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Research Article

The relationship between osteoporosis and the panoramic mandibular index

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Abstract. Background : from a radiological point of view, the periodontium consists of anatomical structures of various densities: the gum and the periodontal ligament (radiolucent), as well as cementum and alveolar bone (radiopaque). The panoramic mandibular index (PMI) is a morphometric method which uses ortopantomography (OPT) in order to determine the width of the mandibular cortex. It can also be used to determine the degree of bone loss. The aim of this study was to research the possible correlations between: PMI and the presence or absence of osteoporosis in post-menopausal women; Bone mineral density (BMD) at levels L1-L4, femoral head, hip, mandible and PMI in post-menopausal women, with or without osteoporosis. Materials and methods: the present study included a total of 97 postmenopausal patients. The diagnosis of osteoporosis was made based on the WHO definition. The results were expressed as absolute BMD values in g/cm2 and as T score form. We used dual x-ray absortiometry (DXA) measurements in assessing the lumbar column, proximal femur and mandible and we calculated the T scores. All the patients were subjected to an OPT radiological investigation. We calculated PMI for all patients. Results: the present study allowed us to find significant differences between the mean PMI values in the group of post-menopausal women that suffered from osteoporosis (0.33), as compared to those without a diagnosis of osteoporosis (0.4), which shows that osteoporosis patients present bone loss at the level of the mandible. Conclusions: there are statistically significant differences between the panoramic mandibular index in post-menopausal women with osteoporosis as compared to non-osteoporotic ones. Statistically significant correlations were identified between L1-L4, femoral head and total hip bone mineral densities and the panoramic mandibular index; the lower the bone mineral density the more the panoramic mandibular index is decreasing.

Key Words: panoramic mandibular index, postmenopausal osteoporosis.

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Introduction

From a radiological point of view, the periodontium consists of anatomical structures of various densities: the gum and the periodontal ligament (radiolucent), as well as cementum and alveolar bone (radiopaque).
The panoramic mandibular index (PMI), first introduced by Benson in 1991, is a morphometric method which uses ortopantomography (OPT) in order to determine the width of the mandibular cortex. It can also be used to determine the degree of bone loss.

Working hypothesis

Over the years, it has been presumed that there might be a connection between systemic osteoporosis and bone loss at the level of the oral cavity. A comparison of x-ray images of the vertebral bodies and of the alveolar bone showed a positive correlation and suggested the fact that radiographs of the alveolar process may be better indicators of systemic osteoporosis than radiographs of other bones (Zachariasen 1999).

The reduced number of studies published internationally – and their absence in Romania – on the relationship between osteoporosis and the degree and the type of alveolar bone resorption and PMI in post-menopausal women as well as its theoretical and practical importance have determined us to propose and conduct this study.

The objective of this study was to establish correlations between: PMI and the presence or absence of osteoporosis in post-menopausal women; Bone mineral density (BMD) measured at levels L1-L4, femoral head, hip, mandible and PMI in post-menopausal women, with or without osteoporosis.

Materials and methods

The study was conducted on 97 post-menopausal female patients whose ages ranged from 47 to 76, with an average age of 60, all of them registered at the Endocrinology Clinic in Cluj-Napoca. They were divided into two samples: one comprising 62 women with osteoporosis whose average age was 62.42 ± 7.85 years and a comparison sample consisting of 35 women without osteoporosis, their average age being 56.80 ±7.00 years.

All the patients were subjected to an OPT radiological investigation that was performed at the Department of Radiology of the University of Medicine and Pharmacy in Cluj-Napoca, using an Orthopantomograph OP100. The purpose of the investigation was to determine the PMI.
The panoramic mandibular index (Benson) is a morphometric method that uses OPT to determine the width of the mandibular cortex and can be used to assess bone loss. PMI represents the ratio between the width of the lower mandibular cortex in the mental area and the distance between the lower margin of the mandible and the lower or upper margin of the mental foramen. In order to calculate this index, the mental foramen is located and a perpendicular line is drawn on the tangent at the lower margin of the mandible which passes through the mental foramen. Along this perpendicular we measure the cortex width, the distance between the lower margin of the mandible and the lower margin of the mental foramen, as well as the distance between the lower margin of the mandible and the upper margin of the mental foramen. The PMI is obtained by calculating the ratio between these distances. It may be considered that a PMI ratio below 0.40 may indicate an osteoporosis related diagnosis. (Klemetti *et al* 1993, Mohammad *et al* 1996; Ledgertone *et al* 1997)
For the purpose of simplification, PMI was calculated as a ratio between the width of the lower mandibular cortex and the distance between the lower margin of the mandible and the lower margin of the mental foramen.
We considered menopause as the permanent cessation of menstruation as a result of the interruption of ovarian activity.
The diagnosing of osteoporosis was made according to the BMD-based definition provided by the World Health Organisation, which compares the patient's bone density to standard values in a population of 20-40 years of age and expresses it as the number of standard deviations in relation to the mean value. The osteoporotic bone tissue has a density of more than 2.5 standard deviations (SD) below the mean value (T<-2,5 score). The osteopenic tissue shows a T-score between -2.5 and -1 . Normal bones have a T-score of -1 or above (Green *et al* 2004). Therefore, the formula applied in calculating the T score is:

([BMD (g/cm²) patient] - [BMD (g/cm²) young adult]) / standard deviation (SD)

The areas of interest considered for the study sample analysis were the lumbar spine (L1-L4 segment), the proximal femur (the femoral head, the trochanter and the total hip) and the mandible. The measurement of the spine was performed with the patient in clinostatic position, both legs being raised at an angle of approximately 80-90˚ from the body, her knees flexed and supported by a dedicated stand. This position ensures the reduction of physiological lumbar lordosis and allows an optimal evaluation of the L1-L4 area. Hip assessment was also carried out with the patient in clinostatic position, lower limbs slightly apart and rotated inward. While performing mandible assessment, the patient was positioned with her cephalic extremity rotated to the left and mouth wide open.
Given the lack of a comparison population at national level against which the results obtained by the DXA measurement could be analysed, T-score computation took into account the data provided by NHANES (National Health and Nutrition Examination Survey) III (Green *et al* 2004).
In the case of the lumbar spine and the hip, the analysis of the assessed areas was performed automatically by using the spine and hip dedicated software of the DPX-NT equipment. As for the mandibular DXA, given the current unavailability of a dedicated software version for the assessment of this area of interest, we decided to use the distal forearm software, while subsequent measurement was performed by manually tracing the outline of the jaw bone for each case individually. The determined mass of bone mineral divided by the measured area in order to obtain jaw bone density (g/cm^2) (Green *et al* 2005).
This was an analytical, transversal, observational, case-control study. For the statistical analysis we used Medcalc software, version 12.3.
The data was labelled as nominal, ordinal, dichotomous and continuous variables. Normality of continuous variable distribution was tested through the Kolmogorov-Smirnov test. In order to describe normal distribution variables we calculated the mean±standard deviation. For the univariate analysis of normal distribution variables, we used the T-test in the case of independent variables (for dichotomous variables), Pearson correlation (for continuous variables) and ANOVA (for nominal variables). For the analysis of ordinal variables we used Spearman's rho correlation. The statistical significance threshold was established at 0.05 of the p parameter.

Results

Comparative values of IMP means in post-menopausal women, with (OP) and without osteoporosis (M).

Table 1. Descriptive statistics

	Sample	N	Mean	Standard deviation	Standard error
PMI	M	21	0.4	0.04	0.01
	OP	32	0.32	0.03	0

As Levene's test of equality of variances showed statistically significant differences of variances between the two samples (p=0.012), we used Student's T-test for unequal variances, its probability p<0.000 showing significant differences among the means of the Panoramic Mandibular Index values between sample M and sample OP (table 2).

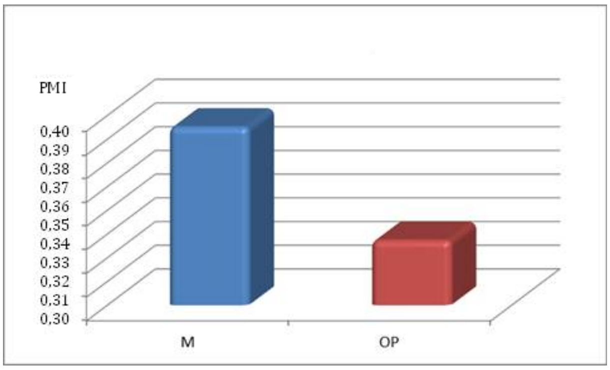

Figure 1. Relationship between the means of the PMI values in the post-menopausal osteoporosis patients sample (OP) and non-osteoporosis patients sample (M)

