CLINICAL INVESTIGATIONS

The relationship between panoramic radiomorphometric indices of the mandible and calcaneus bone mineral density

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Key words: *calcaneus; mandible; osteoporosis; panoramic radiomorphometric indices; DXL Calscan.*

Summary. *Objective. The aim of the study was to determine the relationship between bone mineral density in the calcaneus measured using the dual x-ray and laser osteodensitometry technique and bone mineral density in the mandible calculated using the panoramic radiomorphometric indices obtained by applying linear measurements in panoramic radiograms of postmenopausal women.*

Material and methods. The participants of this study were postmenopausal women (n=129) aged 50 and more. The subjects underwent panoramic radiography of the mandibles, followed by the calculation of the panoramic radiomorphometric indices indicating bone mineral density of the mandible. The dual x-ray and laser osteodensitometer DXL Calscan were used for the measurements of bone mineral density in the calcaneus. Statistical analysis was preformed to find the relationship between bone mineral density measurements in the two anatomically different bones.

Results. Following the diagnostic criteria for osteoporosis recommended by the World Health Organization (1994), the subjects were distributed according to the calcaneus bone mineral density T-score into the normal bone mineral density (group 1), osteopenia (group 2), and osteoporosis (group 3) groups. Mean bone mineral density in the calcaneus in the general studied population was 0.38±0.07; the mean value of bone mineral density of the calcaneus in the group 1 (n=34) was 0.47±0.04 (g/cm²), in the group 2 (n=65) was 0.37±0.03 (g/cm²), and in the group 2 (n=30) was 0.29±0.03 (g/cm²). Differences in bone mineral density between the groups were determined using the analysis of variance (ANOVA) F=285.31; df=2; P<0.001 (T1 vs. T2, P<0.001; T1 vs. T3, P<0.001; T2 vs. T3; P<0.001).

A statistically significant correlation was found in the general group between the mental index and bone mineral density in the calcaneus (r=0.356, P<0.001), and between the panoramic mandibular index and bone mineral density in the calcaneus (r=0.397, P<0.001).

Conclusion. Bone mineral density in the calcaneus and the mandible measured using dual energy x-ray and laser osteodensitometer DXL Calscan and by applying panoramic radiography reflect general changes in the mineralization of these bones, characteristic of the postmenopausal period.

Introduction

Osteoporosis (OP) is a systemic skeletal disease characterized by low bone mass and microarchitectural deterioration of bone tissue, with a subsequent increase in bone fragility and the risk of fractures (1, 2). Bone tissue is a tissue undergoing constant change due to the simultaneous processes of decay (resorption) and formation (regeneration), generally termed as bone remodeling (3). This turnover ensures the continuous replacement of old bone tissue, which, in turn, affects bone adaptation to various mechanical forces exerted on the skeleton.

Reduced bone mineral density (BMD) – and thus the development of OP – is more pronounced in postmenopausal women than in other patients (4). The exceptionally progressive phase of bone destruction, which occurs in women during the period of 5 to 10 years following menopause, is associated with the dramatic drop in estrogen levels (5, 6).

Various bones are analyzed in studies on bone

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mineral density in postmenopausal women. A number of studies have revealed a significant positive correlation between BMD of the mandible and that of the most frequent sites of osteoporosis, namely the lumbar spine, the femoral neck, and the forearm. Yet we have not come across a single academic survey aimed at evaluating the relationship between mandibular and calcaneal (DXL) bone mineral density. It is noteworthy, however, that their anatomical differences notwithstanding, the mandible and the calcaneus are metabolically similar bones.

Mandibular bone tissue is a part of the general skeletal bone structure. The resorption of mandibular bone tissue as well as the morphological-dimensional changes in cortical bone – both typically observed in elderly individuals – is largely attributable to age-related reduction in bone mineral density. Analyses conducted over the last few decades have proven a relationship between mandibular bone mineral density, alveolar bone height, tooth loss, and changes in general skeletal bone mineral density (7–9). Interestingly, while some scientists construe the correlation as particularly strong, others regard it as less reliable. Nevertheless, changes in the skeletal bone mineral density in general should also be expected to affect such functionally active bone as the mandible. Yet contrary to many research findings that seem to have consistently supported the proposition that, on the one hand, general skeletal BMD and changes in cortical thickness and, on the other hand, mandibular bone mineral density, alveolar bone resorption and tooth loss correlate in postmenopausal women (10–16), other studies have traced no such correlation (17, 18).

Approximately 80% of the mandible is composed of cortical bone and 20% of trabecular bone. Subject to the effects of occlusal force, the mandible is a functionally as well as metabolically active bone. Changes in the distribution of functional strain on the mandible result in mandibular bone mass loss (19). The thickness of cortical bone decreases. Although the reduction of the cortical bone layer is a rapid process, it does not normally exceed 2% of the bone mass loss per year, in which regard the mandible closely resembles other bones containing significant amounts of cortical bone tissue (20). Changes in bone mineral density are diagnosed based on the changes detected in cortical bone thickness and integrity in the mandibular base, which is an important symptom of osteoporosis (21). Dutra et al. conclusively demonstrated that cortical bone thickness changes in the mandibular base are characteristic of individuals with osteoporosis, and increasing bone porosity results in decreasing bone mass (8, 10).

