Characterization of knee joint in patients with Rheumatoid Arthritis by Using Ultrasonography

توصيف مفصل الركبة لدى مرضى التهاب المفاصل الروماتويدي باستخدام الموجات فوق الصوتية

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الملخص:

يعد التشخيص المبكر لالتهاب المفاصل الروماتويدي الحاد أمرًا ضروريًا لتقليل عوامل الخطر وتطور المرض، هذه دراسة مقطعية وصفية أجريت في مستشفى أم درمان العسكري ومراكز الرعاية الأخرى في السودان خلال الفترة من يونيو 2022 إلى أغسطس 2022، الهدف من هذه الدراسة هو توصيف مفصل الركبة في مرضى التهاب المفاصل الروماتويدي باستخدام الموجات فوق الصوتية، أجريت الدراسة على 50 مريضًا (تتراوح أعمارهم بين 28 و 70 عامًا) حضروا إلى قسم الموجات فوق الصوتية في مدة ومجال الدراسة وتم تشخيصهم جميعًا سريريًا على أنهم مصابون بالتهاب المفاصل الروماتويدي، في هذه الدراسة، كان 15 من 50 (30.0٪) من الذكور والباقي 35 من أصل 50 (70.0٪) من الإناث. عمر المرضى 2 (4.0٪) أقل من 30 سنة ، 7 (14.0٪) بين 30-40 سنة، 19 (38.0٪) بين 40-50 سنة، 13 (26.0٪) بين 50-60 سنة، 18.09) ٪ ((أكثر من 60 عامًا، التشخيص النهائي للمرضى المبتدئين، الغالبية، 37 من 50 (74.0٪) كانوا من التهاب المفاصل الروماتويدي المزمن والباقي 13 من 50 (26.0٪) كانوا من التهاب المفاصل الروماتويدي الحاد، وخلصت النتائج الرئيسية لهذه الدراسة إلى أن التهاب المفاصل الروماتويدي في يحدث مفصل الركبة بشكل شائع في سن 40-60 سنة. كانت النتائج الأكثر شيوعًا بالموجات فوق الصوتية هي الأربطة السميكة. التهاب الجراب، وذمة، والتواء، وتمزق الغضروف المفصلي في بعض الحالات. أظهرت الدراسة أن التهاب المفاصل الروماتويدي المزمن أعلى من التهاب المفاصل الروماتويدي الحاد. عند الارتباط بين نتائج الموجات فوق الصوتية في مفصل الركبة والجنس والعمر، وجد أن الإصابة بالتهاب المفاصل الروماتويدي في المجموعة المدروسة أعلى في الإناث منها عند الذكور، استنتج أن التصوير بالموجات فوق الصوتية هو طريقة بسيطة غير جراحية للكشف عن التهاب المفاصل الروماتويدي في مفصل الركبة.

Abstract

The early diagnosis of acute rheumatoid arthritis is essential to minimize the risk factors and disease progress, This is a Descriptive cross sectional study carried out in in Omdurman military hospital and other care centers in Sudan during the period from June 2022 to August 2022, The aim of this study was to Characterization of knee joint in patients with Rheumatoid Arthritis by Using Ultrasonography, The study was conducted on 50 patients (age range of 28-70) who attended to the ultrasound department in the duration and area of the study and all were diagnosed clinically to have Rheumatoid Arthritis, In this study, 15 out of 50 (30.0%) were males and the rest 35 out of 50(70.0%) were females. Age of patients 2 (4.0%) Less than 30 years, 7 (14.0%) between 30-40 years, 19 (38.0%) between 40-50 years, 13 (26.0%) between 50-60 years, 9 (18.0%) more 60 years, Final diagnosis of patients understudy, the majority, 37 out of 50 (74.0%) were chronic rheumatoid arthritis and the rest 13 out of 50 (26.0%) were acute rheumatoid arthritis. The main findings of this study concluded that the Rheumatoid Arthritis of the knee joint commonly occur between 40-60 years age. The most frequent Sonographic findings were thickened ligaments; bursitis, edema, sprain and meniscus tear in some cases. The study shows that the Chronic rheumatoid arthritis is higher than acute rheumatoid. When correlating between the ultrasound finding in knee joint, gender, and age, it was found that incidence of rheumatoid arthritis in; the studied group is higher in females than males, It has been concluded that ultrasonography is a simple non-invasive method for detecting the Rheumatoid Arthritis of the knee joint.

1-1 Introduction:

Musculoskeletal ultrasound has been considered a diagnostic tool for a variety of rheumatologic diseases for more than 37 years. However, its use has increased dramatically over the past decade, largely as a result of technological developments and falling costs. The former has allowed the production of high-quality and more easily interpretable images and the latter has made machines more affordable and accessible to the clinician. These improvements have been influential in driving the interests of the rheumatologist, particularly with respect to inflammatory arthritis and the early identification of inflammation and structural damage. The first clinically relevant musculoskeletal ultrasound study was published in 1972, in the British Journal of Radiology, by American radiologists Daniel McDonald and George Leopold. (McDonald and Leopold, 1972)

They described the use of a contact B-mode, real-time scanner to differentiate Baker's cysts from thrombophlebitis. Six years later, in 1978, using greyscale ultrasound, a Canadian radiologist Peter Cooperberg published the first demonstration of synovitis in patients with rheumatoid arthritis. Since then, ultrasound has gained an increasing interest from musculoskeletal practitioners as it allowed the potential to directly visualize the primary site of pathology and a better understanding of joint pathophysiology. In recent years, increasing and changing demands made by the clinicians have influenced the direction of ultrasound development by manufacturers.(Cooperberget, 1978)

Nowadays, the cost of ultrasound equipment is quite variable. Equipment providing the highest image quality and the larger range of software addons is more expensive. However, the less expensive and less sophisticated units have facilitated the diffusion and accessibility of ultrasound training to a larger number of rheumatologists in rheumatoid arthritis (RA), MSUS can be now considered a complement to physical examination. This method evaluates synovitis through gray-scale and power Doppler and it is also able to identify bone erosions.

The utilization of MSUS as a marker of RA activity has received attention in recent literature. Current data account for good correlation of MSUS with classical measures of clinical activity; in some instances, MSUS appears to perform even better. Diagnosis of subclinical synovitis by MSUS might help the physician in RA management.

1-2 Problem of the Study:

- The affected musculoskeletal system lesions as inflammatory changes and tumors my change the musculoskeletal joints size and may lead to enlargement and changing in texture.
- The type of lesion related to musculoskeletal joints involvement is needed to be studded properly in order to clarify the presence of malignancy rather than inflammatory Process.

1-3 Objectives:

1-3-1 General Objective:

To characterize the knee joints Rheumatoid Arthritis by Ultrasound. -

1-3-2 Specific Objectives:

- To correlate rheumatoid factor resulting (lab test) with ultrasonography of the knee joints
- To the correlate rheumatoid arthritis finding with age.
- To the correlate rheumatoid arthritis finding with gender.
- To identify the main sonographic findings of quadriceps muscles in rheumatoid arthritis
- To identify the main sonographic findings of 2 menisci of the knee joints in rheumatoid arthritis.

Literature Review

2-1 Anatomy of the knee joint:

The knee joint is the largest and most complicated joint in the body. Basically, it consists of two condylar joints between the medial and lateral condyles of the femur and the corresponding condyles of the tibia, and a gliding joint, between the patella and the patellar surface of the femur. Note that the fibula is not directly involved in the joint. Above are the rounded condyles of the femur; below are the condyles of the tibia and their cartilaginous menisci; in front is the articulation between the lower end of the femur and the patella. The articular surfaces of the femur, tibia, and patella are covered with hyaline cartilage. Note that the articular surfaces of the medial and lateral condyles of the tibia are often referred to clinically as the medial and lateral tibial plateaus. The joint between the femur and tibia is a synovial joint of the hinge variety, but some degree of rotatory movement is possible. The joint between the patella and femur is a synovial joint of the plane gliding variety. (Snell, 2012)

