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Panoramic radiomorphometric parameters in Polish patients

P. Kalinowski[1], I. Różyło-Kalinowska[2]

[1]*Independent Unit of Epidemiology, Medical University of Lublin, Poland*
[2]*Department of Dental and Maxillofacial Radiology, Medical University of Lublin, Poland*

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Panoramic radiographs are frequently applied in dental radiodiagnostics and might serve as a tool for identification of a subject's bone mass. Only in a few publications can data on men, younger subjects and larger groups of patients be found. No such data are available for the Polish population; therefore, the aim of the study was to determine normal ranges of panoramic radiomorphometric parameters and examine the influence of gender and age on them. The material consisted of 877 digital panoramic radiographs taken in patients aged 20 to 95 years (mean 48.69 years), including 467 females and 410 males. Panoramic parameters such as mandibular height (H) and distance between inferior margin of mental foramen and inferior mandibular cortex (h), which are used for calculation of panoramic radiomorphometric indices, were estimated and the obtained results were subjected to statistical analysis. Gender influenced H and h, while it was found that H was age-dependent and h values were similar in all age groups. When age and gender were discussed simultaneously, the highest values of H were observed in the age group 30–39 years in both genders, followed by a gradual decrease with age. However, in females this decrease was more intense than in males. The elaborated norms of panoramic radiomorphometric parameters and indices in the Polish patients may serve as a source of comparison for radiological and clinical applications. (Folia Morphol 2011; 70, 3: 168–174)

Key words: mandible, panoramic radiographs, radiomorphometric parameters

INTRODUCTION

Bone mass is primarily determined by genetic factors. The most significant of them is gender. The increase in bone mass is the highest in both genders at around 30 years of age, but peak bone mass is greater in males than in females. Individuals who were subjected to malnutrition or inadequate physical activity as young adults do not reach optimal skeletal size and strength [20].

Bone loss occurring with age is a commonly observed phenomenon in humans [1, 17, 19, 20]. It affects both females and males, but it is increased in postmenopausal females [7, 20]. Women suffer from rapid decline of bone mass during the first 5–10 years after menopause, while later the decrease stabilises at a lower rate. In men, bone loss starts later and progresses more slowly than in women [20].

The aetiology of generalised osteopaenia is multifactorial and includes a number of established risk factors such as age, tobacco smoking, menopause, gender, and some medications [2, 16, 19]. Bone mass depends also on the racial background of the patients: it is higher among black patients than in Caucasians, but in these subjects

Address for correspondence: I. Różyło-Kalinowska, Department of Dental and Maxillofacial Radiology, Medical University of Lublin, Poland, ul. Karmelicka 7, 20–081 Lublin, Poland, tel/fax: +48 81 740 77 40, e-mail: p.kalinowski@umlub.pl

bone density is greater than in persons of Mongoloid origin [12].

Panoramic radiographs are indispensable in dental radiodiagnostics, and as they are often taken during dental treatment and repeated during follow-up, they might serve as a tool for identification of a subject's bone mass. It is known that osteoporosis results in reduced jaw bone mass as well as alterations of the mandibular structure, mainly the inferior cortex [6, 10]. For this purpose, various panoramic radiomorphometric indices were elaborated, predominantly based on cortical layer width (IC, Inferior Cortex) as it is evident on radiographs [1, 16, 20]. The material of the majority of papers discussing the clinical value of these indices is limited to females (as they are more prone to osteoporosis than men) aged over 40 years (postmenopausal women). Only in a few publications can data on men [1, 6], younger subjects [6], and larger groups of patients (the OSTEODENT project [4, 8]) be found. No such data are available for the Polish population; therefore, the aim of the study was to determine normal ranges of panoramic radiomorphometric indices and examine the influence of gender and age on these parameters.

MATERIAL AND METHODS

The material consisted of 877 digital panoramic radiographs taken in Caucasian patients aged 20 to 95 years (mean 48.69 years), including 467 females and 410 males. The radiographs were obtained by means of a Proscan (Planmeca, Finland) panoramic X-ray and Dürr Dental (Germany) digital radiography system. Only good quality radiographs of adult patients were selected from the digital archives of the Department of Dental and Maxillofacial Radiology of the Medical University of Lublin, Poland. All examinations were prescribed due to clinical indications; therefore, none were taken only for the purpose of this study.

