson, et al,2016).

2-1-7 -2 Complete tear:-

A complete patellar tendon tear means a total separation between the patellar tendon and the kneecap.(R. Wilkerson,et al,2016).

When a tear is caused by a medical condition, like tendonitis, the tendon usually tears in the middle.

2-1-7 -3 Causes of tears:-

2-1-7 -3-1 Injury:-

A patellar tendon rupture can be caused by a sudden contraction of the quadriceps against resistance .When a strong force affects the knee, a tear can arise. This can happen when movements like jumping, falling andweight lifting are performed. It's most common that a tear arises when the knee is bent and the foot planted on the floor.

2-1-7 -3-2 Surgery:-

There's a higher risk for a tear when a previous major knee surgery is done.(R. Wilkerson ,et al,2016).

2-1-7 -3-3 Tendon weakness:-

Caused by:-

Patellar tendonitis, Chronic diseases,Diabetic PTs,Rheumatoid arthritis,Steroid injections,Calcifications.

(Jerome G. 1999).

2-1-8 Symptoms of tearing:-

The following symptoms are typical for someone with a patellar tendon tear:The patient is unable to continue activity,The patient can't resume weight bearing or does so only with assistance ,Bruising , Cramping , Tenderness ,hemarthosis ,A proximally displaced patella, because it's no longer anchored to your shinbone ,Incomplete extensor function Walking will be difficult, due to the knee buckling or giving way.(Jerome G. 1999).

Figure(2-6) Sag T1 –W image shows patellar ligament tear (Https://www.researchgate.net/16)

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2-1-9 Diagnosis of patellar ligament :-

2-1-9-1 Knee extension test:-

It could be test how well you can extend or straighten, of knee joint while this part of the examination can bepainful , it is important to identify a patellar tendon tear.(Http://American Acadmy Of Orthopidic Surgn ,2014).

Figure (2-7) Shows test of knee extension (Https://orthoinfo.aaos.org2010).

Figure(2-8) Shows flexion test
(https://i.ytimg.com/maxresdefault.jpg)

2-1-10 Imaging tests:-

To confirm the diagnosis , by using conventional x-ray or magnetic reasonance (MRI) scan.

2-1-10-1 Conventional X-Ray:-

Appropriate first line investigation for those with severe pain, and significant functional impairment.Viewing images on sides (lateral). (Clarks ,et al, 2005).

Figure(2-9) x-ray show normal location of patella.
(Https://upload.wikimedia.jpg2018)

Figure(2-10) Shows replaced patella
(Http://TendoneRupture0001.jpg)

2-1-10-2 Magnetic Resonance Imaging:-

MRI is effective in ruling out internal derangement of the knee.High accuracy in the detection of meniscal and ligamentous pathology, and osseous and chondral lesions such as bone marrow oedema, spontaneous osteonecrosis, insufficiency fractures and chondromalacia patella.
(A. Fotiadou ,et al 2009).

Figure (2-11) PD-W image(Https://assets.radiopaedia.org).

2-1-11 Imaging of the knee:-
2-11-1Convenitional X-Ray:-
-Indications :-

Trauma, effusion, arthritis and any degenerative change.

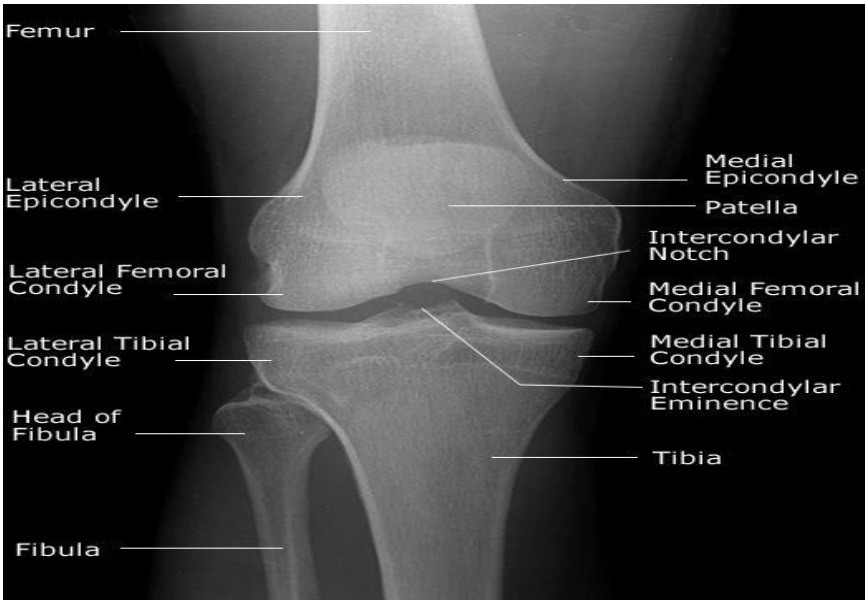
-contraindications : Non.

-Technique:-

Two projection are taken routinely an , anterior – posterior (AP) , and lateral (LAT).

-**AP position of patient:-**

The patient is suited supine or seated on the x-ray table ,with both leg extended .The affected limb is rotated to centerline the patellabetween the femoral condyle ,and sandbag are placedagainst the ankle to help maintain this position. (Charles et al,2005**).**



Figure(2-12) AP X-Ray of knee joint.(Https://i.pinimg.com/originals.jpg).

-Lateral position of patient:

The patient lies on the side to be examined with theknee flexed at 45-90. the another limp is broughtforward in front of the one being. sandbag is placedunder the ankle of the affected side to bring the longaxis of the tibia parallel to the cassette.Using parametersKVp(50-60) MAs(4-5).

(Charles et al,2005**).**

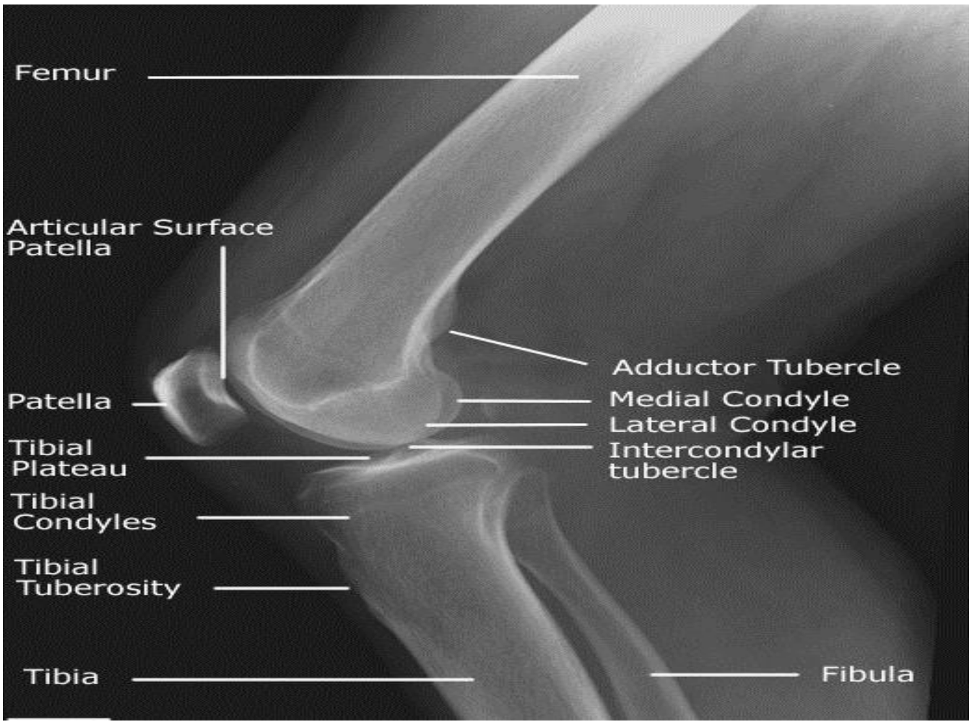


Figure (2-13)Shows lateral knee X-Ray

(Https://i2.wp.com/boneandspine.com 2017)

2-1-11-2 CT computed tomography:

-Indications:

CT remains the modality of choice in certain situations such as Fractures, To evaluate the degree and alignment of fracture fragments, particularly at the articular surfaces,To assess the integrity of the bone around a prosthesis.(Lois et al,2011).

-Contraindications:-Non.

