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Orthopentogram Based Osteoporosis Prediction

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Abstract

The method for estimating reduced bone mineral density from dental radiographs is discussed in this paper. Dual X-ray absorptiometry is the common technique to determine bone mineral density. Because of high costs and limited availability, it is worthwhile to look for alternative diagnostic techniques. The objective of this study was to investigate the use of Dental Radiographic measurements as a predictor for bone mineral density and to identify the subjects with osteoporosis and the increased risk of osteoporosis. Osteoporosis can be' broadly defined as a decrease in the amount of bone mass per unit volume of bone. Early diagnosis of osteoporosis can potentially decrease the risk of fracture and improve the quality of life. Dental radiographs show the entire mandible. Detection of thin inferior cortices of the mandible on dental radiographs could be useful for identifying the subject with low bone mineral density (BMD) or osteoporosis. Careful expert width measurement of the inferior mandibular cortex has been shown to be predictive of low BMD. For automatic measurement of the width, active shape model is to be used. Width measured after fully automatic search are exhibit less variability than manual measurements. The original x- ray image is enhanced, cortical boundaries were determined; distances among the upper and lower boundaries were evaluated.

Keywords - Osteoporosis, Osteopenia, Bone Mineral Density, Mandible, Mental Foramen.

I . INTRODUCTION

OSTEOPOROSIS is a disease characterized by low bone mass and loss of bone tissue that may lead to weak and fragile bones. Osteoporosis results in fractures. Osteoporosis affects all bones in the body. However, breaks are most common in the hip, wrist, and spine. Unfortunately affected individuals are often unaware that they have osteoporosis until they sustain a bone fracture. So solution is to analyze panoramic dental radiographs for early sign of disease. Using the radiographs, software is used to identify and measure the thickness of lower border of the mandible (the cortical width). Normally, your body recycles old bone components to make new ones, and it also deposits new calcium and other minerals into your bone to make them hard and dense. But after you turn 35, your bones stop growing and we gradually lose bone density, which means that the tiny holes in them get larger while the hard substance gets thinner. So your bones become more porous, weaker, and more susceptible to injury and fractures.

Osteoporosis, a condition that affects the strength of the skeletal system and causes problems with posture and with bone weakness, is the result of bone mass loss. The clinical consequence of low bone mass is fracture. In fact, for every one standard deviation below peak bone mass, the risk of vertebral fracture is twice that of normal bone mass, and 2.5 times that for the hip. Low bone mass is a modifiable risk factor for fractures. To explain it in terms of an analogy, low bone mass is to fractures what high cholesterol or high blood pressure is to a heart attack. However, although bone mass loss is a natural part of human aging, preventative and treatment strategies can help to retain bone strength so that fractures are avoidable. [18, 24] Figure 1 shows the standard hip BMD in mg/cm^2.

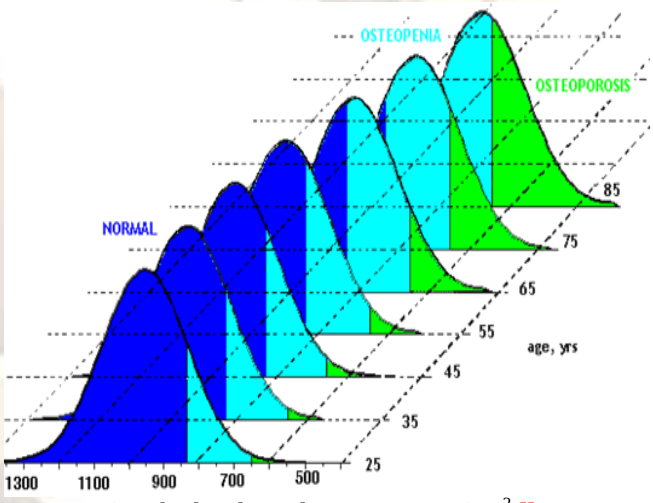

Figure 1: Standardized Total Hip BMD mg/cm^2 []

II. BONE MINERAL DENSITY

It can be given by the amount of minerals per square centimeter of bone, expressed in grams per milliliter. A bone density test uses x-rays to measure how many grams of calcium and other bone minerals are packed into a segment of bone. The mineral content of cortical bone in the mandible is likely to be related to the mineral content of skeleton. Higher the bone density, stronger the bone. The lower jaw has its own separate bone which is called mandible, which is

