

Comparison of Bone Mineral Densities Obtained From X Ray and Dexa Images

R.Sivakumar, R.Tamilselvi, S.R.Saranya, M.V.Supraja and K.Pournam

Department of Electronics and Communication Engineering, RMK Engineering College, Chennai

Abstract. Osteoporosis is a disease of the bones that leads to increased risk of fracture in pelvic girdle, femur, vertebrae and carpal bones. It is most common in women after menopause where it is called post menopausal osteoporosis. Osteoporosis is a condition characterized by a decrease in the density of the bone, decreasing the strength and resulting in fragile bones. Bones that are affected by osteoporosis can break with relatively minor injury that normally would not cause a bone to fracture. The spine, hips, ribs and wrists are common areas of bone fracture from osteoporosis although it can occur in almost any skeletal bone. Osteoporosis can be diagnosed by reduced bone mineral density, disrupted bone micro architecture and alteration in the amount and variety of proteins in bones.

In our proposed work we developed an algorithm to diagnose the osteoporosis related changes in the femur bone of women with the help of X-Ray images by measuring the bone mineral density in it. Also we compare the bone mineral density obtained from the DEXA images with the density obtained from the conventional X-ray image.

Keywords: Segmentation, Bone mineral density, dexa images

1. Introduction

Osteoporosis is defined as a progressive systemic skeletal disorder characterized by low bone mineral density (BMD), deterioration of the micro-architecture of bone tissue, and susceptibility to fracture. Osteoporosis is a disease where the bones become soft and weak making them susceptible to fractures. For an osteoporotic affected person simple activities such as coughing, sneezing, hugging, picking up the newspaper or lifting groceries can cause the bones to break. Osteoporosis is a disease of the bones that leads to increased risk of fracture in pelvic girdle, femur and the carpal bones. The spine, hips, ribs and wrists are common areas of bone fracture from osteoporosis although it can occur in almost any skeletal bone. [1]

More women die from osteoporosis related fractures than from cancers of the breast, ovaries & uterus combined. Men over 50 are at a greater risk of an osteoporosis related fracture than from developing prostate cancer. Approximately, 20% of women and 34% of men will die within one year from a hip fracture and 75% will have some form of permanent disability.

In the first 5 to 7 years after menopause, women can lose from 5% to 30% of their bone mass. Some 20% of women with a hip fracture will die in the subsequent year as an indirect result of fracture. About 20% of post menopausal women who experience a vertebral fracture, will suffer a new vertebral fracture of bone in the forthcoming year. In India alone 61 million people suffer from osteoporosis. 1 out of 2 women and 1 out of 5 men will sustain fractures due to osteoporosis. Canadians spend an incredible \$1.3 billion a year for the treatment of those stricken with this disease. Research estimates that as many as 40% of 50 year old women will suffer an osteoporotic fracture some time during their lives.

One in six women over the age of 70 will break a hip and one quarter will break a vertebra. 1.6 million hip fractures occur each year. That is equivalent to one every 20 seconds. By 2020, the world's population of seniors will double and by 2040, the number of osteoporotic fractures will triple the retina. However, if the vitreous is firmly attached to the retina when it pulls away, it can tear the retina and create a macular hole.

Risk factors for osteoporotic fractures include female sex, advanced age, low calcium intake, genetic factors, smoking, alcohol abuse, low BMD, low body weight, recurrent falls, personal history of fracture,

race or ethnic background, and inadequate physical activity. Osteoporotic fractures affect the vertebral body, distal radius, and proximal femur. An osteoporotic fracture occurs as a consequence of minimal injury. A major complication is a fracture of the femoral neck. About 20-30% of patients who have a femur neck fracture die within a year. Half of the survivors remain disabled to some degree. Osteoporosis causes increased economic and social costs and increased morbidity and mortality rates as a result of bone fragility and fractures. Direct financial expenditures for the management of osteoporotic fractures are estimated to be \$10-15 billion annually. [1]

2. Methodology

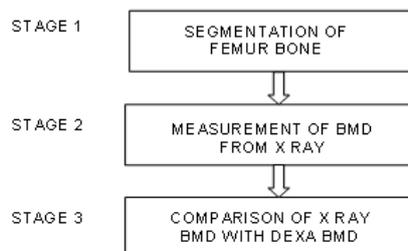


Fig. 1: Proposed System

To observe the bone loss in the femur due to osteoporosis doctors take up specific regions of the femur. These regions are: the neck, the ward, the trochanter and the shaft. To make the analysis easier we have segmented these regions in our femur X ray images and have taken them separately. First we have detected the edges using the Canny filter. For Canny algorithm, the object finds edges by looking for the local maxima of the gradient of the input image. It calculates the gradient using the derivative of a Gaussian filter. This algorithm is more robust to noise and more likely to detect true weak edges.