-Protocol:-

The patient should be supine with feet forward , The legs should be extended and aligned to the table axis , Slice thickness (2mm) , KVp / MAs (140 / 300) , Axial / sagittal / coronal planes should be performed. (ORTHOP TRAUMATOL SURG RES 2012).

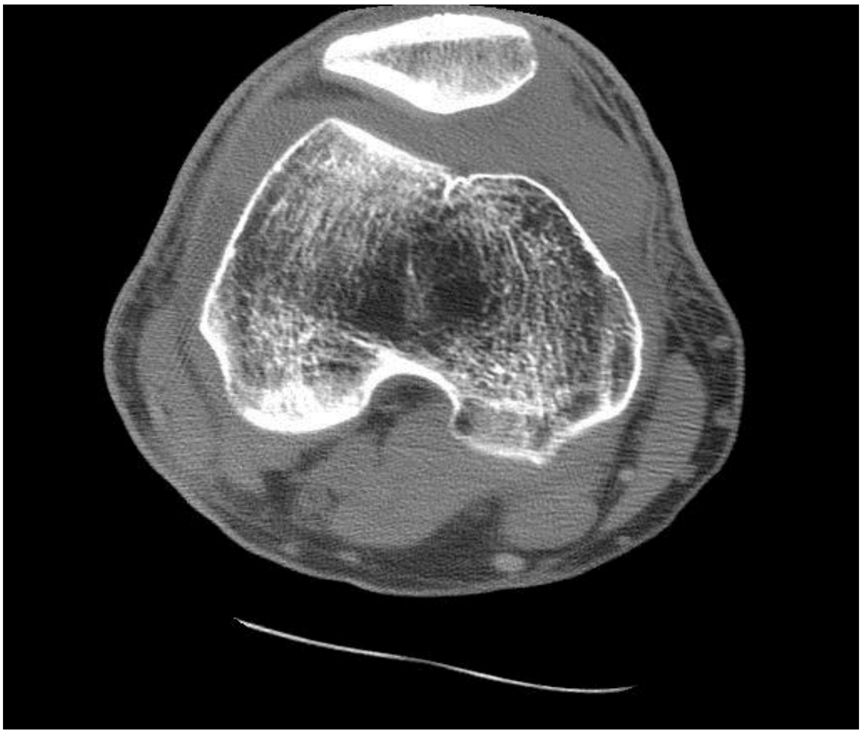
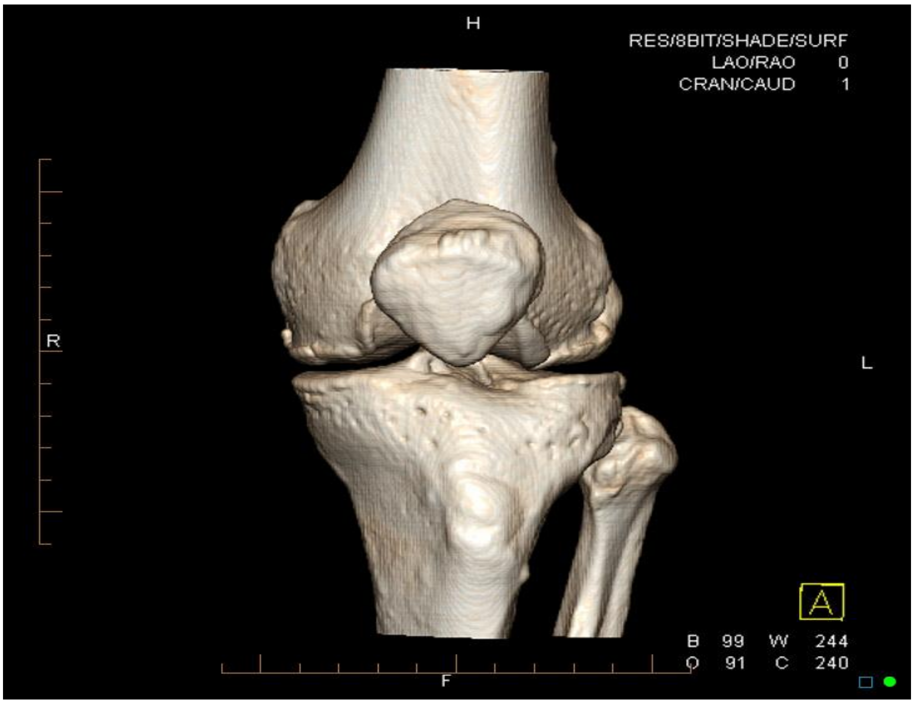


Figure (2-14) Shows axial CT image of the knee joint (Http://www.gentili.net/FBI/images/tibplateauct3.jpg).

Figure (2-15) Shows sagittal CT arthogram
(Https://images.radiopaedia.org2017)

Figure(2-16) Coronal CTof the knee
(Https://www.sciencesource.com).



Figure(2-17) 3D image of the knee
(Https://i.pinimg.com2011)

2-1-11-3 MRI of knee joint:-

Magnetic resonance imaging is an excellent modality for visualizing pathological processes of the kneejoint. It allows high-resolution imaging not only ofthe osseous structures of the knee but, more importantly, alsoofthe soft-tissue structures including the menisci and ligamentousstructures, in multiple orthogonal planes. There aremultiple imaging techniques and pulse sequences for magneticresonance imaging of the knee. The purposes of this report areto update orthopaedic surgeons on the applications of and indicationsfor magnetic resonance imaging of the knee, definethe normal anatomy of the knee as seen on magnetic resonanceimaging, and illustrate the spectrum of disease detectable bymagnetic resonance imaging .(Stoller Dw, 1999).The normal anatomy of the knee was displayed in threeplanes :**sagittal, coronal and axial**.

Sagittal views shows that thefemoral, tibial and patellar cortices give a low intensitysignal and therefore look dark. The soft-tissue structures closely applied to bone, namely the quadriceps tendonthe patellar tendon and the posterior cruciate ligament are conspicuous and also are of low intensity.The bone marrow gives a high-intensity signal because ofits high fat content and therefore looks bright. Sagittal view , in this view the shafts of the tibia and the femur are not seen and only the condyles are visible . The femoral articular cartilage is displayed as a white line on the black subchondral bone. The brightness of the articular cartilage issimilar to that of the bone marrow. The medial meniscus shows quite well with conspicuously low intensity of the anterior and posterior horns. Behind the femoral condyle the semimembranosus is seen as a black line which inserts onto the tibiajust beneath the posteriorjoint line. Coronal view, the medial and lateral menisci can be distinguished at the edges of the joint space but their appearance in this view is less conspicuous than in the parasagittal view. The attachment of the posterior cruciate ligament to the medial condyle can be seen as an area of low intensity.(Moon Kl Jr, et al,1983).

-Indications of knee MRI:-

- Knee pain , weakness , swelling or bleeding in the tissue – in and around the joint , Sport related knee injuries ,build up of fluid in the knee joint ,Internal derangement of the joint as(meniscal tears ,ligaments tears and barsae),Chondromalacia and patella tracking ,Bony tumors and bone damage within the knee joint ,All disorders can be visualized .(Http://The Radiology Info.2014).

contraindication :-

-Patient have claustrophobia (fear of enclosed space) or anxiety.

-Remove any metal and electronic object such as jewelry and watch.

-Patient with the following implant cannot be scanned and should not enter the MRI scanning such as (cochlear, aneurysm and pacemaker). (Http://Radiology Info-Org,2014).

- Protocol of knee:-

The patient lying supine on table , feet first.

-Equipment:-

Knee coil, surface coil or body coli and ear plague. (Catherin Westbrook,1998).

Figure (2-18) Shows MRI machineGantry, Couch and Coil.

(Https://s.hswstatic.com/gif/mri-10.jpg).

Figure(2-19) Shows knee coil (Http://ibnservice.com/).