Findings of histomorphometric and microradiographic studies show that both cortical and trabecular bone tissues of the mandible undergo changes. This, together with the characteristics of the anatomical structure of the mandible as well as the sufficient thickness of its cortical bone, accounts for the use of the mandible to determine changes in BMD. Furthermore, it has been observed that bone mass of the maxilla, as opposed to that of the mandible, does not depend on age and sex of the patients (10).

Changes in mandibular bone and skeletal osteoporosis share multiple risk factors, such as age, menopause, race, smoking, diet low in calcium, certain medications, as well as genetic factors such as family history of osteoporosis.

It is therefore no coincidence that panoramic radiography and radiomorphometric indices used by odontologists for examining the mandible have attracted clinicians' attention. Medical literature abounds in comparisons of bone mineral density at different skeletal sites (dual x-ray absorptiometry, DXA) with panoramic radiomorphometric indices indicating bone mineral density of the mandible. The aforementioned indices are calculated by performing linear measurements of the obtained panoramic radiographic images of the mandible. Panoramic radiomorphometric indices (mental index, MI; panoramic mandibular index, PMI) serve as diagnostic criteria that help to select elderly patients with suspected changes in bone mineral density for further BMD testing (8, 22–24). Mandibular cortical thickness at the mental foramen is also known as the MI. Osteopenia can be identified by the thinning of cortical bone along the lower border of the mandible (MI) (7). The PMI, described by Benson et al., in turn, evaluates bone mineral mass in the mandible (25).

Thorough knowledge of the methods for calculating panoramic radiographic indices as well as for determining which changes in the mandibular cortical bone suggest systemic skeletal osteopenia or osteoporosis is thus highly useful. In addition to that, timely and accurate identification of clinical signs associated with osteoporosis on the part of dental practitioners tends to contribute significantly to effective prevention of early tooth loss.

The calcaneus, which is a weight-bearing bone in addition to being an easily accessible one, offers a number of distinct advantages in terms of bone mineral density measurements. Arguably, the relatively high proportion (approximately 95%) of metabolically active trabecular bone (with a turnover rate exceeding that of cortical bone by 7 to 8 times) in the calcaneus

renders it the best site for early detection of OP (26).

DXL Calscan was invented to measure bone mineral density of the calcaneus. This scanner, which combines dual x-ray and laser techniques, is characterized by a low radiation dose and produces peripheral scans, automatically selects measurement areas, and performs calibration procedures before each measurement. Patient-friendly (approved for use without any additional patient protection requirements), quick (allows for a painless scan of a patient's heel in less than a minute), comfortable to operate and portable, Calscan DXL is intended to speed up the diagnosis of OP (26). According to some authors, the device is particularly suitable for diagnosing post-menopausal osteoporosis (27) and allows for precise and reliable testing (26). Kullenberg and Falch analyzed the results of a series of bone mineral density measurements in the calcaneus with DXL and confirmed that the T-score threshold defined through the use of this innovative method corresponds to the criteria recommended by the WHO and is thus optimal and accurate enough for diagnosing osteoporosis (28). It is important to note that bone mineral density measurements in the calcaneus are not subject to distortion due to kidney diseases, aortic calcification, osteoarthritis, or deformations of the lumbar spine or bone fractures. This peripheral site is therefore particularly suitable for the purposes of monitoring, collecting prognostic information, and estimating the frequency of movement.

The majority of elderly people visit odontologists on a regular basis. They frequently undergo panoramic radiographic examinations, the results of which are used for diagnosing periodontal pathology, identifying the number of teeth, and assessing alveolar bone loss. Patients who have not yet experienced any noticeable symptoms of OP despite being at risk of developing osteoporosis are unlikely to visit health professionals solely for BMD assessment. However, postmenopausal female patients, for example, due to high incidence of periodontal pathology among them, tend to have frequent dental appointments. Odontologists, for their part, through the use of panoramic radiography over the course of their dental treatment, may be able to easily identify signs of bone mineral density loss in sites other than the mandible. Postmenopausal women with suspected low skeletal BMD may then be referred to other professionals for further BMD testing. It can be inferred from the above that constructive interdisciplinary cooperation between odontologists and other medical professionals in the diagnosis and treatment of osteoporosis would benefit patients and would yield good results.

The aim of this study was to assess and find the relationship between BMD of the mandible and of the calcaneus. To this end, a number of objectives were pursued. We measured BMD of the calcaneus using the DXL Calscan. Panoramic radiography of the mandible and, subsequently, vertical linear measurements of the panoramic radiographic images were performed, followed by the calculation of the two panoramic radiomorphometric indices (MI and PMI). Finally, we conducted a statistical analysis in order to establish the relationship between data sets obtained during the research process.

