

Alveolar Bone Changes in Post-menopausal Osteopenic and Osteoporosis Women: An Original Research

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ABSTRACT

Background: Osteoporosis is imposing public health burden especially in postmenopausal women and elderly population. It is leading cause of morbidity and mortality in postmenopausal women. Among multiple modalities of osteoporosis diagnosis, bone mineral density (BMD) is considered as a gold standard by WHO. **Aim:** Evaluate the alveolar bone changes in osteopenic and osteoporosis condition of postmenopausal women. **Materials and Methods:** Totally 1315 postmenopausal women were included in this study. All patients were evaluated by dual-energy X-ray absorptiometry for BMD and dental radiograph such as orthopantomography and radiovesiography. Among those women 72 were normal, 276 were osteopenic and 967 were osteoporotic. Mandibular cortical index (MCI), pixel intensity (PI), mandibular alveolar bone mass (MABM), and Alveolar bone resorption pattern (ABRP) were evaluated from the dental radiograph. Calculation of mean and standard deviation, as well as correlation and difference, were performed using SPSS 11.5 for Windows (Windows XP). **Results:** The changes in the MCI (C2 and C3) were more in osteoporotic condition (87.48%) rather than osteopenic (31.34%) and normal (12.50%). The numbers of presenting teeth were more in normal and osteopenic women rather than osteoporotic women. PI and MABM were significantly different from normal vs. osteopenic and osteoporosis, osteopenic versus osteoporosis. Horizontal ABRP was more in osteoporosis women (91.21%). **Conclusion:** Changes in postmenopausal alveolar bone were strongly correlated with the BMD of systemic skeletal bone. This combined relationship can be used as an easy diagnosis tool for innovations in osteoporotic condition.

Key words: Bone mineral density, dental radiology, dual X-ray absorptiometry, osteopenia, osteoporosis, postmenopause

INTRODUCTION

Osteoporosis is a medical disorder characterized by a generalized low bone mass and fragility with a consequent increase in fracture risk,^[1] particularly of vertebrae, hip, and wrist.^[2] It is a physiological

gender and age-related condition resulting from bone mineral content loss and structural changes in bones. There are two types of osteoporosis: (1) Postmenopausal osteoporosis caused by cessation of estrogen production and characterized by spinal fracture and (2) Osteoporosis that affect an older population and results in proximal femur fracture.^[3]

In future projection, the World population is expected to rise from the current 323 million individuals aged 65 years to more than 1.5 billion by the year 2050. These demographic changes alone can be expected to increase the number of hip fractures occurring worldwide. This incidence is estimated to rise from 1.66 million in 1990

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to 6.26 million in 2050.^[4] A conservative estimate of the worldwide direct and indirect annual cost of hip fracture for the year 1990 was 34.8 billion US dollar. This is set to rise to 131.5 billion in US dollars by 2050 (at a cost of 21000 per patient).^[4,5]

Osteoporosis diagnosis and staging are based on the identification of different risk factors, the most important being low bone mineral density (BMD) of the femoral neck or lumbar spine.^[6] WHO has been established four diagnostic levels of BMD: (1) The normal bone when t score is better than -1 (>833 mg/cm²). (2) Osteopenia when t score are between ≥ 1 and 2.5 (between 833 and 648 mg/cm²). (3) Osteoporosis when t score is <-2.5 (lower than 648 mg/cm²). (4) Established osteoporosis when non-traumatic fractures are included and t score is <-2.5 .^[7]

Suggestion have been made that panoramic radiograph that show progressive periodontal disease, alveolar bone, tooth loss and endosteal resorption of the mandibular inferior cortex may indicate general osteoporosis.^[5] The uses of panoramic radiographs are common a dental sitting. Digital radiographs are an increasingly popular option in the clinic. Such images are composed of the pixel with a specific numerical value for each one. Two important methods of evaluating the pixel in these images are a fractal dimension and pixel intensity (PI).^[8]

PI is a grayscale measure, ranging from 0 (black) to 256 (white) in a digital image. Areas of bone lose represented as darker areas while areas of the bone gain represented as lighter area.^[9]

The alveolar bone is a unique tissue representing the most viable part of the tooth-supporting apparatus. The alveolar process consists of an external plate of cortical bone, the inner socket of thick compact bone, and cancellous trabeculae interposed. Alveolar bone is intramembranous in origin and undergoes continuous remodeling by osteoblast and osteoclast activity.^[9,10]

