A Review on Techniques of Detection of Osteoporosis

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Abstract: Bone density defined as an amount of mineral present in bone. Osteoporosis is a silent process in which loss of bone density occurs. Early diagnosis of osteoporosis is very important to prevent fracture risk of small injury such as fall. Osteoporosis usually diagnosed by measuring bone mineral density. Conventionally DEXA machine is derived as a golden standard method for detection of osteoporosis. This paper reviews different techniques which are developed or in developing stage to diagnose osteoporosis.

Index Terms **- Bone Mineral Density(BMD), Osteoporosis, Fracture Risks.**

I. INTRODUCTION

Bone mineral density (BMD) is the amount of calcium & other minerals in bone tissue. Osteoporosis is silent chronic, progressive condition in which bone density gradually decreases. At this stage bone becomes porous & fragile & may break even by minor injuries as for example if a person falls down, even then bone breaks[1]. There are various factors affect bone mineral loss such as aging, menopause.

Figure 1. Osteoporotic Bone

In current years, it had been found that more than 200 million of individuals affected by osteoporosis all over the world, because of that awareness related to osteoporosis is increasing. In spite of that, above 75% of these not known that they have osteoporosis and they are not subjected to proper medical care. In the group of three female, one female and in a group of five male, one male is affected by osteoporosis over the age of 50. In the United Kingdom, 536,000 fractures are occurred due to this disease. So, it's very important to early detection of this disease.

The response of bone at high strain loading cannot be same as predicted by static analysis because the bone has the property of a viscoelastic material. This implies it should be subjected to dynamic tests to study dynamic behaviour under illness and stable condition.

II. METHODOLOGY

Conventionally osteoporosis diagnosed by measuring an amount of bone mineral density. There are various techniques used for the diagnostic purpose of osteoporosis in which DEXA scan is traditional techniques and also known as a golden standard method to measure bone mineral density because of its high accuracy. Here we are discussing techniques used for osteoporosis assessment.

A DEXA Machine based Technique

In 1987, Dual Energy X-ray Absorptiometry (DEXA) technique was presented after the successful result of DPA (Dual Photon Absorptiometry)[2]. DEXA technique based on X-ray generator which gives two distinct energy levels of X-ray beams. Depends on the tissues nature, these beams are attenuated by it. On the basis of attenuation of energy BMD measured[3].

A DEXA machine (Figure 2) consists of mainly three systems These systems include sources of an X-ray generator, Detector system which detects X-ray emerging from bone and patient table. X-ray generator is placed under the patient table and they move with the detector system. X-ray Detector system is placed over the patient table.

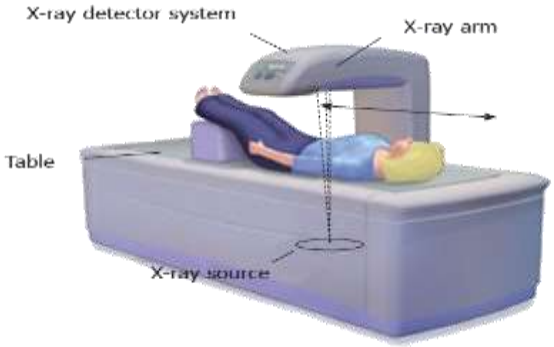

Figure 2. DEXA Machine

Density information given by DEXA machine is in term of T score. T score is a comparison of resulting bone density to 30 year old normal person. According to WHO (World Health Organization), T score range is given below:

Table 1. T score range for bone category

State of Condition	Range of T score(t)
Healthy Bone	t >-1
Bone affected by Osteopenia	-1 ≥ t ≥ -2.5
Bone affected by Osteoporosis	t < -2.5

Quantitative Computed Tomography(QCT)

In the middle of 1970, QCT was presented & is generally measured BMD of the lumbar spine. Measuring linear absorption coefficients, it gives an axial image which depends on X-ray. CT image acquisition is done by two major steps: 1 measuring attenuation coefficients for getting the data. Units of Attenuation coefficients is Hounsfield (HU). 2 Remodel the topographic to making an image from the acquired information of data by using complex mathematical process. The process of getting BMD information from HU is important to phantoms use. Various concentration of material is contained by these phantoms which have similar attenuation characteristics to the bone.

Depending on measurements of linear absorption coefficients, it gives an axial image. By using QCT, we can get 3D density which is similar to real density.

Quantitative Ultrasound(QUS)

QUS system depends on the change in speed of sound (SOS) and broadband attenuation(BUA) when they passed through the subjected bone. There are two probes is placed over subject's skin by using the gel as coupling. One probe as a transmitter and another as a receiver. Using that two BUA and SOS are measured [5].

This system gives information about fracture risk of bone by giving information about bone density. The main advantage of this system is that patient is not subjected to any radiation for measuring bone density or stiffness index of bone.