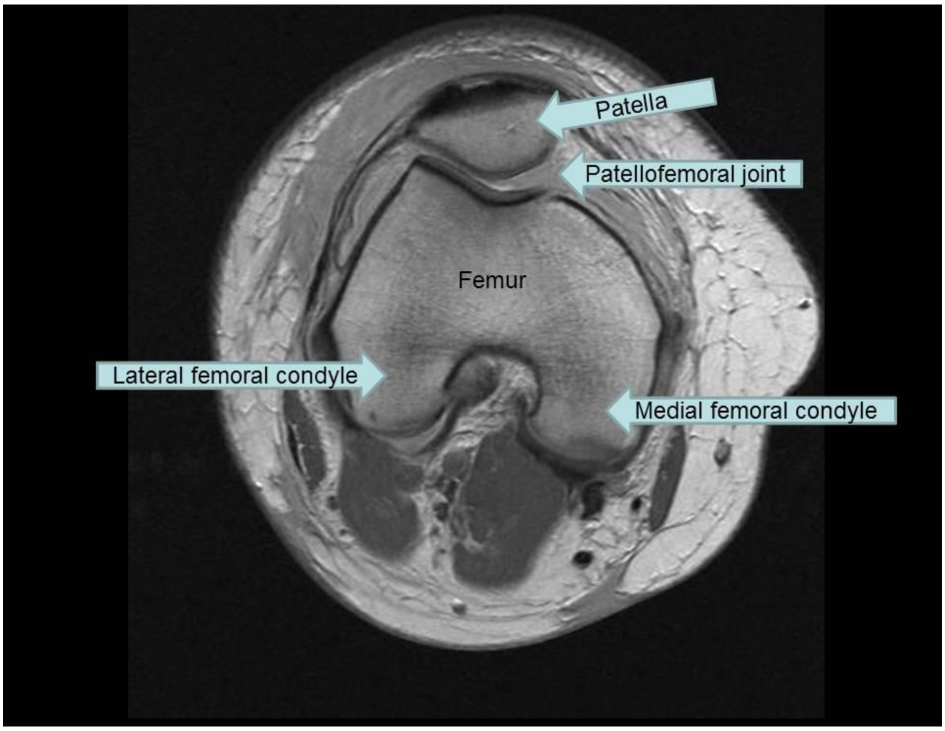
Figure(2-20) Shows patient positioned supine on the table with feet first
www.ucdmc.ucdavis.edu

- Protocol:

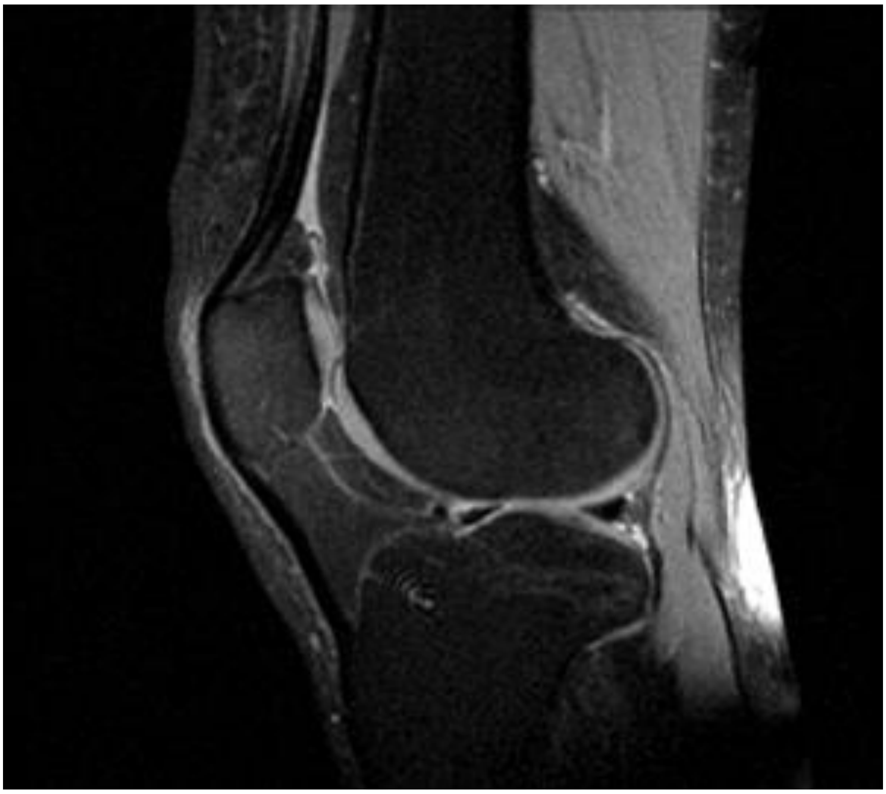
- Axial/ multiplanar coherent gradient echo T2*.
- Sagittal coherent GRE T2*.
- Coronal FSE PD/T2 +/- chemical / spectral presaturation/ STIR .
- Coronal SE/incoherent (spoiled) GRE T1.
- Axial FSE PD/T2 +/-chemical /spectral presaturtion.

(Catherin Westbrook. et al,1998).

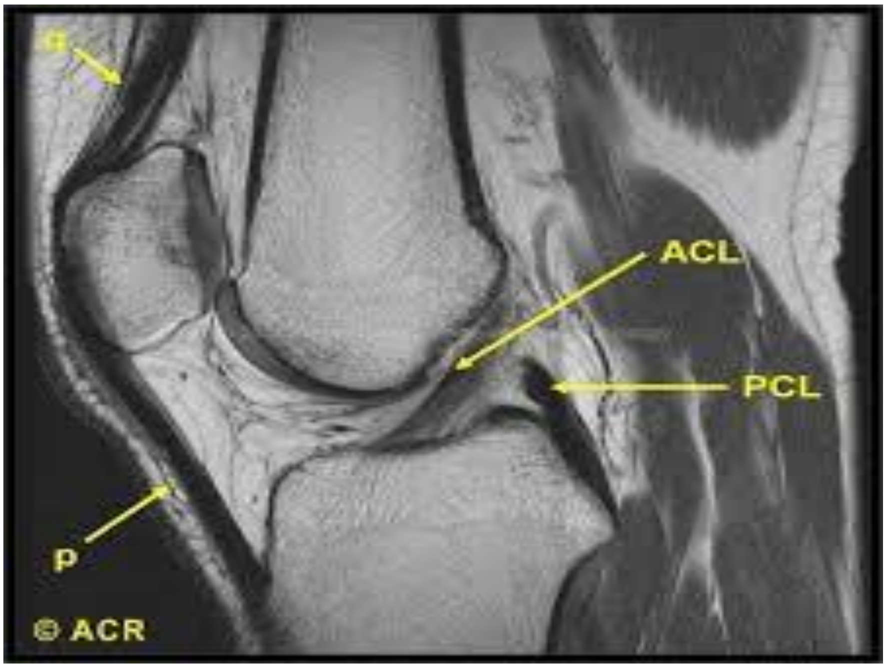
Figure(2-21) Shows sagittal T1-W MRI image for knee joint
(Http://conciergeradiologist.com)



Figure(2-22) Shows axial T1-W image for knee
Http://kneeinjury.weebly.com



Figure(2-23) SagittalFATsat FSE image of knee joint
(www.freitasrad.net).



Figure(2-24) Label show MRI image of sagittal proton density weight image (p)patellar ligament,(q)quadriceps ligament,ACL) anterior cruciate ligament and (PCL) posterior cruciate ligament**.**
(www.reheumaatioigy.org).

Figure(2-25) Coronal T1-W image of the knee
(Https://openi.nlm.nih.gov2015)

2.1.12Additional sequence:-

-Axial SE/FSE T1.

-3D coherent GRE PD/T2* Dynamic imaging. (Catherin Westbrook, et a1998).

2-1-12-1Sequences and parameters:-

Knee MRI uses a wide variety of pulse sequences. Many practices tailor the specifics of each study to optimize the examination for specific clinical questions. The choice of sequences will vary due to local preferences and/or available equipment or software limitations. Spin-echo(SE), fast (turbo) spin-echo(FSE), and gradientrecalledSequences(GRE) each may have a role for knee MRIA typical imaging protocol will becomposed of one ormore of these pulse sequence types. The exact TR, TE, and flipangle chosen will depend on the field strength of the magnet and the relative contrast weighting desire fast (turbo) spin-echo images (TSE) with a relatively short effective TE are most frequently used to examine the menisci .A short-echo train(ETL),short-interecho spacing , and/or tailored radiofrequency pulses can reduce potential blurring .Two dimensional and 3-D gradient-recalled images can also demonstrate meniscal disorders to show ligaments pathology ,water- sensitive images obtained using conventional or fast turbo spin-echo long-TE or T2*-weightedgradient-recalledsequences may be usedincluding at least one plane of T1-weighted sequences is usefulforcharacterizing marrowabnormalitiesvarious stagesof hemorrhage , and muscle pathology. Additionally, T1-weighted images often with fat suppression(FS) are used, after intravenous administration of gadolinium-based contrastagents to show tissue enhancement. STIR is suppressing the signal from fat may enhance the diagnostic yield of some pulse sequences. Direct and indirect MR arthrography may be beneficial for various internal knee derangements and for imaging postoperative conditions.(Rubin Da,et al,1994).