Young alveolar bone is dense bone with smooth walled socket, while aged alveolar bone is osteoporotic with a rough, jagged socket wall; fewer viable cells in lacunae, marrow tissue infiltrated by fat cells and thus diminished tooth support.^[11]

Tooth function is a prerequisite for the maintenance of the alveolar bone and cementum. Loss of alveolar bone (metabolic disease/osteoporosis/aging/periods of

inactivity) is always accompanied by loss of periodontal fibers. Periodontal disease is among one of the oral problems that most extensively affect the human population, being one of the major cause for adult tooth loss.^[12]

Alveolar bone exists to support the teeth. Its structure varies between individual and generally it gets denser with age.^[11] Broadly, there is a dense bone wall near the gingivae and then middle spaces near the tooth apex.^[12]

Osteoporosis may arise in the context of other disease such as inflammatory bowel disease or primary biliary cirrhosis, as the result of medication, most commonly steroids or as a consequence of postmenopausal aging.^[13-15]

Many studies have cited the possible correlation between age, systemic osteoporosis, periodontal disease, tooth loss and changes in quantity and quality of bone of the maxillae and mandible. The restoration of occlusion for partially and the totally edentulous patient often requires adequate bone therapy. Consequently, the frequent use of implant supported prosthesis for elderly patient who are routinely or potentially osteoporotic demand a better understanding of the relationship between osteoporosis, the stomatognathic system. The purpose of this study was evaluating the alveolar bone changes in osteopenic and osteoporosis condition of postmenopausal women.

MATERIALS AND METHODS

Totally 1315 postmenopausal women were included in this study with the complained of osteoporotic symptoms. Patients with suspected conditions affecting bone mineralization or receiving any treatment affecting bone mineralization were excluded. All patients were evaluated by dual energy X-ray absorptiometry (DEXA) for BMD, and dental radiograph such as orthopantomography (OPG), radiovesiography (RVG). Among 1315 postmenopausal women 967 were osteoporotic, 276 osteopenic and 72 normal in condition.

Osteoporosis and Osteopenic were diagnosis by DEXA scans from Comilla Medical College, Bangladesh. BMD at lumbar spine and femoral neck were measured by DEXA scanner.

All Panoramic radiographs are obtained at the time of the DEXA scan from Central Medical College and

Hospital, Comilla. Some visual points were seen in panoramic radiograph there are as follows.

Direction of Bone Resorption

If bone loss is suggested on the films, it may be “horizontal” or “vertical” in character. Horizontal bone loss is indicated when the bone loss interproximally on two adjacent tooth, vertical bone loss is indicated when the bone crest is more apical to the cemento-enamel junction adjacent to one tooth than to other.

Mandibular Cortical Index (MCI)

Panoramic radiograph has been analyzed for MCI. According to Klemmitti *et al.* MCI is classification of appearance of the mandibular inferior cortex distal to the mental foramen, which includes the following criteria.¹⁶

- C₁: The endosteal margin of the cortex is even sharp on both sides of the mandible.
- C₂: The endosteal margin has semilunar defects (resorptive cavities) with cortical residues one to three layers thick on one or both sides.
- C₃: The endosteal margin consists of thick cortical residues and is clearly porous.

Digital Radiograph

After the clinical examination, periapical radiograph were taken by using RVG. RVG are manufactured by Gendex, USA. Vixwin Platinum image processing software is used for the measurement of gray level of bone. Digital periapical radiograph by RVG was used due to their minimal radioactive emission and high image quality that are not lost upon digitalization.

Mandibular Alveolar Bone Mass (MABM)

The MABM by the mean gray level values of the alveolar bone on the digital radiograph. The region of interests (ROIs) were set on the apical radiograph of the individual on the 6 mm step of the reference radiograph with “rectangular tool” avoiding the lamina dura and the most crestal locations. No apical bone was included.^[6] Then the PI were measured from low level to high level (by assigning the value 0 to black 256 to white). Areas of bone loss represent as darker while areas of the bone gain represented as lighter areas.^[6] MABM were evaluated from the mean value of PI. This obtained data are presented as mean \pm standard deviation (SD) and it was posted to the data sheet for statistical analysis.

Calculation of mean and SD, as well as correlation and difference, were performed using SPSS 11.5 for windows (Windows XP). $P < 0.05$ were considered to be statistically significant.