Stiffness index is determined by using values of SOS & BUA as follows[6]:

$$\text{Stiffness Index of bone} = \{(0.28*SOS) + (0.67*BUA)\} - 420$$

Table 2. Stiffness Index of Tibia Bone

State of Condition	Stiffness Index(SI)
Healthy Bone	82.38-108.96
Bone affected by Osteopenia	69.82-82.38
Bone affected by Osteoporosis	59.89-69.82

Impulse Response Based Technique

This is simple noninvasive portable device-based technique. This technique is used for assessment of osteoporosis & osteopenia by study dynamic behaviour of bone. [7].

Generally, tibia bone is subjected to impulse response measurement. Tibia bone as a volume contains trabecular bone approximately 25%to 30% and Cortical bone approximately 70% to 75%. Tibia bone is mainly affected by an extraordinary load in day by day exercises [8].

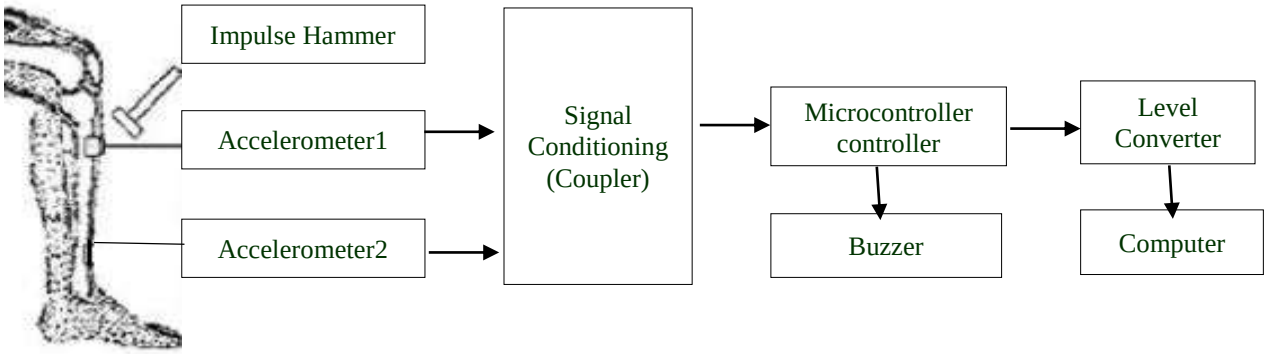

Figure 3. Impulse response-based technique[9]

At the point when bone subjected by impulsive force, the vibrations along these lines caused are detected by the accelerometer, which comes back to the system as a simple voltage signal that depends on the estimation of the natural frequency of the bone. We can get frequency when the signal is examined frequency domain using FFT (Fast Fourier Transform). Bone mineral density directly affects natural frequency of bone.

Table 3. Natural Frequency of Tibia Bone

State of Condition	Natural Frequency
Healthy Bone	Above 100Hz
Bone affected by Osteopenia	75-100 Hz
Bone affected by Osteoporosis	Below 75 Hz

Below graph shows how natural frequency correlates with stiffness index of bone. Stiffness index is measured by QUS

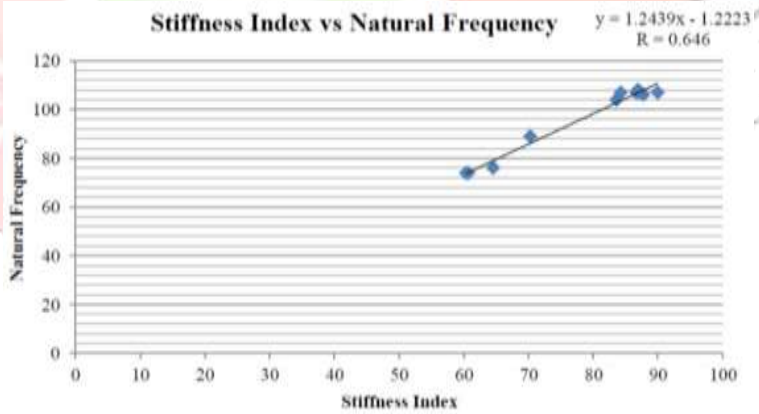

Figure 4. Stiffness Index vs Natural Frequency

As We show in Figure 4, the decrease in natural frequency of reflecting the loss of density of bone and stiffness index of bone with an increase in age. This impulse response method is used to study the dynamic behaviour of tibia bone. It is first line method to detect osteoporosis.

III. CONCLUSION

Here we have discussed different techniques to diagnose osteoporosis. In mentioned techniques, DEXA technique is conventionally used because of its high accuracy. But it has a high cost. DEXA scan exposes x-ray radiation which is harmful to the patient. The result of QCT to measuring bone density are in T score & Z score. Bone density in QCT result is given in milligrams of minerals/millimeter. QCT have higher radiation dose than DEXA. QCT is not properly matched diagnostic criteria of WHO.

QUS technique is an inexpensive, quick and radiation-free technique but, it used at Only peripheral anatomical sites. Impulse response-based technique is a recent developing technique which simple cost-effective system. On the basis of impulse technique, we can get the result quickly. But the impulsive force could be automatic.

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