Materials and methods

The sample. The present study was approved by the Clinic of Dental and Oral Pathology and the Institute of Endocrinology of Kaunas University of Medicine (KMU). The study included 129 postmenopausal women who were treated for periodontal diseases at the Clinic of Dental and Oral Pathology.

Exclusion criteria were patients' age up to 50 years, history of OP treatment or regular drug therapy that would affect bone remodeling during one year, postmenopausal history with estrogen replacement treatment, absence of diseases that may result in secondary osteoporosis, no smoking or alcohol use, diseases of oral mucosa, and edentulous mandibles.

Dual x-ray and laser osteodensitometry. Bone mineral density in the calcaneus was evaluated by applying dual x-ray and laser osteodensitometry using *DXL Calscan P/N 031000* (Demetech AB, Solna, Sweden). DXL Calscan software presents the results of bone mineral density measurements in g/cm² and expresses them as T-score and Z-score. The measurements are graphically presented in the computer monitor. The risk margins for osteopenia and osteoporosis were indicated as colored fields or lines.

The duration of the measurement was 4 minutes, and the irradiation dose was 0.2 μSv. The patients were free to choose whether the right or the left calcaneus should be examined for BMD. Following the diagnostic criteria for osteoporosis recommended by the WHO (1994), the subjects were distributed according the bone mineral density T-score into the normal bone mineral density (group 1), osteopenia (group 2), and osteoporosis (group 3) groups.

Panoramic radiographic measurements. Panoramic radiography (OPG) examination was performed at the Department of Dental and Maxillofacial Orthopedics, KMU, using a panoramic radiograph PC-1000 Panoramic X-ray (Panoramic corporation, Dentalcompare, USA, 1997). The duration of the radiologic

examination was 14 seconds. Current of 6 mA and voltages of 85 kV were used, depending on the patient's constitution. The obtained radiographic images were scanned (using a scanner produced by the VIDAR Systems Corporation, USA, 2006) and digitalized at the resolution of 300 dpi and 265 (8 bits/pixel) gray shade formats, by applying the logarithmic algorithm. Medical imaging software was used to perform vertical linear measurements in panoramic radiographic images, and subsequently panoramic radiographic indices were calculated.

Mandibular cortical thickness at the mental foramen – mental index (MI) – was measured using the technique described by Ledgerton et al.: "a line was traced which passed perpendicular to the tangent to the lower border of mandible and through the center of the mental foramen" (29). We measured the cortical thickness in the region of interest on the right and the left sides of the mandible because different sides of the mandible may be influenced by different occlusal forces and thus could have the asymmetric signs in topographic anatomy. After the measurements, the mean values of the obtained findings were calculated.

Panoramic mandibular index (PMI) according to Benson et al. is the ratio between cortical thickness in the base of the mandible and the distance from the center of the mental foramen to lower border of the base of the mandible (25).

Using the same line as described above for the determination of the mandibular cortical thickness, measurements between the lower border of mandible and both the upper and the lower margins of mental foramen were recorded, and the average of those two values was calculated. PMI calculations were performed bilaterally for each subject, and mean values were calculated. All measurements in this study were adjusted to account for the magnification coefficient of the panoramic radiograph (coefficient, 0.9).

Statistical analysis. Comparison and analysis of the data were performed using the data accumulation and analysis software packages Statistica 5.5, Excel 2000, and SPSS 13.0. The sample volume was calculated during the pilot study. The selected power of the study was β=0.8, and the confidence interval was α=0.05. Continuous data were evaluated using the following statistical characteristics: mean value ($\bar{x}$), median, and standard deviation (SD). Normal distribution of the studied quantitative indices was verified using the Kolmogorov-Smirnov test. Mean values and their dispersions were compared by applying the univariate dispersion analysis technique (ANOVA).

The dependence of the attributes was evaluated by applying Pearson's linear regression (correlation coefficient, *r*). The verification of the statistical hypotheses was performed using the following significance denotations: $P<0.05$ (significant), $P<0.01$ (highly significant), and $P<0.001$ (especially significant); *P* denotes the marginal level of significance in the verification of hypotheses.

Results
Analysis of bone mineral density in the calcaneus. We studied postmenopausal women whose mean age (±SD) was 62.50±6.13 years.

According to the T-score of the bone mineral density in the calcaneus, the subjects were distributed into the following groups: group 1 included 34 women with normal bone mineral density (T-score >–1), group 2 included 65 women diagnosed with osteopenia (T-score ≤–1 to >–2.5), and group 3 – 30 women with osteoporosis (T-score ≤–2.5). The overall mean value of T-scores was –1.62±1.12. The following mean values of T-scores were obtained in the groups: group 1, –0.13±0.55; group 2, –1.77±0.43; and group 3, –2.96±0.48. The difference in T-score in subject groups using the ANOVA was found to be the following: F=289.26; df=2; $P<0.001$ (T1 vs. T2, $P<0.001$; T1 vs. T3, $P<0.001$; and T2 vs. T3, $P<0.001$).