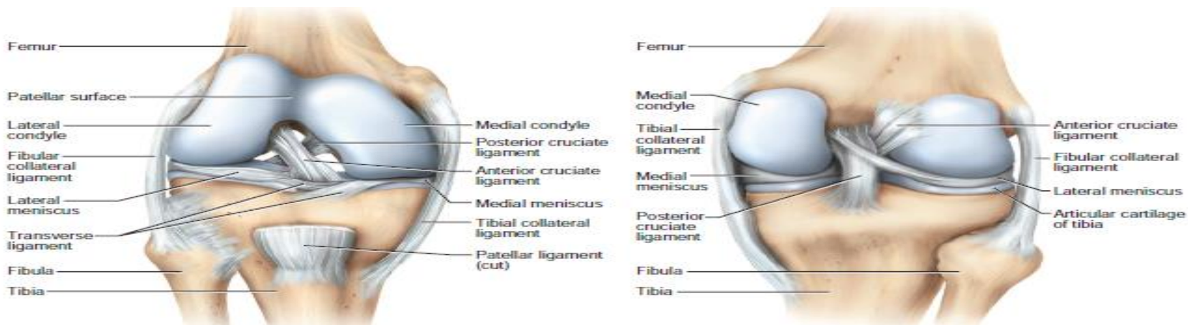


Fig 2-1 the knee (tibiofemoral) joint anterior and posterior view (saladin,2014)

2-1-1 Menisci and Ligaments:

Located between the femoral condyles and tibial plateaus are the paired menisci. These C-shaped menisci, composed of fibrous connective tissue, cushion the articulation between the femoral condyles and tibial plateaus and are commonly divided into anterior and posterior horns. On cross section they appear wedge shaped, with a thickened outer margin that flattens medially. Their outer margins fuse with the joint capsule, and their anterior and posterior horns attach to the intercondylar eminence of the tibia. The menisci differ in size and shape. The medial meniscus is crescent shaped, with the posterior horn being wider than the anterior horn. The medial meniscus is attached to the medial collateral ligament, making it far less mobile than the lateral meniscus. The lateral meniscus almost forms a closed ring with anterior and posterior horns of approximately the same width. Two ligaments arise from the posterior horn of the lateral meniscus. The posterior meniscofemoral ligament (ligament of Wrisberg) passes behind the posterior cruciate ligament to attach to the medial femoral condyle. The anterior meniscofemoral ligament (ligament of Humphry) connects the posterior horn to the medial condyle, passing in front of the posterior cruciate ligament. The two menisci are connected anteriorly by the transverse ligament. (Kelley, 2007)

The ligaments of the knee are divided into external (extracapsular) and internal (intracapsular) ligaments. The external ligaments are arranged around the knee and serve to strengthen and support the joint capsule. The internal ligaments are found within the joint capsule and serve to provide stability to the tibia and femur. External ligaments of the knee include the collateral, patellar, and patellar retinaculum; oblique popliteal; and arcuate popliteal ligaments. The collateral ligaments provide support for the knee by reinforcing the joint capsule on the medial and lateral sides. The medial collateral (tibial collateral) ligament is a flattened triangular ligament that originates from the medial femoral epicondyle and extends to the medial tibial condyle, continuing to the medial shaft of the tibia. Along its path it fuses with the medial meniscus. The shorter, lateral collateral (fibular collateral) ligament is more of a rounded cord arising from the lateral femoral epicondyle and attaching to the head of the fibula. The anterior joint capsule is strengthened by the patellar ligament and patellar retinaculum. (Kelley, 2007)

The patellar ligament is the strong thick band representing the continuation of the quadriceps tendon and extends from the patella to the tibial tuberosity. The patellar retinaculum is formed mainly by fibrous extensions and fascia of various muscles about the knee. The medial patellar retinaculum is formed mainly by fibers from the vastus medialis muscle and runs distally to attach to the tibia anterior to the medial collateral ligament. The lateral patellar retinaculum consists of fibers from the vastus lateralis and rectus femoris muscles as well as the iliotibial tract and attaches distally to the lateral margin of the tibial tuberosity to increase stability of the lateral joint capsule. The oblique and arcuate popliteal ligaments help reinforce the dorsal surface of the joint capsule. The oblique popliteal ligament is an expansion of the semimembranosus tendon that reinforces the central region of the posterior joint capsule. It extends laterally to attach to the intercondylar line of the femur. The inferolateral portion of the posterior capsule is strengthened by the arcuate popliteal ligament as it passes superiorly from the apex of the fibular head to spread out over the posterior capsule with fibers continuing to the posterior intercondylar area and to the posterior surface of the lateral femoral condyle. (Kelley, 2007)

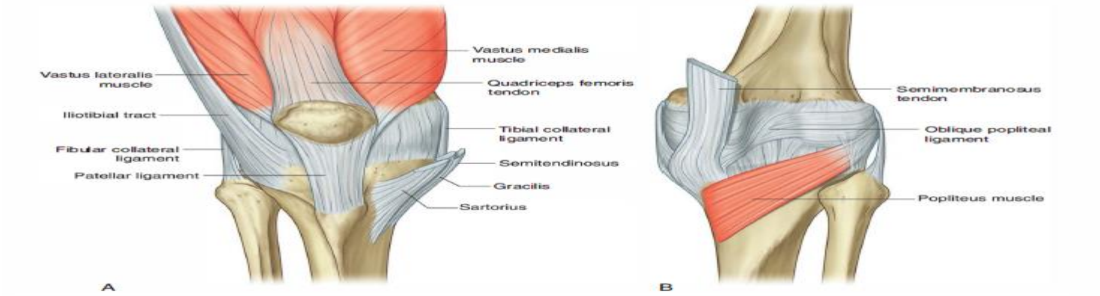


Fig 2-2 fibrous membrane of the knee joint capsule A anterior view B posterior view(Drake , 2015)

Cruciate (cross-shaped) ligaments are strong bands of fibers that provide anterior and posterior stability to the knee. The cruciate ligaments are located within the joint capsule but outside the synovial membrane. The anterior cruciate ligament arises from the anterior part of the tibial spine and extends to attach to the posterior part of the medial surface of the lateral femoral condyle. It helps prevent hyperextension and anterior displacement of the tibia. The posterior cruciate ligament is the stronger of the two and extends from the posterior tibial spine to the anterior portion of the medial surface of the medial femoral condyle. It functions to prevent hyperflexion and posterior displacement of the tibia. (Kelley, 2007) There are more than 10 bursae located around the knee joint owing to the number of muscles associated with the knee. The major bursa includes the suprapatellar, prepatellar, infrapatellar (superficial and deep), gastrocnemius (medial and lateral), semimembranosus, and popliteus bursae. The suprapatellar (quadriceps) bursa is a large extension of the synovial capsule located between the femur and the quadriceps tendon. The subcutaneous prepatellar bursa lies between the anterior surface of the patella and the skin, whereas the superficial infrapatellar bursa lies over the patellar ligament between the skin and the tibial tuberosity. The deep infrapatellar bursa is a small bursa located beneath the patellar ligament and anterior to the tibia just above the tibial tuberosity. Behind each femoral condyle is usually a bursa for the respective head of the gastrocnemius muscle. The gastrocnemius bursae are located between each muscle head and the joint capsule. The semimembranosus bursa is located between the medial head of the gastrocnemius and semimembranosus tendon, and the small popliteus bursa lies between the lateral tibial condyle and the popliteus tendon. (Kelley, 2007).

2-1-2 Blood supply of knee joint:

The arteries supplying the knee joint are the 10 vessels that form the peri-articular genicular anastomoses around the knee: the genicular branches of the femoral, popliteal, and anterior and posterior recurrent branches of the anterior tibial recurrent and circumfl ex fi bular arteries. The middle genicular branches of the popliteal artery penetrate the fi brous layer of the joint capsule and supply the cruciate ligaments, synovial membrane, and peripheral margins of the menisci. (Moore, 2014)

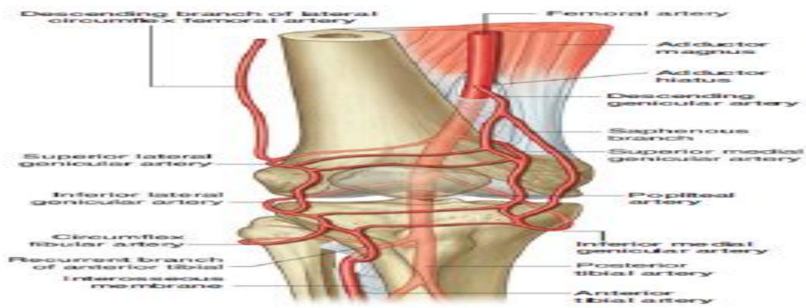


Fig 2.3 anastomoses of arteries round the knee. anterior view(Drake , 2015)

