Chapter one

1.1 Introduction:

Conventional radiographic examination of the human body dates back to the genesis of diagnostic radiology in 1895 when Wilhelm Roentgen produced the first x-ray film image of his wife’s hand. Conventional radiography remains fundamental to the practice of diagnostic imaging.

Computed radiography (CR) uses very similar equipment to conventional radiography except that in place of a film to create the image, an imaging plate (IP) made of photostimulable phosphor is used.

Osteoarthritis (OA) is a slowly developing degenerative joint disorder characterized by damage of articular cartilage, changes in subchondral bone, and osteophyte formation [1, 2]. Objective quantification of these changes is still difficult. Imaging techniques such as ultrasonography are not sensitive enough to evaluate the severity of OA [3]. Arthroscopic evaluation, although sensitive for evaluating cartilage surface irregularities, has the disadvantage of being an invasive surgical procedure. Moreover, it is not yet clear whether it can detect subtle changes in the joint over time. Magnetic resonance imaging (MRI) is a promising technique, but has not yet evolved far enough to detect subtle changes in joint cartilage. Currently, it seems to underestimate the extent of cartilage abnormalities as seen with arthroscopy Radiographic evaluation also has its drawbacks: there appears to be a significant difference in actual damage of articular cartilage as judged by arthroscopic evaluation and the abnormalities found on radiographs.

The most important features of OA visualized on radiographs are joint space narrowing, subchondral sclerosis, osteophyte formation, and subchondral cysts. Grading systems have been developed for several joints on the basis of radiographically observed changes related to OA [4].The accuracy of measurements of joint space width can be improved by digital image analysis of the radiographs, by standard radiography of the joint, by correction for radiographic magnification, and by microfocal radiography [5].

The current research aims to compare the appearance of degenerative changes on both conventional and computed radiography as well as the accuracy of measurement carried out by both systems.

1.2 Problem of the study:

In Sudan still conventional radiography in use. There is no guideline in assessing the measurement of bone degenerative changes if the orthopedists or radiologist observe the image created by conventional or computed system.

1.3 Objectives:

1.3.1 General objective:

The main objective of this study is to determine the best modality that has high diagnostic accuracy.

1.3.2 Specific objectives:

Compare between conventional and computed radiography in detection of bone degenerative disease

1.4 Overview of the research

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Chapter 2: Literature review

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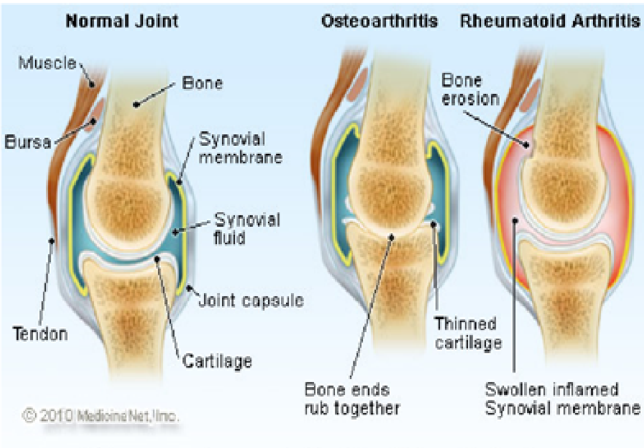
Chapter two

