

بسم الله الرحمن الرحيم

# **Sudan University of Science and Technology**

College graduated studies

## **Characterization of bone density diseases using DEXA scan**

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مزدوج الطاقات

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

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قال تعالى:

بسم الله الرحمن الرحيم

قُلْ يُحْيِيهَا الَّذِي أَنْشَأَهَا \* (وَضَرَبَ لَنَا مَثَلًا وَنَسِيَ خَلْقَهُ قَالَ مَنْ يُحْيِي الْعِظَامَ  
(وَهِيَ رَمِيمٌ) أَوَّلَ مَرَّةٍ وَهُوَ بِكُلِّ خَلْقٍ عَلِيمٌ).

صدق الله العظيم

( (سوره يس الآيه 78-79

## Abstract

This study is retrospective and analytic study, the general objective of this study was to identify the role of DEXA scan in the diagnosis of bone density. The study was done in Khartoum state Royal Care Hospital. In period between September 2015 - to March 2016 used DEXA scan to evaluate the bone density for 50 patients, whom their ages were range between (15 – 85 year).The result demonstrates the DEXA scan is most accurate and sensitive in diagnoses of bone density. DEXA scan is most accurate and sensitive in diagnoses osteoporosis (100%) and osteopenia (100%).The sensitivity of DEXA scan was highest in case of osteoporosis diagnosis using spine rather than hip which are equal to 100% and 91.7% respectively. Oppositely for osteopenia the highest accuracy was associated with the scan of the spine where

the accuracy equal 100% versus 72.7% of the hip. In conclusion the result of this study showed that t-score had strong correlation with age, which can be used with the t-score to have normal, osteopenia or osteoporosis classification score.

## ملخص الدراسة

هذه الدراسة دراسة وصفية وتحليلية أجريت لدراسة حالات سابقة , الأهداف العامة لهذه الدراسة معرفة دور جهاز تقييم هشاشة العظام في تشخيص كثافة العظام.

أجريت هذه الدراسة في مستشفى رويال كير بولاية الخرطوم في الفترة من سبتمبر 2015 الي مارس 2016 باستخدام جهاز تقييم هشاشة العظام ( DEXA ) لتقييم كثافة العظام لخمسين مريض خضعوا للفحص في مدى عمري يتراوح بين (15 – 85 سنة).

أظهرت نتائج هذه الدراسة مدى دقة وفاعلية استخدام جهاز تقييم كثافة العظام في تشخيص حالات هشاشة العظام الحادة بنسبة ( 100% ) و تشخيص حالات هشاشة العظام المتوسطة بنسبة (100%).

حساسية (DEXA) (كَانَتْ أَعْلَى فِي حالة إستعمال تشخيص هشاشه العظام الحادة للعمود الفقري بدلاً مِنْ عظم الفخذ التي كانت مساوية إلى 100 % و 91.7 % على التوالي.

والعكس لحالة تشخيص هشاشة العظام المتوسطة الدقة الأعلى إرتبطت بمسح العمود الفقري حيث نظير الدقة 100 % مقابل 72.7 % الفخذ.

ومن نتائج هذه الدراسة وجدنا ان ل ( t-score ) ارتباط قوي بالعمر، والذي يمكن ان يستعمل لنتيجة تصنيف اذا ما كان الشخص طبيعي او لديه هشاشة عظام حادة او متوسطة.

# **Dedication**

This thesis is dedicate to support me in my life

To my parents

And also dedicate

To my brothers

To my sisters

To my friends

To my teacher

Dr. Mohammed El-fadil

## **Acknowledgment**

I would like to thank God for enabling to complete this thesis; I am very thank Dr.Mohammed El-fadil supervisor of my thesis for his guideness and patience. I am greatly thank for all who supported and help me to complete this thesis.

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## List of contents

<b>Quran.</b>	N.o
<b>Dedication.</b>	I
<b>Acknowledgment.</b>	II
<b>Abstract (English).</b>	III - IV
<b>Abstract (Arabic).</b>	V - VI
<b>List of contents.</b>	VII-IX
<b>List of figures.</b>	XI
<b>List of abbreviation.</b>	XII

### **Chapter one: Introduction.**

<b>No</b>	<b>Contents</b>	<b>Page No</b>
1.1	Introduction	1
1.2	Problem of the study.	2
1.3	Objectives.	2
1.3.1	General objective.	2
1.3.2	Specific objectives.	2
1.4	Hypotheses.	2

### **Chapter two: literature review and background studies**

<b>No</b>	<b>Contents</b>	<b>Page No</b>
2.1	Anatomy of the skeletal system.	3
2.1.2	Axial skeleton.	4
2.1.2.1	Bones of the skull.	4



2.1.2.2	<b>Bones of vertebral column.</b>	4
2.1.2.2.1	<b>Cervical vertebrae.</b>	4
2.1.2.2.2	<b>Thoracic vertebrae.</b>	5
2.1.2.2.3	<b>Lumbar vertebrae.</b>	5
2.1.2.3	<b>Ribs.</b>	6
2.1.2.4	<b>Sternum.</b>	7
2.1.3	<b>Appendicular skeleton.</b>	7
2.1.3.1	<b>Upper limbs.</b>	7
2.1.3.1.1	<b>Bones of the shoulder girdle and arm.</b>	7
2.1.3.1.2	<b>Clavicle.</b>	7
2.1.3.1.3	<b>Scapula.</b>	8
2.1.3.1.4	<b>Humerus.</b>	8
2.1.3.1.5	<b>Radius.</b>	9
2.1.3.1.6	<b>Ulna.</b>	9
2.1.3.1.7	<b>Bones of the hand.</b>	9
2.1.3.2	<b>Lower limb.</b>	10
2.1.3.2.1	<b>The Pelvis.</b>	10
2.1.3.2.2	<b>Hip bone.</b>	10
2.1.3.2.3	<b>Femur</b>	11
2.1.3.2.3.1	<b>Tibia.</b>	11
2.1.3.2.3.2	<b>Fibula.</b>	12
2.1.3.2.4	<b>Bones of foot.</b>	12
2.2	<b>Physiology of the skeletal system</b>	12
2.3	<b>Pathology of the skeletal system.</b>	13
2.3.1	<b>Osteoporosis.</b>	13
2.3.2	<b>Osteopenia.</b>	14

2.4	<b>DEXA scans.</b>	15
2.4.1	<b>History.</b>	15
2.4.2	<b>Common uses.</b>	15
2.4.3	<b>Equipment.</b>	16
2.4.3.1	<b>Components of (cDXA).</b>	16
2.4.3.2	<b>X-ray Detectors.</b>	17
2.4.3.2.1	<b>Type of beam x-ray.</b>	17
2.4.3.3	<b>Accessory.</b>	17
2.4.3.3.1	<b>Padded box.</b>	17
2.4.3.3.2	<b>Brace.</b>	18
2.4.3	<b>Procedure work</b>	18
2.4.5	<b>Protection.</b>	19
2.4.6	<b>Technique.</b>	19
2.4.6.1	<b>Indication.</b>	19
2.4.6.2	<b>Contraindication.</b>	19
2.4.6.3	<b>Patient preparation.</b>	19
2.4.6.4	<b>Procedure.</b>	20
2.4.6.4.1	<b>PA Lumbar Spine.</b>	20
2.4.6.4.2	<b>Lateral Vertebral Assessment (LVA).</b>	20
2.4.6.4.3	<b>PA hip.</b>	20
2.4.7	<b>Results of DEXA.</b>	20
2.4.7.1	<b>T-Score and Z- score.</b>	21
2.4.7.2	<b>Report of DEXA.</b>	21
2.4.8	<b>Benefits of DEXA.</b>	21
2.4.9	<b>Risks of DEXA.</b>	22
2.4.10	<b>Limitations of DEXA.</b>	22

2.5	<b>Backgrounds studies.</b>	22
2.5.1	<b>Study (1).</b>	22
2.5.2	<b>Study (2).</b>	23
2.5.3	<b>Study (3).</b>	23
2.5.4	<b>Study (4).</b>	24
2.5.5	<b>Study (5).</b>	25