2-1-3 Nerve supply:

The joint is supplied from the femoral nerve through its branches to the three vasti, from the sciatic nerve by the genicular branches of its tibial and common peroneal components, and from the obturator nerve by the twig from its posterior division, which accompanies the femoral artery through the gap in the adductor magnus into the popliteal fossa. During arthroscopy it must be remembered that, although local anaesthesia affects the overlying skin, the cruciate ligaments remain sensitive (tibial nerve). The horns of the menisci are innervated but their central parts are devoid of sensory fibres. (Sinnatamby, 2011)

2-2 Physiology of the knee joint:

The principal movements of the knee joint are flexion and extension. Flexion is produced mainly by the hamstrings (semimembranosus, semitendinosus and biceps) assisted by the two heads of gastrocnemius. Extension is produced by quadriceps femoris acting through the patellar ligament. Gluteus maximus, acting through the iliotibial tract, maintains stability of the knee in the extended position. (Gosling, 2008)

Because of the shape of the articular surfaces, the femur rotates medially during the later stages of extension. The lateral condyle and meniscus (moving in unison because of the meniscofemoral ligament) glide forwards on the lateral tibial condyle whilst the medial condyle completes its movement of extension on the medial meniscus. Full extension is achieved with completion of medial rotation and further movement is prevented by tension in the collateral and oblique posterior ligaments. During the early stages of flexion, lateral rotation of the femur on the tibia is produced by popliteus, which also pulls the lateral meniscus posteriorly. During flexion and extension the patella glides over the patellar surface of the femur. Slight active rotation of the tibia on the femur can occur when the knee is in a flexed but non-weight-bearing position. Sartorius, gracilis and semitendinosus rotate medially while biceps femoris rotates laterally. (Gosling, 2008)

The knee joint is very stable. The most important factors are muscle tone, especially in quadriceps, and the ligaments. The cruciate ligaments stabilize the femur on the tibia, preventing excessive anteroposterior movement. The collateral ligaments assist medial and lateral stability while the iliotibial tract stabilizes the knee during extension. All of these ligaments, together with the oblique posterior ligament, prevent hyperextension. Cruciate and collateral ligament injuries together with meniscal tears commonly occur in sports, particularly following twisting movements during which the foot is anchored to the ground. Owing to angulation of the femur relative to the tibia, contraction of quadriceps femoris tends to displace the patella laterally. This displacement is prevented firstly by the lowest fibres of vastus medialis, which insert into the medial patellar border and whose active contraction resists lateral movement of the patella, and secondly by the large size and prominence of the lateral femoral condyle, making lateral patellar movement mechanically difficult. Occasionally, the lateral femoral condyle fails to develop normally, resulting in patellar instability. (Gosling, 2008)

2-3 Pathology of the knee joint:

Disorders of the joints are disabling conditions which cause serious morbidity to the affected individual. They are of major economic importance both to the patients, who may have long periods off work, and to society as a whole. Joint replacement is a very common and expensive operation in terms of professional time, bed occupancy and prosthetic materials. Over 40 000 total hip replacements and a similar number of knee replacements are carried out each year in the UK, mostly for osteoarthritis and rheumatoid arthritis. Osteoarthritis, the most common form of joint disease and rheumatoid arthritis, one of the autoimmune diseases, and many other less common forms of inflammatory arthritis. (Levison, 2008)

2-3-1 Rheumatoid Arthritis:

In contrast with osteoarthritis, rheumatoid arthritis is a systemic inflammatory disease, the brunt of which usually falls on the joints. It is common, affecting 1% of the adult population, and occurs more often in females.Any age from childhood to old age may be affected, but the onset is typically in the fourth to sixth decades. Rheumatoid arthritis may involve any synovial joint, but is usually a symmetrical polyarthritis affecting principally the metacarpophalangeal and proximal interphalangeal joints, the wrist, shoulder and knee. Patients complain of pain and stiffness especially in the morning. The affected joints are warm and swollen due to joint effusion and synovial hyperplasia. The onset is usually insidious over weeks or months, but rarely symptoms may develop more acutely over days. In most cases the disease follows a course of repeated, partial or complete remissions and relapses, with further loss of function during each relapse. Less commonly, the disease progresses rapidly with joint destruction and severe disability. Some patients have one episode of arthritis which resolves, and have no further problem. In 75% of patients, rheumatoid factors can be identified in the serum and synovial fluid. These are antibodies, usually of IgM, IgG and IgA type, which react with the Fc compartment of IgG to form immune complexes. Patients whose serum contains these antibodies are known as seropositive. This is associated with more aggressive disease than those without rheumatoid factors (seronegative). More recently, antibodies against cyclic citrullinated proteins (CCP) appear to be equally sensitive but far more specific than rheumatoid factors for the diagnosis of rheumatoid arthritis. (Levison, 2008)

Joint involvement in rheumatoid arthritis is characterized by inflammation and hyperplasia of the synovium followed by destruction of articular structures. The synovium is thrown into villous folds often matted together by fibrin; hyperplasia of synovial lining cells occurs. The synovium is infiltrated by lymphocytes and plasma cells; lymphoid aggregates with germinal centres are often seen. Fibrin exudes onto the synovial surface, sometimes forming loose bodies known as rice bodies. Neutrophil polymorphs are present in synovial fluid from inflamed joints but are seen in the superficial synovium in significant numbers only during acute exacerbations. (Levison, 2008)

These changes in the synovium are reversible; however when granulation tissue grows over the surface of the articular cartilage the pannus so formed interferes with the nutrition of cartilage and causes degradation of its matrix. Permanent joint damage now results. Resorption of the subchondral bone gives rise to radiological 'erosions'. If much articular cartilage is lost, granulation tissue from both sides of the joint forms adhesions, followed sometimes by fibrous union (fibrous ankylosis). (Levison, 2008)

Destruction of the joint capsule and tendons, which are eroded by inflamed synovium of tendon sheaths, leads to striking deformities. Ulnar deviation of the fingers is common and dislocation and subluxation lead to characteristic boutonnière and swan-neck deformities. There is atrophy of muscles surrounding the joints (e.g. interossei in the hand), while a combination of disuse atrophy and local hyperaemia leads to loss of bone close to the bone ends (juxta-articular osteoporosis). Involvement of the cervical spine may lead to atlantoaxial subluxation and spinal cord compression. Hyperextension during intubation for general anaesthesia may precipitate neurological damage. (Levison, 2008)

2-4 Assessment of Rheumatoid arthritis:

Degenerative osteoarthritis of the knee is very frequent musculoskeletal condition, and a common cause of long lasting and reccurent pain and disability. Traumatic knee injuries and repetitive microtraumas are very common, affecting all age groups. These injuries in athletes remain a major problem, because of the requirment for immediate and correct diagnosis and therapy, and need for repetitive follow up Although other, more advanced imaging methods (MRI, MDCT) are the major imaging modality choices in evaluating the knee pathology, ultrasound still plays an important role and helps establishing the diagnosis. It has some advantages over MRI: ultrasound is widely available, cheap, immediate method which allows good dynamic evaluation and immediate correlation with structures of the contralateral knee. (European society of radiology 2013) (Fig 2-1) (Fig 2-2) (Fig 2-3)

Rheumatoid arthritis has been focused primarily in rheumatology ultrasound in terms of early detection, grading and treatment of synovitis. Since the first greyscale ultrasound demonstration synovitis of the knee joint, many studies have confirmed the superiority of ultrasound over clinical examination in the detection of synovitis, synovial hypertrophy, effusion and related pathologies the next focus moved to how to assess synovitis using power or Colour Doppler.

In rheumatology, especially in arthritis evaluation, the power Doppler technique is unique in terms of measurement of blood flow at a level of microvascularity.

Power Doppler has been preferred to colour Doppler for the assessment of disease activity due to its technical advantages, including lack of aliasing, less angle dependency and greater sensitivity for low velocity blood flow. Thus, interest in whether power Doppler.

With Doppler in particular, more quantitative measures have been tested, such as the calculation of the resistive index or pixel counting in the region of interest the downside of these measures.

Fig 2-4 Intra-articular loose body. a Longitudinal 12–5 MHz US image of the suprapatellar recess performed with the knee flexed shows a calcified loose body(Bianchi, 2007).