RESULT

The result showed that the BMD of lumbar spine and femoral neck were -0.76 ± 0.38 and -0.49 ± 0.34 respectively with PI level 81.40 ± 26.90 to 128.65 ± 31.92 , MABM were 104.5 ± 14 , horizontal alveolar bone resorption (HABR) were 48.61%, and mandibular cortical changes (MCI - C2 and C3) were 12.5% in normal postmenopausal patients. Whereas in osteopenic patients the BMD of lumbar spine and femoral neck were -1.88 ± 0.6 and -1.25 ± 0.73 respectively with PI level 70.02 ± 29.22 to 1113.25 ± 33.62 , MABM were 91.5 ± 12.84 , HABR were 72.10%, and mandibular cortical changes (MCI - C2 and C3) were 31.34%. But in osteoporosis patients the BMD of lumbar spine and femoral neck were -3.47 ± 0.99 and -2.73 ± 1.65 respectively with PI level 63.63 ± 28.37 to 104.73 ± 32.86 , MABM were 83.5 ± 12.27 , HABR were 91.21%, and mandibular cortical changes (MCI - C2 and C3) were 87.48%. In statistical analysis $P < 0.05$. All data showed BMD and dental radiographic finding were running parallel [Table 1].

DISCUSSION

In this study, we found that mean BMD in three types of condition were significantly different from each others. Other associated variables like age, weight and height were also significantly different ($P < 0.05$) except age when compare between normal and osteopenic patient ($P = 0.24$). Alterations in the mandibular alveolar bone (bone mass, PI, presenting teeth, alveolar bone resorption pattern [ABRP]) were related to the BMD level. The golden standard for fracture risk is BMD of the proximal femur measured with DXA.^[16] This study was to compare alveolar bone changes with skeletal bone change in postmenopausal patient.

PI changes

The PI of alveolar bone in normal postmenopausal patients was significantly different from osteopenic and osteoporosis patients. The minimum and maximum level of PI were reduced in both osteopenic and osteoporosis patients when compare to the normal postmenopausal condition [Tables 2 and 3]. In osteoporosis patients,

the minimum and maximum level of PI were reduced significantly from osteopenic patients [Table 4].

The deficit in bone formation in cortical bone result in increased number of lacunae and porosities and later on in thinner cortical plates,^[17-19] it leads to larger intertrabecular spaces and thinning of the trabeculae in the cancellous bone.^[20] When the cortices and trabeculae are thinner, and intertrabecular spaces are larger in a certain area (ROI), the mineral content is decreased, and therefore, also the PI was decreased.

Mandibular Alveolar Bone Mass

The mandibular alveolar mass of normal postmenopausal patient were significantly different from osteopenic and osteoporosis patients. MABM was reduced significantly reduced with the level of femoral and lumbar BMD. Although the MABM were calculated from PI, it is not mandatory to changes with PI. Because the changes in BMD were associated with changes in the PI of the mandibular alveolar bone measured between premolars, but not with changes in MABM.^[9] In other study showed the mandibular bone mass were improved with the parallel improvement of BMD after treatment with zoledronic acid.^[21]

Presenting Teeth

The number of presenting teeth in postmenopausal normal and osteopenic patients were not significantly difference. But in postmenopausal osteoporotic patients, the number of presenting teeth were significantly reduced when compare to the normal and osteopenic patients.

In another study, association between dental status and skeletal bone density were investigated in a group of 329 healthy postmenopausal women with normal bone density. Significant positive linear relationships were observed between number of teeth and BMD at the spine and radius.^[22] Some others study had establish a significant association between osteoporosis and tooth loss,^[23] mandibular bone mass, and tooth loss.^[19]

Mandibular Cortical Index

Several radiographic indices in the mandible on OPG have been developed to assess general skeletal BMD or osteoporosis status: MCI, PMI, gonial index (GI), antegonial index (AI), mental index (MI) and the ratio of alveolar bone height to basal bone height of the mandible.^[24-27] The general dental practitioner will