'U' shaped and stretches from one ear down to the chin area and back up again to the other ear. The mandible seems to be the bone within the human skeleton that is most exposed to severe decrease in its mineral content as it is one of the primary source of the available calcium in the body. The mineral content of the mandible is low in patients with osteoporosis. So BMD of the mandibular bone is related with osteoporosis that is low skeletal BMD.[16, 23, 26]

III. Materials and Methods

There are different techniques used to measure bone mineral density. Four techniques are discussed in this section are as flows:

A. Quantitative Computed Tomography

Quantitative computed tomography (QCT) was introduced in the mid 1970s. The technique is most commonly applied to 2D slices in the lumbar spine to measure trabecular bone mineral density (BMD; mg/cm^3). Although not as widely utilized as dual-energy X-ray absortiometry (DXA) QCT has some advantages when studying the skeleton (separate measures of cortical and trabecular BMD; measurement of volumetric, as opposed to 'areal' DXA-BMD a, so not size dependent; geometric and structural parameters obtained which contribute to bone strength). A limitation is that the World Health Organization (WHO) definition of osteoporosis in terms of bone densitometry (*T* score −2.5 or below using DXA) is not applicable. QCT can be performed on conventional body CT scanners, or at peripheral sites (radius, tibia) using smaller, less expensive dedicated peripheral CT scanners (pQCT). Although the ionizing radiation dose of spinal QCT is higher than for DXA, the dose compares favorably with those of other radiographic procedures (spinal radiographs) performed in patients suspected of having osteoporosis. The radiation dose from peripheral QCT scanners is negligible. Technical developments in CT (spiral multi-detector CT; improved spatial resolution) allow rapid acquisition of 3D volume images which enable QCT to be applied to the clinically important site of the proximal femur, more sophisticated analysis of cortical and trabecular bone, the imaging of trabecular structure and the application of finite element analysis (FEA). [14](QCT) has some important advantages compared with DXA because it provides a three-dimensional assessment of the structural and geometric properties of the examined bone, and a separation of cortical and trabecular bone. A major disadvantage is the high-radiation dose (50–100 μSv), making it unsuitable for use in the pediatric population [12]

B. Quantitative Ultrasonography

It is attractive as a test for osteoporosis, being precise, radiation-free, portable, and inexpensive, but it is still no substitute for the gold standard test, dual-energy x-ray absorptiometry (DXA). Quantitative ultrasonography measures the speed and attenuation of sound in bone; the higher these values, the stronger the bone. It can also give an estimate of bone mineral density, but not an actual measurement. T scores obtained by quantitative ultrasonography are different than T scores derived by DXA and cannot be used with the World Health Organization classification of bone mineral density to diagnose osteoporosis However, despite its advantages, this test is not yet a substitute for DXA for diagnosing and classifying osteoporosis nor for monitoring therapy. The various ultrasound devices are not comparable to one another, quality assurance and instrument calibration are uncertain, standardized reference databases are lacking, and we do not have enough data to correlate ultrasonographic measures with clinical risk factors for fracture. The devices use high-frequency sound waves, typically between 0.1 and 1.0 MHz, which are produced and detected by highly efficient piezoelectric transducers. The transducers must make good acoustical contact with the skin over the bone being tested, which is achieved by "wet" methods (eg, a water bath),"dry" methods (eg, silicone pads, ultrasound gel), or a combination of these methods. The precision of QUS is generally reported to be poorer than that of DXA.[12, 28]

C. Dual Energy X-ray Absorptiometry

Dual-energy X-ray absorptiometry (DXA, previously DEXA) is a means of measuring BMD. Dual-energy X-ray absorptiometry is the most widely used and most thoroughly studied bone density measurement technology.

Figure 2: Setup used for DEXA [28]

DEXA is relatively easy to perform and the amount of radiation exposure is low. A DEXA scanner is a machine that produces two X-ray beams, each with different energy levels. One beam is high energy while the other is low energy. The amount of X-rays that pass through the bone is measured for each beam. This will vary depending on the thickness of the bone. Based on the difference between the two beams, the bone density can be measured. Figure 2 shows the DEXA system setup. DEXA scanning focuses on two main areas, the hip and spine. DEXA measurements are based on a three compartmental

model (total body mineral (from bones), fat-free soft (lean) mass and fat tissue mass) rather than two compartments as in most other methods. DEXA can also distinguish regional as well as whole body parameters of body composition. As such, it is considered a reference standard, and the latest body composition research uses this method. The radiation exposure from a DEXA scan is actually much less than that from a traditional chest X-ray. DEXA is still considered the gold standard, with established clinical efficacy. The main disadvantage of this method is equipment is expensive, and often requires trained radiology personnel to operate. [11, 17, 25, 28]

