# Orthopantogram based Evaluation of Osteoporosis by Studying Jaw Bone Changes

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## ABSTRACT
Osteoporosis is characterized by compromised bone strength and is considered to be a silent disease that entails significant social and economic burdens. This disease causes reduction in weight and bone fractures. Dual X-ray Absoptiometry i.e. DXA is the commonly used technique to determine Bone Mineral Density. The high cost and limited availability of DXA necessitates looking for alternative diagnostic technique. Orthopantogram can be use for prediction of Osteoporosis. The person suffering with the osteoporosis has mandible with low mineral content. So Bone Mineral Density ( BMD ) of the mandible bone is related with osteoporosis that is low skeletal BMD. To predict osteoporosis the cortical width of the lower border of the mandible is to be measure. In this paper preprocessing work for measurement of cortical width for osteoporosis determination is discuss. Then the person can be classified as having normal bone mineral density, osteoporosis or osteopenia .

## Keywords
Osteoporosis, Bone Mineral Density, Osteopenia, Orthopantogram

## 1. INTRODUCTION
Osteoporosis is defined as a systemic skeletal disease characterized by decrease bone mass and strength along with micro architectural deterioration of bone tissue leading to bone fragility and increased susceptibility to fracture. Osteo means bone, porosis means full of holes i.e. osteoporosis means bones that are full of holes. Women tend to lose BMD more rapidly than men especially after the menopause. As a result osteoporosis is more common among women than men. Normally, body recycles old bone components to make new ones, and it also deposits other minerals and calcium into your bone to make them dense and hard. But your bones stop growing and gradually lose bone density after you turn 35. This means that the small holes in them get larger while the hard substance gets thinner. So your bones become more weaker, porous and susceptible to fractures and injury [1,2].

## 2. MATERIALS AND METHODS
There are different techniques used to measure bone mineral density. Four techniques are discussed in this section are as follows:

### 2.1 Quantitative Ultrasonography
Quantitative Ultrasonography measures the bone density of the trabecular bone at the heel. It has the advantage of being radiation-free, noninvasive, mobile and friendly to both user and patient, making it ideal for use in children. However, despite its advantages, this test is not yet a substitute for DXA for diagnosing and classifying osteoporosis nor for monitoring therapy. The precision of QUS is generally reported to be poorer than that of DXA.[4,5]

### 2.2 Quantitative Computed Tomography
Quantitative computed tomography (QCT) is most commonly applied to 2D slices in the lumbar spine to measure trabecular bone mineral density (BMD; mg/cm3). 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 [6].

### 2.3 Dual Energy X-ray Absorptiometry
Dual-energy X-ray absorptiometry (DXA, previously DEXA) is Gold Standard test to determine bone mineral density. It measures bone mineral density at hip and spine. It is considered the most accurate test for bone density. DXA method can predict changes after about a 1% change in BMD while standard x-rays show changes in BMD after about 40-45% of bone loss. The main disadvantage of this method is equipment is high cost, and often requires trained personnel to operate. [7, 8].

### 2.4 Dental Radiographs
Dental radiographs always depict some changes in mandible or maxillary bone and hence offer an opportunity for a screening tool for osteoporosis. There are different types of dental radiographs, bitewing, priapical and panoramic radiographs.

- Bitewing X-ray- Bitewing x-ray are most common type of x-rays , taken at routine check-ups.
- Periapical x-ray- It is specific type of x-rays and shows entire tooth, including root, crown and bone.
- Panoramic x-ray- It gives broad coverage of facial bone. It shows not only teeth also bone structure beneath the teeth

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.

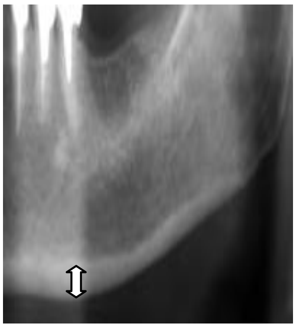


**Fig. 1(a) Normal**

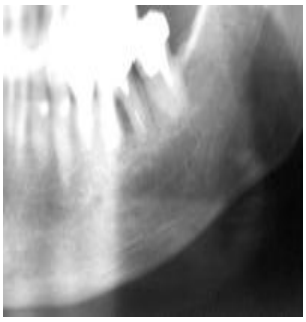


**Fig.1(b) Osteoporosis**

Figure 1(a) shows woman with normal left mandibular inferior cortex detected on dental panoramic radiograph. Figure 1(b) shows woman with severely eroded left mandibular inferior cortex detected on dental panoramic radiograph. Note the thinning of the inferior mandibular cortex in Figure 1(b) compared with figure 1(a). Area shown by a arrow in Figure 1(a) is the area of interest.