Mean bone mineral density in the calcaneus in the general group of subjects was 0.38±0.07; mean BMD in the group 1 was 0.47±0.04, in the group 2 was 0.37±0.03, and in group 3 – 0.29±0.03. The difference in bone mineral density between the groups determined using the ANOVA was the following: F=285.31; df=2; $P<0.001$ (T1 vs. T2, $P<0.001$; T1 vs. T3, $P<0.001$; and T2 vs. T3, $P<0.001$).

Morphometric analysis of the mandible. We performed vertical linear measurements on panoramic radiographic images of the mandible. The data were adjusted for the magnification coefficient of the panoramic radiograph (coefficient, 0.9). The analysis of the findings of the measurements showed that the magnification coefficient did not affect the accuracy of the findings.

The region of the mandible where morphometric analysis on panoramic radiographic images was performed is shown in Fig. 1.

The lower mandibular cortical thickness was measured at the mental foramen, and mean measurement values of the mental index (MI) on the left and the right sides of the mandible were calculated. The lowest
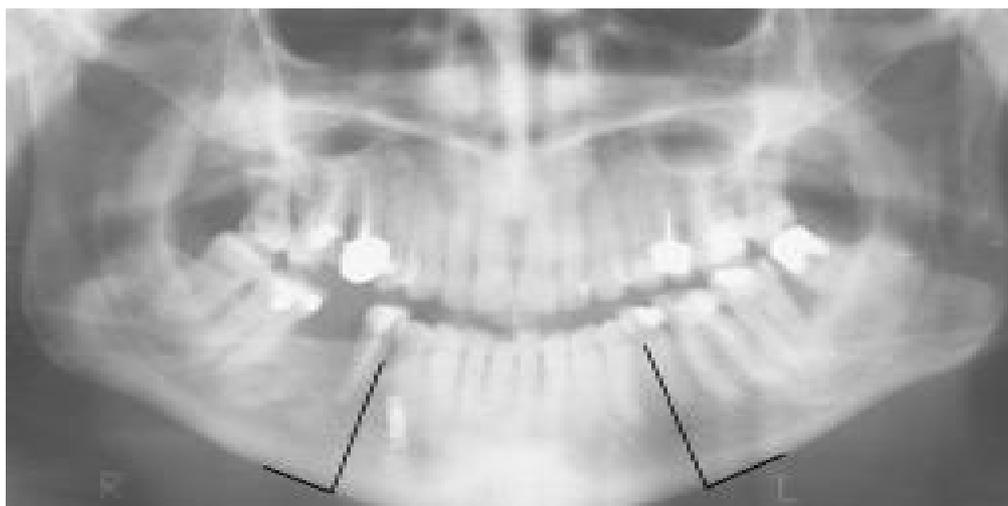
Fig. 1. Linear measurements of the mandible at the mental foramen on panoramic radiograms

value was found to be 1.46, and the highest – 5.82 (mode 2.48; median 3.07). The differences in the MI between subject groups were calculated by applying ANOVA (F=9.98; df=2; P<0.001). The data of the mental index in the groups are presented in Table 1.

The accuracy of the measurements calibration was performed by three observers. A statistically significant difference was found in the measurements of the cortical thickness in the base of the mandible at the mental foramen between investigators 1 and 2 (P<0.001), and between investigators 2 and 3 (P<0.001).

Using findings of the linear morphometric measurements in subject groups, we calculated the PMI. Mean values (±SD) of the PMI are given in Table 2.

The relationship between the mental and the panoramic mandibular indices, and bone mineral density in the calcaneus. The relationships between the MI and mean values of the calcaneus BMD measurements in the groups are presented in Table 3.

Table 3 shows a statistically significant correlation between the MI and mean values of the calcaneus BMD in the general group (r=0.356, P<0.001). No correlation was detected between measurement data in the groups 1, 2, or 3.

The relationship of the mental index (MI) with bone mineral density of the calcaneus in the groups is presented in Fig. 2.

The relationship between the panoramic mandibular index and bone mineral density in the calcaneus. The relationships between the PMI and the mean values of the calcaneus BMD measurements in the groups are presented in Table 4.

Table 1. The mean values of mental index measurements in subject groups

Group	n	MI, mean±SD, mm	Difference in MI between the groups
1	34	3.69±0.98	1 vs. 2, P=0.069;
2	65	3.34±0.93	1 vs. 3, P<0.001;
3	30	2.69±0.72	2 vs. 3, P<0.001.
General	129	3.28±0.96	

MI, mental index.

