Original Article

Mandibular Cortical Index Can Be Possible Indicator of Osteoporosis in Postmenopausal Woman: A Prospective Study

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ABSTRACT

Objective: The consequences of aging often involve the risk of osteoporosis, leading to an impaired quality of life of the elderly patients specially postmenopausal women. Osteoporosis accounts 0.83% of non-communicable disease globally having significant health and economic impact. The aim of this study was to evaluate and correlate the changes of mandibular cortical bone with bone mineral density (BMD) in postmenopausal osteoporotic patient. **Materials and Methods:** 300 postmenopausal osteoporotic patients included in these study. All patients were evaluated by dual-energy X-ray absorptiometry for BMD, and orthopantomograph (OPG). Mandibular cortical index (MCI) was seen from OPG categorized into C1, C2, and C3 as the appearance of the mandibular inferior cortex distal to the mental foramen. The criteria of C1 endosteal margin of the cortex is even sharp on both sides of the mandible, C2 endosteal margin has semilunar defects (resorptive cavities) with cortical residues one to three layers thick on one or both sides, C3 endosteal margin consists of thick cortical residues and is clearly porous. **Results:** The result of this study was showed that mean femoral neck T-score in C1 group and C2 were 2.26 ± 0.81 versus 2.88 ± 0.73, respectively, ($P < 0.05$) that was statistically significant, lumbar spine T-score in C1 group and C2 were 2.49 ± 0.96 and 2.62 ± 0.72, respectively, ($P > 0.05$) was not statistically significant and mean femoral neck T-score in C2 group and C3 were 2.88 ± 0.73 *vs* 2.49 ± 0.96, respectively, ($P > 0.05$) that was not statistically significant, lumbar spine T-score in C2 group and C3 were 2.62 ± 0.72 and 3.21 ± 1.18, respectively, ($P < 0.05$) was statistically significant. MCI-C3 is almost perfect indicator of osteoporosis. **Conclusion:** Changes of MCI are correlated significantly ($P < 0.01$) well with osteoporosis variable. Simple, low-cost investigation OPG determining MCI may be helpful as diagnostic tool for osteoporosis.

Key words: Bone mineral density, dual-energy X-ray absorptiometry, mandibular cortex index, orthopantomograph, osteoporosis, radiovesiograph

INTRODUCTION

Osteoporosis is a medical disorder characterized by a generalized low bone mass and fragility with a consequent increase in fracture risk, particularly vertebrae, hip and wrist.[1] 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 the older population and results in proximal femur fracture.[2]

Charles Dent said that "senile osteoporosis is a pediatric disease," meaning that failure to achieve adequate peak bone mass during adolescence increase the risk of osteoporosis in later life.[3]

Alveolar bone is a unique tissue representing the most viable part of the tooth-supporting apparatus. The alveolar process

Access this article online	
Publisher	Website: www.renupublishers.com
RP	DOI:10.5958/2394-4196.2016.00014.5

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Submission: 24 Feb 2016; **Revision:** 24 Mar 2017; **Acceptance:** 28 Mar 2017

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.[4,5] 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 human population, being one of the major causes for adult tooth loss.[6]

At present, 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 lumber spine. The World Health Organization has been an established the diagnostic level of BMD < -2.5 for defined osteoporosis.[7] Suggestion has been made that panoramic radiograph that shows progressive periodontal disease, alveolar bone, tooth loss, and endosteal resorption of the mandibular inferior cortex (MIC) may indicate general osteoporosis.[4,8] The uses of panoramic radiographs are common in dental sitting. Morphology and functional oral sequel of aging are well documented in dental literature, but not those resulting from osteoporosis. 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.[9-11] The aim of this study was to evaluate the changes of mandibular cortical bone in postmenopausal osteoporotic patients.

MATERIALS AND METHODS

A total of 97 postmenopausal osteoporotic patients were selected for the study. For osteoporosis diagnosis, BMD of the lumbar spine and femoral neck were measured by dual-energy X-ray absorptiometry (DEXA) at Comilla Medical College, Comilla, Bangladesh. Panoramic radiographs of mandible were obtained simultaneously with DEXA scan. Panoramic radiograph has been analyzed for mandibular cortical index (MCI). According to Klemitti *et al.*, "MCI is classification of the appearance of the mandibular inferior cortex distal to the mental foramen," which includes the following criteria.[10] C_1: The endosteal margin of the cortex is even sharp on both sides of the mandible. C_2: The endosteal margin has semilunar defects (resorptive cavities) with cortical residues one to three layers thick on one or both sides. C_3: The endosteal margin consists of thick cortical residues and is clearly porous.

