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Panoramic Radiographs in Assessment of the Bone Mineral Density

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SUMMARY

Efficacy of two panoramic-based indices (Mandibular Cortex Index (MCI) and the height of mandibular inferior cortex (CI)) were compared with a bone mineral density (BMD) of the lumbar area L2-L4 by dual-energy x-ray absorptiometry in 130 women as diagnostic key. MCI is a simple three-graded classification. It changes in the bone cortex of mandible and allows to distinguish normal and osteopenic/osteoporotic women. Correlations between mandibular cortex groups and between the height of cortical bone of mandible and the bone mineral density were significant. The efficacy of the panoramic-based mandibular indices in diagnosing osteopenia/osteoporosis is high. The results of this study indicated that panoramic dental radiographs should be used to assess the patient's status regarding osteoporosis.

Key words: mandible, radiography, panoramic, bone mineral density, osteoporosis, diagnosis.

INTRODUCTION

In human beings, the loss of bone mass with increasing age is a universally observed phenomenon [1]. Human bones decrease in density and increase in porosity beginning at about the third decade of life [1,2,3,4,21]. Osteoporosis, the most common metabolic bone disease, is characterized by low bone mass, microarchitectural weakening leading to bone fragility and an increase in fracture risk [5, 6, 8]. Osteoporosis affects a large portion of the elderly population.

The earliest suggestion of an association between osteoporosis and oral bone loss was made in 1960 [7]. The effect of general mineral loss of skeleton, osteoporosis, on the jawbones has been studied intensively, especially with new radiologic methods. These methods, such as single-photon absorptiometry (SPA), dual-photon absorptiometry, . single-energy x-ray absorptiometry (SXA), dual-energy x-ray absorptiometry (DXA or DEXA), radiographic absorptiometry (RA), quantitative ultrasound (QUS), ultrasound densitometry (USD) and quantitative computed tomography (QCT), that measure bone mineral density (BMD), bone mineral content (BMC), or bone mass have developed rapidly during the last two decades [8]. The above mentioned methods are expensive to use and are often unavailable to ordinary practitioners. With technology currently available in the dental office, dentists do not have an efficient preliminary, noninvasive method of identifying patients with osteoporosis.

The panoramic radiograph is widely used for routine examinations, especially for edentulous patients before the construction of a complete denture. It would be very useful to answer whether radiographic changes in the mandible indicate skeletal osteopenia and could have a role in the detection of osteoporosis.

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Some authors concluded that panoramic dental radiographs should not be used to assess the patient's status regarding osteoporosis [12, 15, 16, 17, 18] or could be reliable in screening for osteoporosis [10, 16, 19, 20].

The aim of this study was to evaluate the diagnostic efficacy of the panoramic based mandibular indices and to determine whether they correlate with bone mineral density (BMD) of the lumbar area.

MATERIAL AND METHODS

In this study, 130 women aged 30.1-79.2 yr (mean 60.4), living in Lithuania, were examined. The study was approved by the local ethics committee and informed consent was obtained from all subjects. Every fifth woman consulting a doctor in the National Osteoporosis Center, were recruited. None of the participants were known to have endocrine, metabolic, skeletal disorders. None of women were on hormonal replacement therapy (HRT) or taking calcitonin, bisphosphonates or fluorides except of low doses of calcium or vitamin D.

The values for bone mineral density of the lumbar area L2-L4 were determined by a dual-energy x-ray absortiometry apparatus, Lunar DPX (Lunar Corporation, Madison, WI, USA) by the same operator. Each women was classified into one of three (OST 1-3) groups according to the bone mineral density (OST1 from 0.67 to 0.93; OST2 from 0.94 to 1.19 and OST3 from 1.20 to 1.46) and into three groups according to T-score (T-score 1-3) according to WHO. T-score groups were assessed according to the following criteria: T-score 1 (osteoporotics) defined as T-score more than 2.5 SD below above the normal young female value, group T-score 2 (osteopenics) defined as T-score ranging from 1 to 2.5 SD below value and group T-score 3 (normals) defined as a T-score to 1 SD below the normal young female value.

The mandibles were examined on panoramic images taken with radiographic apparatus ORTHOPHOS 3 (Sirona, Germany) by single operator. The position of the head was standardized as much as possible. Each panoramic radiograph was viewed by the same investigator in a blinded fashion. Measurements of CI were made with an odontometer. A magnification loupe with frames (SDI, Sweden) creating a dark setting was used. On the both sides of mandible two measurements were recorded:

1. The height of the mandibular inferior cortex (CI);
2. Mandibular Cortical Index (MCI).

According to Klemetti *et al.* classification [18] all women were divided into three groups based on findings of Mandibular Cortical Index (MCI), whic is a three-point index (C1-C3) based on the appearance of the lower border of mandibular cortex distally from the mental foramen, as viewed on panoramic radiographs. MCI was assessed according to the following criteria: C1) the endosteal margin of the cortex was even sharp on both sides; C2) the endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one or two layers) on one or both sides; C3) the cortical layer formed heavy endosteal cortical residues and was clearly porous.

The results of the study of panoramic images were compared with the skeletal mineral status grouping (OST 1-3) and T-score grouping (T-score 1-3) of the subjects. All statistical analyses were performed using STATISTICA for Windows. The data were expressed as mean and standard deviation. Analysis of variance (ANOVA) was performed to determine group differences in bone mineral density. Person correlation coefficients were used to identify relationship between variables. P values were considered to be statistically significant.