2-1-12-2Artifacts:-

Various techniques are useful to reduce artifacts that can degrade imaging quality. Wraparound artifact, including that originating from signal received from the contralateral knee, can be reduced by phase oversampling. Truncation (Gibbs) artifacts may obscure or mimic meniscal tears; changing the phase-encoding direction or increasing the imaging matrix will reduce this artifact. Ensuring patient comfort combined with gentle immobilization when necessary may reduce involuntary patient motion. Presaturation pulses or the use of gradient moment nulling will reduce ghosting artifacts from flowing blood. Chemical shift artifact is more severe at higher field strengths and may necessitate an increase in the receiver bandwidth. Susceptibility artifacts, which originate from local field heterogeneity, are also more severe at higher field strengths and when using gradient-recalled pulse sequences. Avoiding gradient-echo imaging and reducing the voxel size by increasing the imaging matrix and/or decreasing the slice thickness and FOV will help reduce the magnitude of susceptibility artifacts. (PEH WC,et al,2001) .

2-1-12-3 Limitation of each modality:-

-Conventional X-RAY:-

-Invasive technique ,Could be done to any patient have symptom except first trimester pregnant women ,Highly quality in evaluation bone , especially fractures(Http://Radiology Info-Org, 2014).

-CT computed tomography:-

CT is more radiation, Ability to perform multiplaner and three-dimensional reformate ,Highly quality in evaluating bone , Relatively expensive compared with conventional x-ray.(Loise et al,2011).

-MRI magnetic reasons imaging:-

Person with an implant or other metallic object sometimes make it difficult to obtain clear image ,Patient movement can have the same effect , Safety devices , MRI takes more time to perform examinations than a other modalities.(Http://Radiology Info-Org,2014).

2-2Previous study:-

Found some previous study related to patellar ligament first study about patellar tendon length – and factor in patellar instability.In this study used two group , group have history of patellar dislocation and group control knee and compare between these to measure the patellar tendon length and the factor in patellar instability material used lateral x-ray and a magnetic reasons image were e mean was 44mm in control taken of each knee. (Ph.Neretk,et al,2007).

The mean radiological patellar tendon length was 46mmin,the control and 52mm in the dislocation from MRI image,the mean was 44mm in control and 52 mm in dislocationgroup , this means that the patellar tendon is significantly(p`0.0001) longer in patient with history of patellardislocation on both MRI and x-ray measuring the length ofthe patellar tendon using MRI is more specific and more sensitive. Another study provides the geometer of patellar andpatellartendon measurement on sagital and axial. As for patellar tendon the longitudinal length was 40,2mm ,the width of proximal, distal part were 30,3 m , 24,0m the thickness of proximal and distal part were 3.2m and 5,0m. The geometry of the patellar tendon was larger in malethan in female (p`0.001). These data can provide useful information in the field ofknee surgery and sport medicine .(Jae -Hoyoo et al, 2007).

Another previous study about MRI criteria for patella Alta whishdefinitional the patella rides higher in the direction ofthe hip above the knee joint line than normal, and Baja byusing patellar length to patellar length ration on magneticreasons imaging of the knee , in order to aid in theestablishment him.(Jae -Hoyoo et al, 2007).

Patellar length (pl) and patellar tendon (Tl) were measureby single musculoskeletal radiologist on sagittal image .TheTl/pl range between 0,56-1,71 mean (1,05) , and femalehigher than male.

Another study assessed the ultrasound chart artistic of patellartendon according to echo change , used twogroups of volley ball pear , one without knee symptoms'and one group with symptom of jumper knee by clinicalexamination diagnosis the jumper knee for group withsymptom in the patellar and had normal ultrasound findingand u/s change observed in group without symptomobserved change associated to (thickening – echo signal change irregular patron appearance). This study suggest that the specificity and sensitivity ofultrasound is low in the evaluation of patient with mildsymptoms of jumper knee. **.**(K. J. Holen,et al,1966).

CHAPTER THREE
(Material and method)

3-1 Material:-
The study is about the knee joint specially patellar ligament to asses and measure the patellar ligament and the information would be used in the diagnosis of the ligament.

3-1-1 Study Sample:-
Study population was 50 patients, including normal patients their ages were between (20-70) years old and traumatic patients were excluded. The data were collected from Radiological departments in AL-Khrtoum, Modern Medical Center and East Nile Hospital during the periodfrom November 2017 to February 2018.By using **MRI** machine.

3-2 Study Method:-
The data were collected from the patients refer to the MRI scan , and before scan , weight of patients and height were measured using measuring devised firstly all the patientswere prepared remove from any metallic object and enterthe room for scan patients lying in supine on the couch,will feet first, with coil under , the center of knee w as withcenter of coil(surface coil or body coil) ear plugs were usedto protect from noising of gradient change, doorwas closed to complete the scan , the ,protocol was usedfrom the computer system, it differs according tohospital and radiographer worker, the technique used inmodern medical system, patient data obtained from work sheet is used tocollect on 8 variables (appendix2) (age, gender, weight ,BMI ,patient height ,patellar length ,patellar thickness onthree levels upper-medial –lower**).**Any data taken from every patient were signed and agreed from the patients.

3-3 Data analysis

Descriptive statistic using statistic package.Datawere taken from normal patients and traumatic patients were excluded. All the variables were obtained in data sheet. Patellar ligament length and patellar ligament thickness were measured on sagittal sections of the knee . Patellar ligment length measured from below apex of the patella to tibialtuburosity by (mm) unit. And patellar ligament thickness measured in upper , middle and lower parts of the ligament also by(mm) unit.

CHAPTER FOUR
(Results)

	Frequency	Percent	Valid Percent	Cumulative Percent
Female	15	30.0	30.0	30.0
Male	35	70.0	70.0	100.0
Total	50	100.0	100.0	

Table (4.1) frequency distribution of gender

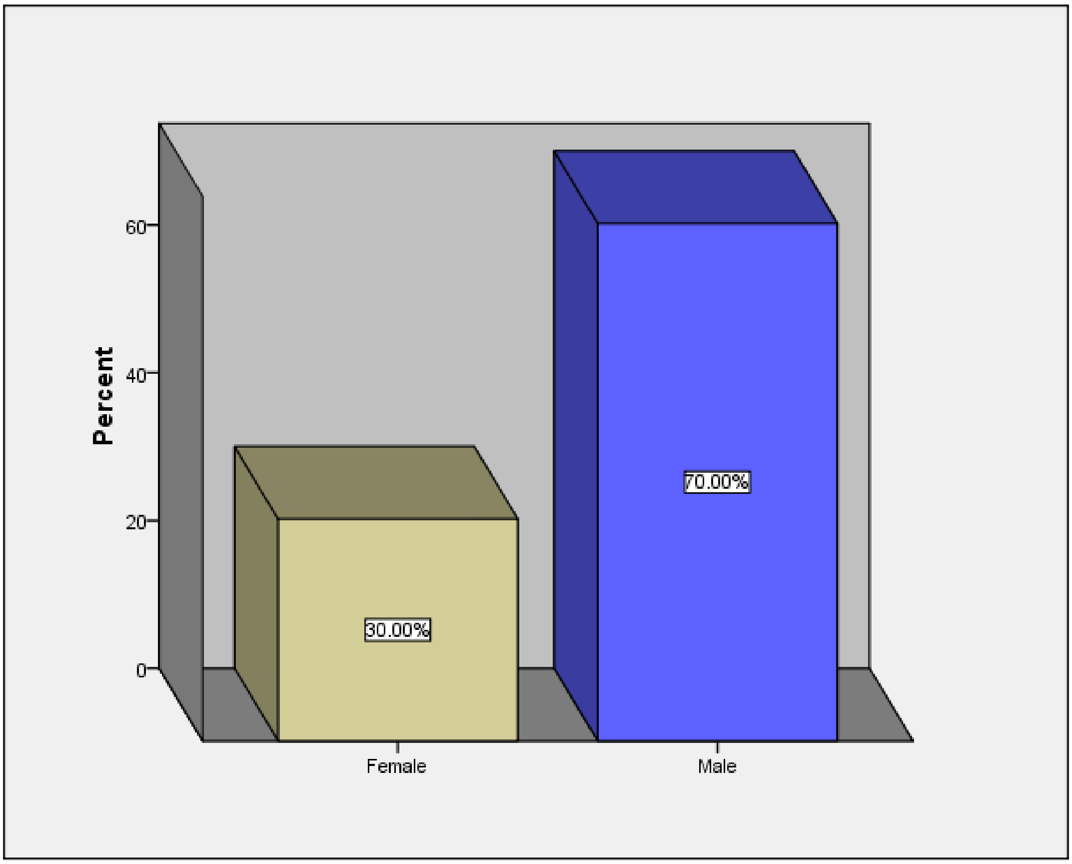


Figure (4.1) frequency distribution of gender

	Frequency	Percent	Valid Percent	Cumulative Percent
20-30 years	18	36.0	36.0	36.0
31-41 years	11	22.0	22.0	58.0
42-52 years	9	18.0	18.0	76.0
53-63 years	8	16.0	16.0	92.0
more than 63 years	4	8.0	8.0	100.0
Total	50	100.0	100.0	