## 3. OPG Based Osteoporosis Determination

Osteoporosis detection based on orthopantogram is explained in this section. Figure 4 shows the system block diagram. Panoramic digital x-rays are used for diagnosis of osteoporosis. These radiographs firstly preprocessed for filter out unwanted background present with teeth. Then distance of cortical width is measured. After cortical width measurement the person is classified as suffering with osteoporosis, osteopenia or having normal bone mineral density.

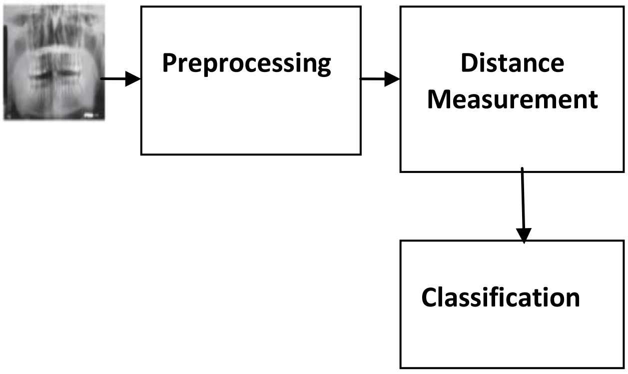



**Fig.2 System Block Diagram**

## 4. PREPROCESSING OF RADIOGRAPH

Preprocessing of radiograph includes resizing of image, image enhancement, edge detection and high pass filtering.

### 4.1. Image Resize:

We have chosen the size for the images as 200x620 pixels. Fig.3 shows resized image.

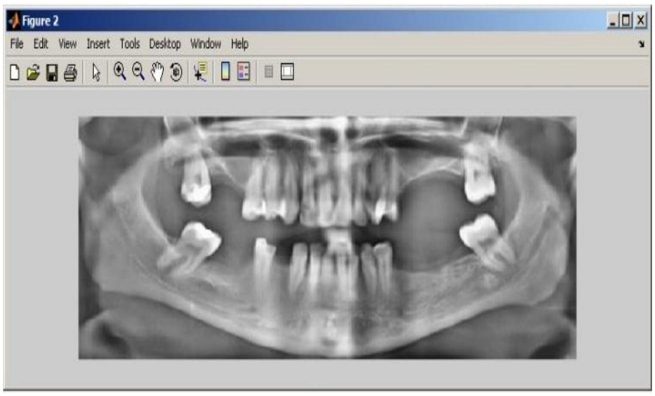



**Fig. 3 Resized Image**

### 4.2. Image Enhancement:

Image Enhancement refers to sharpening or accentuation of image features such as boundaries, edges or contrast to make a graphic display more useful for analysis and display. Histogram of resized grayscale radiograph is prepared. The histogram is a graph of number of pixel values versus gray levels. The histogram is shown in fig.4

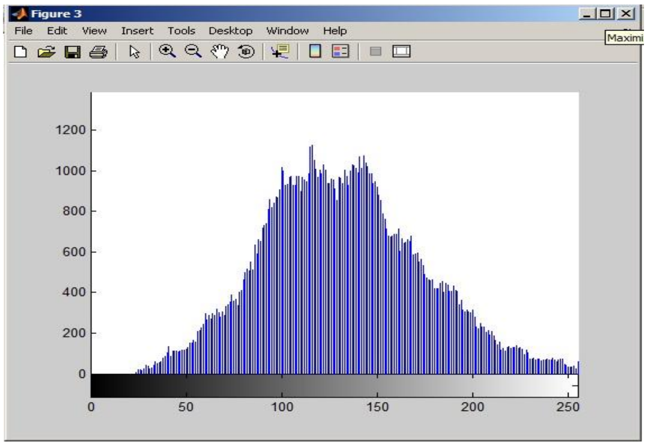



**Fig.4 Histogram of Grayscale Radiograph**

Histogram equalization is done for image enhancement. Histogram equalization is a method used to get uniform or equalized histogram. For any r in the [0,1] interval, transformation is:

$$S_k = T(r_k) = \sum_{j=0}^{k} p_r(r_j) = \sum_{j=0}^{k} \frac{n_j}{n}$$

For k=0,1,2,….L-1 where $S_k$ is the intensity value in the output image corresponding to value $r_k$ in the input image. Equalized histogram is $S_K$*L-1

Fig 5 shows histogram after histogram equalization.