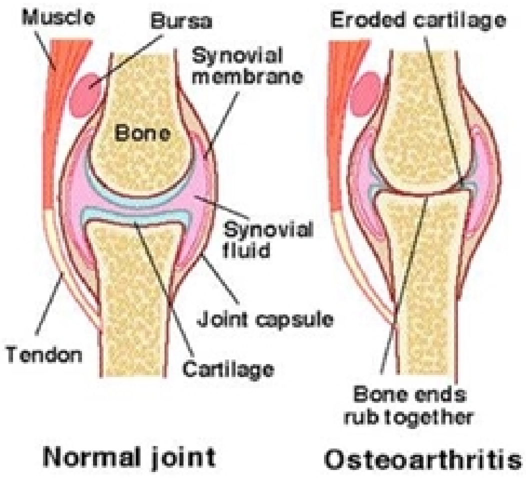
Literature review

1.1 Degenerative bone diseases

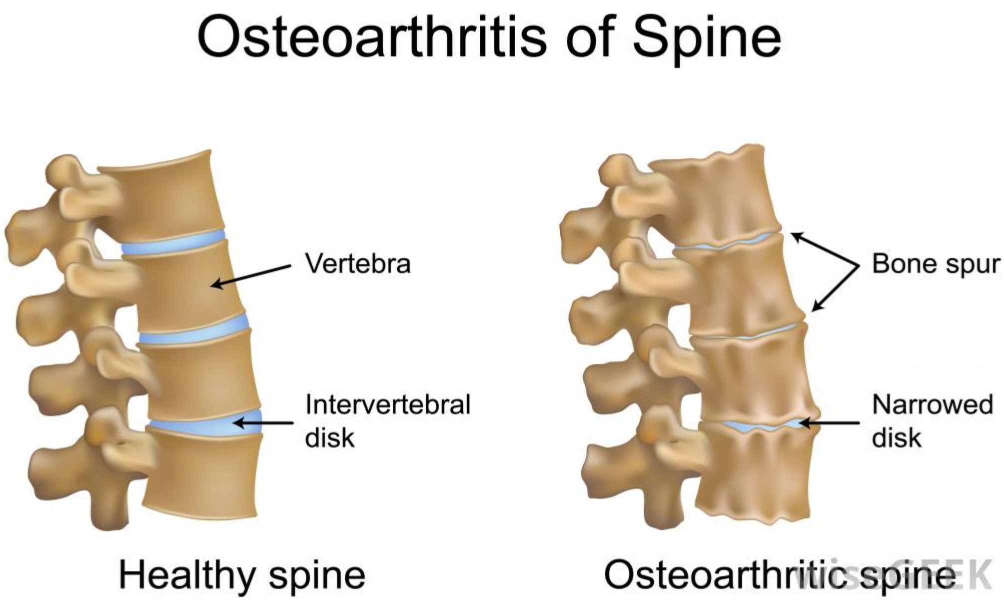
Degenerative bone disease is fairly common and is known by the more common term osteoporosis. It can occur in both men and women, although it's more prevalent in women. Primarily, osteoporosis causes the bones to weaken and become brittle. Small impacts can cause fractures in those with the advanced form of this disease. However, treatments are available to help people live a more fulfilling and productive life the common sites ofdegenerative disease are hip, ankle, spin and knee. (Fig 2-1)



A


Muscle
Bursa
Synovial membrane
Bone
Synovial fluid
Joint capsule
Tendon
Cartilage
Normal joint
Eroded cartilage
Bone ends rub together
Osteoarthritis

B



C

FIGURE 2-1 illustration of the degenerative changes in the knee joint (A and B) and the changes in the spine (C)

In case of osteoarthritis of the hip sometimes have problems walking. Diagnosis can be difficult at first. That's because pain can appear in different locations, including the groin, thigh, buttocks, or knee. The pain can be stabbing and sharp or it can be a dull ache, and the hip is often stiff, thecausesof osteoarthritis of the hip are not known. Factors that may contribute include joint injury, increasing age, and being overweight.

In addition, osteoarthritis can sometimes be caused by other factors:The joints may not have formed properly.There may be genetic (inherited) defects in the cartilage.The person may be putting extra stress on his or her joints, either by being overweight or through activities that involve the hip.

The symptoms includeJoint stiffness that occurs as you are getting out of bedJoint stiffness after you sit for a long time, pain, swelling, or tenderness in the hip jointa sound or feeling ("crunching") of bone rubbing against bone, inability to move the hip to perform routine activities such as putting on your socks**.** Osteoarthritis of the spine may cause stiffness or pain in the neck or back. It may also cause weakness or numbness in the legs or arms if it is severe enough to affect spinal nerves or the spinal cord itself. Usually, the back discomfort is relieved when the person is lying down. Some people experience little interference with the activities of their lives. Others become more severely disabled. In addition to the physical effects, a person with osteoarthritis might also experience social and emotional problems. For instance, a person with osteoarthritis that hinders daily activities and job performance might feel depressed or helpless.AnkleOsteoarthritis is a degenerative joint disease. With this type of arthritis, cartilage wears away gradually. Most cases of ankle osteoarthritis are related to a previous ankle injury. The injury may have occurred years before there is evidence of osteoarthritis in the ankle. Injury can damage the cartilage directly, or it can alter the mechanics of the ankle joint.