Table (4.2) frequency distribution of age group

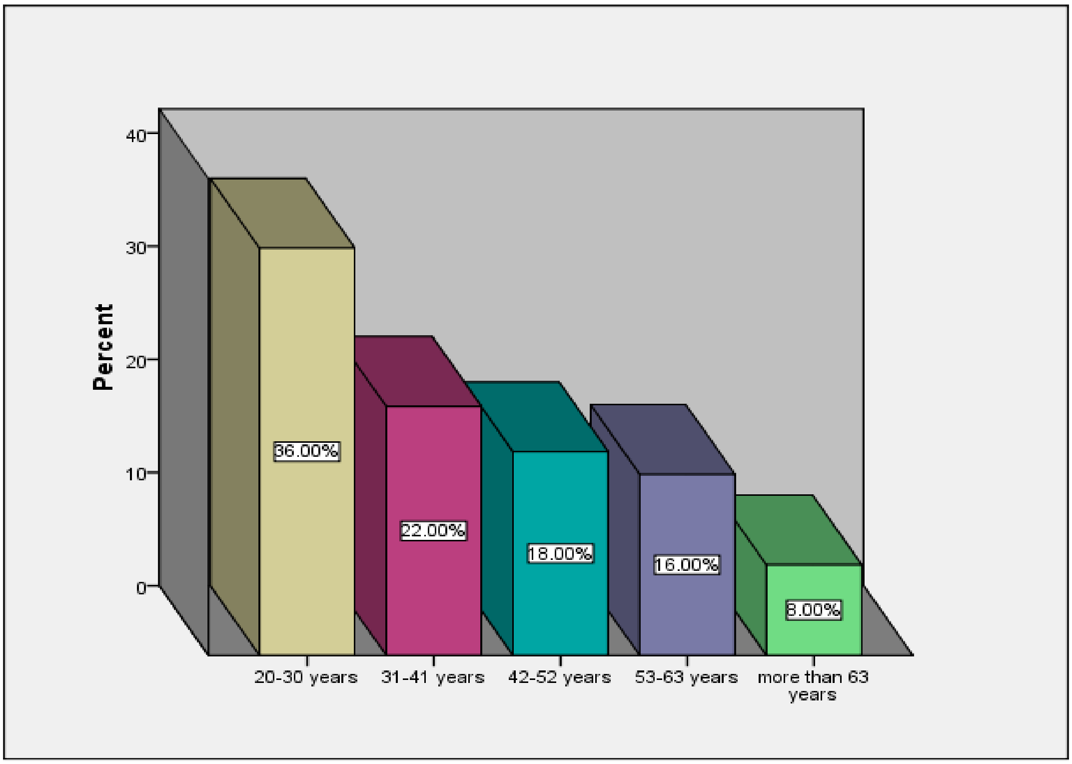


Figure (4.2) frequency distribution of age group

Table (4.3) descriptive statistic for age, weight, height ,BMI and patellar length ,thickness

	N	Minimum	Maximum	Mean	Std. Deviation
Age	50	20.00	68.00	39.6000	14.53918
Weight (Kg)	50	55.00	143.00	84.7600	18.96459
Height (M)	50	1.64	1.90	1.7288	.05568
BMI (W/length2)	50	18.20	44.60	28.4560	6.04518
Patellar length (mm)	50	41.90	64.40	50.8260	5.21575
Patellar thickness (upper) (mm)	50	2.00	6.90	4.1480	1.01544
Patellar thickness(middle) (mm)	50	3.00	5.40	4.0480	.66677
Patellar thickness(lower) (mm)	50	3.00	6.20	4.3420	.89809
Valid N (listwise)	50				

Table (4.4) means patellar length and thickness according to gender

GEN		Patellar length	Patellar thickness upper	Patellar thickness middle	Patellar thickness lower
Female	Mean	48.3333	4.2467	3.8800	3.7267
	Std. Deviation	3.91511	.86344	.62014	.45586
	Minimum	43.50	3.10	3.00	3.00
	Maximum	58.20	6.00	5.00	4.80
Male	Mean	51.8943	4.1057	4.1200	4.6057
	Std. Deviation	5.38314	1.08301	.68161	.91553
	Minimum	41.90	2.00	3.00	3.00
	Maximum	64.40	6.90	5.40	6.20
Total	Mean	50.8260	4.1480	4.0480	4.3420
	Std. Deviation	5.21575	1.01544	.66677	.89809
	Minimum	41.90	2.00	3.00	3.00
	Maximum	64.40	6.90	5.40	6.20

Table (4.5) ANOVAs test for relation between gender and patellar length ,thickness

ANOVA Table[a]

			Sum of Squares	df	Mean Square	F	Sig.
Patellar length * Gender	Between Groups	(Combined)	133.144	1	133.144	5.326	.025
	Within Groups		1199.852	48	24.997		
	Total		1332.996	49			
Patellar thickness upper * Gender	Between Groups	(Combined)	.209	1	.209	.199	.658
	Within Groups		50.316	48	1.048		
	Total		50.525	49			
Patellar thickness middle * Gender	Between Groups	(Combined)	.605	1	.605	1.371	.247
	Within Groups		21.180	48	.441		
	Total		21.785	49			
Patellar thickness lower * Gender	Between Groups	(Combined)	8.114	1	8.114	12.400	.001
	Within Groups		31.408	48	.654		
	Total		39.522	49			

Table (4.6) means patellar length and thickness according to age

Age group		Patellar length	Patellar thickness upper	Patellar thickness middle	Patellar thickness lower
20-30 years	Mean	51.0000	3.5889	3.9000	4.3611
	Std. Deviation	4.38097	.78207	.56360	.81971
	Minimum	44.30	2.00	3.00	3.20
	Maximum	58.20	5.10	4.90	5.80
31-41 years	Mean	50.2545	4.4091	3.9909	4.3636
	Std. Deviation	6.69035	.88708	.85376	1.06703
	Minimum	41.90	3.40	3.00	3.10
	Maximum	64.40	6.00	5.40	6.20
42-52 years	Mean	52.1889	4.4556	4.0778	4.4000
	Std. Deviation	4.40325	1.24611	.60162	1.06184
	Minimum	44.10	3.00	3.00	3.00
	Maximum	61.00	6.90	5.00	5.60
53-63 years	Mean	51.1250	4.4250	4.2500	4.4125
	Std. Deviation	6.90812	1.23722	.83324	.94934
	Minimum	43.50	3.10	3.10	3.40
	Maximum	61.00	6.30	5.20	5.80
more than 63 years	Mean	47.9500	4.7000	4.4000	3.9250
	Std. Deviation	2.25758	.14142	.16330	.45000
	Minimum	46.60	4.50	4.20	3.30
	Maximum	51.30	4.80	4.60	4.30
Total	Mean	50.8260	4.1480	4.0480	4.3420
	Std. Deviation	5.21575	1.01544	.66677	.89809
	Minimum	41.90	2.00	3.00	3.00
	Maximum	64.40	6.90	5.40	6.20

Table (4.7) correlation between age , weight ,height ,BMI and patellar length ,thickness

		Age	Weight	Height	BMI
Patellar length	Pearson Correlation	-.069-	.045	.716**	-.170-
	Sig. (2-tailed)	.633	.754	.000	.237
	N	50	50	50	50
Patellar thickness upper	Pearson Correlation	.324*	.302*	-.032-	.325*
	Sig. (2-tailed)	.022	.033	.826	.021
	N	50	50	50	50
Patellar thickness middle	Pearson Correlation	.194	.208	-.084-	.248
	Sig. (2-tailed)	.177	.147	.564	.083
	N	50	50	50	50
Patellar thickness lower	Pearson Correlation	-.094-	.116	.055	.094
	Sig. (2-tailed)	.518	.422	.705	.518
	N	50	50	50	50
*. Correlation is significant at the 0.05 level (2-tailed).					
**. Correlation is significant at the 0.01 level (2-tailed).					