2-5 Sonographic appearance of the knee joint arthritis:

Knee effusion can be easily and convincingly demonstrated by ultrasound. It's a very good alternative and more precise method than clinical evaluation. It can give some information about the quality of effusion (clear, hemorrhagic in trauma), estimate the amount of effusion, and make a clinical decision for aspirating the fluid. Suprapatellar and parapatellar recesses are easily assessed by ultrasound. Suprapatellar recess is positioned deep to the distal part of quadriceps tendon, between the suprapatellar and prefemoral fat pad, above the patella. (Fig 2-4) .

Synovial thickening can occur as a result of various conditions (arthritis, knee degeneration, acute trauma, repetitive micro-trauma, malignances).

Synovitis in osteoarthritis of the knee is common, even in early stages of the disease. It is associated with pain, and cartilage degeneration. Synovitis can also be assessed by scanning the suprapatellar and parapatellar recesses.

Patellar tendinopathy, tendonitis, or "jumper's knee" is one of the most common patellar ligament pathologies. Usually occurs in adult athletes and the most common ligament pathologies. Usually occurs in adult athletes, and the most common symptom is chronic anterior knee pain. Ultrasound findings include ligament thickening, focal or diffuse ligament hypoechogenicity. (fig 2-5) increased vascularity on color Doppler.

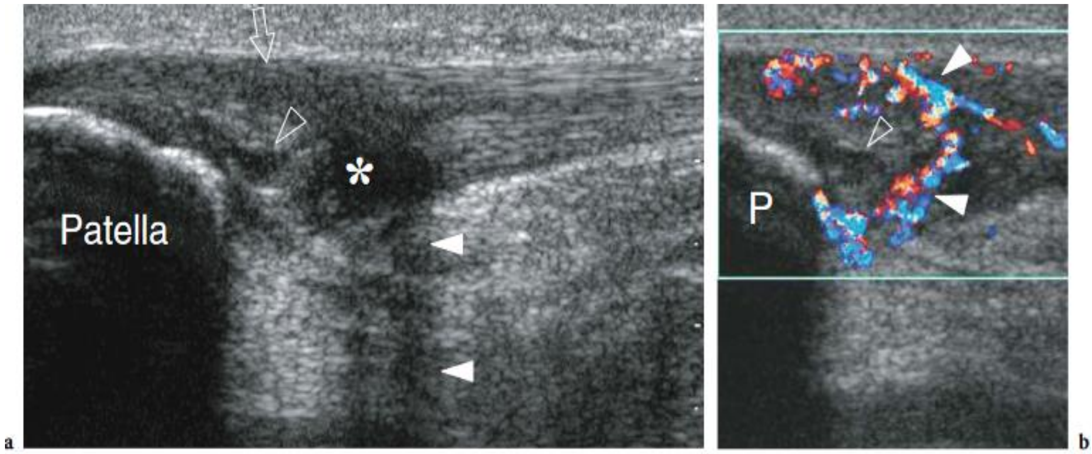


Fig 2-5 Jumper's knee. Partial thickness tear of the patellar tendon. a Longitudinal image b Color Doppler imaging reveals a diffuse intratendinous hyperemia(Bianchi , 2007).

Prepatellar bursa is a thin, superficial bursa, localized in the subcutaneous tissue anterior to patella. Prepatellar bursitis or a "Housemaid's knee" is common inflammation affecting the bursa. It could be a result of acute trauma, chronic repetitive microtrauma, or inflammatory conditions (gout). The bursa is distended and could be filled with anechogenic fluid (in acute conditions), blood (trauma), or synovial hypertrophy (chronic conditions), and the subcutaneous tissue could also be edematous. (Fig 2-6)

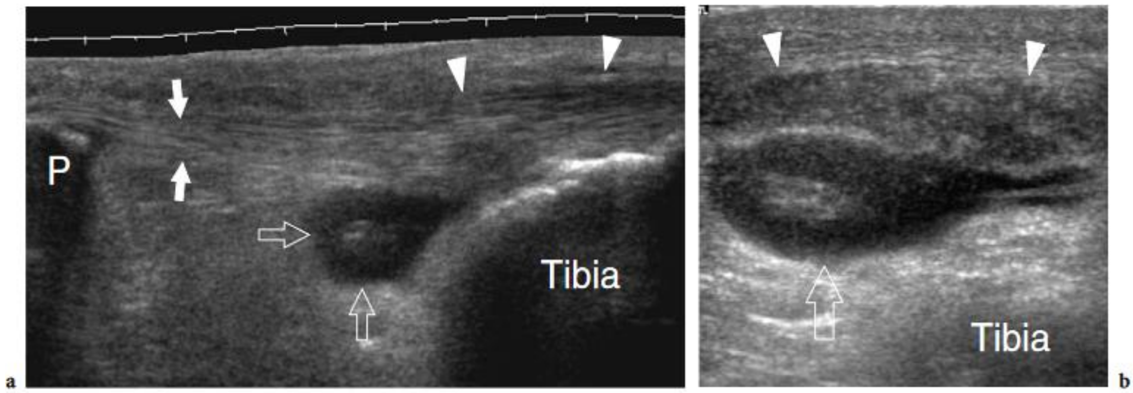


Fig 2-6: Distal patellar tendinopathy and infrapatellar bursitis. a Longitudinal –viewandbtransverse images of the infrapatellar region(Bianchi ,2007)

Sprain, partial or total rupture of the ligament can be assessed by ultrasound, and major signs for traumatic injury are increased thickness of ligament, hypoechoity of the ligament in sprains and tears, fibers discontinuity in partial and full thickness tears. (Fig 2-7)

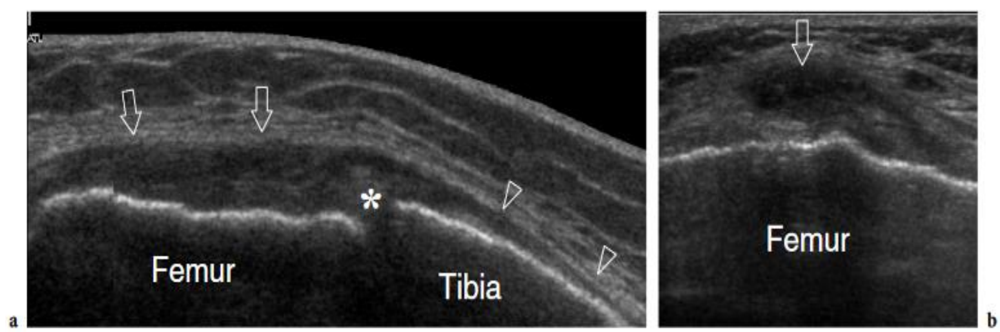


Fig 2-7: Intrasubstance tear of the medial collateral ligament. a Long-axis extended field-of-view and b short-axis (Bianchi, 2007)

The menisci usually appear as hyperechoic, well demarcated, triangular shaped structures. Although MRI is the most accurate method for evaluating meniscal pathology, ultrasound can help in establishing correct diagnosis, especially in peripheral tears, meniscal cysts and meniscal degeneration. (Fig 2-8)

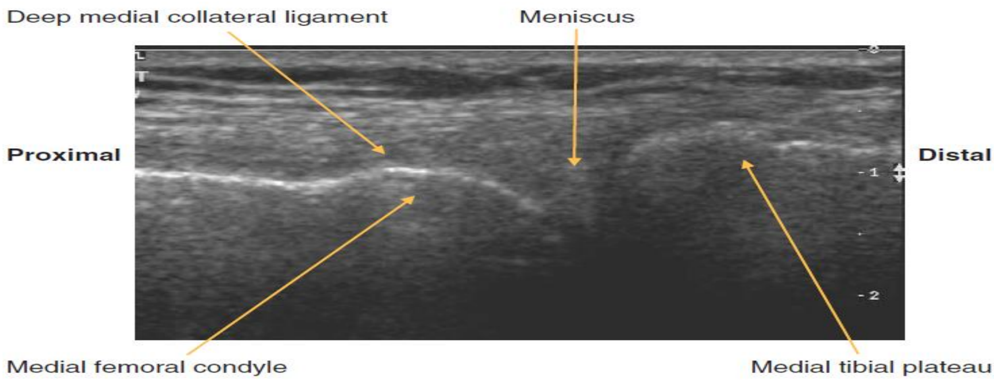


Fig 2-8 : ls normal medial meniscus(Bradley,2004)