### **Chapter three: Methodology**

<b>No</b>	<b>Contents</b>	<b>Page No</b>
3.1	<b>Material and methods.</b>	27
3.1.1	<b>The type of study.</b>	27
3.1.2	<b>Population of patients.</b>	27
3.1.3	<b>Sample and sample size.</b>	27
3.1.4	<b>Data collection.</b>	27
3.1.5	<b>Data analysis.</b>	27
3.1.6	<b>Data storage.</b>	27
3.1.7	<b>Area of study.</b>	28
3.1.8	<b>Duration of study.</b>	28

### **Chapter four: discussion of result**

<b>No</b>	<b>Contents</b>	<b>Page No</b>
4.1	<b>Discussion</b>	29
<b>4-2</b>	<b>Result</b>	31

## **Chapter five: Recommendations, conclusions, references and appendices.**

<b>No</b>	<b>Contents</b>	<b>Page No</b>
5.1	<b>Conclusions.</b>	35
5.2	<b>Recommendations.</b>	36
5.3	<b>References.</b>	37
5.4	<b>Appendices.</b>	38

### **List of abbreviations**

DXA	Dual x-ray absorptiometry.
DEXA	Dual energy x-ray absorptiometry.
BMD	Bone mineral <a href="#">density</a> .
C,T,L	Cervical, thoracic and lumbar vertebrae.
CDEXA	Central Dual energy x-ray absorptiometry.
LVA	Lateral vertebral assessment.
T-score	Indicates the difference between the patient's measured BMD and the ideal peak bone mass achieved by a young adult.

Z-score	Indicates the difference between the patient's measured BMD and the ideal peak bone mass achieved by aged-matched peers.
ADT	Androgen deprivation therapy.
PA	Posterior anterior.
OP	Primary osteoporosis.
BMI	Bone mass index.
SMA	Spinal muscular atrophy.
DP	Density peak.
WHO	World health organization.
ALP	Alkaline phosphates.
OR	Outcome research.
ASIS	Anterior superior iliac spine.
CI	Clinical investigation.
RA	Rheumatoid arthritis.
HT	Hyperparathyroidism.
SPSS	Statistical package for social science.

# **Chapter One**

# Chapter one

## 1.1 Introduction

Bone density scanning, also called dual-energy x-ray absorptiometry -DEXA- or bone [densitometry](#), is an enhanced form of [x-ray](#) technology that is used to measure bone loss. DXA is today's established standard for measuring bone mineral [density](#) (BMD) and common diagnosis osteoporosis and osteopenia. It is most often performed on the lower spine and hips .In children and some adults; the whole body is sometimes scanned.

The skeleton is divided into two descriptive regions axial skeleton, bones of the skull, vertebral column, ribs, and sternum , and appendicular skeleton which consists of the bones of the limbs, including pectoral and pelvic girdles.

Osteoporosis, which means "porous bones" 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. In many cases, bones weaken when you have low levels of calcium and other minerals in your bones. A common result of osteoporosis is fractures. Most of them occur in the spine, hip or wrist. Although it's often thought of as a women's disease, osteoporosis affects men too.

Osteopenia is a bone condition characterized by a decreased density of bone, which leads to bone weakening and an increased risk of breaking a bone fracture. Osteopenia and osteoporosis are related conditions. In osteopenia, however, the bone loss is not as severe as in osteoporosis.

That means someone with osteopenia is more likely to fracture a bone than someone with a normal bone density but is less likely to fracture a bone than someone with osteoporosis.

## **1.2 Problem of study**

Osteopenia and osteoporosis is most common causes pathological fracture unless diagnosed and treated in early stage.

## **1.3 Objectives**

### **1.3.1 General objective**

- To identify the role of DEXA scan in the diagnosis of bone density.

### **1.3.2 Specific objectives**

- To monitor the ability of DEXA in diagnostic of the osteoporosis.
- To monitor the ability of DEXA in diagnostic of the osteopenia.
- To identify the role of DEXA scan to measure increase bone density.

## **1.4 Hypotheses**



DEXA is the most important method in diagnosis bone densitometry.

## **Chapter Two**

## **Chapter two**

### **Literature review and background studies**

#### **2-1 Anatomy of the skeletal system**

Compact bone, or dense bone, is contains many cylinder shaped units called osteons. The osteocytes bone cells are intiny chambers called lacunae that occur between concentric layers of matrix called lamellae. The matrix contains collagenous protein fibers and mineral deposits, primarily of calcium and phosphorus salts. In each osteon, the lamellae and lacunae surround a single central canal. Blood vessels and nerves from the periosteum enter the central canal. The osteocytes have extensions that extend into passageways called canaliculi, and thereby the osteocytes are connected to each other and to the central canal. Spongy bone, or cancellous bone, is contains numerous bony bars and plates, called trabeculae. Although lighter than compact bone, spongy bone is still designed for strength. Like braces used for support in buildings, the trabeculae of spongy bone follow lines of stress. In infants, red bone marrow, a specialized tissue that produces blood cells, is found in the cavities of most bones. In adults, red blood cell formation, called hematopoiesis, occurs in the spongy bone of the skull, ribs, sternum (breastbone), and vertebrae, and in the ends of the long bones.

The skeleton is divided into two descriptive regions, Axial skeleton is consist bones of the skull, vertebral column, ribs, and sternum. Appendicular skeleton is consist bones of the limbs, including pectoral and pelvic girdle

## **2-2Bones of the skull**

The skull is composed of several separate bones united at immobile joints called sutures. The connective tissue between the bones is called a sutural ligament. The mandible is an exception to this rule, for it is united to the skull by the mobile temporomandibular joint. The bones of the skull can be divided into those of the cranium and those of the face. The vault is the upper part of the cranium, and the base of the skull is the lowest part of the cranium. The skull bones are made up of external and internal tables of compact bone separated by a layer of spongy bone called the diplo. The internal table is thinner and more brittle than the external table. The bones are covered on the outer and inner surfaces with periosteum. The cranium consists of frontal bone, parietal bones, occipital bone, temporal bones, sphenoid bone and ethmoid bone. The facial bones consist of zygomatic bones, maxillae, nasal bones, lacrimal bones, vomer, palatine bones, inferior conchae and mandible.<sup>(2)</sup>

## **2-3Bones of vertebral column**

### **2-3-1 Cervical vertebrae**

There are seven cervical vertebrae. The atlas vertebra C1 is a ring of bone with no vertebral body. It articulates superiorly with the occipital condyles of the skull as the atlanto-occipital joints. The axis vertebra C2 has a superior extension, the odontoid process or dens which represent the body of C1. C3 to C6 may be regarded as typical. The small, oval vertebral bodies increase in size to C7. The spinous processes may be bifid and the transverse processes terminate with anterior and posterior tubercles.

Each transverse process encloses the foramen transversarium, which transmits the vertebral arteries and veins on each side. C7, the vertebra prominens, has a long, non-bifid spine, and no anterior tubercle on its transverse process. Its foramen transversarium is often small; it only transmits small tributaries of the vertebral vein – the artery enters at C6. The vertebral arteries arise from the subclavian arteries, enter the foramen transversarium of C6, traverse the successive foramina transversaria above this level and enter the skull through the foramen magnum. The cervical canal is funnel-shaped in the sagittal plane, widest superiorly. <sup>(2)</sup>