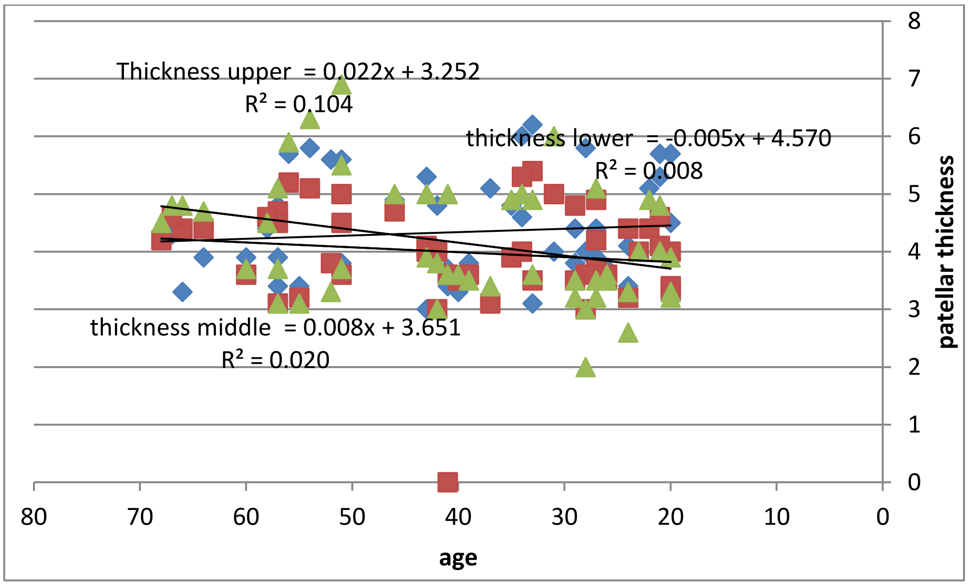


Figure (4.3) Regression analysis shows relationship between age and patellar thickness

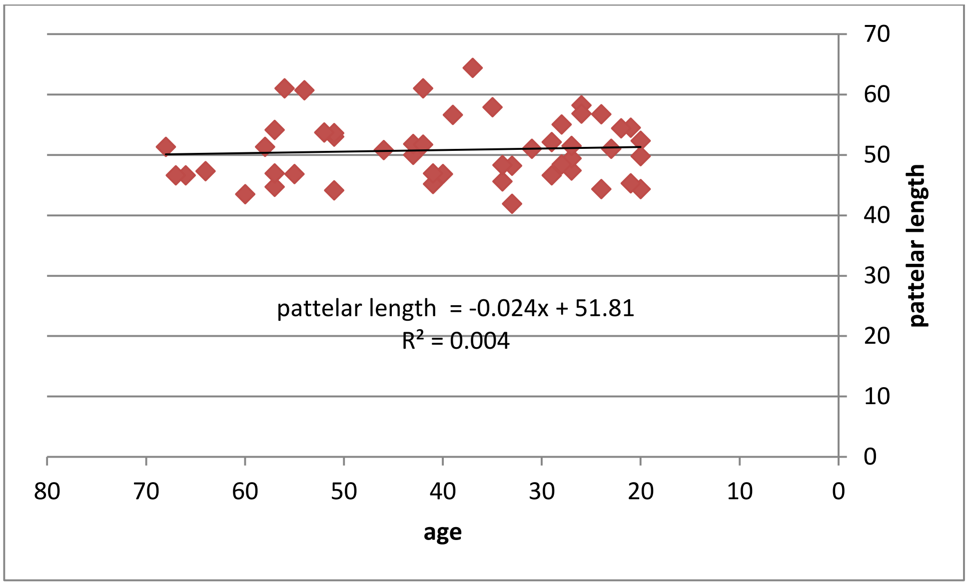


Figure (4.4) Regression analysis shows relationship between age and patellar length

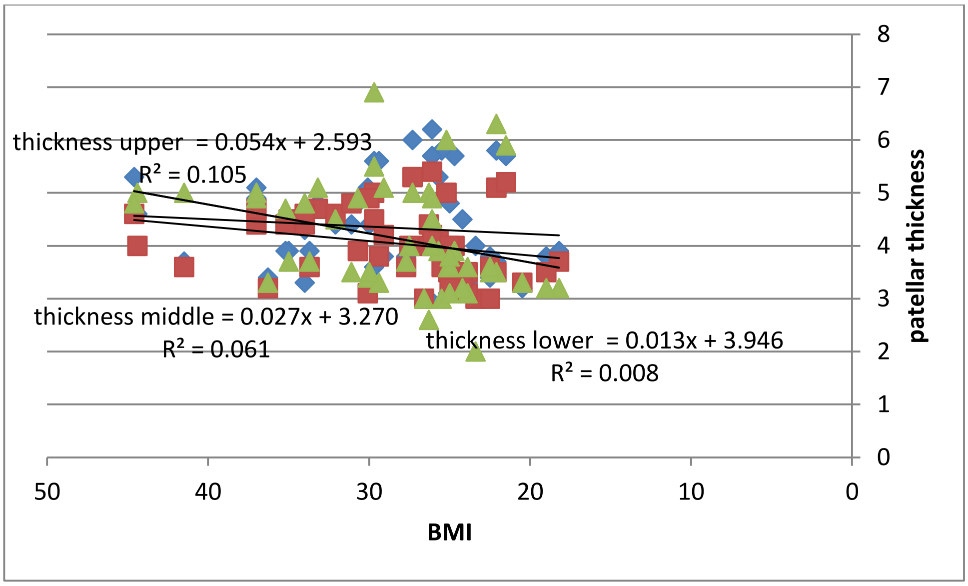


Figure (4.5) Regression analysis shows relationship between BMI and patellar thickness

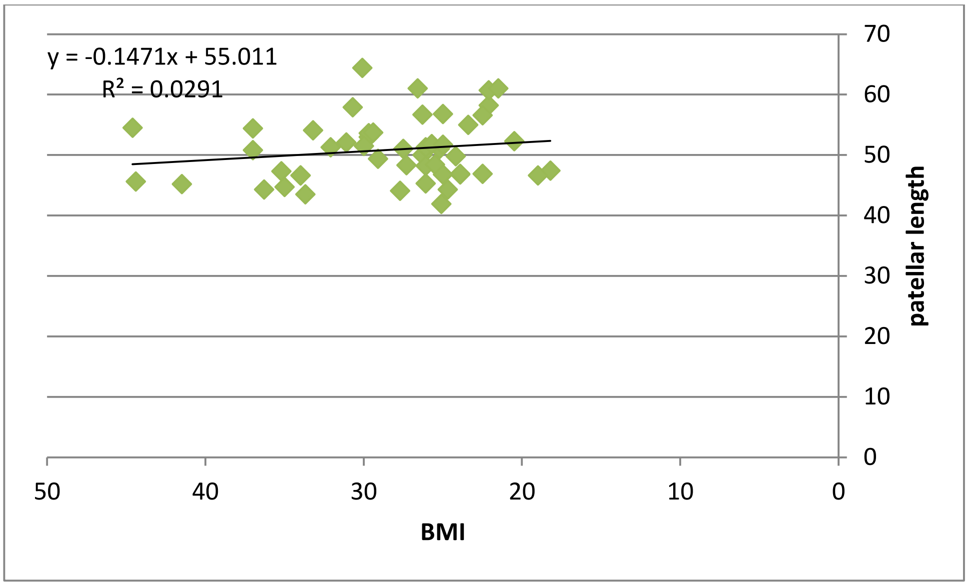


Figure (4.6) Regression analysis shows relationship between BMI and patellar length