RESULTS

In this study, 130 women were examined. 26.2% (n=34) of them have normal bone mineral density (BMD), 2.3% (n=3) BMD was above normal, 49.2% (n=64) were osteopenic and 22.3% (n=29) have osteoporosis.

According to Klemetti *and all.*[18] classification women were divided in to three groups C1, C2 and C3. 13.9% (n=18) of them had the endosteal margin of the cortex even sharp on both sides (C1), in 61.5% (n=80) the endosteal margin showed semilunar defects (lacunar resorption) or seemed to form endosteal cortical residues (one or two layers) on one or both sides (C2) and in 24.5% (n=32) the cortical layer formed heavy endosteal cortical residues and was clearly porous.

The distribution of cortical changes C1-C3 in skeleton groups is presented in Table 1.

From 130 examined women 22.3% (n=29) were defined as osteoporotics, 49.2% (n=64) were defined as osteopenics and 28.5% (n=37) were defined as normals. The distribution of cortical changes C1-C3 in T-score groups is presented in Table 2.

The means of the bone mineral density (BMD) values and the means of T-score values in the groups C1-C3 were compared. Findings are represented in Table 3.

The distribution of the mean value of height of cortical bone from left and right sides of mandible are shown in Table 4.

According to the Person correlation coefficient, MCI correlated positively with the height of cortical bone (CI) and with the BMD ($p<0.01$). Correlations between the height of cortical bone and bone mineral density inside the groups and between T-score groups were high significant ($p<0.01$).

Table 1. Observed frequencies of cortical changes (C1-C3) in skeletal mineral density groups (OST 1-3).

Groups \ OST	OST1	OST2	OST3	Total
C1	-	7	11	18
C2	4	70	6	80
C3	24	8	-	32
Total	28	85	17	130

Table 2. Observed frequencies of cortical changes (C1-C3) in the T-score groups (T-score1-3).

Groups \ T-score	Osteoporosis	Osteopenia	Normal	Total
C1	-	1	17	18
C2	4	56	20	80
C3	25	7	-	32
Total	29	64	37	130

Table 3. The means of the bone mineral density (BMD) and the of T-score values in the groups C1-C3.

MCI groups	N	BMD mean ± SD	T-score mean ± SD
C1	18	1,2351±9,279E-02	0,3722±0,7843
C2	80	1,0405±0,1133	-1,2425±0,9513
C3	32	0,8637±7,802E-02	-2,7313±0,6438
Total	130	1,0239±0,1524	-1,3854±1,2759

DISCUSSION

In previous panoramic studies, mineral changes in jawbones have been measured by determining the area of the cortex and the visible trabeculae of the spongiosa and then comparing these areas with the total area of the mandible on the images. Real or proportional heights of the cortex and the remaining bone have also been measured in different regions of the jaws, often at the mental foramen.

These methods are not accepted by all researches. The varying shadows of soft tissues as well as particular kilovoltage (kV) and exposure (mAs) for each patient affect the resulting images. The difficulty of standardizing the position of the head leads to projection errors on the radiograph. Due to this it may be difficult to locate the mental foramen in x-ray images [28, 29]. Mineral loss the mandibular cortex seems to depend on the speed of mineral loss in the skeleton and on the age [30]. It has been reported that regions distal to the mental foramen, the buccal cortex correlate better with skeletal mineral density values than the lingual portion [16]. If classes C1-C3 were detected buccally on occlusally projected intraoral films, the sensitivity and specificity in diagnosing osteoporosis might be better than on panoramic images.

By using QCT, Kribbs *et al.* [31] found that in elderly mandibular density does not correlate with any skeletal

Table 4. The mean values of height of cortical bone (CI) in the right an left sides of mandible in groups C1-C3.

MCI Groups	The height of cortical bone of mandible in right and left sides (CI)									
	N		Mean±SD		SE		Minimum		Maximum	
	R	L	R	L	R	L	R	L	R	L
C1	18	18	4,6222±0,9503	4,4500±0,9192	0,2240	0,2167	2,80	2,50	6,10	5,80
C2	80	80	3,4612±1,2625	3,6625±1,1531	0,1411	0,1289	0,90	1,40	7,30	6,20
C3	32	32	2,4594±1,1951	2,4219±1,0661	0,2113	0,1885	0,60	0,60	5,60	5,10
Total	130	130	3,3754± 1,3667	3,4662± 1,2760	0,60	0,60	7,30	0,60	7,30	6,20

measurements except vertebral bone, although even this correlation was not significant. On he other hand, according to von Wowern *et al*. [32], there is no relationship between mandibular and the lumbar spine bone mineral content (BMC).

In our study significant positive correlation between the height of the mandibular cortex and the mineral density in the skeleton was found. These findings were partly due to successful standardization of head positioning, which in normal practice is very difficult when images are taken by different practitioners at different times. Our study suggests that if there are changes in cortex groups (C1-C2) and if the inferior mandibular cortex is low, the tendency toward osteoporosis is high. The results of this study mainly confirm that panoramic x-ray images yield suitable information for diagnosing osteoporosis risk. It is statistically possible to show positive correlations and dependencies between the mineral density of the skeleton and changes in the mandibular cortex shown on panoramic x-ray images. Our study indicates that the osteoporosis risk for a single person can be diagnosed with certainty by using panoramic x-ray images.

CONCLUSIONS

Mandibular Cortical Index is a simple three-graded classification of changes in the bone cortex, which is enable to distinguish normal and osteopenic/osteoporotic women. Correlations between mandibular cortex groups also between the height of cortical bone of mandible and the bone mineral density were significant. The efficacy of the panoramic-based mandibular indices in diagnosing osteopenia/osteoporosis is high.

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