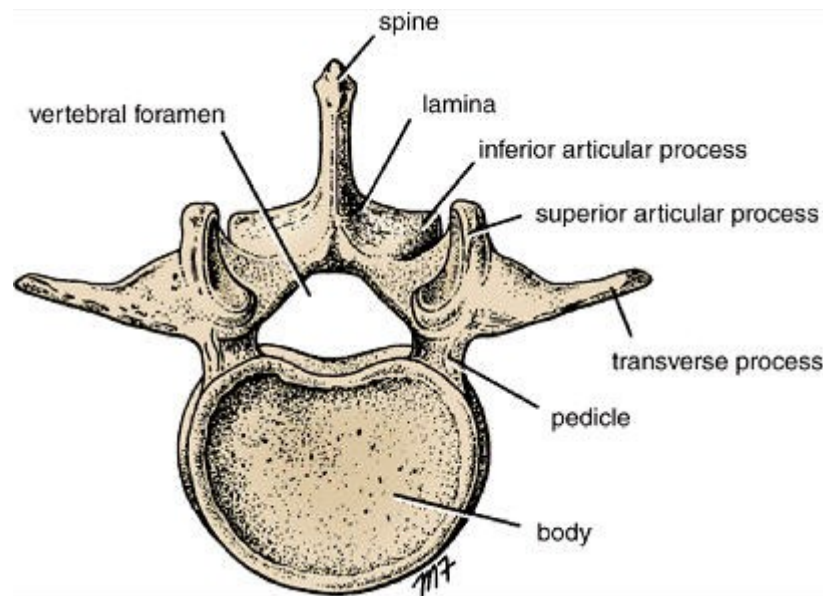
### **2-3-2 Thoracic vertebrae**

There are 12 thoracic vertebrae distinguished by articulations for the ribs. The vertebral bodies have a slight wedge-shape anteriorly. They also bear demifacets for the

ribs on the superior and inferior vertebral bodies. Otherwise, the anatomy conforms to that of the “typical vertebra” given above. The ribs attach at two places: the head of the rib attaches to the vertebrae at the disk and additionally the tubercle of the rib attaches to the transverse process costotransverse joint. Typically, therefore the ribs arise posteriorly between vertebrae. The first rib articulates only with T1 and similarly the tenth, eleventh, and twelfth ribs articulate only with T10, T11, and T12 vertebrae.<sup>(2)</sup>

### **2-3-3 Lumbar vertebrae**

There are five lumbar vertebrae, the third L3 being the largest. Projecting posteriorly are bilateral pedicles composed of thick cortical bone connecting to lamina forming the spinal canal. L5 is somewhat atypical with a wedge-shaped body, articulating inferiorly with the sacrum. Not infrequently, it may be fused, wholly or partly, with the body of the sacrum sacralization of L5. Extending from the pedicles is a bony plate called the pars articularis from which extend the superior and inferior articular facets.<sup>(2)</sup>



**Fig (2-1)** Shows fifth lumbar vertebra.

## 2-3-4 Ribs

There are 12 pairs of ribs, all of which are attached posteriorly to the thoracic vertebrae. The ribs are divided into three categories. True ribs are the upper seven pairs are attached anteriorly to the sternum by their costal cartilages. False ribs are the 8th, 9th, and 10th pairs of ribs are attached anteriorly to each other and to the 7th rib by means of their costal cartilages and small synovial joints. Floating ribs is the 11th and 12th pairs have no anterior attachment. <sup>(2)</sup>

## 2-3-5 Sternum

The sternum, or breastbone, is a flat bone that has the shape of a blade. The sternum, along with the ribs, helps protect the heart and lungs. During surgery the sternum may be split to allow access to the organs of the thoracic

cavity. The sternum is composed of three bones that fuse during fetal development. These bones are the manubrium, the body, and the xiphoid process. The manubrium is the superior portion of the sternum. The body is the middle and largest part of the sternum and the xiphoid process is the inferior and smallest portion of the sternum. The manubrium joins with the body of the sternum at an angle. The xiphoid process is the third part of the sternum. Composed of hyaline cartilage in the child, it becomes ossified in the adult. The variably shaped xiphoid process serves as an attachment site for the diaphragm, which separates the thoracic cavity from the abdominal cavity.

### **3-Appendicular skeleton**

#### **2-3-1 Upper limbs**

##### **Bones of the shoulder girdle and arm**

The shoulder girdle consists of the clavicle and the scapula, which articulate with one another at the acromioclavicular joint.

##### **Clavicle**

The clavicle is the only bony attachment between the trunk and the upper limb. It is palpable along its entire length and has a gentle S-shaped contour, with the forward-facing convex part medial and the forward-facing concave part lateral. The acromial end of the clavicle is flat, whereas the sternal end is more robust and somewhat quadrangular in shape. The acromial end of the clavicle has a small oval facet on its surface for articulation with a similar facet on the medial surface of the acromion of the scapula. The sternal end



has a much larger facet for articulation mainly with the manubrium of the sternum, and to a lesser extent, with the first costal cartilage.

## **Scapula**

The scapula is a large, flat triangular bone had three angles lateral, superior, and inferior. Three borders superior, lateral, and medial. Two surfaces costal and posterior. Three processes acromion, spine, and coracoid process. <sup>(6)</sup>

## **Humerus**

The humerus articulates with the scapula at the shoulder joint and with the radius and ulna at the elbow joint. The upper end of the humerus has a head, which forms about one third of a sphere and articulates with the glenoid cavity of the scapula. Immediately below the head is the anatomic neck. Below the neck are the greater and lesser tuberosities, separated from each other by the bicipital groove. Where the upper end of the humerus joins the shaft is a narrow surgical neck. About halfway down the lateral aspect of the shaft is a roughened elevation called the deltoid tuberosity. Behind and below the tuberosity is a spiral groove, which accommodates the radial nerve. The lower end of the humerus possesses the medial and lateral epicondyles for the attachment of muscles and ligaments, the rounded capitulum for articulation with the head of the radius, and the pulley-shaped trochlea for articulation with the trochlear notch of the ulna. Above the capitulum is the radial fossa, which receives the head of the radius when the elbow is flexed. Above the trochlea anteriorly is the coronoid fossa, which during the same movement receives the coronoid process of the ulna. <sup>(2)</sup>

## **Radius**

The radius is the lateral bone of the forearm. Its proximal end articulates with the humerus at the elbow joint and with the ulna at the proximal radioulnar joint. Its distal end articulates with the scaphoid and lunate bones of the hand at the wrist joint and with the ulna at the distal radioulnar joint.

## **Ulna**

The ulna is the medial bone of the forearm. Its proximal end articulates with the humerus at the elbow joint and with the head of the radius at the proximal radioulnar joint. Its distal end articulates with the radius at the distal radioulnar joint, but it is excluded from the wrist joint by the articular disc.

## **Bones of the hand**

There are eight carpal bones, made up of two rows of four. The proximal row consists of from lateral to medial the scaphoid, lunate, triquetral, and pisiform bones. The distal row consists of from lateral to medial the trapezium, trapezoid, capitate, and hamate bones. Together, the bones of the carpus present on their anterior surface a concavity, to the lateral and medial edges of which is attached a strong membranous band called the flexor retinaculum. In this manner, an osteofascial tunnel, the carpal tunnel, is formed for the passage of the median nerve and the flexor tendons of the fingers. <sup>(2)</sup>

### **2.1.3.2 Lower limb**

#### **2.1.3.2.1 The Pelvis**

The pelvis is divided into two parts by the pelvic brim, which is formed by the sacral promontory anterior and upper margin of the first sacral vertebra behind, the iliopectineal line that runs downward and forward around the inner surface of the ileum laterally, and the symphysis pubis joint between bodies of pubic bones anteriorly. Above the brim is the false pelvis, which forms part of the abdominal cavity.

Below the brim is the true pelvis, false pelvis of little clinical importance. It is bounded behind by the lumbar vertebrae, laterally by the iliac fossa and the iliacus muscles, and in front by the lower part of the anterior abdominal wall. The false pelvis flares out at its upper end and should be considered as part of the abdominal cavity. It supports the abdominal contents and after the third month of pregnancy helps support the gravid uterus. During the early stages of labor, it helps guide the fetus into the true pelvis. True pelvis knowledge of the shape and dimensions of the female pelvis is of great importance for obstetrics, because it is the bony canal through which the child passes during birth. The true pelvis has an inlet, an outlet, and a cavity.

#### **2.1.3.2.2 Hip bone**

The mature hip bone is the large, flat pelvic bone formed by the fusion of three primary bones ilium, ischium, and pubis at the end of the teenage years. The ilium forms the largest part of the hip bone and contributes the superior part of the acetabulum. The ilium has thick medial portions columns for weight bearing and thin, wing-like, posterolateral portions, the alae that provide broad surfaces for the fleshy attachment of muscles. The ischium forms the posteroinferior part of the hip bone. The superior part of the body of the ischium fuses with the pubis and ilium, forming the

posteroinferior aspect of the acetabulum. The pubis forms the anteromedial part of the hip bone, contributing the anterior part of the acetabulum, and provides proximal attachment for muscles of the medial thigh. The pubis is divided into a flattened medially placed body and superior and inferior rami that project laterally from the body.