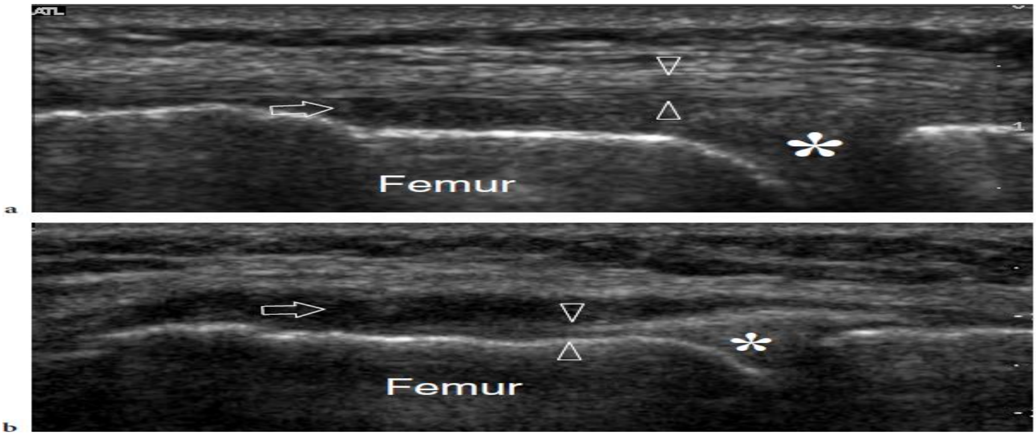


Fig 2-9: A.b- Partial-thickness tears of the medial collateral ligament(Bianchi, 2007)

Meniscal tears usually appear on ultrasound as linear or complex hypoechoic fluid filled defects. (Fig 2-8) (Fig 2-9)

Baker's cyst is the most common mass in the popliteal fossa. It is most frequent in patients with osteoarthritis, but it's also strongly associated with arthritis. Simple Baker's cyst is an anechoic, thin wall cyst, located between medial gastrocnemius head and semimembranosus tendon, usually communicating with the joint (fig). Complex cyst can have synovial hypertrophy, septa, and calcified loose bodies. (Fig 2-10)

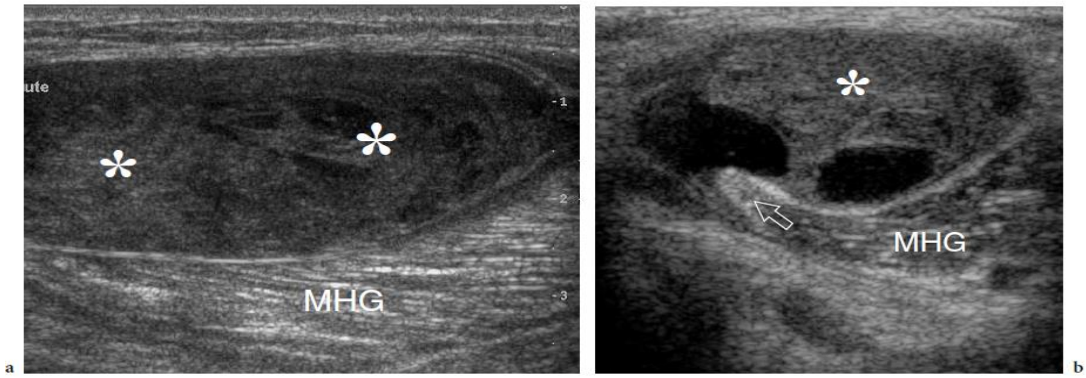


Fig 2-10: complicated Baker's cyst: intrabursal hemorrhage A longitudinal b transverse(Bianchi , 2007)

2-5 Ultrasound machine:

2-5-1 Transducer:

Diagnostic ultrasound instruments use electricity to generate an image. The ultrasound machine produces between 10 and 500 V in order to drive the piezoelectric elements. If a crack occurs in the transducer housing, there is a potential risk for electrical shock to either the practitioner or the patient. Consequently, the ultrasound transducer is insulated not only to protect the image from outside electrical interference but also to protect the user and the patient. The transducer is also electrically shielded to protect the signal from extraneous radiofrequency interference. The transducer is equipped with a matching layer that lies between the piezoelectric element and the patient's skin. The purpose of the layers is to step down the impedance from that of the element to that of the patient's skin. The matching layer improves the efficiency of transmitting sound into the patient by decreasing this impedance mismatch. (Penny, 2018)

An additional matching layer, employed by the sonographer, is the coupling medium, or gel. In addition to removing air between the transducer and the patient, gel is specially formulated to have an impedance value between that of the matching layer and the patient's skin to further enhance the transmission of sound. The backing material, as the name implies, sits on the back of the transducer, behind the elements. The purpose of the backing material, also referred to as the damping material, is to provide damping of the piezoelectric element. The damping material serves to shorten the length of the pulse by decreasing the number of cycles in the pulse. This material is composed of an epoxy resin loaded with tungsten. (Penny, 2018)

There are two methods of sending out scan lines to form an image using real-time: mechanical scanning (via mechanical transducers) and electronic scanning (via electronic transducers). Both of these methods provide a means for sweeping the ultrasound beam through the tissue repeatedly and rapidly. (Penny, 2011).

2-5-2 Instruments:

Sonographic systems produce visual displays from the echo voltages received from the transducer. The instrument is composed of a beam former, a signal processor, an image processor, and a display. (Kremkau, 2016)

2-5-2-1 Beam former:

The beam former is where the action originates. It consists of a pulser, pulse delays; transmit/receive (T/R) switch, amplifiers, analog- to-digital converters, echo delays, and a summer. The pulser produces electric voltages that drive the transducer, forming the beam that sweeps through the tissue to be imaged. The driving voltages are typically in the form of a single cycle of voltage of the desired operating frequency. In response, the transducer produces ultrasound pulses that travel into the patient. The frequency of the voltage pulse determines the frequency of the resulting ultrasound pulse. Frequency ranges from 2 to 20 MHz for most applications. Thus far, the job of the beam former appears simple, but we must remember that with arrays, complicated sequencing and phasing operations are involved. Sequencing, phase delays, and variations in pulse amplitudes, which are necessary for the electronic control of beam scanning, steering, transmission focusing, aperture, and apodization, must be accomplished. (Kremkau, 2016)

The pulser and pulse delays carry out all of these tasks. The pulse delays have a single input from the pulser but multiple outputs to the transducer elements; that is, there are actually many delay paths in the pulse delay circuitry. The reason for this is that each of the many elements in the array needs a different delay to form the ultrasound beam properly. The transmit/receive (T/R) switch directs the driving voltages from the pulser and pulse delays to the transducer during transmission and then directs the returning echo voltages from the transducer to the amplifiers during reception. The T/R switch protects the sensitive input components of the amplifiers from the large driving voltages from the pulser. (Kremkau, 2016)

Amplifiers increase voltage amplitude. The beam former has one amplifier for each channel. Amplification is the conversion of the small voltages received from the transducer elements to larger ones suitable for further processing and storage. Gain is the ratio of amplifier output to electric power input. After amplification, the echo voltages are digitized; that is, they pass through analog-to-digital converters (ADCs). An ADC (also called a digitizer) converts the voltage from analog to digital form. (Kremkau, 2016)

After the ADC, echo voltages are replaced by a series of numbers, and further manipulation of the echoes is accomplished as digital signal processing (mathematical manipulation of numbers representing echoes). After amplification and digitizing, the echo voltages pass through digital delay lines to accomplish reception dynamic focus and steering functions. After all the channel signal components are delayed properly to accomplish the focus and steering functions, they are added together in the adder to produce the resulting scan line, which, along with all the others, will be displayed after signal processing and image processing.