Then we have segmented the regions by masking. We defined an ROI by creating a binary mask, which is a binary image that is the same size as the image we want to process with pixels that define the ROI set to 1 and all other pixels set to 0. After segmenting out the regions, we calculated the areas in which we actually needed to measure the BMD. As the edges are clear it is easier to measure the area.

The area obtained was in pixels, so we used pixel conversion calculator to attain the area in centimeter square.

$$\text{For example, } 444(\text{in pixels}) = 11.74(\text{in cm}^2)$$

In DEXA images, the areas defined for the neck region is a rectangle, for the ward region it is a square and for the shaft and the trochanter it is a triangle. So we too wanted to take the same areas so that the comparison becomes flexible.

The formulae we used for measuring the above said area are as follows:

For neck: $\text{Areaofneck} = \text{length} \times \text{breadth}$. For ward: $\text{Areaofward} = \text{side} \times \text{side}$.

For shaft and trochanter: $\text{Areaoftroch} = \sqrt{[s \cdot (s-a) \cdot (s-b) \cdot (s-c)]}$

Where, a, b, c are the sides of the triangle

$$s = (a+b+c)/2$$

The next step in our project is measurement of the BMD from the calculated areas of the femur regions. The formula used to calculate BMD is

$$\text{BMD}(\text{in g/cm}^2) = \text{BMC}(\text{in g}) / \text{area of region}(\text{in cm}^2).$$

Where,

BMD=Bone Mineral Density, BMC=Bone Mineral Content

The area of region is obtained from our calculation whereas the BMC values of the normal femur and the osteoporotic femur is collected from doctors. From the collected BMC values it was able to calculate the BMD values. The BMD values were calculated for all the 25 osteoporotic images and 1 normal image.

It is not easy to collect a DEXA image and an X ray image of a same bone. So we categorized the bone into normal and abnormal and collected the range of values for those two images for a particular area. Based on the values the BMC for other images were calculated. The values are listed as follows

Table 1 Standard BMC values for normal femur

REGIONS	Areaofregion(in cm ²)	BMC(in g)
Neck	5.49	4.65
Ward	1.08	0.64
Trochanter	11.21	8.94
Shaft	20.75	23.40

Table 2 Standard BMC values for osteoporotic femur

REGIONS	Areaofregion(in cm ²)	BMC(in g)
Neck	5.33	3.4907
Ward	1.11	0.5325
Trochanter	12.58	6.3832
Shaft	24.03	18.763