Statistical Analysis

Data were summarized as mean ± standard deviation. Group was compared by independent Student's *t*-test. Pearson correlation analysis was performed to assess the association between the variables. A two-tailed ($\alpha = 2$) $P < 0.05$ were considered statistically significant. Analyses were performed using SPSS 11.5 for Windows XP.

RESULTS

Table 1 shows baseline characteristics of the study population; mean age was 60.29 ± 9.55 years. Educational status of majority patients 64 (66.0%) were primary to secondary. Most of patients 87 (90.7%) were house wife. Majority 71 (73.2%) came from middle-class socioeconomic

Table 1: Baseline characteristics of the study population

Baseline characteristics	Frequency (%)
Age group (years)	
41-50	19 (19.6)
51-60	32 (33.0)
61-70	35 (36.1)
71-80	11 (11.3)
Mean±SD	60.29±9.55
Range	41-80 years
Educational status	
Illiterate	10 (10.3)
Primary	30 (30.9)
Secondary	34 (35.1)
SSC	17 (17.5)
HSC	4 (4.1)
Graduate	2 (2.1)
Occupational status	
Service holder	10 (10.3)
House wife	87 (90.7)
Socio-economic status	
Lower class	21 (21.6)
Middle class	71 (73.2
Higher class	5 (5.2)
Residential status	
Rural	66 (68.0)
Urban	31 (32.0)
Associated disease	
Diabetes mellitus	13 (13.4)
Hypertension	10 (10.3)
Coronary heart disease	4 (4.1)
Previous stroke	2 (2.1)
Dyslipidaemia	4 (4.1)
Endocrine disorder	4 (4.1)
Personal history	
Tobacco chewing	14 (14.4)
Smoker	3 (3.1)
Taking OCP	6 (6.2)
Family history	
Family history smoking	59 (60.8)
Family history diabetes mellitus	16 (16.5)
Family history hypertension	16 (16.5)
Family history IHD	2 (2.1)
Family history stroke	5 (5.2)

SD: Standard deviation, SSC: Secondary school certificate, HSC: Higher secondary certificate, OCP: Oral contraceptive pill, IHD: Ischemic heart disease

status and from rural area 66 (68.0%). Clinical presentation of the study population 13 (13.4%) presented with diabetes mellitus, 10 (10.3%) presented with hypertension, coronary heart disease, dyslipidemia and endocrine disorder 4 (4.1%), respectively. Personal history of smoking, tobacco chewing, oral contraceptive pill (OCP), diabetes mellitus (DM), hypertension (HTN), and ischemic heart disease (IHD) was 59 (60.8%), 14 (14.4%), 6 (6.2%), 16 (16.5%), and 2 (2.1), respectively.

Table 2 shows mean T-score of femoral neck and lumbar spine −2.93 ± 0.99 and 2.82 ± 1.05 of 97 patients, respectively [Figure 1].

Table 3 shows mean femoral neck T-score in C1 group and C2 were 2.26 ± 0.81 and 2.88 ± 0.73, respectively ($P < 0.01$), and the difference was statistically significant ($P < 0.01$). In contrast, lumbar spine T-score in C1 group and C2 were 2.49 ± 0.96 and 2.62 ± 0.72), respectively, but the difference was statistically insignificant ($P > 0.05$).

Table 4 shows mean femoral neck T-score in C1 group and C3 were 2.26 ± 0.81 and 2.49 ± 0.96, respectively, and the difference was statistically insignificant ($P > 0.05$). In contrast, lumbar spine T-score in C1 group and C3 were 2.49 ± 0.96 and 3.21 ± 1.18, respectively, and difference was statistically significant ($P < 0.01$).

Table 5 shows mean femoral neck T-score in C2 group and C3 were 2.88 ± 0.73 *vs* 2.49 ± 0.96, respectively, ($P > 0.05$) that was statistically insignificant. In contrast, lumbar spine T-score in C2 group and C3 were 2.62 ± 0.72 and 3.21 ± 1.18, respectively, and was statistically significant ($P < 0.05$) [Figure 2].