Osteoarthritis is a disorder that affects both the hyaline cartilage and the subchondral bone. With plain radiography, OA of the tibiofemoral joint may be diagnosed by the presence of marginal osteophytes, while the degree of the degeneration is indicated by the severity of joint space narrowing. AHLBÄCK and LEACH et al. found that weight-bearing examination was superior to that obtained in the supine position for demonstration of joint space narrowing in tibiofemoral OA. With general degeneration of the joint cartilage, joint space narrowing is easily found with examination underweight bearing, but with local chondral lesions this may be difficult.

1.2 Symptoms:

The primary symptom associated with osteoarthritis in the ankle joint is pain. Initially, pain is present with movement or activity (walking, climbing stairs, etc.) As osteoarthritis progresses, pain is present even during inactivity or rest. Other symptoms of ankle osteoarthritis include:

- joint stiffness
- joint swelling
- lost flexibility
- reduced range-of-motion
- difficulty walking
- difficulty with weight bearing, which may even cause slips and falls

1.3 Causes:

The most common cause of osteoarthritis of the knee is age. Almost everyone will eventually develop some degree of osteoarthritis. However, several factors increase the risk of developing significant arthritis at an earlier age.

1. **Age**. The ability of cartilage to heal decreases as a person gets older.
2. Weight. Weight increases pressure on all the joints, especially the knees. Every pound of weight you gain adds 3 to 4 pounds of extra weight on your knees.
3. **Heredity**. This includes genetic mutations that might make a person more likely to develop osteoarthritis of the knee. It may also be due to inherited abnormalities in the shape of the bones that surround the knee joint.
4. **Gender**. Women ages 55 and older are more likely than men to develop osteoarthritis of the knee.
5. **Repetitive stress injuries**. These are usually a result of the type of job a person has. People with certain occupations that include a lot of activity that can stress the joint, such as kneeling, squatting, or lifting heavy weights (55 pounds or more), are more likely to develop osteoarthritis of the knee because of the constant pressure on the joint.
6. **Athletics**. Athletes involved in soccer, tennis, or long-distance running may be at higher risk for developing osteoarthritis of the knee. That means athletes should take precautions to avoid injury. However, it's important to note

that regular moderate exercise strengthens joints and can decrease the risk of osteoarthritis. In fact, weak muscles around the knee can lead to osteoarthritis.

7. Other illnesses. People with rheumatoid arthritis, the second most common type of arthritis, are also more likely to develop osteoarthritis. People with certain metabolic disorders, such as iron overload or excess growth hormone, also run a higher risk of osteoarthritis.

Osteoporosis causes bones to become weak and brittle — so brittle that a fall or even mild stresses like bending over or coughing can cause a fracture. Osteoporosis-related fractures most commonly occur in the hip, wrist or spine. Theretypically are no symptoms in the early stages of bone loss. But once bones have been weakened by osteoporosis, you may have signs and symptoms that include:

1. Back pain, caused by a fractured or collapsed vertebra
2. Loss of height over time
3. A stooped posture
4. A bone fracture that occurs much more easily than expected.

4.4 Key variables in knee radiography:

Obtaining a satisfactory plain radiograph of the knee is not a trivial matter. As discussed recently by Buckland-Wright [6, 7], several steps in the production of the conventional plain knee radiograph make quality control difficult: for example, the technician performing the examination may have developed his or her own preference for positioning of patients, especially when faced with someone who is markedly obese or who otherwise has difficulty standing or walking. Idiosyncratic variation in technique can lead to unintended variation in the degree of knee flexion, misalignment of the X-ray beam, and magnification of the radiographic image of the joint.

Since publication of the classic monograph by Ahlback [8] and the supporting paper by Leach et al. [18], the standard knee radiograph hastypically been obtained with the patient standing and the joint fully extended. However, in patients with advanced OA, radiographs obtained with the knee fully extended tend to overestimate the amount of cartilage remaining on the articular surface. Exaggeration of the magnitude and variability of JSW in radiographs taken with the knee in the extended position (see below) is caused by the femur 'riding up' on cartilage at the anterior margin of the tibia [9]. In contrast, the semi flexed position more closely approximates the normal anatomic standing position of the tibiofemoral joint than the fully-extended view [10].

4.5 X-Ray beam alignment:

The position of the central ray of the X-ray beam relative to the center of the joint, i.e., the joint space, is another important variable. The X-ray beam is tangent to the plane of the joint at a single point on the radiograph. All other points in the image are distorted because the X-ray beam diverges in a cone-shaped manner around the central tangent ray. Therefore, a change in the angle of the beam will result in distortion of the relationships of the articular margins on the radiograph projection. This distortion increases with increasing angulation (i.e., increasing distance from the central ray). The degree of misalignment of the beam necessary to alter results is not large; Fife et al. [11] found a 17% decrease in JSW when the X-ray beam was displaced by 1 cm below its original alignment centered at the mid-point of the patella.