## **Femur**

The femur is the longest and heaviest bone in the body. It transmits body weight from the hip bone to the tibia when a person is standing. Its length is approximately a quarter of the person's height. The femur consists of a shaft body and two ends, superior or proximal and inferior or distal.

### **2.1.3.2.3.1 Tibia**

The tibia is the large weight-bearing medial bone of the leg. It articulates with the condyles of the femur and the head of the fibula above and with the talus and the distal end of the fibula below. It has an expanded upper end, a smaller lower end, and a shaft. At the upper end are the lateral and medial condyles sometimes called lateral and medial tibial plateaus, which articulate with the lateral and medial condyles of the femur and the lateral and medial menisci intervening. Separating the upper articular surfaces of the tibial condyles are anterior and posterior intercondylar areas; lying between these areas is the intercondylar eminence.

### **2.1.3.2.3.2 Fibula**

The fibula is the slender lateral bone of the leg. It takes no part in the articulation at the knee joint, but below it forms the lateral malleolus of the ankle joint. It takes no part in the transmission of body weight, but it provides attachment for muscles. The fibula has an expanded upper end, a shaft, and a lower end. The upper end, or head, is surmounted by a styloid process. It possesses an articular surface for articulation with the lateral condyle of the tibia. The shaft of the fibula is long and slender.

#### **2.1.3.2.4 Bones of foot**

The bones of the foot include the tarsus, metatarsus, and phalanges. There are 7 tarsal bones, 5 metatarsal bones, and 14 phalanges.

### **2.2 Physiology of the skeletal system**

Support the skeleton provides the framework for the body. Bones provide the basic shape and structure for the body. The mandible and maxilla support the tooth. Bones of the lower limbs, pelvis and vertebral column hold up the body. Protection the skeleton protects organs in the body. Bones can cover and protect many of our major organs the cranium protects the brain, ribs and sternum protect the lungs, heart and some digestive organs, the pelvis protects and supports the digestive and reproductive organs and the vertebral column protects the spinal cord. Blood cell production inside of the long bones in our bodies, there is a cavity that is filled with a substance called bone marrow. In this tissue, new blood cells are produced, and damaged blood cells are repaired. Red bone marrow produces red blood cells, white blood cells and other blood elements. Movement the bones are the levers that help the body move in different directions and in different ways. Mineral storage is a substance that the body needs to carry out all of

our bodily functions like thinking, breathing and moving around. One of the minerals that the body needs is calcium. Calcium is a major part of bone, and this is where the body stores its calcium. It is very important to need in construction of the bones. The less calcium the bone has, the weaker it will become.

### **3 Pathology of the skeletal system**

#### **3.1 [Osteoporosis](#)**

Osteoporosis is a disease characterized by increased porosity of the skeleton resulting from reduced bone mass. It is associated with an increase in bone fragility and susceptibility to fractures. The disorder may be localized to a certain bone or region, as in disuse osteoporosis of a limb, or may involve the entire skeleton, as a manifestation of a metabolic bone disease. Generalized osteoporosis may be primary, or secondary to a large variety of conditions. Symptoms of osteoporosis in the early stages of bone loss, you usually have no pain. Loss of height over time, a stooped posture, fracture of the vertebra, wrist, hip or other bone and back pain, which can be severe, as a result of a fractured or collapsed vertebra. Causes of osteoporosis post-menopausal woman and not taking estrogen, have a personal or maternal history of hip fracture or smoking. man with clinical conditions associated with bone loss, use medications that are known to cause bone loss, high bone turnover, which shows up in the form of excessive collagen in urine samples, thyroid condition, such as [hyperthyroidism](#), parathyroid condition, such as [hyperparathyroidism](#) and experienced a fracture after only mild trauma.

Complications bone fractures, particularly in the spine or hip, are the most serious complication of osteoporosis.<sup>(3)</sup>

### **3.2 Osteopenia**

Osteopenia is a bone condition characterized by a decreased density of bone, which leads to bone weakening and an increased risk of breaking a bone fracture. Osteopenia and osteoporosis are related conditions. In osteopenia, however, the bone loss is not as severe as in osteoporosis. That means someone with osteopenia is more likely to fracture a bone than someone with a normal bone density but is less likely to fracture a bone than someone with osteoporosis. Osteomalacia, osteomyelitis, and osteoarthritis are different conditions that are frequently confused with osteopenia because they sound similar. Osteomalacia is a disorder of the mineralization of newly formed bone, which causes the bone to be weak and more prone to fracture. There are many causes of osteomalacia, including vitamin D deficiency and low blood phosphate levels. Osteomyelitis is bone infection. Osteoarthritis is joint inflammation featuring cartilage loss and is the most common type of arthritis. Osteoarthritis does not cause osteopenia, osteoporosis, or a decreased bone mineral density. Causes of Osteopenia geneticsfamilial predisposition to osteopenia or osteoporosis, as well as other genetic disorders, hormonal causes, including decreased estrogen such as in women after [menopause](#) or testosterone, [smoking](#), [excess alcohol](#), thin frame, Immobility, certain medications such as corticosteroids, including [prednisone](#) and antiseizure medications, malabsorption due to conditions such as [celiac](#)

[sprue](#) and chronic inflammation due to medical conditions such as [rheumatoid arthritis](#).

Symptoms and signs of osteopenia does not cause pain unless a bone is broken fractured. Interestingly, fractures in patients with osteopenia do not always cause pain.<sup>(4)</sup>

Osteopenia or osteoporosis can be present for many years prior to diagnosis for these reasons. Many bone fractures due to osteopenia or osteoporosis, such as a hip fracture or vertebral fracture of a bone in the spine, are very painful. However, some fractures, especially vertebral fractures of the bony building blocks of the spine, can be painless and therefore osteopenia or osteoporosis may go undiagnosed for years. Complications menorrhagia is the most common cause of anemia reduction in red blood cells in premenopausal women. A blood loss of more than 80mL around three tablespoons per menstrual cycle can eventually lead to anemia. Most cases of anemia are mild.<sup>(4)</sup>

## **4 DEXA scan**

### **History**

Established in 1969 in province of Palembang in the South of Sumatra Island in Indonesia.<sup>(1)</sup>

### **Common uses**

DXA is most often used to diagnose [osteoporosis](#), it is also effective in tracking the effects of treatment for osteoporosis, other conditions that cause bone loss and the DXA test can also assess an individual's risk for developing fractures.<sup>(1)</sup>