Table 6 shows in the correlation between osteoporosis and BMD (lumbar spine T-score and Femoral neck T-score) were determined. The Pearson *r*-values were −0.456 and −0.370, respectively, which was indicating negative (inverse) and significant ($P < 0.01$) correlation.

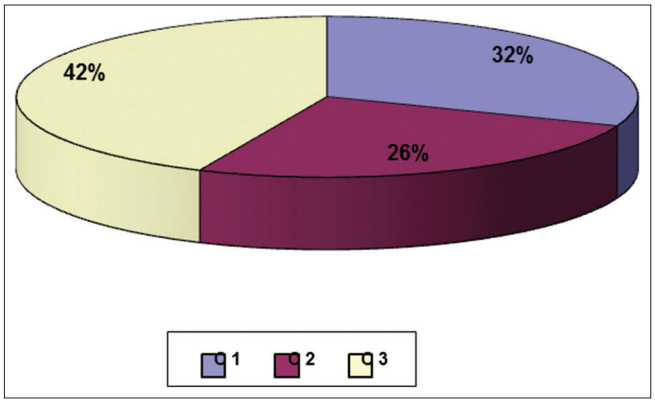

Figure 1: Distribution of different osteoporosis patient

DISCUSSION

Osteoporosis is a systemic skeletal disease characterized by low bone mass and micro architectural deterioration of the bone scaffold that result in increased bone fragility and susceptibility to fracture.[12] Osteoporosis has been recognized as an established and well-defined disease that affects more than 75 million people in the United States,

Table 2: Mean BMD T-score (*n*=97)

BMD findings	Mean±SD	Range (min-max)
Lumbar spine T-score	−2.82±1.05	−0.80 to −6.20
Femoral neck T-score	−2.93±0.99	−0.30 to −5.10

BMD: Bone mineral density, SD: Standard deviation

Table 3: Mean BMD score difference between C1 and C2 post menopausal osteoporosis patients

Variables	Study patients		*P* value
	C1	C2	
	Mean±SD (*n*=31)	Mean±SD (*n*=25)	
Lumbar spine T-score	2.49±0.96	2.62±0.72	0.58^{ns}
Femoral neck T-score	2.26±0.81	2.88±0.73	0.004**

BMD: Bone mineral density, SD: Standard deviation, NS: Not significant, **: *P* Value

Table 4: Mean BMD score difference between C1 and C3 postmenopausal osteoporosis patients

Variables	Study patients		*P* value
	C1	C3	
	Mean±SD (*n*=31)	Mean±SD (*n*=41)	
Lumbar spine T-score	2.49±0.96	3.21±1.18	0.007**
Femoral neck T-score	2.26±0.81	2.49±0.96	0.286^{ns}

BMD: Bone mineral density, SD: Standard deviation, NS: Not significant, **: *P* Value

Table 5: Mean BMD score difference between C2 and C3 postmenopausal osteoporosis patients

Variables	Study patients		*P* value
	C2	C3	
	Mean±SD (*n*=25)	Mean±SD (*n*=41)	
Lumbar spine T-score	2.62±0.72	3.21±1.18	0.028*
Femoral neck T-score	2.88±0.73	2.49±0.96	0.086^{ns}

BMD: Bone mineral density, SD: Standard deviation, NS: Not significant, *: *P* Value

Table 6: Correlation between osteoporosis and BMD T-score and Z-score

Variables	Correlations	*P* value
Lumbar spine T-score	−0.456**	<0.01
Femoral neck T-score	−0.370**	<0.01