4.6 Radiographic Magnification:

Although radiographic magnification is not generally taken into account, the distance between the center of a joint and the X-ray filmwillaffectthe degree of magnification oftheradiographicimage. The distance between the center of the joint and the X-ray film can be large, and is influenced by factors such as obesity (common in subjects with knee OA) and restriction of joint movement because of pain, osteophytosis or soft tissue contracture. In an assessment of standard radio- graphs of the knee obtained in the standing extended view, Buckland-Wright et al. [12] found magnification of JSW ranging from 9-35% relative to a fixed magnification marker. Buckland-Wright's protocol for standardized knee radiography requires that a magnification marker (i.e., a 5ram ball encased in plexiglass or another semi-radiolucent material) be affixed with tape to the skin overlying the head of the fibula [12]. Any measurement of JSW from that image can be corrected for the degree of magnification apparent inthe image ofthe marker.

4.7 Reproducibility of quantitative radiographic measurements:

The validity of measurements of the radio- graphic features of OA is dependent not only upon image quality, but also upon the reproducibility of the mensural procedure [13, 14]. Some investigators have reported estimates of JSW without describing their methods in detail [15, 16]. Others have used a ruler [17, 18] or calipers [1, 19] and/or a magnifying lens with a fitted graticule [20]. Although regarded as more precise than semi- quantitative scoring systems [21], such as the Kellgren and Lawrence scale [22], the reproducibility of these quantitative methods (i.e., the degree to which repeated examinations of the same joint by the same observer, or by different observers, yield the same estimate of JSW) is subject to observer error.

The reproducibility (or precision) of a mensural procedure for JSW measurement can be expressed as the standard deviation (S.D.) of repeated measurements of JS Within the same joint(s)-- also referred to as the standard error of measurement (SEm). To standardize the scale of precision estimates, the reproducibility of repeated measurements of the same individuals is frequently quantified as a coefficient of variation (CV), the ratio of the S.D to the mean of repeated measurements. Lack of attention to standardization of the technique in routine clinical knee radiography can result in a CV as high as 20% for repeated manual measurements (i.e., with a ruler) of JSW made directly on fully-extended, AP views of the same subjects [23]. In contrast,Lequesne [1, 19] has described a highly-standardized method of manual JSW measurement in which the points of a pair of calipers are used to measure the interbone distance on a radiograph. The points are then used to prick a sheet of paper on which the distance between the pinpricks is measured with a 10x magnifying lens fitted with a 10 mm graticulewith 0.1 mm divisions. The intra-observer CV for repeated measures with this technique was 3.8% [24].

Chapter three

Material and method

3.1 subjects:

Fifty patients (23 male and 27 female) were enrolled in the study. They were known case of degenerative diseases and their age (50 to 70).

3.2 Area of the study:

The study has been carried out at Ribat National Hospital, where radiology department uses both conventional and computed radiography system.

3.3 Duration of study:

The study has been conducted between May and August 2014.

3.4 imaging systems:

We use two type of image acquisition:

1. **film /screen :**

In this type combination of screen and film in which the image is create and then processed, this system still used in radiology because of its good image quality as well as its cheapest running cost

2. Computed radiography (CR):

This is the first step in the digitalization of radiologic images. these system use photostimulable phosphor imaging plate replace the film/screen after taking each image the phosphor plate carried to the scanners to get the visible image.

3.5 Common affected area:

1. Knee
2. Hip
3. Spine

3.6 measurements and observations:

Two types of images have been obtained for the same patient on the same area of the body. The resultant images were assessed by the professional radiologist who gave his comments about both image types.

Evaluation includes:

1. Image quality
2. Appearance of degenerative changes

3. Measurement of joint space (for the knee joint)

4. Assessment of subchondoralandsubarticularchanges (for the tibia)

3.6.1 The technique of measurement:

Digital image:

Separate ROIs were identified for the assessment of trabecular bone structure consisting of the subchondral and subarticular regions within the medial and lateral compartments (Fig. 3-1). To account for variation in tibial size between patients, ROI width measured 3/4 of tibial compartment width measured from a vertical line projected down from either the medial or lateral tibial spine to the outer tibial margin. The outer 1/4 of the width of the tibial compartment was not included for analysis due to the frequent presence of periarticular osteopenia adjacent to marginal osteophyte formation.