Reception apodization and dynamic aperture functions are also accomplished as part of this summing process. (Kremkau, 2016)

2-5-2-2 Signal processor:

The reception portion of the beam former amplifies and combines the contributions from the individual elements and channels to form the stream of echoes returning from each transmitted pulse and sends them on to the signal processor. Operations carried out here include filtering, detection, and compression. Tuned amplifiers are used to reduce noise in the electronics. They operate at a specific frequency with a bandwidth that includes the frequencies in the returning echoes and eliminates the electronic noise outside that bandwidth. A tuned amplifier is simply an amplifier with an electronic filter called the bandpass filter. Detection (also called demodulation) is the conversion of echo voltages from radio frequency form to amplitude form. This is done by detecting and connecting the maxima of the cyclic variations. The cyclic voltage form is called radio frequency because it is similar to voltages found in a radio receiver, and the frequencies are similar to those in the low end of the shortwave radio band. The detected form retains the amplitudes. The ratio of the largest to the smallest amplitude or power that a system can handle is called dynamic range. Dynamic range is expressed in decibels. (Kremkau, 2016)

2-5-2-3 Image processor:

Until this point (through the beam former and signal processor), the echo data are traveling in scan-line form serially through the system, that is, one scan line at a time. No image has yet been formed. The image processor converts the digitized, filtered, detected, and compressed serial scanline data into images that are stored in image memory, all in preparation for presentation on the instrument display. (Kremkau, 2016)

After detection of the echo voltage amplitudes in the signal processor, the scan-line data enter the image processor, where they are preprocessed and stored in image form and then are processed in image form. (Kremkau, 2016)

2-5-2-4 Display:

Gray-scale operation causes a brightening of the spot for each echo in memory. The brightness (gray scale) is proportional to the echo strength. The memory is filled with echoes from many pulses as the beam is scanned through the anatomy to be imaged. The 2D gray-scale scan is a brightness image that represents an anatomic cross-section in the scanning plane, as if the sound beam cuts a section through the tissue similar to a knife. Each individual image is called a frame. Because several frames can be acquired and presented every second, this is called real-time display. Several 2D scans can also be acquired to form a 3D volume of stored echo information. (Kremkau, 2016)

Frame rate is the number of sonographic 2D or 3D images entered into the image memory per second, whereas refresh rate is the number of times per second that images are retrieved from the memory and presented on the display. These two rates can be, but are not necessarily, equal. The information delivered to the display can be presented in several ways. Common to all clinical applications is brightness mode, also called B mode, B scan, or gray-scale sonography. Gray-scale anatomic displays can be in 2D or 3D forms. In echocardiography, motion mode (M mode) is also used. In ophthalmology, amplitude mode (A mode) is used as well. (Kremkau, 2016)

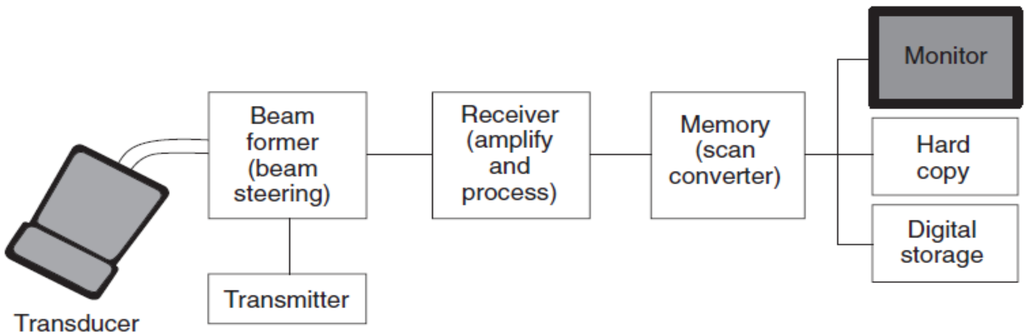


Figure 2-11: Components of an ultrasound system. (Hagen, 2018)

2-6 Previous studies:

Aurélie Najm et al 2018 had studied 26 patients with active arthritis in a knee joint and recent onsets of disease were prospectively included. Subjects with actively inflamed knee joint having crystal arthropathies, rheumatoid arthritis, psoriatic arthritis or ostoearthritis were prospectively recruited from rheumatology clinics after giving their written consent I 2015. The institutional ethics committee approved study. The knee was divided into three compartments (medial, lateral, superior). Patients had a knee US followed by a knee arthroscopy with biopsies retrieval from each compartment. Biopsies were blindly scored for lining layer hyperplasia, inflammation, vascularity, CD68 and factor VIII staining. Correlation was determined using the Spearman's correlation test. Found that Strong correlations were observed between US synovitis grade and histological inflammation score (r=0.63; P=0.002), US Doppler grade and histological score for vascularity (r=0.68; P<0.001); US measured synovial thickness and lining layer hyperplasia (r=0.61; P=0.002). Moderate correlation was found between US synovitis grade and CD68 score (r=0.49; P=0.02). US findings correlate with histological inflammation and vascularity scores in actively inflamed knee joints. US accurately describe knee synovitis. (Najm, 2018)

Markus Walther et al 2001 had studied the knee joints of 23 patients who were undergoing arthroplasty of the knee joint because of osteoarthritis or rheumatoid arthritis were examined with ultrasound before arthroplasty. The vascularity of the synovial membrane was classified semiquantitatively using PDS. A sample of synovial tissue was obtained during the arthroplasty, and the vascularity of the synovial tissue was evaluated by immunohistochemistry (factor VIII) and was graded qualitatively by a pathologist who was unaware of the PDS findings. The visual qualitative grading by the examiner was controlled by analyzing PDS images and histologic samples using a digital image evaluation system the visual estimation of vascularity based on PDS images and on tissue sections were compared with the results of digital image processing by Spearman's rank correlation test. The correlation between visual and digital interpretation of PDS was 0.89 by Spearman's ρ PDS(power Doppler sonography) proved to be a reliable diagnostic method qualitative grading of the vascularity of the synovial tissue. In clinical practice, PDS allows further differentiation of the hypertrophic synovium. (Walther, 2001)

M van Holsbeeck et al 1998 had studied Twenty patients with longstanding polyarticular rheumatoid arthritis (including knee involvement) were selected for this study. The severity of the knee synovitis was assessed before and during treatment (with intra articular corticosteroid injections) using clinical scores sonography, and thermography. In all patients, the inflammation regressed during treatment. During follow up, the quantity of synovial fluid, as measured sonographically 10 days after the start of therapy, correlated best with the clinical status. Maximal regression of synovialthickening was noted on delayed sonograms performed three months after treatment. Thermographic peak temperature showed good correlation with the clinical status, but the thermographic index was unreliable Quantification of pain and inflammation in rheumatoid arthritis is a difficult clinical problem; 1 as a result, any evaluation based on patient symptoms is fraught with error. A standardized and reproducible method of grading both the severity of disease and the response to treatment is sorely needed. Of the original 20 patients who entered into thier study, seven were lost to follow-up (94 days), and four were eliminated because of technically unsatisfactory sonographic examinations. All parameters, except the thermographic measurements showed a significant change in comparison to the pretreatment measurements, on the 10- and 94- day follow-up examinations following intra-articular injection of the long-acting corticosteroid. (Holsbeeck, 1998)

Li-na Shang et al 2016. Had studied 82 patients with RA who sought treatment in the Affiliated Hospital of Hebei University were included in this study. Data on ultrasonic and anti-CCP(Anti-cyclic citrullinated) antibody, ESR, and RF were collected and compared. The RA patients were divided into two groups of mild disease activity (DAS28 ≤ 3.2) and moderate-severe disease activity (DAS28 > 3.2) to compare the changes in synovial thickness of joints. The changes of joint ultrasonography were also compared between positive and negative anti-CCP antibodies group. It is found that the number of patients suffering from joint involvement in the negative anti-CCP antibody group was larger than that of the anti-CCP positive antibody group ($P < 0.05$); the thickness of the synovium of joints of patients in the group with moderate-severe disease activity evaluated via ultrasonography was significantly larger than that of the group with mild disease activity ($P < 0.05$). It is possible to observe the degree of disease activity dynamically by combining ultrasonography with anti-CCP antibody and make a better assessment of patients to facilitate treatment. (Shang, 2016)

L. Riente et 2010, the aims of their study were to investigate the prevalence of ultrasound (US) pathologic abnormalities and to compare them with the clinical findings in the knee of rheumatoid arthritis (RA) patients. One hundred RA patients were enrolled in the study. Bilateral US examination of the knee was performed to visualize the presence of effusion, synovial proliferation, bone erosions, femoral cartilage abnormalities, quadricipital and / or patellar enthesopathy. The popliteal fossa and the calf region were also evaluated to detect popliteal cyst. they observed joint effusion in 140 out of 200 (70%) knees. Synovial hypertrophy was present in 115 out of 140 (82%) knees associated with effusion and in 22 out of 115 (19%) knees intra-articular power Doppler (PD) signal was found. Hyperechoic spots within the cartilage layer, suggestive of pyrophosphate crystals deposit, they detected in the knees of 3 patients. US signs of quadricipital and / or patellar enthesopathy were detected in 53 out 200 (26%) knees. Bone erosions were visualized in 16 out 200 (8%) knees. Popliteal cyst was found in 66 out of 200 (33%) joints. US examination of the knee is more sensitive than clinical examination in the detection of joint inflammation and allows for the identification of different patterns of pathologic changes at knee level, including morphostructural changes at both cartilage and tendon level. (Riente, 2010)

Materials and Methods

3.1 Materials:

3.1.1 Study design:

- This is a Descriptive cross sectional study.