D. Dental Radiographs

Different types of dental x-rays are used depending on diagnosis.They are bitewingx-rays, periapical x-rays, occlusal x-rays and panoramic x-rays. For the measurement of osteoporosis dental panoramic radiographs are used. Panoramic x-rays makes a complete circle of the head from one ear to the other to produce two –dimensional representation of all the teeth. This x-ray will also show bone structure beneath the teeth. The main advantages of the panoramic x-rays are broad coverage of facial bone and teeth, low patient dose.

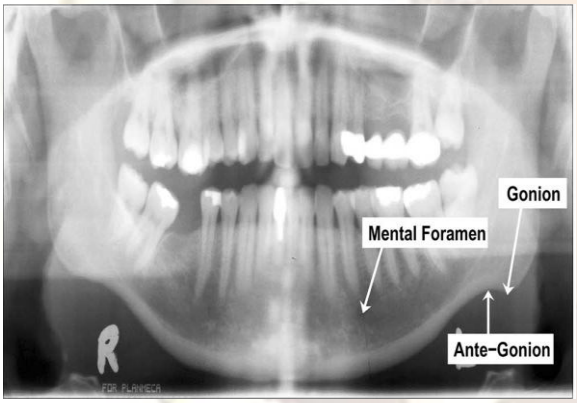

Figure 3: OPG of Normal Patient [1, 2]

Above figure shows an example of panoramic dental radiographs of a normal (non-osteoporotic) patient. The mental foramen is a hole in the mandible through which the mental nerve passes and which is faintly described on the DPT. The Gonion and Ante-Gonion are recognizable points where the curvature of the mandible changes. [1] Figure 4 shows schematic diagram of the right mandible point at which the inferior mandibular cortex thickness is measured by dentist (Mental Index MI)[1,2]

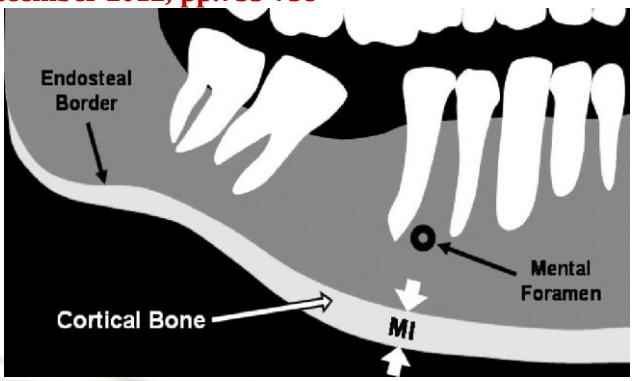

Figure 4: Schematic Diagram of the Right Mandible [1, 2]

Figure 5(A) shows portion of dental radiograph of the mandibular cortex in a normal (nonosteoporotic) patient. Figure 5(B) shows portion of dental radiograph of mandibular cortex for a patient with osteoporosis. Note the thinning of the inferior mandibular cortex in Figure 5(B) compared with figure 5(A). [1] Area shows by a green arrow in Figure 5 (A) is the area of interest. We can make out that, this area has been significantly decreased in Figure 5(B).

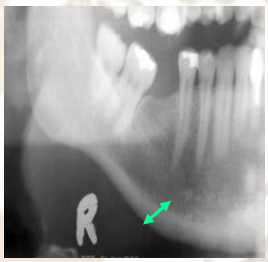

Figure 5(A): Normal Osteoporotic

Figure 5(B):

The results of bone density measurement are reported in T-score. T score is the bone mineral density at the site when compared to the young normal reference mean. T-score compares your bone density to the optimal peak bone density for your gender. Using the World Health Organization criteria, patients are defined as osteopenic if their T-score value is between –1 and -2.5 and osteoporotic if their T-score value is less than -2.5. [4, 19, 20, 23]