**Correlation is significant at the 0.01 level (two-tailed). BMD: Bone mineral density

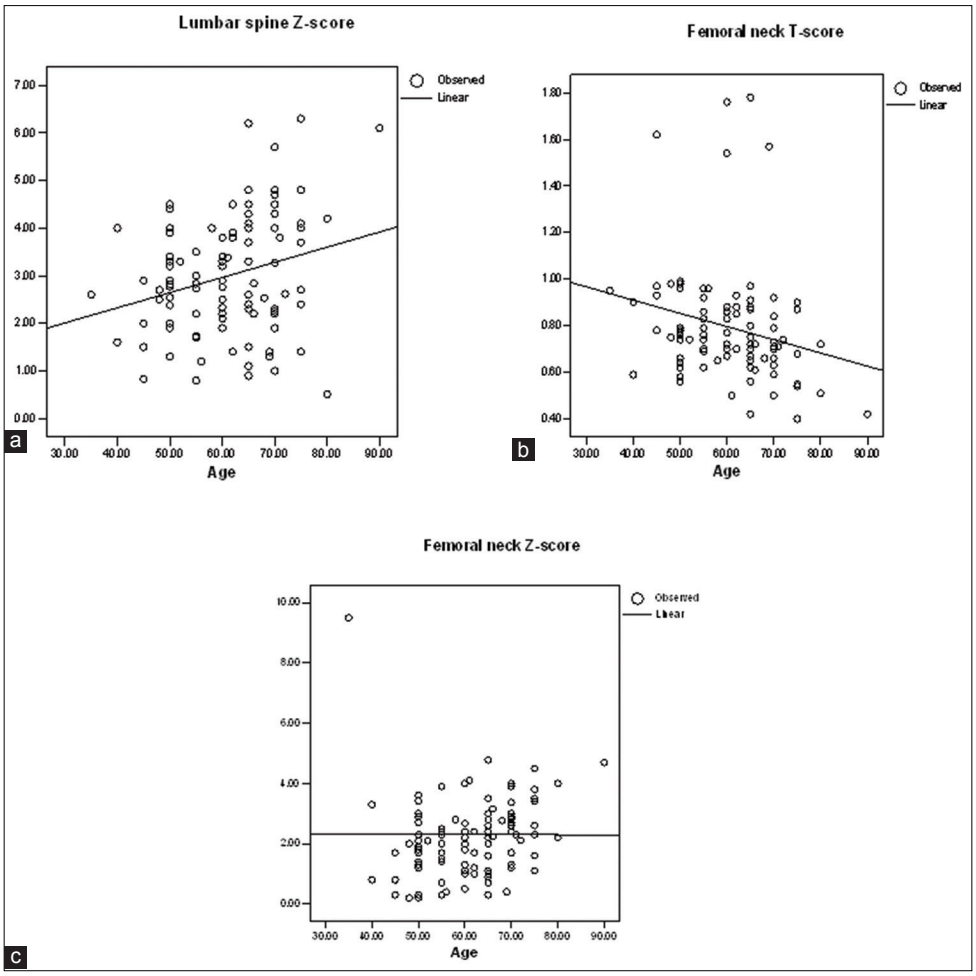

Figure 2: (a) Lumbar spine Z-score, (b) femoral neck T-score, (c) femoral neck Z-score

Europe and Japan. Osteoporosis causes more than 8.9 million fractures annually worldwide, of which more than 4.5 million occur in the Americas and Europe.[13] A highly conservative estimate by a group of experts suggested that 26 million Indians suffer from osteoporosis, and this number is expected to reach 36 million by 2013.[14] Osteoporosis occurs during the postmenopausal period due to low peak bone mass, accelerated bone loss after the menopause with ageing and a combination of both factors. There is an accelerated phase of bone loss in women after the menopause due to estrogen deficiency which causes uncoupling of bone resorption and bone formation, that the amount of bone removed during bone remodeling cycle slightly exceeds that which is replaced.[15] It was a descriptive observational study carried out in the Department of Medicine, Comilla Medical College Hospital, Comilla, Bangladesh from January 2014 to June 2014, 97 cases were included in the study. Osteoporosis may be occur in bone tissue as a result of ageing, after the age of 35 the BMD of men and women gradually decreases with increasing age. Women tend to lose BMD especially after the menopause since the disease is preventable, diagnostic techniques are of major importance.[16-19]

In this study shows demographic characteristics of the study population, mean age was 60.29 ± 9.55 years. Minimum age was 41 years and maximum age was 80 years of age. Compared with the other study showed mean age was both osteoporotic and normal were (70.40 ± 5.22) and (61.40 ± 4.41) years.[20] Gaur *et al.*, study showed the number of subjects in the age group of 40-49 years was 13 (32.5%), in the 50-59 years age group, it was 14 (35%) and in the 60-69 years age group, it was 13 (32.5%). A majority were in the osteoporotic (40%) group, followed by osteopaenic (37.5%) and normal (22.5%) groups.[21] A study done by Hardanti *et al.*, in 2011, to obtain the description of the mandibular bone quality of female patients between 40 and 60 years old and their differences based on mandibular cortical bone thickness measured using mental index.[22] In 2006, a study done by Taguchi *et al.*, to 158 healthy Japanese postmenopausal women aged 46-64 years for identifying women with low BMD or osteoporosis at either the lumbar spine or the femoral neck and concluded that cortical measurements detected on dental panoramic radiographs may be useful for identifying younger postmenopausal women with low BMD or osteoporosis so dentists should refer postmenopausal women with eroded cortex or thin