3.1.2 Study area:

- This study was carried out in Omdurman military hospital and other care centers in Sudan.

3.1.3 Study duration:

- This study was carried in the period from august 2022 to January 2023.

3.1.4 Sample of study:

- This study was conducted on 40 patients (age range of 28-70) who attended to the ultrasound department in the duration and area of the study and all were diagnosed clinically to have Rheumatoid Arthritis.

3.1.5 Equipment used in the study:

Figure 3-1: ACUSON X300™ Ultrasound System with linear array ultrasound transducer, Frequency**:** 7.5,10, 15, 12 MHz.

Figure 3-2: Esaote pie medical ultrasound machine with linear transducer, Frequency: 7.5,10 MHz.

3.2 Methods:

3.2.1 Technique used:

Knee joints was in numerous patient positions, anterior, posterior fossa , medial and lateral, essential to use the highest frequency possible and to have the transducer focused in the region of interest, The sound beam is directed through the most depended portion of the knee joints.

On anterior knee joints position patient lies supine on bed with knee flexed 20-30 degrees. Identify quadriceps tendon (tears/tendonitis) suprapatella bursa (bursitis, synovial thickening and loose bodies) and patella.

On medial and lateral knee joints position assess the medial and lateral collateral ligaments and meniscal margins. Joints lines to demonstrate (ligament thickening, meniscal cyst and joint effusion).

On posterior fossa patient prone on bed, flexed slightly with a pad under the ankle for support. Survey the entire fossa to identify posterior joint effusion and demonstrate baker cyst, or popliteal cyst witch occur as a communication between the posterior joint capsule and the gastrocnemius semimembranosus bursa.

3.2.2 Data collection:

- Data collection sheets were designed especially for this study.

3.2.3 Statistical analysis:

- All data will be analyzed by using statistical package for social science (SPSS).

3.3 Ethical consideration:

- Permission for conducting the study was obtained from head of the Radiology department at Omdurman military hospital hospital.

Result

Table (4.1) : Distribution of patients according to gender

Gender	Frequency	Percentage
Male	15	45.0%
Female	35	55.0%
Total	50	100.0%

Source: Prepared by the researcher from field study data 2022

Table (4.2) : Correlation between gender and Diagnostic findings

Correlations			
		gender	Diagnostic findings
Gender	Pearson Correlation Sig. (2-tailed) N		0.501** 0.001 50
Diagnostic findings	Pearson Correlation Sig. (2-tailed) N	0.501** 0.001 50	

Source: Prepared by the researcher from field study data 2022

Correlation between genders there are female (70.0%) less than male (30.0%) show significant correlation (0.001).

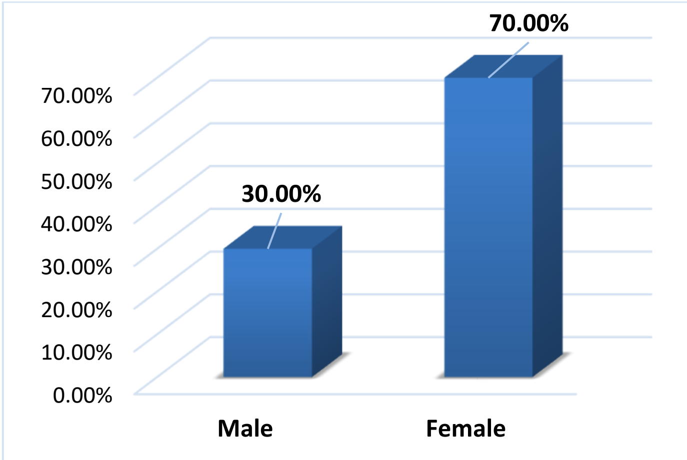


Fig (4.1): Distribution of patients according to gender

Table (4.3) : Distribution of patients according to Age

Age	**Frequency**	**Percentage**
Less than 30 years	2	4.0%
30-40 years	7	14.0%
40-50 years	19	38.0%
50-60 years	13	26.0%
More than 60 years	9	18.0%
Total	50	100.0%

Source: Prepared by the researcher from field study data 2022

Table (4.4) : Correlation between age and Duration

Correlations			
		age	Diagnostic findings
Age	Pearson Correlation Sig. (2-tailed) N		0.163** 0.007 50
Diagnostic findings	Pearson Correlation Sig. (2-tailed) N	0.163** 0.007	200 0.000

		50	

Source: Prepared by the researcher from field study data 2022

High ratio is (40-50) years (38.0 %) give right answer, there was correlation between age there are high ratio (< 40) (82.0%). show significant correlation (0.007).

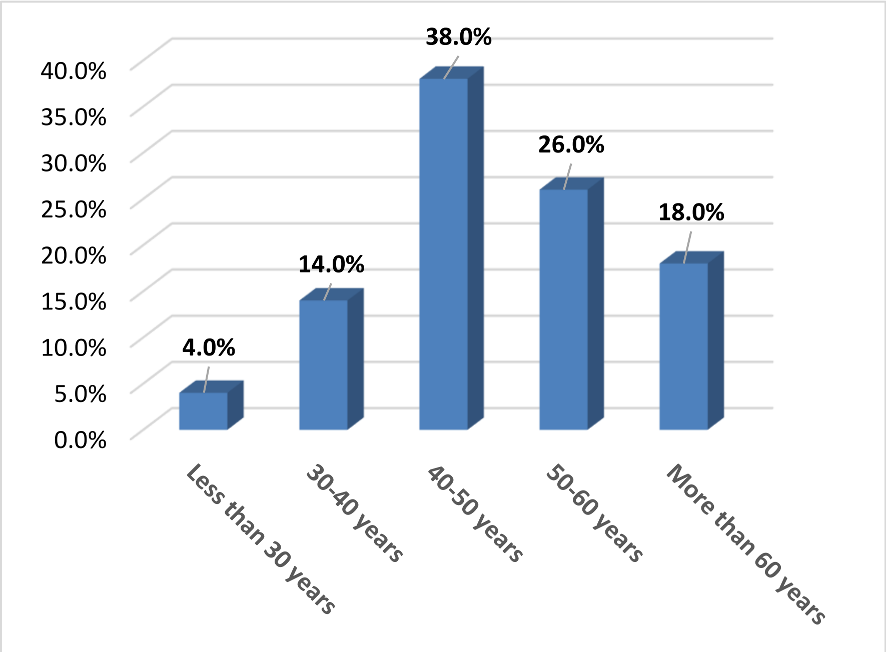


Fig (4.2): Distribution of patients according to Age

Table (4.5): Distribution of patients according to Diagnostic findings

Diagnostic findings	**Frequency**	**Percentage**
Joint effusion	4	8.0%
Mild joint effusion	5	10.0%
Tear	4	8.0%
Normal scan	15	30.0%
Baker's cyst with calcification	4	8.0%
Minimal edema in Mcl	5	10.0%
Moderate chronic effusion + Baker's cyst	4	8.0%
Moderate effusion	5	10.0%
Heterotopic calcification in medial condyle	1	2.0%
Pre patellar bursitis	1	2.0%