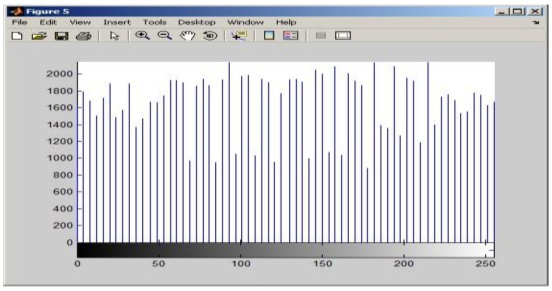



**Fig.5 Histogram of Histogram Equalization**

We get image after histogram equalization shown in fig.6 this can give us proper distribution of pixel values for further processing

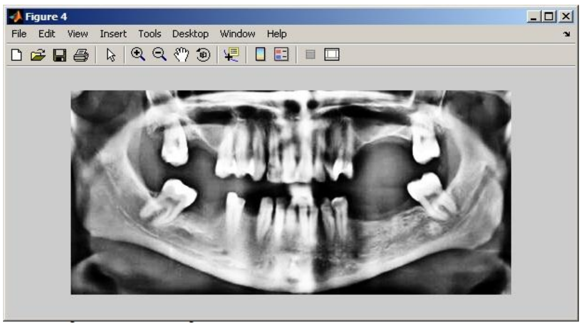



**Fig. 6 Radiograph after Histogram Equalization**

## 4.3. Specifying Region of Interest:

A region of interest is a portion of an image that you want to filter or perform some other operations. We can define a region of interest by creating binary mask, which is the binary image of same size.[10,11] The mask contains 1 for all the pixels that are part of the region of interest and 0 everywhere else. We get the ROI as shown in fig. 7.

**Fig.7 Region of Interest**

## 4.4 Edge Detection:

Edge detection is nothing but locating areas with strong contrasts. Edge detection significantly reduces the amount of data and filters out useless information, while preserving the important structural properties in an image. For edge detection we use Sobel operator.

### *4.4.1. Sobel Operator:*

Technically Sobel operator is a discrete differentiation operator, computing an approximation of the gradient of the image intensity function. The Sobel edge detector uses a pair of 3x3 convolution masks, one estimating the gradient in the x-direction (columns) and the other estimating the gradient in the y-direction. The Sobel masks are shown below

| | | |
|---|---|---|
| -1 | 0 | +1 |
| -2 | 0 | +2 |
| -1 | 0 | +1 |

a) Gx mask

| | | |
|---|---|---|
| +1 | +2 | +1 |
| 0 | 0 | 0 |
| -1 | -2 | -1 |

b) Gy mask

**Fig.8 Sobel Mask**

The magnitude of the gradient is calculated using the formula:

$$|G| = \sqrt{Gx^2 + Gy^2}$$

The angle of orientation of the edge is given by,

$$\theta = \tan^{-1}(Gy/Gx)$$

After Sobel applied on radiograph the output shown in fig.9.

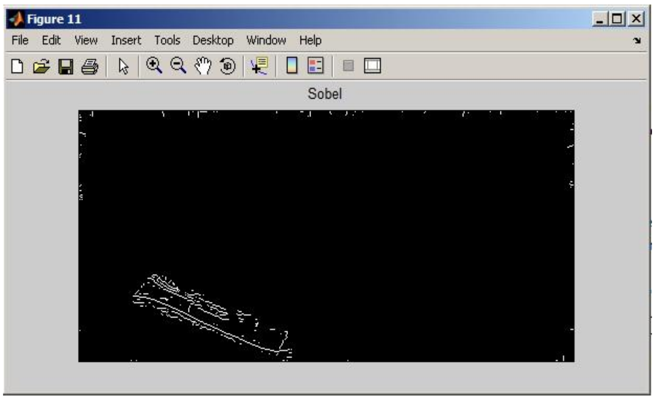



**Fig. 9 Sobel operator output**

## 4.5 High Pass Filtering:

Edges and fine detail in images are associated with high frequency components. High pass filtering sharpens the image by passing high frequencies and attenuating low frequencies. The transfer function for the high pass filtering is given by

$$H_{HP}(u,v) = 1 - H_{LP}(u,v)$$

High Pass Filtering output is as shown in fig. 15

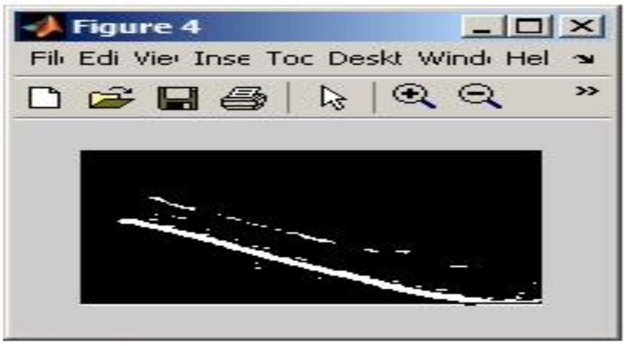
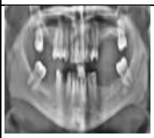
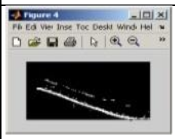
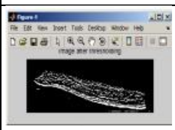
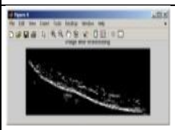