The X-rays were next exported from the digital radiography DBSWIN v. 3.2.2-E software (Dürr Dental) as bitmap files to Emago® ver. 3.42 software (Oral Diagnostic Systems, ACTA, Holland) dedicated to advanced analysis of digital dental radiographs. After image calibration (using an endodontic tool of known length and Endo Length option) the following radiomorphometric measurements were performed:

— mandibular height — the distance from the inferior margin of the mandible to the upper limit of the alveolar process in the region of the mental foramen (H);
— the distance between the inferior mandibular cortex and the inferior margin of the mental foramen (h).

These two distances were determined because, on their basis, the following radiomorphometric indices can be calculated:

— panoramic mandibular index (PMI)

$$PMI = IC : h$$

— mandibular ratio (MR)

$$MR = H : h$$

Mean, minimum and maximum values of the H and h parameters were analysed regarding age groups (20–29 years; 30–39 years; …; 60–69 years; and over 70 years of age) as well as taking into account gender — in the total group as well as within the age groups.

Statistical analysis was performed by means of the Statistica software package for Windows (StatSoft Media, license no. BXXP807E041622FA-R). Descriptive statistics was used in order to analyse the mean, median, and maximum and minimum values of panoramic radiomorphometric parameters in the whole group as well as taking into account gender, age, and both variables simultaneously. Shapiro-Wilk test was used to determine the distribution of the obtained data, and depending on its results U Mann-Whitney test or Student's t test were applied in order to study differences between the groups regarding gender.

RESULTS

Mean values of determined panoramic radiographic indices in the study group are presented in Table 1.

Table 1. Descriptive statistics of panoramic radiomorphometric parameters for the entire group

Variable	No.	Mean	Median	Minimum	Maximum	SD
H right side	877	27.24278	27.83333	7.75	38.5	4.63193
H left side	877	27.2252	27.75	8.166667	38.33333	4.622041
h right side	877	11.12638	11.08333	4.75	17.16667	1.710587
h left side	877	11.37533	11.33333	4.583333	17.08333	1.74203

Table 2. Correlations between age and panoramic radiomorphometric indices (Spearman's correlation coefficients) (statistically significant correlations marked with an asterisk)

Pair of variables	No.	R Spearman's coefficient	Statistics t(N-2) value	P
Age and H right side	877	–0.333258	–10.4556	0.00*
Age and H left side	877	–0.330338	–10.3527	0.00*
Age and h right side	877	0.080199	2.379985	0.017527
Age and h left side	877	0.040927	1.211648	0.225974

Table 3. Differences in panoramic radiomorphometric indices between females and males — U Mann-Whitney test results (apart from the h parameter) (statistically significant differences marked with an asterisk)

Variable	Gender	No.	Mean	SD	U Mann-Whitney test results	P
H right side	Females	467	25.52034	4.699250	12.27935	0.00*
	Males	410	29.20467	3.680430		
H left side	Females	467	25.62562	4.631797	11.60700	0.00*
	Males	410	29.04715	3.881174		

Table 4. Descriptive statistics of the right side H parameter regarding age and gender

Age group	No.	Mean	Standard deviation	Minimum	Maximum
Total					
20–29 years	158	28.95622	3.056653	20.7500	37.83333
30–39 years	149	29.25783	3.464621	19.08333	36.25000
40–49 years	154	28.20996	3.925461	16.16667	37.33333
50–59 years	148	26.22917	4.123471	12.08333	34.16667
60–69 years	132	25.52462	5.063619	7.75000	35.16667
> 70 years	136	24.71998	5.909700	8.16667	38.50000
Males					
20–29 years	62	30.89919	2.924799	24.25000	37.83333
30–39 years	81	30.66770	2.972253	20.58333	35.75000
40–49 years	75	30.13444	3.068656	23.33333	37.33333
50–59 years	70	27.83095	3.380582	15.33333	34.16667
60–69 years	58	27.70259	3.636308	19.08333	35.16667
> 70 years	64	27.48568	4.371942	16.33333	38.50000
Females					
20–29 years	96	27.70139	2.427537	20.75000	32.91667
30–39 years	68	27.57843	3.271310	19.08333	36.25000
40–49 years	79	26.38291	3.788137	16.16667	34.75000
50–59 years	78	24.79167	4.218247	12.08333	31.25000
60–69 years	74	23.81757	5.381872	7.75000	33.00000
> 70 years	72	22.26157	6.035049	8.16667	34.25000