cortical width (<3.0 mm) for bone densitometry which was in conformity with Mohammed *et al.* study.[20,23] Hastar *et al.*, in 2011, was found there was statistically different mandibular cortical width in patients with osteoporosis and without osteoporosis ($P < 0.05$) by panoramic radiographs of 487 elderly dental patients (age range 60-88 years) which is in agreement with our finding.[24] A study done by Roberts *et al.*, in 2011, to evaluate the mandibular cortical width of 4,949 dental panoramic tomograms, in patients aged 15-94 years and found that the pattern of decrease in mandibular cortical width with age was similar to the known pattern of bone loss from the hip, accelerating in women after the age of 42.5 years.[25]

In this study, 13 (13.4%) had present with diabetes mellitus, 10 (10.3%) had present with hypertension, coronary heart disease, dyslipidaemia and endocrine disorder were 4 (4.1%) each. Smoker was 3 (3.1%). And showed family history of smoking, tobacco chewing, OCP, DM, HTN, and IHD were 59 (60.8%), 14 (14.4%), 6 (6.2%), 16 (16.5%), and 2 (2.1%), respectively.

In this study, mean femoral neck T-score and lumbar spine T-score were −2.93 ± 0.99 and −2.82 ± 1.05, respectively. Mean femoral neck T-score in C1 group and C2 were 2.26 ± 0.81 versus 2.88 ± 0.73, respectively, ($P < 0.05$) that was statistically significant; lumbar spine T-score in C1 group and C2 were 2.49 ± 0.96 and 2.62 ± 0.72, respectively, ($P > 0.05$) was not statistically significant. Mean femoral neck T-score in C1 group and C3 were 2.26 ± 0.81 versus 2.49 ± 0.96, respectively, ($P < 0.001$) that was statistically significant; lumbar spine T-score in C1 group and C3 were 2.49 (± 0.96) and 3.21 (± 1.18), respectively, ($P < 0.05$) was statistically significant. Mazumder *et al.*, in 2014, studied in Department of Medicine, Comilla Medical College, Bangladesh. They showed the lumbar spine and femoral neck BMD were 0.706 ± 0.11 and 0.723 ± 0.12, 0.743 ± 0.15 and 0.694 ± 0.11, respectively, in osteoporotic patient (Group A), treated osteoporotic patient (Group B). Those were statistically non-significant.[15]

Balcikonyte *et al.*, study showed the distribution of cortical changes C1-C3 in skeleton groups. The distribution of cortical changes C1-C3 in T-score groups. The means of the BMD values and the means of T-score values in the groups C1-C3 were compared. According to the Pearson correlation coefficient, MCI correlated positively with the height of cortical bone and with the BMD ($P < 0.01$). Correlations between the height of cortical bone and BMD inside the groups and between T-score groups were high significant ($P < 0.01$).[26]

In the Gaur *et al.*, study, no significant relationship was observed between alveolar index and low bone mass density ($P = 0.135$), which was contradicting to the results of Ledgerton *et al.* and Mahl *et al.*[21,27,28] According to Bras *et al.*, the relatively constant thickness of cortical bone at the mandibular angle, following the adolescent growth spurt and the decrease in cortical thickness in postmenopausal women, suggested that the cortical thickness may be useful as a parameter for evaluating metabolic bone loss.[29] In Gaur *et al.*, study also, there was a significant difference in the mean GIs of the three groups, which had $P = 0.00$.[21] This result was in accordance with those of the other studies which were done by Miliuniene *et al.*[30] and Mahl *et al.*[28] One of the most commonly studied parameters of mandibular bone with respect to osteoporosis is the porosity of the mandibular cortical bone. Results of our study showed a significant correlation between the skeletal BMD and MCI ($P < 0.001$). A study which was done by Horner and Devlin on 40 edentulous females showed a significant correlation between BMD and MCI, but there were problems in repeatability of assessments, which could limit their use in clinical practice.[31] Taguchi *et al.* reported that subjects with severely eroded cortices had significantly lower vertebral BMDs than those with mildly to moderately eroded cortices or normal cortices. The study of Yasar and Akgunlu.[32,33]