Table 1: Age, weight, height, lumber and femoral BMD

Variables	Age	Weight	Height	Lumber BMD	Femoral BMD
				t score (g/cm ²)	t score (g/cm ²)
Normal	54.47±6.55	60.63±9.52	152.75±7.01	-0.76±0.38 (1.10±0.10)	-0.49±0.34 (1.016±0.08)
Osteopenia	55.75±8.8	55.47±9.98	149.27±5.81	-1.88±0.6 (0.924±0.11)	-1.25±0.73 (0.887±0.12)
Osteoporosis	62.06±10.45	47.52±9.3	147±7.46	-3.47±0.99 (0.705±0.13)	-2.73±1.65 (0.668±0.13)

BMD: Bone mineral density

Table 2: Changes in normal postmenopausal patients versus osteopenic patients

Variables	Presenting teeth	PI (min)	PI (max)	MABM	MCI (C2 and C3) n (%)	HABR n (%)
Normal	28.37±4.52	81.40±26.90	128.65±31.92	104.5±14	9 (12.50)	35 (48.61)
Osteopenic	28.18±7.77	70.02±29.22	113.25±33.92	91.5±12.84	131 (31.34)	199 (72.10)
P<0.05	0.842	0.003	0.0005	0.0001		

PI: Pixel intensity, MABM: Mandibular alveolar bone mass, MCI: Mandibular cortical index, HABR: Horizontal alveolar bone resorption

Table 3: Changes in normal postmenopausal patients versus osteoporosis patients

Variables	Presenting teeth	PI (min)	PI (max)	MABM	MCI (C2 and C3) n (%)	HABR n (%)
Normal	28.37±4.52	81.40±26.90	128.65±31.92	104.5±14	9 (12.50)	35 (48.61)
Osteoporosis	24.91±8.25	63.63±28.37	104.73±32.86	83.5±12.27	846 (87.48)	882 (91.21)
P<0.05	0.0005	0.0001	0.0001	0.0001		

PI: Pixel intensity, MABM: Mandibular alveolar bone mass, MCI: Mandibular cortical index, HABR: Horizontal alveolar bone resorption

Table 4: Changes in osteoporosis patients versus osteopenic patients

Variables	Presenting teeth	PI (min)	PI (max)	MABM	MCI (C2 and C3) n (%)	HABR n (%)
Osteopenic	28.18±7.77	70.02±29.22	113.25±33.92	91.5±12.84	131 (31.34)	199 (72.10)
Osteoporosis	24.91±8.25	63.63±28.37	104.73±32.86	83.5±12.27	846 (87.48)	882 (91.21)
P<0.05	0.0001	0.0001	0.0001	0.0001		

PI: Pixel intensity, MABM: Mandibular alveolar bone mass, MCI: Mandibular cortical index, HABR: Horizontal alveolar bone resorption

tend to select women with C3 cortex rather than C1 and C2 cortex on OPG for identifying women with low BMD.^[28]

In our study, the mandibular cortex (C2 and C3) were more changes in osteoporotic patients rather than osteopenic patients. On the other hand, few numbers of normal postmenopausal patients had showed the mandibular cortical changes (C2 and C3). Determine the diagnostic validity of the MCI for the diagnosis of osteoporosis in peri and post-menopausal women, MCI had low sensitivity but high specificity for the diagnosis of osteoporosis.^[29]

Although some study could not find any correlation with the skeletal BMD,^[30] MCI is relatively simple because no measurements of calculation are required but it depends on visual assessment. Its repeatability has been evaluated and especially inter-observer agreement is reported to be poor.^[30,31] For this reason, single observer for MCI evaluation was used in this study.

Alveolar Bone Resorption Pattern

Horizontal bone resorption is the most common pattern of bone loss in periodontal disease.^[32] The present study showed the number of horizontal bone resorption pattern were increased in postmenopausal osteoporotic patients rather than osteopenic and normal patients.

The systemic influence on the response of alveolar bone has been termed as the “bone factor concept” in periodontal diseases.^[33] In recent years, lot of studies focused on the possible relationship between periodontal bone loss and osteoporosis.^[34]

CONCLUSION

Changes in the alveolar bone mass in postmenopausal women's were strongly correlated in this study with the BMD level of skeletal bone. Though BMD is the gold standard for diagnosis and follow-up of osteoporosis, Dental radiographical finding comprising of PI, MCI, MABM, and ABRP determination can be used as diagnostic tool in post-menopausal osteoporosis and osteopenic women and for follow-up. Hence, it was concluded that this combined relationship can be utilized as a logarithm for innovations in making a smooth diagnostic tools in post-menopausal osteoporotic women.

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