Table 2. The mean values of the panoramic mandibular index by different groups

Group	n	PMI (mean±SD)	Difference in PMI between the groups
1	34	0.29±0.08	1 vs. 2, P=0.016;
2	65	0.26±0.07	1 vs. 3, P<0.001;
3	30	0.21±0.06	2 vs. 3, P=0.009.
General	129	0.26±0.07	

PMI, panoramic mandibular index.

Table 3. The relationship between mental index and calcaneus bone mineral density in the groups

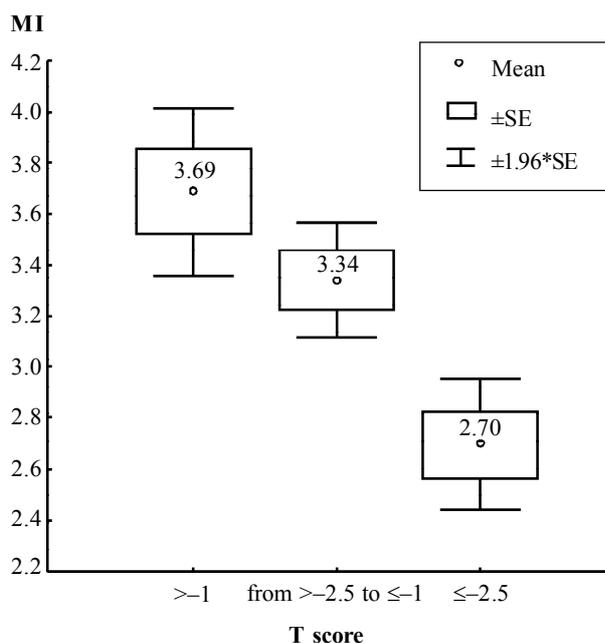| Group	n	MI, mean±SD mm	Calcaneus BMD mean±SD, g/cm²	Correlation
1	34	3.69±0.98	0.47±0.04	r=0.158; P=0.372
2	65	3.34±0.93	0.37±0.03	r=0.151; P=0.228
3	30	2.69±0.72	0.29±0.03	r=0.003; P=0.988
General	129	3.28±0.96	0.38±0.07	r=0.356; P<0.001

MI, mental index; BMD, bone mineral density.

MI

Fig. 2. The relationship of the mental index (MI) with bone mineral density of the calcaneus in the groups

Table 4. The relationship between panoramic mandibular index and calcaneus bone mineral density in the groups

Group	n	PMI, mean±SD mm	Calcaneus BMD, mean±SD g/cm²	Correlation
1	34	0.29±0.08	0.47±0.04	r=0.131; P=0.459
2	65	0.26±0.07	0.37±0.03	r=0.186; P=0.139
3	30	0.21±0.06	0.29±0.03	r=0.853; P=0.915
General	129	0.26±0.07	0.38±0.07	r=0.397; P<0.001

PMI, panoramic mandibular index; BMD, bone mineral density.

As seen in Table 4, a statistically significant correlation was found between the PMI and the mean values of the calcaneus BMD in the general group (r=0.397, P<0.001). No significant correlation was found between the data in the groups 1, 2, or 3.

Discussion

With age, bone density gradually decreases in all anatomical sites. Postmenopausal bone loss severely affects women in the first 10 years after the menopause, whereas subsequently the importance of this factor diminishes. Annual bone loss rates vary substantially among different individuals, ranging between less than 1% to more than 5% for the trabecular bone, and from 0.5% to 2% for the cortical bone. The most significant bone mass loss is observed in the spinal bone (34).

The present study sought to assess BMD of the mandible by the use of panoramic radiography as a diagnostic method, primarily due to the fact that mandibular bone mineral density is a parameter closely associated with alveolar bone resorption and early tooth loss. However, the aforementioned medical conditions are subject of further studies and thus are not analyzed in this article.

Overall, our analysis suggests that determining BMD of the mandible (based on panoramic radiographs) and comparing it with BMD of the calcaneus (measured by DXL) is expedient for several reasons. As panoramic radiographic examinations are convenient and informative, and are common in odontological practice, we expect this study to serve as an impetus for the advancement of diagnostic and clinical collaboration between dental practitioners and other medical professionals in predicting low general skeletal BMD. For instance, our research findings indicate that the use of panoramic radiography for assessing bone mineral density of the mandible also allows for determining general skeletal bone mineral density loss in elderly female patients. These measurements, coupled with criteria such as other clinical risk factors and/or family history of OP, could therefore prove to be a promising instrument in the assessment of skeletal osteoporosis risk. Furthermore, panoramic radiographs could produce particularly accurate BMD assessments when calibrated well with the DXA method (30).