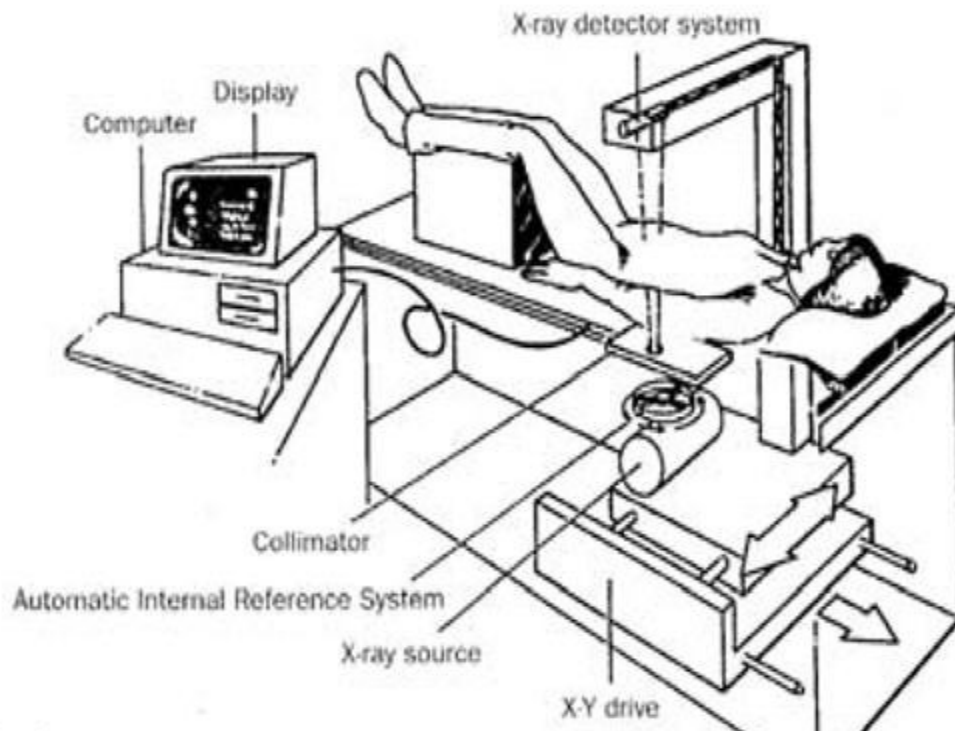
### **Equipment**



Central DXA devices measure bone density in the hip and spine, usually located in hospitals and medical offices and central devices have a large, flat table and an "arm" suspended overhead.<sup>(1)</sup>

### **Components of (cDXA)**

X-ray tube, cross arm, x-ray generator, x-ray drive, flat table, x-ray detector system, collimator, automatic internal reference system, computer and display system.<sup>(1)</sup>



**Fig** components of cDXA.<sup>(10)</sup>

### **X-ray Detectors**

Solid materials in which the energy of x-ray is converted to light photons. Then the emitted light is converted into electrical current by using photomultiplier tube.<sup>(11)</sup>

### **Type of beam x-ray**

Fan beam has scan time 30 – 60 sec, better image quality and low patient dose.

## **Accessory**

### **1. Padded box**

Support the patient's legs to flatten pelvis and lower [lumbar](#) spine. <sup>(1)</sup>



**Fig** Shows the padded box. <sup>(17)</sup>

### **2.4.3.3.2 Brace** Rotates the hip inward. <sup>(1)</sup>

**Fig (2.4)** Shows the brace.)



### **2.4.2 Procedure work**

The DXA machine sends a thin, invisible beam of low - dose x-ray with two energy, one energy is absorbed mainly by soft tissue and the other by bone. The soft tissue amount can be subtracted from the total and what remains is a patient's bone mineral density and DXA machines feature special software that compute and display the bone density measurements on a computer monitor.<sup>(1)</sup>

### **2.4.5Protection**

State-of-the-art x-ray systems have tightly controlled x-ray beams with significant filtration and dose control methods to minimize stray or scatter radiation. This ensures that those parts of a patient's body not being imaged receive minimal radiation exposure.<sup>(1)</sup>

### **2.4.6Technique**

#### **2.4.6.1 Indication**

[Osteoporosis](#) , osteopenia, osteomalacia and assess an individual's risk for developing fractures.<sup>(1)</sup>

#### **2.4.6.2 Contraindication**

Barium examination, vertebroplasty, scoliosis, pregnant, lumber 5 and Lumber 1 with ribs.<sup>(1)</sup>

#### **2.4.6.3 Patient preparation**

Patient eat normally and should not take calcium supplements for at least 24 hours before exam, patient should wear loose, comfortable clothing, avoiding garments that have zippers, belts or buttons made of metal, objects such as keys or wallets that would be in the area being scanned should be removed., remove some or all of clothes and to wear a gown during the

exam , remove jewelry and any metal objects or clothing that might interfere with the x-ray images and explain the examination for patient.<sup>(1)</sup>

#### **2.4.6.4 Procedure**

##### **2.4.6.4.1 PA Lumbar Spine**

Patient at rest supine, the mid sagittal plane In the central of the table, the legs support by Padded box, the hand beside the body and support the head by the billow, tube direction vertical.<sup>(1)</sup>

Center point at the level of the lower costal margin L3.<sup>(9)</sup>

##### **2.4.6.4.2 Lateral Vertebral Assessment (LVA)**

Do for older patients if lost more than an inch of height and have unexplained back pain.<sup>(1)</sup>

The mid axillary lines at the center of the table, the hand over the head, flexible the knee to avoid lordotic curvature, tube direction vertical. Center point at the axillary line at the level of the lower costal margin L3.<sup>(9)</sup>

##### **2.4.6.4.3 PA Hip**

Patient at the rest in supine, the mid sagittal plane at the center of the table, rotate the foot 15 degree inward by brace and the hand beside the body or over the trunk, tube direction vertical.<sup>(1)</sup>

Center point 2 cm distally from the mid of the line between the ASIS and symphysis pubis.<sup>(9)</sup>

**Note** Rotate foot 15 degree.

#### **2.4.7 Results of DEXA**

##### **2.4.7.1 T-Score and Z- score**

T-score indicates the difference between the patient's measured BMD and the ideal peak bone mass achieved by a young adult. If T-score is  $< -2.5$  at the spine, hip, or forearm; the patient is classified as having osteoporosis. If T-score is between  $-2.5$  and  $-1$  at the spine, hip, or forearm; the patient is classified as having osteopenia. If T-score is  $> -1$  the patient is classified as normal. Z-score indicates the difference between the patient's measured BMD and the ideal peak bone mass achieved by age-matched peers. Z-score can not be used to diagnose osteoporosis. Indicate a need for further medical tests.<sup>(1)</sup>

#### **2.4.7.2 Report of DEXA**

A radiologist, a physician specifically trained to supervise and interpret radiology examinations. Analyze the images and send a signed report to your primary care or referring physician. DXA scans are also interpreted by other physicians such as rheumatologists and endocrinologists.<sup>(1)</sup>

#### **2.4.8 Benefits of DEXA**

DXA bone densitometry is a simple, quick procedure, no anesthesia is required, the amount of radiation used is extremely small less than one-tenth the dose of a standard chest x-ray, DXA bone density testing is the most accurate method available for the diagnosis of osteoporosis, considered an accurate estimator of fracture risk, DXA equipment is widely available making DXA bone densitometry testing convenient for patients and physicians alike and no radiation remains in a patient's body after an x-ray examination.<sup>(1)</sup>

#### **2.4.9 Risks of DEXA**

There is always a slight chance of cancer from excessive exposure to radiation and women should always inform their physician or x-ray technologist if there is any possibility that they are pregnant.<sup>(1)</sup>

#### **2.4.10 limitations of DEXA**

A DXA test cannot predict who will experience a fracture but can provide indications of relative risk, central DXA devices sensitive and expensive <sup>(1)</sup>

### **2.5 Backgrounds studies**

#### **2.5.1 Study (1)**

Done by Buttros Dde A, Nahas-Neto J, Nahas EA, Cangussu LM, Barral AB, Kawakami MS. They studied risk factors for osteoporosis in postmenopausal women from southeast Brazilian and the results are according to WHO criteria, 106 (24.6%) women showed osteoporosis (T-score < -2.5 DP), 188 (43.6%) osteopenia (-1.0/-2.4 DP), and 137 (31.8%) were normal (> -1.0 DP). Osteoporosis was detected in 12% of women aged 40-49 years, in 21.8% of women aged 50-59 years and in 45.7% of women aged > 60 years ( $p < 0.001$ ). Osteoporosis occurred in 11.8% of women with a menopause period < 5 years, in 29.4% with a menopause period from 6 to 10 years, and in 41% of women with a menopause period > 10 years ( $p < 0.001$ ). Of the women with early menopause, 80% showed osteopenia/osteoporosis ( $p = 0.03$ ), and of those with BMI < 20 kg/m<sup>2</sup>, 50% were osteoporotic ( $p < 0.001$ ). The risk for osteoporosis detection increased with age (OR = 1.1; CI 95% = 1.0-1.1), time of menopause (OR = 1.1; CI 95% = 1.0-1.1), smoking (OR = 1.9; CI 95% = 1.2-3.2), RA (OR = 3.6; CI 95% = 1.3-9.6) and maternal fracture history (OR = 2.1; CI 95% = 1.1-3.0) ( $p < 0.05$ ). In contrast, HT use (OR = 0.3; 95% CI = 0.2-0.6) and high BMI (OR = 0.9; 95% CI = 0.8-0.9) reduced the risk. <sup>(12)</sup>