In this study showed, the correlation between osteoporosis and BMD (Lumbar spine T-score and Femoral neck T-score) were determined. The $r = -0.456$ and 0.37, respectively, which was indicating negative correlation. The $P < 0.001$ showing statistical significance. In 2006, Arifin *et al.* investigated panoramic radiographs of 100 postmenopausal women who had BMD assessments of the lumbar spine and the femoral neck were used in this study mandibular cortical width below the mental foramen was measured.[34] Cortical width measured by computer-aided system was compared with BMD of the lumbar spine and the femoral neck. There were statistically significant correlation between cortical width measured by the computer-aided system and spinal BMD ($r = 0.50$) and femoral neck BMD ($r = 0.54$). These correlations were similar with those between cortical width by manual measurement and skeletal BMD.

Kavitha *et al.*, study also showed there were significant correlations between the cortical width derived from this system and BMD at the lumbar spine and femoral neck. The correlation coefficient for identifying women with low spinal BMD and femoral neck were ($r = 0.43$, $P < 0.001$) and ($r = 0.48$, $P < 0.001$) on the right side of mandibular cortical width, however, on the left side of cortical width it was ($r = 0.51$, $P < 0.001$) and ($r = 0.49$, $P < 0.001$), respectively.[35]

A study by White *et al.*, and another by Drozdzowska *et al.*, demonstrated that a cortex thickness of 4 mm can be used to distinguish abnormal BMD from normal BMD.[36,37] A mandibular angle cortex height of 4 mm was recognized by Drozdzowska *et al.* as a cutoff threshold with a sensitivity of 21% and a specificity of 81%.[37] The specificity of that study is agreement with the specificity of the present study,

but there is a large difference between the sensitivity of the two studies; this could be due to a difference in the area of measurement. Devlin and Horner also recommend that a cutoff threshold of 3 mm of mandibular angle cortex with a sensitivity of 20% and a specificity of 100% should be considered for the diagnosis of osteopenia, and that a cutoff threshold of 3 mm with a sensitivity of 25.9% and a specificity of 93.6% should also be considered for the diagnosis of osteoporosis.[38] In this regard, Arifin *et al.* recommended that the cutoff threshold value of the mandibular angle cortex should be 3.08 mm for men and 2.69 mm for women;[34] these values were much closer to the results of this study. A cutoff threshold value of 2.85 mm for men and 2.75 mm for women was determined by ROC analysis in the current study for recognition of osteopenic and osteoporotic individuals. The studies previously undertaken by Devlin and Horner, Taguchi *et al.* and Ishii *et al.*, Drozdzowska *et al.*, White *et al.*, and also Arifin *et al.* demonstrated that the determined cortical measurements from panoramic radiography could be used for the diagnosis of menopausal women with a reduced BMD or with osteoporosis.[33,34,36-39] The results of these studies confirmed that dentists should refer patients with a thin or eroded cortex for a specialist consultation for osteoporosis diagnosis to internist or orthopedic surgeon. The results of this study are also similar to the above mentioned studies. In dental panoramic radiography, which is used for the primary evaluation of teeth and adjacent areas, is also available for more anatomic landmark investigations for osteoporosis. Dentists are able to refer patients at risk of decreased BMD and osteoporosis for bone densitometry on the basis of incidental findings in panoramic radiographs. This study indicates that the detection of the MCI could be useful for identifying individuals who are at risk of having osteoporosis and correlates well with decreased BMD. Hence, MCI determination can be alternative tool for the diagnosis of osteoporosis in comparison with BMD. The all the authors contributed in the study and writing the article.

CONCLUSION

Changes of MCI are correlate significantly well with osteoporosis variable. Simple, low-cost investigation orthopantomograph determining MCI may be used as diagnostic tool for osteoporosis. Study should be conducted on large sample size for take accepted decision.

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How to cite this article: Mazumder MI, Shakib N, Harun MASI, Al-Amin M, Ahmed T. Mandibular Cortical Index Can Be Possible Indicator of Osteoporosis in Postmenopausal Woman: A Prospective Study. Int J Dent Med Spec 2016;3(4):3-9.

Source of Support: None; **Conflict of Interest:** None