In the course of the study, we measured the thickness of the cortical bone using digitized panoramic radiographic images, which facilitates the evaluation of the trabecular to cortical bone thickness ratio in the mandible. Precise determination of the inner and outer margins of the cortical bone together with rigorous vertical linear measurements is a prerequisite for the calculation of panoramic radiomorphometric indices. It should be emphasized, however, that the MI values obtained while using a computer-aided system for measuring mandibular cortical thickness are generally somewhat lower than those resulting from manual measurement (31). In addition, MI values in females are commonly expected to be lower, owing to significantly higher rates of bone loss among women beyond the fourth decade of life (22, 32). Kribbs et al., Klementti et al., Taguchi et al., and Bollen et al., among others, discovered that the thickness of the lower border of the mandible tends to be reduced in subjects with osteoporosis (11–15). Although Devlin et al. also examined panoramic radiographs and reported higher MI values (normal bone density MI,

4.73±0.88; reduced bone density MI, 3.96±0.88), their measurements were not adjusted to account for the magnification effect, which renders any meaningful comparison of their findings with those of other researchers difficult (7).

Our analysis attests to the existence of a significant correlation between the data on mandibular cortical thickness (MI) and the mean values of BMD in the calcaneus in the postmenopausal age group of the population. On the other hand, lower MI values without any significant correlation with the values of calcaneal BMD were observed in the groups of patients with osteopenia and osteoporosis.

Benson et al., Klementti et al., and Horner and Devlin focused their studies on another panoramic radiomorphometric index, namely, panoramic mandibular index (14, 25, 33). They concluded that PMI had no distinct advantages over MI as a tool for mandibular BMD measurement. Our study revealed a statistically significant correlation between PMI and BMD of the calcaneus in the general population of patients, which corroborates such conclusion.

As already pointed out, approximately 80% of the mandible is composed of cortical bone (35); thus, the mass of its trabecular portion is relatively small. The calcaneus, by contrast, is predominantly trabecular in its composition (95% of trabecular bone). After the menopause, accelerated trabecular bone loss occurs, and bone mineral density of the calcaneus progressively declines throughout the postmenopausal period. In the immediate postmenopausal years, considerable bone tissue resorption occurs in the trabecular bone, while during the sixth and seventh decade of life, the process gathers momentum in cortical bone as well, thus leading to intensified resorption in both types of tissues (36).

Although the calcaneus is a classic example of a weight-bearing bone, it is noteworthy that the mandible is likewise loaded, with occlusal force being the most direct origin of that load. Therefore, examining the functionally as well as metabolically active sites of the calcaneus and the mandible in tandem is essential for an in-depth understanding of changes in bone turnover. Whereas reduced calcaneal BMD is firstly reflected in its trabecular area, and only later in its cortical component, mandibular BMD loss manifests itself through the decrease in its cortical thickness. For instance, mean bone loss in the mandible among females in their early 70s is estimated to be 1.5% per year (13). Mandibular bone loss is similar to other

sites consisting mainly of cortical bone and the rate of mandibular bone loss is relatively high. The fast bone loss is intrinsic to this part of the skeleton due to some additional yet still unclear local factors (20).

We traced no statistically significant correlation between calcaneal and mandibular BMD loss in the examined osteoporotic population. This can probably be explained by the fact that changes in the calcaneal trabecular bone become conspicuous at an earlier stage than those occurring in the mandible. We are also inclined to assume that our findings are influenced to a significant extent by variables such as bone aging, bone composition, as well as several secondary factors. In particular, different age-related processes, disturbances affecting bone resorption and deposition, osteodystrophic diseases, hormonal fluctuations, and tooth loss induce alterations in cortical bone of the mandible, such as changes in cortical thickness, BMD, lacunar resorption in the cortical layer, and/or the development of alveolar bone destruction (10, 12, 21, 24, 37).

The National Osteoporosis Society (NOS) recommended DXL Calscan for peripheral x-ray absorptiometry examinations in 2004. Comparative studies, assessing BMD of the calcaneus with the use of DXL Calscan and that of other skeletal sites, have been published (28). However, to date, no investigations similar to ours, namely aimed at comparing panoramic radiomorphometric indices of the mandible with DXL measurements of the calcaneus, have been presented in the academic literature on the subject.

Conclusions

The results of the study showed that bone mineral density of the mandible calculated using the panoramic radiomorphometric indices correlated with bone mineral density of the calcaneus measured using DXL Calscan and reflected general changes in the mineralization of these bones, characteristic of the postmenopausal period. The results of our study may be explained by different anatomical structure of these two bones and by different rates of the bone aging process.

Determination of bone mineral density in the calcaneus and radiomorphometric examinations of the mandible may be used for determining changes in bone mineral density among women of this age.

Acknowledgments

Apatinio žandikaulio panoraminių radiomorfometrinių indeksų ryšys su kulnakaulio kaulų mineralų tankiu

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Raktažodžiai: kulnakaulis, apatinis žandikaulis, osteoporozė, panoraminiai radiomorfometriniai indeksai, DXL Calscan.