#### **2.5.2 Study (2)**

Done by Khatri IA, Chaudhry US, Seikaly MG, Browne RH, Iannaccone ST. They studied Low bone mineral density in spinal muscular atrophy and the results are Eighty-four dual-energy x-ray absorptiometry scans were

performed on 79 patients between the ages of 4 months and 18 years with the mean age of 8 years. Z scores were used to compare their BMDs. BMD was lowest in patients with spinal muscular atrophy (SMA) with Z score of  $-2.25 \pm 0.31$  standard deviation scores. The Z score for patients with Duchenne muscular dystrophy was  $-1.72 \pm 0.1$ . The BMD in nonambulatory patients with SMA was significantly decreased compared with ambulatory patients with SMA ( $P < 0.05$ ).<sup>(13)</sup>

### **2.5.3 Study ( 3 )**

Done by Jiang E, Wang Z, Meng Q, Li S, Wang F, Shao G, Zhang L .They studied study on bone density at various skeletal sites for the diagnosis of primary osteoporosis and the results are the objective of this study was to evaluate the diagnostic value of bone density changes in lumbar vertebrae and femoral necks in patients with primary osteoporosis (OP) at various ages. Dual-energy X-ray absorptiometry (DXA) scans were performed on patients who had their primary visits between March 2008 and February 2009. The bone mineral density (BMD) of the lumbar vertebrae 1-4 (L1-L4) in anteroposterior projection and the proximal femoral neck in lateral projection were measured. If the BMD values (T score) of any site is  $-2.5$  or less ( $T \leq -2.5$ ), the patients were diagnosed as primary OP, and the T scores were statistically analyzed.<sup>(14)</sup>

The 81 patients who had lumbar vertebrae with a  $T \leq -2.5$  led to a positive rate of 80.1 % in the diagnosis of primary OP; the 47 patients who had femoral neck with a  $T \leq -2.5$  gave a positive rate of 47.0 %. The patients with type I or type II primary OP were divided into two age groups of  $\leq 70$  and  $\geq 71$  years old. The comparison of lumbar spine T score values did not show significant statistical difference ( $P > 0.05$ ) between the age groups,

while the result of the femoral necks revealed significant difference between the two groups ( $P < 0.001$ ). In diagnosis of primary OP, anteroposterior lumbar spine offers a significantly higher detection rate than that of the femoral neck, but to the patients older than 70, the measurement of femoral neck may generate higher detection rate. It is more sensitive to measure lumbar trabecular bone, especially to the patients in early postmenopausal period. BMD in elderly patients may falsely increase with age; attention should be paid to the determination of the hip bone mass. <sup>(14)</sup>

#### **2.5.4 Study (4)**

Done by Sieber PR, Rommel FM, Theodoran CG, Russinko PJ, Woodward CA, Schimke L. They studied the role of distal third radius dual energy x-ray absorptiometry (DXA) and central DXA in evaluating for osteopenia and osteoporosis in men receiving androgen deprivation therapy for prostate cancer and the results are the authors assessed the use of distal third radius dual energy X-ray absorptiometry (DXA) concomitantly with central (hip and lumbar spine) DXA to identify men with osteopenia or osteoporosis receiving androgen deprivation therapy (ADT) for prostate cancer. Initial classification with central DXA demonstrated 60 (17%) normal, 187 (55%) osteopenic, and 96 (28%) osteoporotic patients. <sup>(15)</sup>

Sixteen of 60 (27%) normal patients were reclassified as osteopenic (14) or osteoporotic (2), and 20 of 187 (11%) osteopenic patients were reclassified as osteoporotic with



the combination of central DXA plus distal third radius DXA. The difference in reclassification was statistically significant. The addition of distal third radius to central DXA scanning in men with bone loss associated with ADT identifies a statistically significant number of men being reclassified as having osteopenia or osteoporosis. Combined central and distal third radius DXA scanning should be considered routine in the evaluation of all men suspected of bone loss associated with ADT. This has specific significant clinical relevance because of the large number of men with none valuable central DXA studies. Fracture risk prediction and treatment recommendations based on this reclassification will need to be determined by follow-up studies. <sup>(15)</sup>

### **2.5.5 Study (5)**

Done by Marwaha RK, Tandon N, Kaur P, Sastry A, Bhadra K, Narang A, Arora S, Mani K. They studied establishment of age-specified bone mineral density reference range for Indian females using dual-energy x-ray absorptiometry and the results are we undertook this study to establish age-specified bone mineral density (BMD) reference range for Indian females using dual-energy X-ray absorptiometry. BMD at multiple skeletal sites was measured in 2034 healthy women aged 18-85yr. The effect of anthropometry and biochemical parameters on BMD was determined. <sup>(16)</sup>

Peak BMD was observed between 30 and 35yr at the hip, lumbar spine, and radius. Significant positive correlation of height and weight with BMD was observed at 33% radius, femur neck, and lumbar spine, whereas significant negative correlation was seen between serum alkaline phosphatase (ALP) and serum parathyroid hormone levels with BMD at aforementioned sites. On multivariate regression analysis, age, weight, and serum ALP were the most consistent contributors to variance in the BMD. Compared with age-matched United States females, BMD of lumbar spine was significantly lower for our subjects in all age groups. Prevalence of osteoporosis among women aged older than 50yr was significantly higher based on Caucasian T-scores as opposed to using peak BMD/standard deviation values from the population under review at lumbar spine but not at femoral neck. <sup>(16)</sup>

## **Chapter Three**

## **Chapter three: Methodology**

### **3.1 Material and methods**

#### **3.1.1 The type of study**

Retrospective and analytical and study for 50 patients was be investigated by DEXA scan in Khartoum state Royal Care Hospital.

#### **3.1.2 Population of patients**

All the patients was investigated by DEXA scan with different age and gender in the duration from September 2015 - November 2015.

#### **3.1.3 Sample and sample size**

Simple sample random for 50 patients whom investigation by DEXA scan.

#### **3.1.4 Data collection**

The data was collected by data collection sheets which was be designed by different variables to register the outcome result of direct DEXA examinations.

#### **3.1.5 Data analysis**

The data was analyzed by using statistical package for social science (SPSS) because it gives more specific and accurate data analysis.

### **3.1.6 Data storage**

Patient data collecting sheets was kept out of the reach and stored in personal computer.

### **3.1.7 Area of study**

The study was carried out in DEXA department in Khartoum state Royal Care Hospital.

### **3.1.8 Duration of study**

September 2015– March 2016



## **Chapter Four**

## **Chapter four**

### **Results and discussion**

#### **4-1 Discussion**

Fifty patients with different age and gender were diagnosed by DEXA scan in Royal Care Hospital, the distribution of age group for 50 patients whom diagnosed by DEXA scan. The magnitude number of patients in the age group of (45-65 yrs) 26(52%) because BMD decrease when the age increase, due to decrease testosterone and estrogen hormones as mentioned by Buttros Dde he said the risk factor of the decrease bone density increase with age increase.

The gender group for 50 patients whom diagnosed by DEXA scan; females 42 (84%) and males 8. The magnitude number of patients in the females were higher because BMD decrease after the post menopause in the females this result agree with Buttros Dde they said the risk factor of decrease bone density common detected in post menopause females.

The highest frequency concerning the height for 50 patients whom diagnosed by DEXA scan was (150 - 160 cm) 21 and (160 - 170 cm) 18, because BMD decrease when height decrease as Marwaha RK said positive correlation of height and weight with bone mineral density (BMD).