**Fig. 10 High Pass Filtering**

## 5. CONCLUSION

**Table 1. Comparative studies of BMD evaluation after high pass filtering**

| Sr. No. | Image | Result after High pass Filtering | Decision |
|---|---|---|---|
| 1 |  |  | Person is having Normal BMD (Non osteoporotic) |
| 2 |  |  | Person is having Low BMD (Osteoporotic) |
| 3 |  |  | Person is having Low BMD (Osteopenia) |

Preprocessing stage includes resizing of image, image enhancement, edge detection and high pass filtering. Image enhancement is done using histogram equalization. Histogram equalization gives better results. Sobel edge detector is used for edge detection. For sharpening the image High pass filtering is used. The above table contains OPG and results of high pass filtering of 3 different persons. After high pass filtering we can see the edges of cortical bone of mandible clearly of image 1 means we can say that person is having normal BMD. But for image 2 and 3 mandible is seems to be porous means person may have low bone mineral density. Future scope of this work will be measurement of cortical width and classification.

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## 7. REFERENCES

[1] Hisham I. Otham, Suliman A. Ouda, "Mandibular Radiomorphometric Measurement as Indicator of Possible Osteoporosis in Celiac Patients." JKAU: Med. Sci., Vol.17 no.2, 2010

[2] P. Danny Allen, Jim Graham, Damian J. J. Farnell, Elizabeth J. Harrison, "Detecting Reduced Bone Mineral Density From Dental Radiographs Using Statistical Shape Models ", IEEE Transaction On Information Technology in Biomedicine VOL. 11, NO. 6, November 2007.

[3] P. D. Allen1, J. Graham1, D. J. J. Farnell1, E. J. Marjanovic1, J. Adams1, "Detecting Osteoporosis. From Dental Radiographs Using Active Shape Models" IEEE conference publication 2007

[4] E. Micheals Lewiecki, Bradford Richmond, Chmond, Paul D. Miller, "Uses and misuses of quantitative ultrasonography in managing osteoporosis," Cleveland Clinic Journal Of Medicine Volume 73 Number 8 August 2006.

[5] Plauto Christopher Aranha Watanabe; João Paulo Mardegan Issa; Tatiane Martin de Oliveira; Solange Aparecida Caldeira Monteiro; "Morphodigital Study of the Mandibular Trabecular Bone in Panoramic Radiographs" Int. J. Morphol., 25(4):875-880, 2007.

[6] Klaus Engelke,Judith E. Adams,,b Gabriele Armbrecht,,b Peter Augat,,b Cesar E. Bogado," Clinical Use of Quantitative Computed Tomography and Peripheral Quantitative Computed Tomography in the Management of Osteoporosis in Adults" The 2007 ISCD", vol. 11, no. 1, 123e162, 2008 ,The International Society for Clinical Densitometry

[7] W Pulskiewiez, B Tarnawska, B Drozdzowska "Mandibular Bone mineral Density measured using dual X-ray absorptiometry " A British Journal of Radiology (2000)

[8] C.P. Ho, R.W. Kim, M.B. Schaffler and D.J. Sartoris, of the lumbar spine: Cadaver study", *Radiology*, vol. 176, pp. 171-173, 1990.

[9] M. G. Roberts, J. Graham, H. Devlin., Imaging Science and Biomedical Engineering, School of Cancer and Enabling Sciences, University of Manchester, UK. 2 School of Dentistry, University of Manchester, UK. , Improving ,"The Detecting Of Osteoporosis From Dental Radiographs using Active Appearance Models " 1424406722/07/$20.00 ©2007 IEEE

[10] M S Kavitha, Akira Asano BMC Medical Imaging 2012 ,"Diagnosis of osteoporosis from dental panoramic radiographs using the support vector machine method in a computer-aided system "

[11] Agus Zainal Arifin, Akira Asano, "Computer-aided system for measuring the mandibular cortical width on panoramic radiographs in osteoporosis diagnosis." Image processing, Vol.5747

[12] Diane Vernetti-Callahan, RDH, BS Continuing Education," Osteoporosis: Prevention, Management, and Screening Using Dental Radiographs"