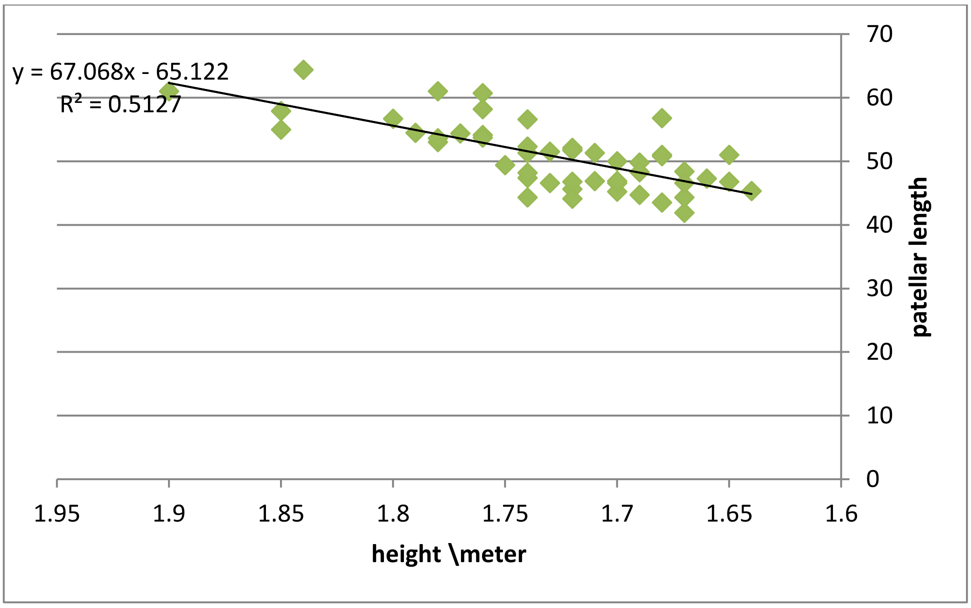


Figure (4.7) Regression analysis shows relationship between height and patellar length

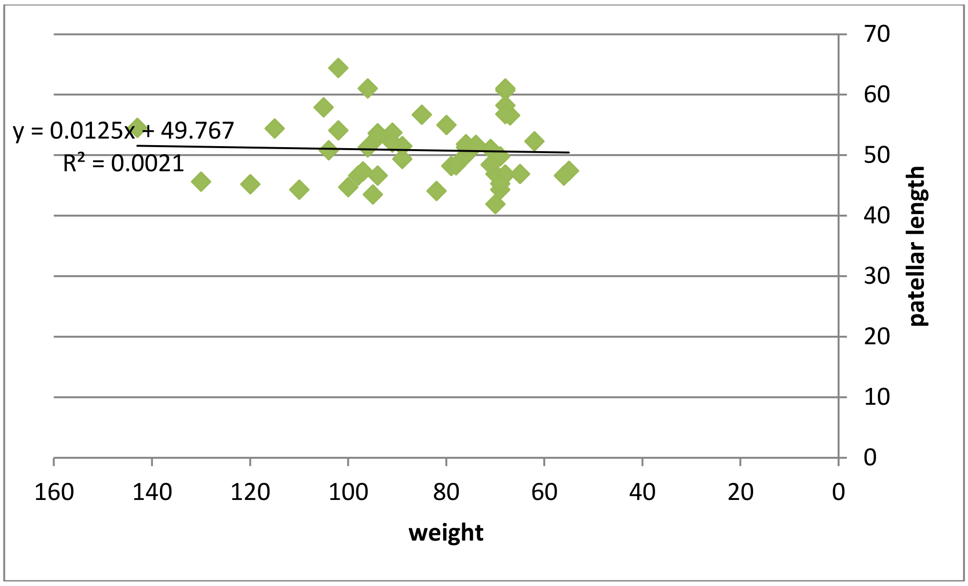


Figure (4.8) Regression analysis shows relationship between weight and patellar length

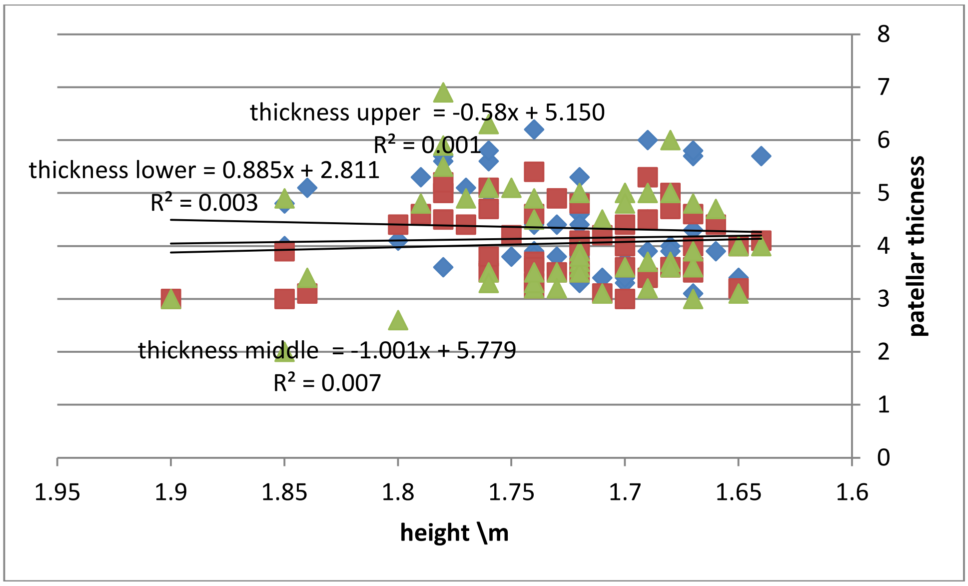


Figure (4.9) Regression analysis shows relationship between height and patellar thickness

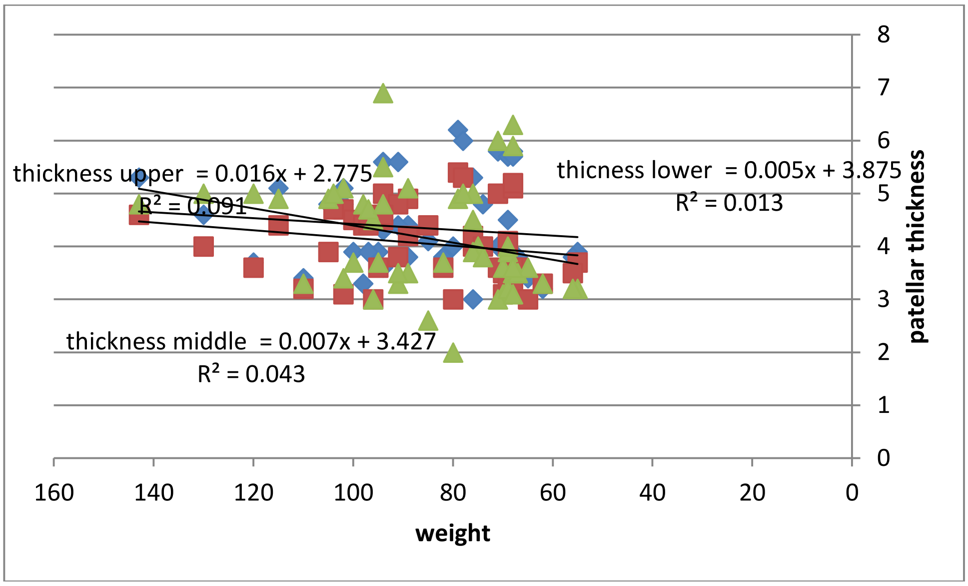


Figure (4.10) Regression analysis shows relationship between weight and patellar thickness

CHAPTER FIVE
(Discussion ,Conclusion and Recommendation)
5-1 Discussion:-

This chapter discuss the results . The study was conducted on 50 patients who refered to MRI department 15 female and 35 males at different ages between 20 to 70 years old using MRI machine and data were collected .

(Table 4-1) discuss the frequency of males was found (70 %) more than frequency of females (30%) . This is due to history of patients relatively sport associated with what was found in the current study.

The sample was classified according to the age group starting from 20 to 70 years old , patients of 20-30years old have the most frequency distribution 36% .(Table 4-2) and (figure 4-2) showed this result.