The subchondral ROI commenced immediately beneath the inferior border of the medial or lateral cortical plates (Fig. 3.1), drawn onto the image by an automated ridge-tracing function in Mdisplay (Fig. 3-1). The subarticular region commenced immediately below the inferior border of the subchondral ROI.

Joint space has been measured as shown on (Fig 3-2)

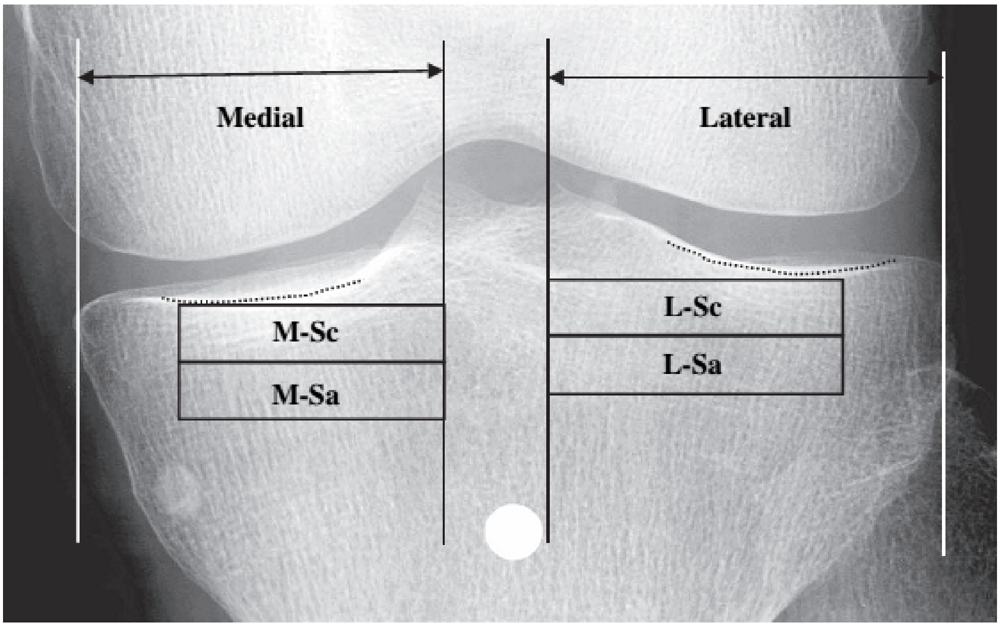


FIGURE 3.1 placement of the medial (M) and lateral (L), subchondral (Sc) and subarticular(Sa)

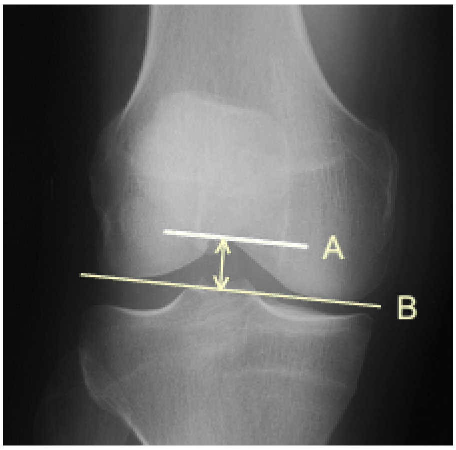


FIGURE 3-2 measurement of joint space

Conventional image:

The same measurements of digital image were taken on conventional image manually.

4.7 Score for comparison:

The table below represents the calculation of the score of comparison between conventional radiography (**A**) and computed radiography (**B**)

SCORE	BASIC COMPARISON

-3	A is significantly better than B
-2	A is much better than B
-1	A is slightly better than B
0	A is similar to B
3	B is significantly better than A
2	B is much better than A
1	B is slightly better than A

4.8 Statistical analysis:

Analysis was performed using SPSS software. $P < 0.05$ was statistically considered as significant and data were presented as mean ± SEM.

Chapter four

Results

4.1 Comparison Scores of Computed Radiography versus film/screen system:

Table 4-1 score of comparison (image quality)

Features	Mean	SEM
Bone cortex	0.9946	0.033
Bone trabeculae	1.5634	0.044
Soft tissue	0.6594	0.056
Fat planes	0.7533	0.035
Overall contrast	1.3334	0.046
Overall density	1.2611	0.043

As seen from the table above, the positive score indicated that the computed radiography system is better than the film/screen system.