Table 2. Independent Samples Test for PMI

		Levene's test of equality of variances		Student's T-test of equality of means						
		F	P	t	fd	P	Means differences	Standard error differences	CI 95% lower	CI 95% upper
PMI	Equal variances	6.743	0.012	4.374	51	<0.001	0.048	0.011	0.026	0.070
	Unequal variances			4.086	33.315	<0.001	0.048	0.012	0.024	0.072

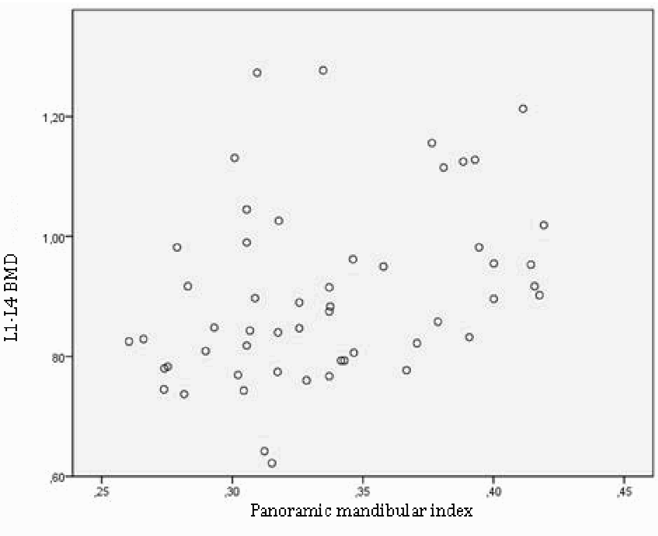

Figure 2. Correlation between L1-L4 BMD and PMI in post-menopausal women

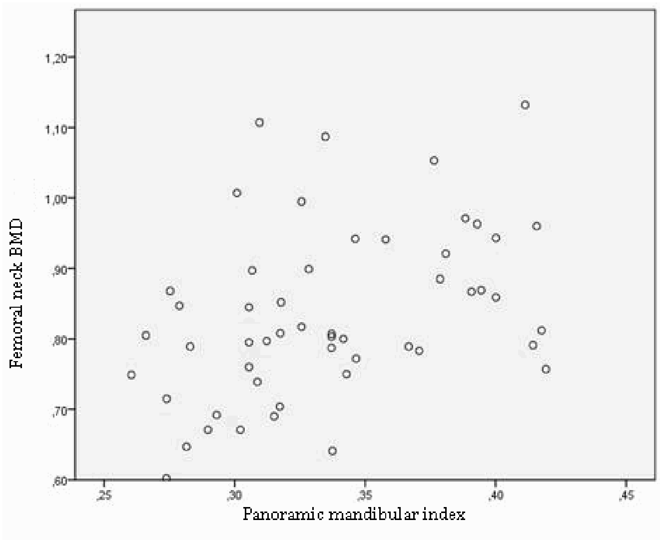

Figure 3. Correlation between femoral neck BMD and PMI in post-menopausal women

Table 3. Correlation between BMD at different levels and the PMI in post-menopausal women

		PMI
L1-L4 BMD	Correlation Coefficient	0.362
	P	0.008
	N	53
Femoral head BMD	Correlation Coefficient	0.410
	P	0.003
	N	52
Total Hip BMD	Correlation Coefficient	0.302
	P	0.029
	N	52
BMD Mandible	Correlation Coefficient	0.068
	P	0.732
	N	28
PMI	Correlation Coefficient	1
	P	
	N	53

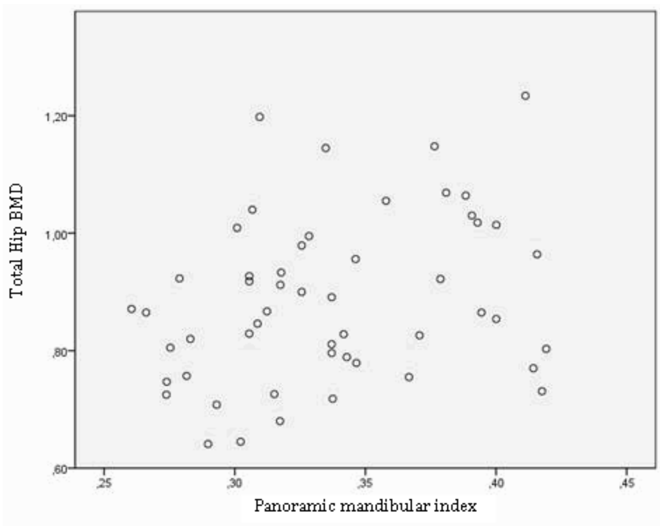

Figure 4 . Correlation between total hip BMD and PMI in post-menopausal women

Discussion

The present study aimed at establishing a correlation between different types of bone lesions associated with the periodontal disease, which are radiologically detectable by using OTP, and