Also the result of this study showed that according to weight for 50 patients whom diagnosed by DEXA scan, 23 patient



were obese and 27 were thin. According to group distribution weight showed the following data; less than 18.52 underweight,(18.5-24.9)11 normal range,(25.9-29.9)14overweight, (30-39.9)21 obese, (more than 40)2 over obese, magnitude number of patients is (30-39) 21 obsess. The results according to DEXA finding for 50 patients whom diagnosed by DEXA scan; normal 19 (T - score < -1 ), osteopenia 17 ( T -score -1 / -2.5) and osteoporosis 14 (T-score 2.5 or less)

The sensitivity of DEXA scan was highest in case of osteoporosis diagnosis using spine rather than hip which are equal to 100% and 91.7% respectively. Oppositely for osteopenia the highest accuracy was associated with the scan of the spine where the accuracy equal 100% versus 72.7% of the hip.

## 4-2 Result

**Table (1)** distribution according to age group.

Age group	No.
15 – 25	2
25 – 45	-
45 – 65	26
65 – 85	22
Total	50

**Table (2)** distribution according to gender group.

Gender group	No.
Male	8
Female	42
Total	50

**Table (3)** distribution according to height.

Height	No.
140 – 150 cm	2
150 – 160 cm	21
160 – 170 cm	18
170 – 180 cm	1
180 – 190 cm	9
Total	50

**Table (4) distribution according to weight.**

Weight	No.
Obese	23
Thin	27
Total	50

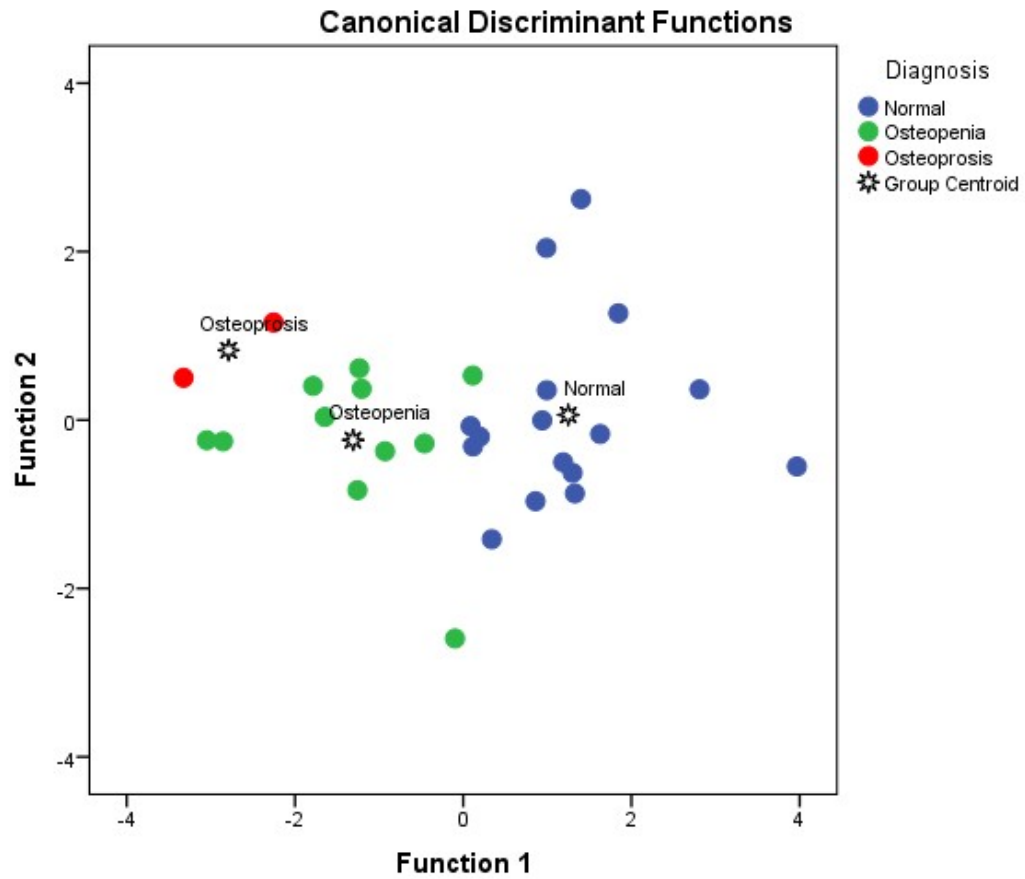
**Table (5) distribution according to BMI group.**

BMI group	No.
less than 18.5	2
18.5 – 24.9	11
25 - 29.9	14
30 – 39.9	21
More than 40	2
Total	50

**Table (6) distribution according to DEXA finding.**

<b>DEXA finding</b>	<b>No.</b>
<b>Normal</b>	<b>19</b>
<b>Osteopenia</b>	<b>17</b>
<b>Osteoporosis</b>	<b>14</b>
<b>Total</b>	<b>50</b>

**Using hip joint as site of Tscore and Zscore**



Diagnosis	Predicted Group Membership	Total		
	Normal	Osteopenia	Osteoporosis	
Normal	<u>100</u>	0	0	100
Osteopenia	9.1	<u>72.7</u>	18.2	100
Osteoporosis	0	0	<u>100</u>	100

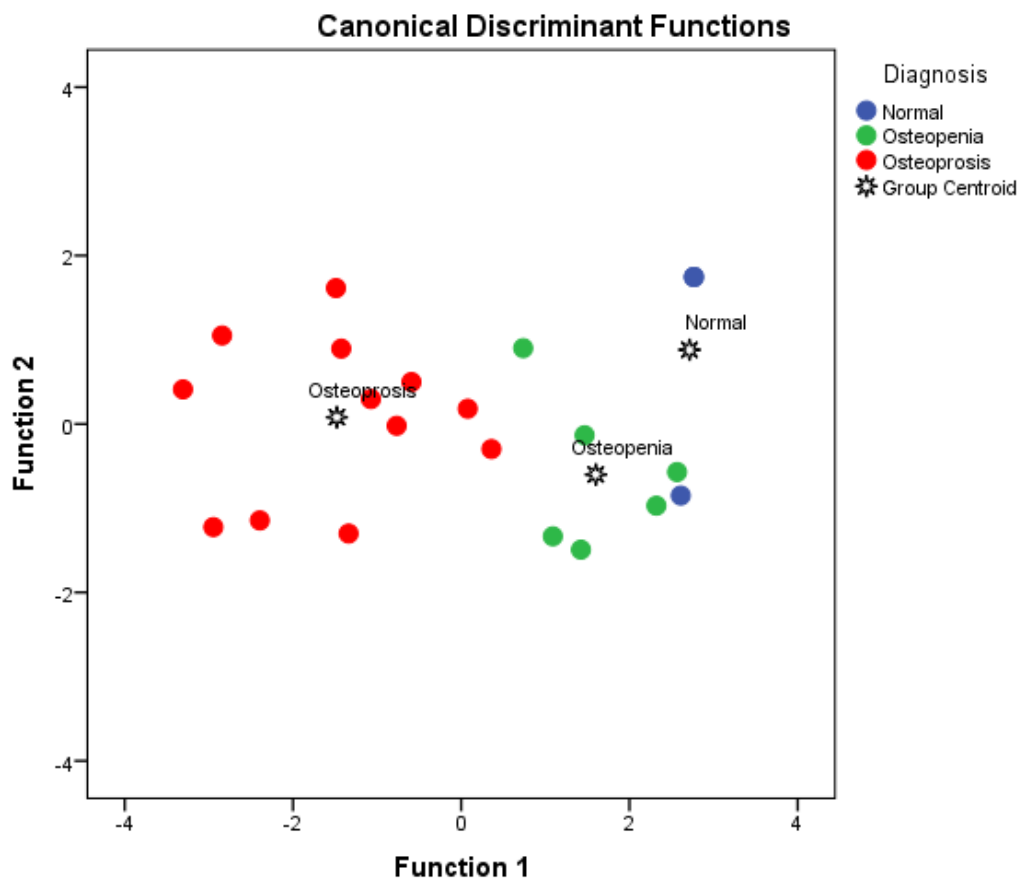
89.7% of original grouped cases correctly classified

$$\text{Normal} = (\text{tscore} \times -1.786) + (\text{Zscore} \times 1.875) - 2.267$$

$$\text{Osteopenia} = (\text{tscore} \times -4.232) + (\text{Zscore} \times -.573) - 4.774$$

$$\text{Osteoporosis} = (\text{tscore} \times -7.227) + (\text{Zscore} \times -.555) - 11.326$$