(Table 4-3) showed mean measurements of variables ,patellar length and thickness of normal patients, mean of age 39.6±14.5year , mean of weight 84.76±18.96mm, mean of height 1.72±0.05mm , mean of BMI 28.45± 6.04mm , mean of ligament length 50.82±5.21mm , mean of upper ligament thickness 4.14±1.01mm , mean of middle ligament thickness 4.04±0.66mm , mean of lower ligament thickness 4.34±0.89mm.

(Table 4-4) showed the relation between the patellar ligament length and thickness with gender .The female mean patellar length was 48.33 ±3.91mm , upper patellar thickness was 4.24±0.86mm , middle patellar thickness was 3.88±0.62mm , and lower patellar thickness was 3.72±0.45mm. The male mean patellar length was 51.89±5.38mm higher than females ,and this result was not agree with what was mentioned in (Jae Hayoo,2007)"the mean gender range of the patellar length is higher in female than male".Upper patellar thickness was 4.10±1.08mm ,middle patellar thickness was 4.12±0.68mm and lower patellar thickness was 4.60±0.91mm.

(Table 4-5) ANOVA test showed the relation between gender with patellar length and thickness . Patellar length was significantly related to gender at p=0.025 ,as well as the lower patellar thickness was significantly related to gender at p= 0.001.

(Table 4-6) showed the comparison between means age and patellar length and thickness. As the age increases the patellar length decrease (figure 4-4) and this result agree with the previous studydone by(platzer etal,2004)"the patellae increased the leverage of the tendone and increasing the angle that affected on patellar length to decrease". As the age increases the patellar thickness will also increases (figure 4-3) showed the regression analysis relationship between age and patellar thickness and also this agreed with the previous resulting in physiologically the patellar ligament workswith the muscles ,so that the thickness more affected according to age (K. J. Holen ,1966).

(Table 4-7) showed the correlation between age , weight , height , BMI with the patellar length and thickness . The correlation between height and patellar length was significantly related at P= 0.01. Correlation betweenage ,weight , BMI and upper patellar thickness was significantly related at P=0.05.

(Figure 4-5) showed theregression analysis relationship between BMI and patellar thickness as the BMI increases the upper patellar thickness increases by 0.054mm,as it was known the BMI is equal to weight / length^2.Thisresult was mentioned in (Henry Gray anatomy ,2015)the upper patellar thickness started from origin of ligament fibers , and fiber bands increase thickness with the increase in weight. The justification of this result is due to fact that was mentioned in (Henry Gray anstomy,2015) .Also increase in BMI the middle patellar thickness increase by 0.027mm,also the justification of this result is due to fact that was mentioned in(Henry Gray anatomy,2015). As increases in BMI related to increase in lower patellar thickness by 0.008mm and this result was not agreed with the previous study(Henry Gray anatomy .2015) that result in increasing in weight may lead to change and depression on knee joint and affect the lower patellar thickness to decrease .

(Figure 4-6) showed the relationship between BMI and patellar length as the BMI increase the patellar length decrease by 0.147mm.This result was associated with the previous study done by(Nore Ali, 2015).

(Figure 4-7) showed the relationship between height and patellar length.As the patellar length increases with the increase in height.The justification of this result is due to fact that was mentioned in(Amir M Navali,etal,2015),"Taller people have longer patellar ligament length".(Figure 4-9)showed the relationship between the height and patellar thickness .As the upper patellar thickness is decreased as the height increase by 0.85mm , the middle patellar thickness also decreased with increase in height by 1.001mm and the lower patellar thickness increased with increase in height by 0.885mm.

(Figure 4-8)and (4-10) showed the regression analysis relationship between weight and patellar length and thickness , patellar length increased with weight by 0.012mm.Also the patellar thickness increase as the weight increase.

5-2 conclusion:-

This study is to characterize the patellar ligament using MRI machine to measure the ligament length and thickness.And theseinformation could be used in diagnosis of tearing. As a conclusion The patellar ligament length and lower patellar thickness are significantly different with gender at (p =0.025) and (p =0.001) respectively. The patellar ligament length have significant relation with height at (p=0.000) and the upper patellar thickness have significant relation with age, weight and BMI at (p= 0.022, 0.033 and 0.021) respectively……

5-3 Recommendation:-

-The study measurement should be in large group of patients.

-MRI of knee joint also must be considered as gold standard in looking in knee ligament**.**

-MRI should be considered the standerd imaging modality for detecting ligament tearing.

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Appendices :

-Appendix 1 : The way of measurement of patellar ligament length .

Figure (5-1)Sagittal PD-Fat Sat of a 32y male patient.

Showing how to measure the patellar ligament length starting from the apex of the patella ending in tibialtuburosity.

Patellar length=47.1mm.

-Appendix 2: The way of measurement of the patellar ligament thickness upper , middle and lower.

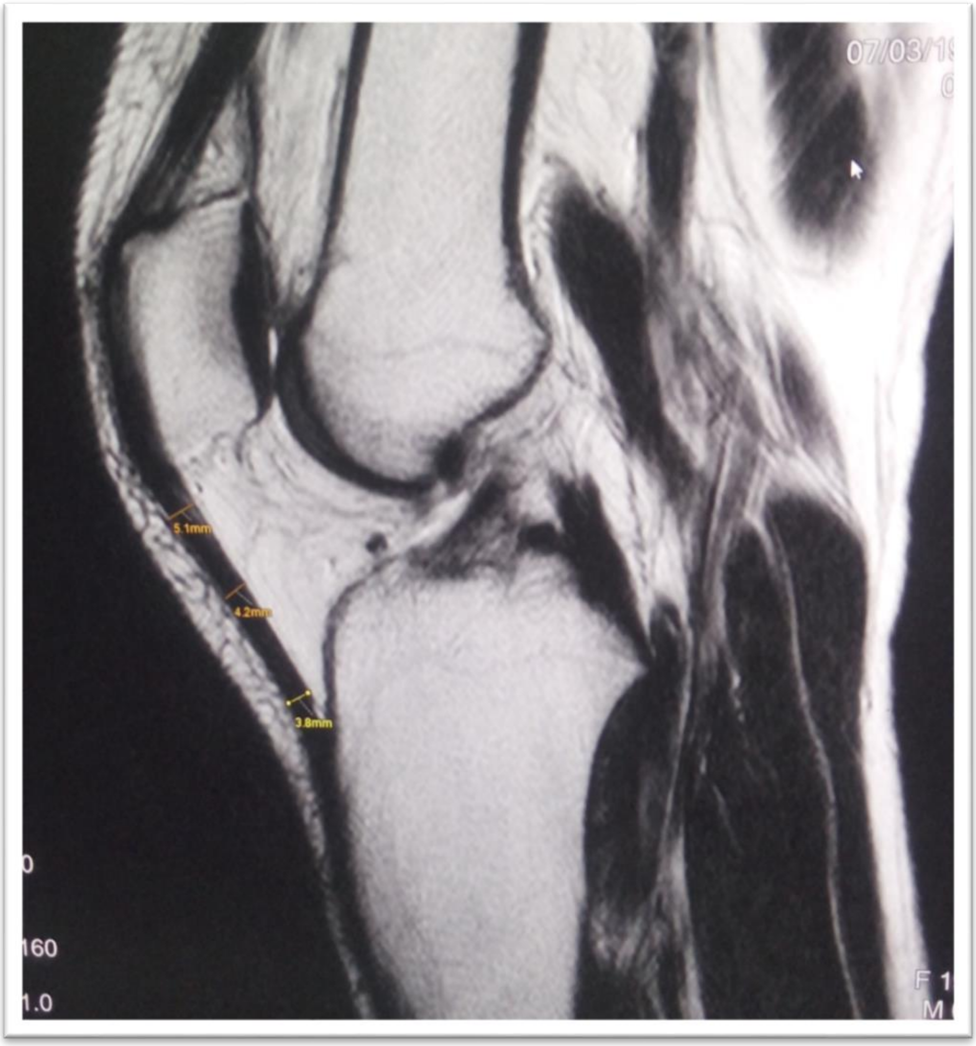

Figure (5-2)Sagittal T2-W FSE for the same patient ,

Showing how to take measurements of the ligament thickness

at the upper= 5.1mm , middle= 4.2mmand lower= 3.8mm.

Appendix 3 : Work sheet

Pt No	Age	Gender	Weight Kg	Height m	BMI Kg/m^2	Patellar Length mm	Patellar thickness mm UPP / MID/ LOWER