3. Results

3.1 Femur image results

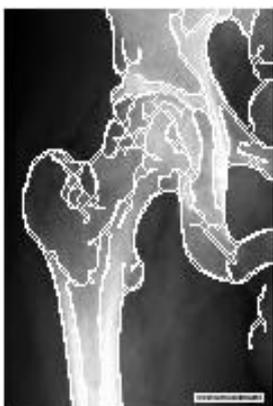


Fig. 2.1: Normal image

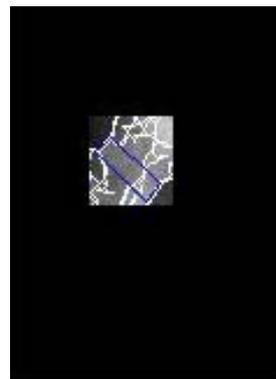


Fig. 2.2: Detected Edges



Fig. 2.3: Neck of normal femur



Fig.2. 4 : Ward of normal femur

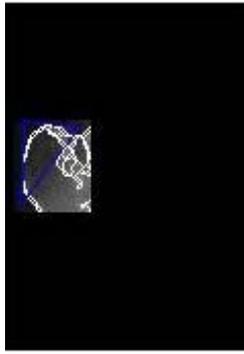


Fig. 2.5: Troch of normal femur

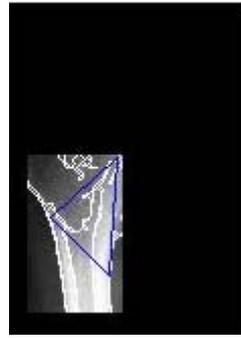


Fig.2.6: Shaft of normal femur

3.2 Osteoporotic femur image

BONE MINERAL DENSITY MEASUREMENT			
	BMC (in g)	AREA (in cmsquare)	BMD (in g/cmsquare)
NECK	7.4857	11.43	0.654917
WARD	2.8016	5.84	0.479726
TROCH	11.249	22.17	0.507397
SHAFT	20.0123	25.63	0.780815

STATUS OF THE BONE **OSTEOPOROTIC**

Fig. 3: Bone Mineral density measurement



Fig.3. 1: Osteoporotic image

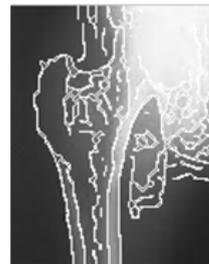


Fig. 3.2: Detected images



Fig.3. 3: Neck of osteoporotic femur



Fig.3.4: Ward of osteoporotic femur

Table 3: Comparison of BMD Obtained from X ray and DEXA Images

REG ION S	BMD(in g/cm ³)			
	NORMAL FEMUR		OSTEOPOROTIC FEMUR	
	DEX A image	X ray image	DEX A image	X ray image
Neck	0.847	0.846994	0.632	0.654917
Ward	0.593	0.59259	0.419	0.479726
Trochanter	0.797	0.7975	0.457	0.507397
Shaft	1.128	1.12771	0.787	0.780815

4. Comparison Charts

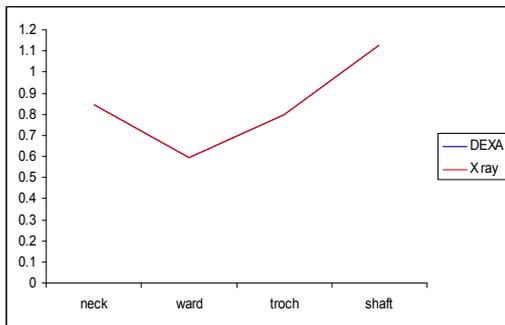


Fig. 4: BMD comparison chart – normal femur

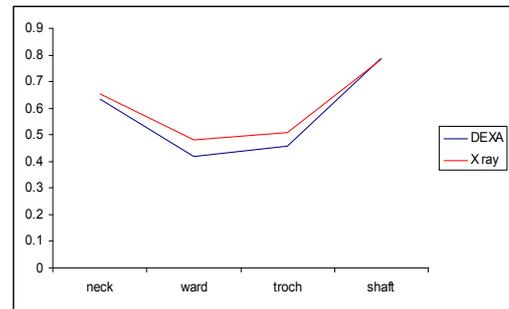


Fig.5: BMD comparison chart – osteoporotic femur

5. Results and Discussions

The proposed work deals with the comparison of bone mineral densities of the femur bone using DEXA and X-ray images. The proposed algorithm gives better result for X-ray image when compared with the DEXA image. The algorithm is analyzed with the 25 images. The results are analyzed for both normal and osteoporotic condition. The bone mineral densities graph shows that the proposed algorithm give better efficiency of 99% compared with DEXA images.

6. Conclusion

Thus we have measured BMD of right proximal femur from X ray images. It is much simpler than the DEXA method. The results show some promising correlations with the DEXA scan results both for normal and osteoporotic femur. The values of BMD from X ray and DEXA images show very less variations. The measurement is cost effective. As measurement of BMD is possible with the conventional X ray image, hospitals need not replace their X ray machines with high cost DEXA equipment to diagnose osteoporosis, especially to measure BMD. This would be of great use in rural hospitals. Moreover special training to personnel to handle the DEXA equipment is also not needed. So we can conclude that for economically weaker people we can recommend this method to detect osteoporosis.

7. References

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