Santrauka. *Tyrimo tikslas.* Nustatyti ryšį tarp kulnakaulio kaulų mineralų tankio, išmatuoto dvigubos energijos rentgeno ir lazerio osteodensitometrijos metodu („DXL Calscan") ir apatinio žandikaulio kaulų mineralų tankio, apskaičiuoto pagal panoraminius radiomorfometrinius apatinio žandikaulio indeksus (mentalinį indeksą, panoraminį apatinio žandikaulio indeksą), apskaičiuotus atlikus linijinius panoraminių radiogramų matavimus pomenopauzinio amžiaus moterims.

Tirtųjų kontingentas ir tyrimo metodai. Tyrime dalyvavo 129 pomenopauzinio amžiaus moterys nuo 50 metų ir vyresnės. Tiriamosioms atliktas panoraminis radiografinis apatinių žandikaulių tyrimas, apskaičiuoti panoraminiai radiomorfometriniai apatinio žandikaulio indeksai, parodantys žandikaulių kaulų mineralų tankį. Dvigubos energijos rentgeno ir lazerio osteodensitometru „DXL Calscan" išmatuotas kulnakaulio kaulų mineralų tankis. Atlikta statistinė analizė anatomiškai skirtingų kaulų mineralų tankių ryšiui nustatyti.

Rezultatai. Remiantis PSO (1994) nustatytais osteoporozės diagnostikos kriterijais, pagal kaulų mineralų tankio T lygmenį, tiriamosios suskirstytos į normalaus kaulų mineralų tankio (1), osteopenijos (2) ir osteoporozės (3) grupes. Kulnakaulio kaulų mineralų tankio vidurkis (±SN) bendroje tiriamųjų grupėje 0,38±0,07; 1 grupės (n=34) tiriamųjų kulnakaulio kaulų mineralų tankio vid.±SN 0,47±0,04 (g/cm²); 2 grupės (n=65) vid.±SN 0,37±0,03 (g/cm²); 3 grupės (n=30); vid.±SN 0,29±0,03 (g/cm²). Kaulų mineralų tankio skirtumai tiriamųjų grupėse nustatyti ANOVA F=85,31; l.l.s.=2; p<0,001. (T1 vs T2 p<0,001; T1 vs T3 p<0,001; T2 vs T3 p<0,001).

Tarp mentalinio indekso (MI) ir kulnakaulio kaulų mineralų tankio bendroje tiriamųjų grupėje nustatyta statistiškai reikšminga koreliacija (r=0,356; p<0,001), tarp panoraminio apatinio žandikaulio indekso (PMI) ir kulnakaulio kaulų mineralų tankio (r=0,397; p<0,001).

Išvados. Kulnakaulio ir apatinio žandikaulio kaulų mineralų tankis, išmatuotas dvigubos energijos rentgeno ir lazerio osteodensitometru „DXL Calscan" ir panoraminės radiografijos metodais, atspindi bendrus mineralizacijos pokyčius šiuose kauluose, būdingus pomenopauzinio amžiaus periodui.

References

1. White SC, Rudolph DJ. Alterations of the trabecular pattern of the jaws in patients with osteoporosis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1999;88:628-35.
2. Baranauskaitė A. Osteoporozė: stuburo slankstelių lūžių diagnostika ir gydymas. (Osteoporosis: spinal fractures diagnostic and treatment.) Medicina (Kaunas) 2002;38(8):862-5.
3. Lopata G. Dabartinis požiūris į kaulinio audinio remodeliaciją (Recent standpoint on physiology of bone and factors affecting the process of remodeling.) Lietuvos endokrinologija 2003; 11(1,2,3):82-8.
4. Riggs BL, Melton LJ 3rd. Involutional osteoporosis. N England J Med 1986;26:1676-86.
5. Urbonienė J. Calcaneus ultrasound and clinical risk factors value in osteoporosis diagnostics [summary of doctoral dissertation] Vilnius: Vilnius University; 2007.
6. Ito M, Nakamura T, Tsurusaki K, Uetani M, Hayashi K. Effects of menopause on age-dependent bone loss in the axial and appendicular skeletons in healthy Japanese women. Osteoporos Int 1999;10:377-83.
7. Devlin H, Horner K. Mandibular radiomorphometric indices in the diagnosis of reduced skeletal bone mineral density. Osteopor Int 2002;13:373-8.
8. Dutra V, Yang J, Devlin H, Susin Ch. Radiomorphometric indices and their relation to gender, age, and dental status. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2005; 99(4):479-84.
9. Taguchi A, Suei Y, Sanada M, Ohtsuka M, Nakamoto T, Sumida H, et al. Validation of dental panoramic radiography measures for identifying postmenopausal women with spinal osteoporosis. AJR Am J Roentgenol 2004;183:1755-60.
10. Hildebolt CF. Osteoporosis and oral bone loss. Dentomaxillofac Radiol 1997;26:3-15.
11. Bollen AM, Taguchi A, Hujoel PP, Hollender LG. Case-control study on self-reported osteoporotic fractures and mandibular cortical bone. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2000;90:518-24.
12. Taguchi A, Suei Y, Ohtsuka M, Otani K, Tanimoto K, Ohtaki M. Usefulness of panoramic radiography in the diagnosis of postmenopausal osteoporosis in women. Width and morphology of inferior cortex of the mandible. Dentomaxillofac

Radiol 1996;25:263-7.