BMD-determined osteoporosis. It also attempted to establish a correlation between PMI and BMD at different levels. OPT was selected as a radiological technique for the following reasons: a) it is currently one of the most widespread radiological examination techniques in our country; b) it does not require sophisticated equipment; c) it is a simple and quick technique to acquire details of the deep marginal periodontium. OPT also provides certain advantages in the study of periodontal diseases, such as: the possibility to visualise all the teeth and their support structures at the level of both arcades on a single image; acquiring the most complete radiological assessment (from among classical techniques) of generalised periodontal lesions; an exact depiction of the far-end molars, which is more difficult to accomplish by retroalveolar radiography due to the difficulty in positioning the film; the radiation dose is relatively low especially when using modern equipment (the equivalent of 3-4 retroalveolar x-rays).

PMI represents the ratio between the ratio between the width of the lower mandibular cortex in the mental area and the distance between the lower margin of the mandible and the lower or upper margin of the mental foramen. It may be considered that a PMI value below 0.40 may indicate an osteoporosis-related diagnosis (Klemetti *et al* 1993; Mohammad *et al* 1996; Ledgerton *et al* 1997).

Although it is a radiomorphometric method, PMI calculation includes a degree of subjectivism, mainly because of the amount of time it requires to establish the optimum visual distance, which is determined by the individual visual acuity and affects the perception of small details. There are also other difficulties in identifying the borders of the mental hole caused by what appears to be several mental holes, or by the porous aspect of the mandibular body or the dense trabecular pattern, or, occasionaly, technical conditions (Phillips *et al* 1992; Hessi *et al* 1994).

The present study allowed us to find significant differences between the mean PMI values in the group of post-menopausal women that suffered from osteoporosis (0.33), as compared to those without a diagnosis of osteoporosis (0.4), which shows that osteoporosis patients present bone loss at the level of the mandible. Also, the determination of a low PMI value also represents a warning sign for the osteoporosis patients, pointing at a need for more complex investigations.

As far as the relationship between PMI and BMD is concerned, we identified statistically significant correlations between L1-L4 BMD, femoral head BMD and hip BMD and the PMI. We revealed a direct correlation between PMI and BMD; thus, the lower the BMD the more decreased the PMI, which shows that bone mineral density in other skeletal areas is in concordance with the mandibular density.

International studies regarding these relationships are relatively few and controversial.

A recent cross-sectional study on a larger sample of post-menopausal women (1,314 cases) focused on the association between alveolar crestal height (ACH) and skeletal bone density. The resulting data revealed a strong association between bone density and oral bone loss in the areas surrounding the teeth. Specifically, post-menopausal women with increased T-scores, low bone mass and/or osteoporosis present a substantially higher probability of decreasing alveolar crestal bone height than women with T-scores within normal limits.

These results support the conclusion that in the case of post-menopausal women there is a strong connection between the deterioration of the T-score and ACH loss and that age is a determining and important factor of this connection. The results persisted even after adjusting results for various factors known for their association with ACH reduction, including age. The results of this study demonstrate that crestal bone loss around teeth is associated with low bone mass and may explain the existence of fewer teeth in women suffering from osteoporosis (Wactawski-Wende *et al* 2005).

Kalokairinos and Motogna (1999) have also found that PMI value is lower in women suffering from osteoporosis and that finding low values is a warning sign in the patients that are at risk of developing osteoporosis. Without being an infallible method of making a diagnosis of osteoporosis, PMI can be used for orientation purposes in distinguishing osteoporotic patients from healthy ones.

Conclusions

There are statistically significant differences between the panoramic mandibular index in post-menopausal women with osteoporosis as compared to non-osteoporotic ones.

2. Statistically significant correlations were identified between L1-L4, femoral head and total hip bone mineral densities and the panoramic mandibular index; the lower the bone mineral density the more the panoramic mandibular index is decreasing.

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