Mild knee joint effusion	2	4.0%
Total	50	100.0%

Source: Prepared by the researcher from field study data 2022

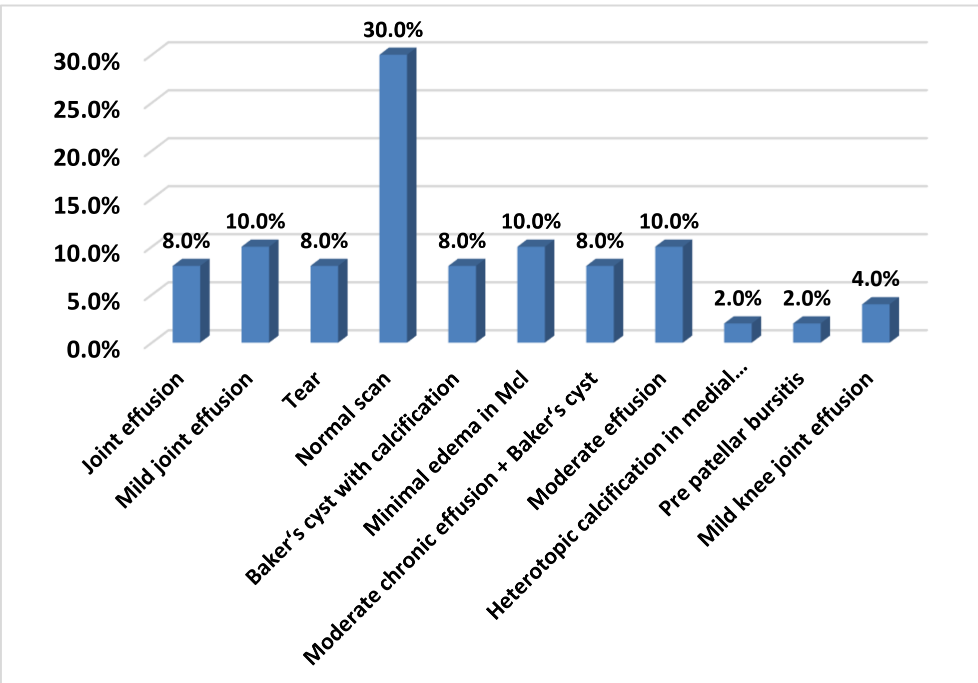


Fig (4.3): Distribution of patients according to Diagnostic findings

Table (4.6): ANOVA

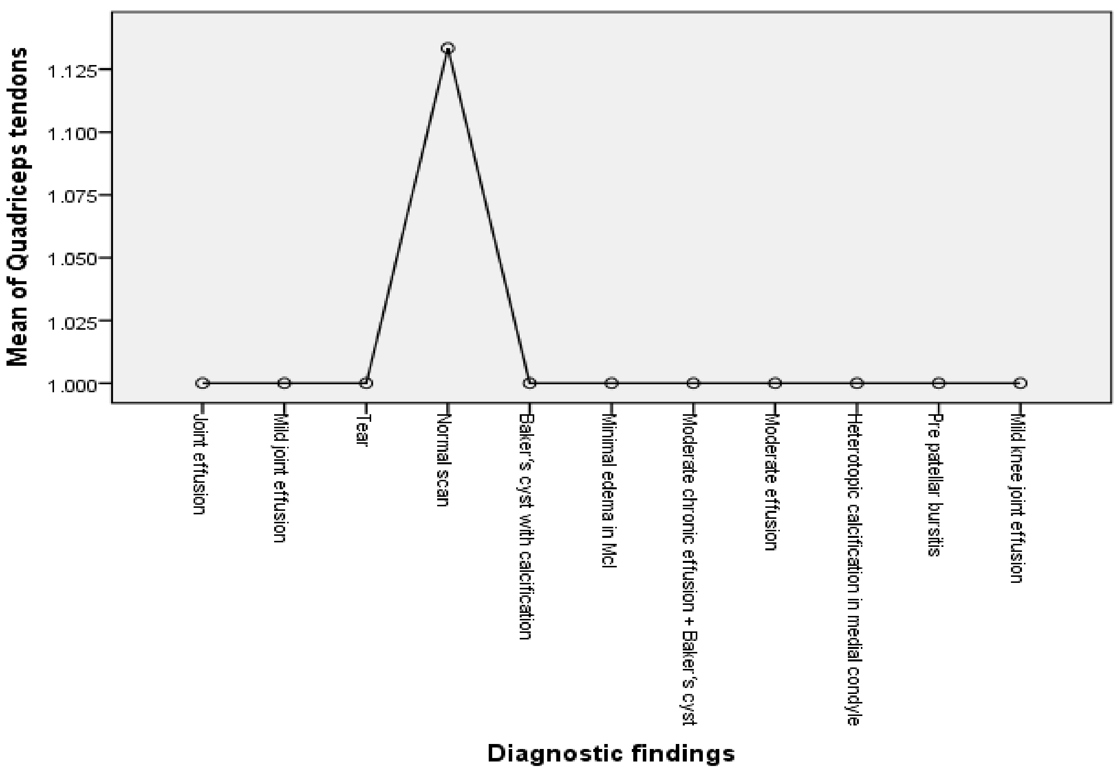
ANOVA

				Sum of Squares	df	Mean Square	F	Sig.
Medial meniscus	Between Groups	(Combined)		0.000	10	0.000		
		Linear Term	Unweighted	0.000	1	0.000		
			Weighted	0.000	1	0.000		
			Deviation	0.000	9	0.000		
	Within Groups			0.000	37	0.000		
	Total			0.000	47			
Lateral meniscus	Between Groups	(Combined)		0.000	10	0.000		
		Linear Term	Unweighted	0.000	1	0.000		
			Weighted	0.000	1	0.000		
			Deviation	0.000	9	0.000		
	Within Groups			0.000	37	0.000		
	Total			0.000	47			
Quadriceps tendons	Between Groups	(Combined)		.183	10	.018	.182	.997
		Linear Term	Unweighted	.001	1	.001	.011	.917
			Weighted	.008	1	.008	.080	.779
			Deviation	.175	9	.019	.193	.994
	Within Groups			3.733	37	.101		
	Total			3.917	47			
patellar tendons	Between Groups	(Combined)		13.867	10	1.387	4.008	.001
		Linear Term	Unweighted	.569	1	.569	1.645	.208
			Weighted	.516	1	.516	1.492	.230
			Deviation	13.351	9	1.483	4.288	.001
	Within Groups			12.800	37	.346		
	Total			26.667	47			
Medial Collateral Ligament (MCL)	Between Groups	(Combined)		2.517	10	.252	.513	.870
		Linear Term	Unweighted	.013	1	.013	.026	.873
			Weighted	.014	1	.014	.029	.865
			Deviation	2.502	9	.278	.567	.815
	Within Groups			18.150	37	.491		
	Total			20.667	47			
Lateral Collateral Ligament (LCL)	Between Groups	(Combined)		0.000	10	0.000		
		Linear Term	Unweighted	0.000	1	0.000		
			Weighted	0.000	1	0.000		
			Deviation	0.000	9	0.000		
	Within Groups			0.000	37	0.000		
	Total			0.000	47			
	Total			11.479	47			
(lab test) with ultrasonography of the joints	Between Groups	(Combined)		7.600	10	.760	6.391	.000
		Linear Term	Unweighted	.016	1	.016	.133	.718
			Weighted	.358	1	.358	3.014	.091

	Deviation	7.242	9	.805	6.766	.000
	Within Groups	4.400	37	.119		
	Total	12.000	47			

Source: Prepared by the researcher from field study data 2022

Fig (4.5): ANOVA



5.1 Discussion:

A total of 50 ultrasound scan of different patients with different age and weight that rheumatoid arthritis is the one of most frequent complication of the knee In this study as shown in Table (4-1), 15 out of 50 (30.0%) were males and the rest 35 out of 50(70.0%) were females. This result agrees with the previous studies, which found that female more affected rheumatoid arthritis High prevalence of RA in LAC women with a ratio of 5.2 women per man.

Colombian women with RA are more at risk of having an early age at onset and developing polyautoimmunity and abdominal obesity.

Rheumatoid arthritis can occur at any age, but it most commonly begins in middle, in this study Age of patients was illustrated in Table (4-2). 2 (4.0%) Less than 30 years, 7 (14.0%) between 30-40 years, 19 (38.0%) between 40-50 years, 13 (26.0%) between 50-60 years, 9 (18.0%) more 60 years.

Final diagnosis of patients understudy was shown in Table (4-6), the majority, 37 out of 50 (74.0%) were chronic rheumatoid arthritis and the rest 13 out of 50 (26.0%) were acute rheumatoid arthritis.

In this study I found statistically significant at $p < 0.05$ of patient with rheumatoid arthritis with age.

In this study I found statistically significant at $p < 0.05$ of patient with rheumatoid arthritis with Gender.

5-2 recommendations

- Large sample can be used to have better overall accuracy.
- Use the conventional X-ray &MRI for compares of results with US
- Maintaining an ideal weight.

5-3 Conclusion:

The study showed that chronic rheumatoid arthritis is higher than acute rheumatoid arthritis. The incidence of rheumatoid arthritis in the studied group was higher in the age group from 40 years to 60 years. The study also reflects that the complications of rheumatoid arthritis mainly affect females compared to males.

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