13. Kribbs PJ. Comparison of mandibular bone in normal and osteoporotic women. J Prosthet Dent 1990;63(2):218-22.

14. Klementti E, Kolmakov S, Heiskanen P, Vainio P, Lassila V. Panoramic mandibular index and bone mineral densities in postmenopausal women. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1993;75:774-9.

15. Klementti E, Kolmakov S, Kroger H. Pantomography in assessment of the osteoporosis risk group. Scand J Dent Res 1994;102:68-72.

16. Taguchi A, Tanimoto K, Suei Y, Otani K, Wada T. Oral signs as indicators of possible osteoporosis in elderly women. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;80:612-6.

17. Mohajery M, Brooks SL. Oral radiographs in the detection of early signs of osteoporosis. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1997;73:112-7.

18. Law AN, Bollen AM, Chen SK. Detecting osteoporosis using dental radiographs: a comparison of four methods. J Am Dent Assoc 1996;127:1734-42.

19. Martin RB, Burr DB, Sharkey NA. Skeletal tissue mechanics. New York: Springer; 1998.

20. Drozdzowska B, Pluskiewicz W. Longitudinal changes in mandibular bone mineral density compared with hip bone mineral density and quantitative ultrasound at calcaneus and hand phalanges. Br J Radiol 2002;75:743-7.

21. White SC. Oral radiographic predictors of osteoporosis. Dentalmaxillofac Radiol 2002;31:84-92.

22. Ledgerton D, Horner K, Devlin H, Worthington H. Radiomerphometric indices of the mandible in a British female population. Dentomaxillofac Radiol 1992;28:173-81.

23. Bras J, van Ooij CV, Abraham-Inpijn L, Kusen GJ, Wilmink JM. Radiographic interpretation of the mandibular angular cortex: a diagnostic tool in metabolic bone loss. Part I. Normal state. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1982;53:541-5.

24. Taguchi A, Tanimoto K, Suei Y, Wada T. Tooth loss and mandibular osteopenia. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79:127-32.

25. Benson BW, Prihoda TJ, Glass BJ. Variations in adult cortical bone mass as measured by a panoramic mandibular index.

26. Coe J. Speeding up assessment of bone mineral density. Practice Nursing 2008;19(4):177-80.

27. Thorpe JA, Steel SA. The DXL Calscan heel densitometer: evaluation and diagnostic thresholds. Br J Radial 2006; 79(940):336-41.

28. Kullenberg R, Falch J. Prevalence of osteoporosis using bone mineral measurements at the calcaneus by dual X-ray and laser (DXL). Osteoporos Int 2003;14(10):823-7.

29. Ledgerton D, Horner K, Devlin H, Worthington H. Panoramic mandibular index as a radiomorphometric tool: an assessment of precision. Dentomaxillofac Radiol 1997;26:95-100.

30. Ay S, Gursoy UK, Erselcan T, Marakoglu I. Assessment of mandibular bone mineral density in patients with type 2 diabetes mellitus. Dentomaxillofac Radiol 2005;34:327-31.

31. Arifin A Z, Asano A, Taguchi A, Nakamoto T, Ohtsuka M, Tsuda M, et al. Computer-aided system for measuring the mandibular cortical width on dental panoramic radiographs in identifying postmenopausal women with low bone mineral density. Osteoporos Int 2006;17:753-9.

32. Knezović Zlatarić D, Celebić A, Lazić B, Baucić I, Komar D, Stipetić-Ovcaricek J, et al. Influence of age and gender on radiomorphometric indices of the mandible in removable denture wearers. Coll Antropol 2002;26(1):259-66.

33. Horner K, Devlin H. The relationship between mandibular bone mineral density and panoramic radiographic measurements. J Dent 1998;26(4):337-43.

34. Alekna V, Tamulaitienė M. Sveikų Lietuvos moterų kaulų mineralų tankis. (Bone mineral density of healthy Lithuanian women.) Medicina 2003;39(5):498-501.

35. Von Wowern N. Bone mass of mandibles. Danish Med Bull 1986;33:23-44.

36. Hadjidakis D, Kokkinakis E, Giannopoulos G, Merakos G, Raptis SA. Bone mineral density of vertebrae, proximal femur and os calcis in normal Greek subjects as assessed by dual-energy X-ray absorptiometry: comparison with other population. Eur J Clin Invest 1997;27:219-27.

37. Klemetti E, Collin HL, Forss H, Markkanen H, Lassila V. Mineral status of skeleton and advanced periodontal disease. J Clin Periodontol 1994;21(3):184-8.