IV OSTEOPOROSIS DETERMINATION BASED ON OPG

Osteoporosis detection based on orthopentogram is explained in this section. Figure 6 shows the system block diagram. Panoramic digital x-rays are used for diagnosis of osteoporosis. Enhancing the image is needed for distinguishing cortical bone from other objects. For image enhancement histogram equalization algorithm is used to obtained new enhanced images with a uniform histogram. The enhancement method of

thresholding is used to assign a pixel to one class if its gray level is greater than a specified threshold and otherwise assign it to the other class for seperating objects from its background. The region around the mental foramen is assigned as the region of interest. [4, 5] We need to choose a region of interest , because processing the large size of original image may require a long computation time. Cortical Margin is determined .[4] For measurement of the distance between the upper and lower margins of the cortical bone Active Shape Model is used. Person is classified as having normal bone mineral density, osteopenia or osteoporosis. [1, 2, 21, 22]

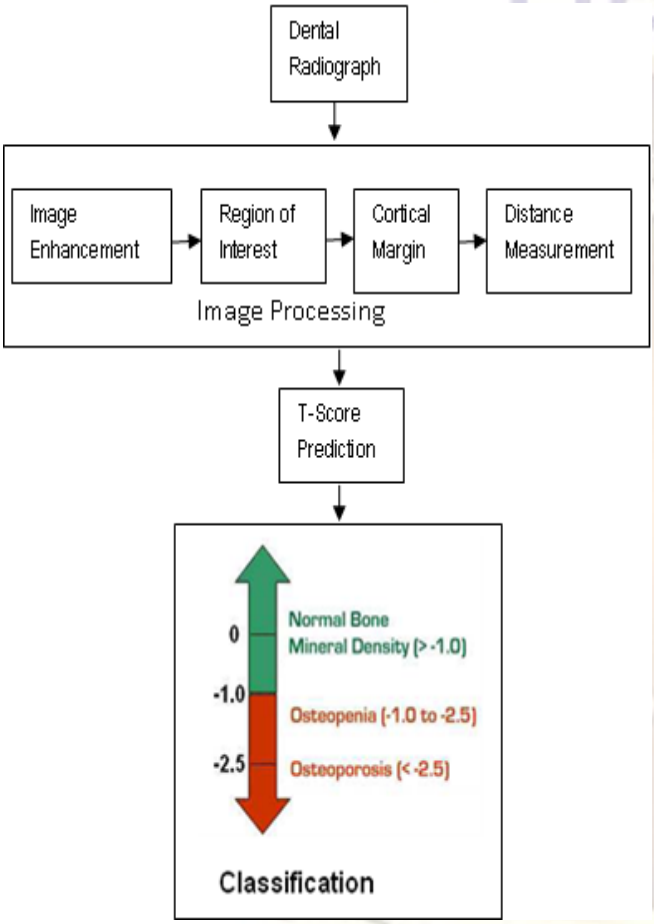

Figure 6: System Block Diagram

V. DISCUSSION

Osteoporosis is a general loss of bone mineral density and can lead to an increased risk of fracture. Although osteoporosis affects both men and women, the female population is the most affected by osteoporosis. A bone mineral density (BMD) test measures how much calcium and other types of minerals are in an area of your bone. Bone mineral density (BMD) tests are used to diagnose bone loss and osteoporosis, to see how well osteoporosis medicine is working and predict your risk of future bone fractures. Osteoporosis is determined for the women over 65 years or a man over age 70 years of age. Women under age 65 years and men ages 50 - 70 years are at increased risk for osteoporosis if they have broken bone caused by normal activities ("fragility fracture"), chronic kidney disease, eating disorders early menopause (either from natural causes or surgery), significant loss of height, strong family history of osteoporosis. In above mentioned cases doctors suggest to get the T score (measure of BMD) at hip, spine or at the wrist. The DEXA is the whole body scanning method which is most commonly used to detect T score at specific area such as hip, spine or at wrist. The method of osteoporosis prediction by using dental radiographs can give the T score at a specific area i.e. mandible. Determination of T score at any other area is not possible by this method.

VI. CONCLUSION

An approach for measuring the cortical width of the lower border of the mandible below the mental foramen on panoramic radiographs is used to predict osteoporosis. There is scientific evidence that the decrease in bone mass due to osteoporosis also affect the mandible. Because of high costs and limited availability of DXA equipment it is worthwhile to look for alternative diagnostic techniques for osteoporosis. The purpose of this study was to obtain a possible means of early detection of osteoporosis by radiographic examination, which is simple, and affordable by public as well as cost effective. In this work we first determine region of interest based on the position of mental foramen. Since we need to distinguish cortical bone from other object, image enhancement is done .For measurement of the distance between the upper and lower margins of the cortical bone Active Shape Model is used and then Person is classified as having normal bone mineral density, osteopenia or osteoporosis.

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