4.2 Joint space width (JSW)

Table 4-2 Joint space width measurements

	JSW (mm)mean± SEM	S.D
Computed radiography	3.02±0.83	0.28
Conventional	3.33±1.10	0.33

FIGURE 4-1 Joint space width measurements. There is no significant difference observed, *p*> 0.05 (paired t- test)

	Conventional	Computed radiography

	(Mean ±SEM)	(Mean ±SEM)
Subchondoral sclerosis (mm)	1.6 ± 0.13	1.5 ± 0.09
Suarticular sclerosis (mm)	1 ± 0.29	1.7 ± 0.24

Table 4-3 Subchondoral and subarticular sclerosis measurements

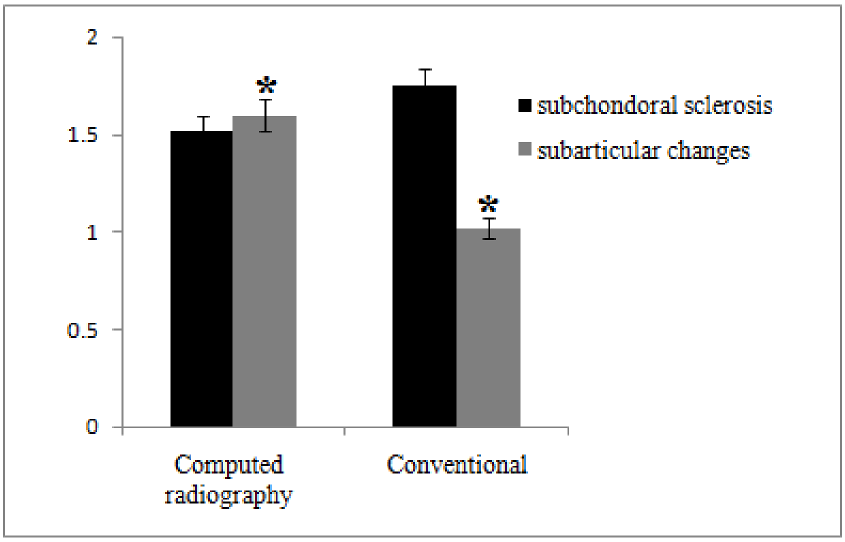


FIGURE 4-2 Subchondoral and subarticular sclerosis measurements, * mean significant difference between computed and conventional radiography in measurement of subarticular sclerosis (paired t-test, $p < 0.05$)

Chapter five

5.1 Discussions:

This is a prospective study, it has been carried out to compare between two imaging system for detection of degenerative changes. Fifty patient radiographic findings were assessed on both imaging systems.

Our study revealed that the computed radiography has high image quality which aid in measurement of joint space easily. Furthermore subarticular changes can be detected accurately with computed radiography.

Regarding osteophytes, they can be identifying easily on both imaging modalities. Previous studies showed that there are some considerations should be except during measurement of joint space, such as degree of flexion of knee joint. Because this fact beyond the scope of this study. Our study showed that both imaging modalities can be used to measure the joint space. Regarding subarticularchanges, our study showed that the computed radiography is better than conventional radiography. It suggested that this is due to the light image quality obtained by computed radiography. However conventional radiography can be used, but the magnification errors should be concerned.

In conclusion, computed radiography is better than conventional radiography in case of detection of degenerative changes. Because it is easy to manipulate the digital image and easy to draw specific lines that used for measurement.

5.2Conclusion:

The wide dynamic range of CR system allows high tolerance for variations in exposure technique. Typically as we reduce the radiation exposure, the resultant image has more noise which reduces the image quality. Therefore, optimal exposure technique is needed to ensure the best image quality at the lowest possible patient exposure.

This article compared between computed radiography and conventional radiography in detection of bone degenerative disease, we found that image quality in CR image better than the image quality on conventional image. Furthermore measurements related to degenerative changes assessment were easy to get from digital image.

5.3Recommendations:

1. Image quality should be ensured for better visualization and detection of degenerative changes.
2. Optimum exposure factor should be selected because the detection of degenerative changes is sensitive to appearance of trabiculae.
3. Digital imaging system should be available at Khartoum medical centre for its reliability to detect degenerative changes.

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