## Using spine as site of Tscore and Zscore



Diagnosis	Predicted Group Membership			Total
	Normal	Osteopenia	Osteoporosis	
Normal	<u>100</u>	0	0	100
Osteopenia	0	100	0	100
Osteoporosis	0	0	100	100

				0
	0	<b><u>100</u></b>	0	1
Osteopenia				0
				0
	0	8.3	<b><u>91.7</u></b>	1
Osteoprosi				0
s				0

97.2% of original grouped cases correctly classified

## **Chapter Five**



## 5.1Conclusions

- The DEXA scan is the most accurate and sensitive to evaluate bone density, which is the most accurate and sensitive in diagnoses osteoporosis and osteopenia (100%).
- Osteoporosis result associated by decrease calcium serum in BMD, increase when age increase ( 50% ), increase in females more than males (84%) because post menopause females had decrease in estrogen, increase in the thin ( 54% ), increases when height decrease (78% ).
- Osteopenia associated by decreases in calcium serum in BMD, increase when age increase ( 57.2% ), increase in males more than females (45.4%) because BMD decrease when testosterone decrease and increase the age in the males, increase with the thin ( 42% ), increase when height decrease ( 57.1% ).
- In conclusion acquisition of the z-score and t-score, the study showed that t-score for osteopenia, osteoporosis and normal had strong correlation with age therefore these three conditions can be estimated using linear regression equation quantitatively as follows.

$$\text{Normal} = (\text{age} \times 1.18) + (\text{Tscore} \times -1.189) - 37.274$$

$$\text{Osteopenia} = (\text{age} \times 1.082) + (\text{Tscore} \times -2.862) - 32.888$$

$$\text{Osteoporosis} = (\text{age} \times 1.380) + (\text{Tscore} \times -5.566) - 58.468$$

## **5.2 Recommendations**

- Every one showed do routine evaluations every two years by DEXA scan to see a significant change in bone mineral density.
- Every patient, such as patients on high dose of steroid medication, may need follow-up periodically by intervals of six months.
- DEXA scan modality should be introduced in the syllabus of the faculties of radiology.
- The post menopause female should takes estrogen to avoid decrease bone density.

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## **5.4 Appendices**

### **Data Collection Sheet (Questionnaire)**

NO (   )

#### **Patient Data**

##### **Age**

25 – 40 yrs (   )

40 – 55 yrs (   )

55 – 70 yrs (   )

70 – 85 yrs (   )

85 – 100 yrs (   )

##### **Gender**

Male (   )      Female (   )

##### **Weight**

Obese (    )

Thin (    )

**Height**

140 – 150 cm (    )

150 – 160 cm (    )

160 – 170 cm (    )

170 – 180 cm (    )

180 – 190 cm (    )

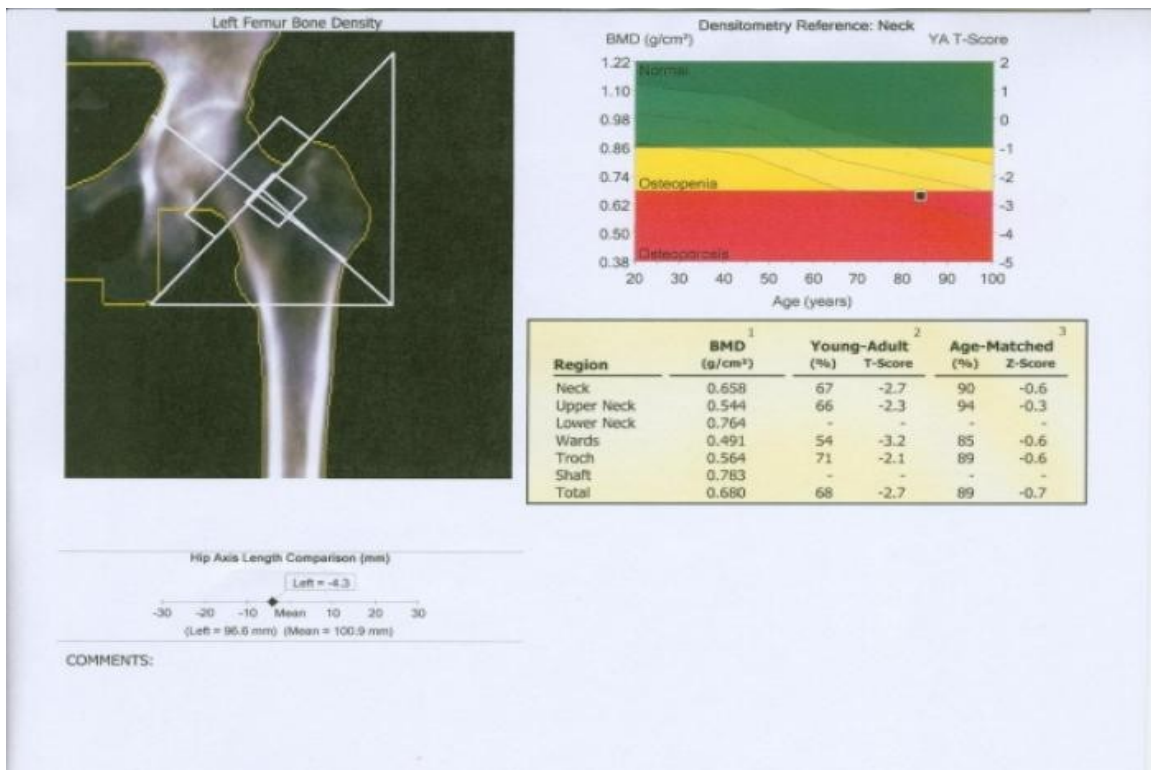
**DEXA finding**

Osteoporosis (    )

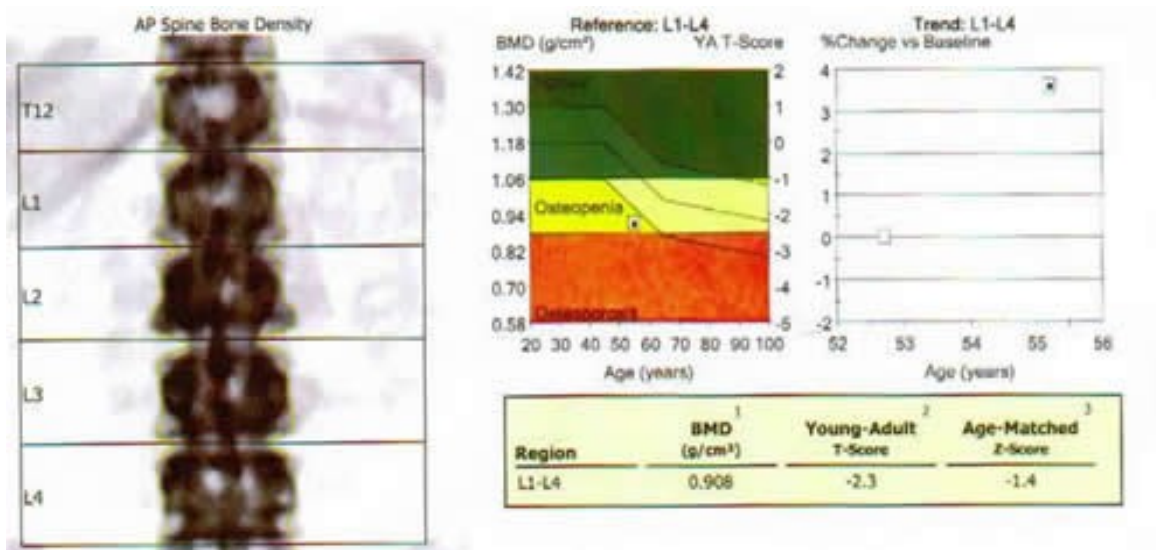
Osteopenia    (    )Normal (    )

# Images

# Images



**Image (5.1)** Shows osteoporosis (T - score -2.7).



**Image (5.2)** Shows osteopenia (T - score -2.3).