Table 5. Descriptive statistics of the left side H parameter regarding age and gender

Age group	No.	Mean	Standard deviation	Minimum	Maximum
Total					
20–29 years	158	28.97152	3.055785	19.33333	37.75000
30–39 years	149	29.19407	3.350455	18.50000	37.25000
40–49 years	154	28.04762	3.951984	15.75000	37.41667
50–59 years	148	26.38288	4.295809	12.91667	35.25000
60–69 years	132	25.26199	5.142397	8.16667	34.75000
> 70 years	136	24.93015	5.790533	8.41667	38.33333
Males					
20–29 years	62	30.97715	2.812936	24.25000	37.75000
30–39 years	81	30.54115	3.139442	20.50000	37.25000
40–49 years	75	29.85111	3.374695	20.75000	37.41667
50–59 years	70	28.07857	3.838001	16.66667	35.25000
60–69 years	58	27.09770	3.875912	15.91667	33.41667
> 70 years	64	27.17057	4.369266	16.50000	38.33333
Females					
20–29 years	96	27.67622	2.455715	19.33333	32.83333
30–39 years	68	27.58946	2.867272	18.50000	34.83333
40–49 years	79	26.33544	3.706009	15.75000	34.75000
50–59 years	78	24.86111	4.131664	12.91667	33.50000
60–69 years	74	23.82320	5.563166	8.16667	34.75000
> 70 years	72	22.93866	6.186176	8.41667	32.50000

Age correlated negatively with mandibular height, while no such correlation was determined for the distance between inferior mandibular cortex and lower margin of the mental foramen (h) (Table 2).

Mean mandibular height measured at the mental foramen (H) equalled 27.2 mm in the total group (± 4.6 mm, minimum: 7.75 mm, maximum: 38.5 mm). In females it was 25.52 ± 4.7 mm on the right and 25.63 ± 4.63 mm on the left. In males the mean values were significantly greater (29.2 mm on the right side and 29.05 on the left side of the mandible). The differences were statistically significant p = 0.00) (Table 3). Mean height of the mandible decreased with age, starting from the age group 30–39 years. In all age groups on the right side it was greater in males than in females. In the oldest patients (over 70 years) the gender-related difference was the most pronounced — 27.48 mm in males and 22.26 mm in females (Table 4). On the left side the disparities between the H parameter measurements in both genders were also evident and were most pronounced in the two oldest age groups (Table 5).

When the distance between the mandibular inferior margin and lower margin of the mental foramen (h parameter for the right and left side) is taken into account, normal range was from 4.58 mm to 17.1 mm, but bilaterally the mean and median values were close to 11 mm (Table 1). No age-related decrease of h values was noted either in the total group or regarding gender (Tables 2, 6, and 7). There was no correlation between the h parameters on the right and left sides (r = 0.049 and r = 0.019, respectively). On the other hand, statistically significant differences were observed between males and females (p = 0.00) (Table 8).

DISCUSSION

The main purpose of the majority of papers discussing panoramic radiomorphometric indices is to evaluate their diagnostic efficiency as a tool to identify patients with high risk of osteoporotic fracture [5, 7–9, 11,

Table 6. Descriptive statistics of the right side h parameter regarding age and gender

Age group	No.	Mean	Standard deviation	Minimum	Maximum
Total					
20–29 years	158	10.79536	1.712419	7.166667	17.16667
30–39 years	149	11.24329	1.584563	7.000000	16.41667
40–49 years	154	11.16829	1.563224	6.916667	15.41667
50–59 years	148	11.19989	1.693094	7.250000	15.33333
60–69 years	132	11.25758	1.753509	4.750000	15.33333
> 70 years	136	11.12806	1.944654	5.583333	16.16667
Males					
20–29 years	62	11.70968	1.865389	8.166667	17.16667
30–39 years	81	11.87346	1.528213	8.166667	16.41667
40–49 years	75	11.80667	1.453106	6.916667	15.41667
50–59 years	70	11.81548	1.586914	8.333333	15.00000
60–69 years	58	11.95833	1.322622	9.333333	15.33333
> 70 years	64	11.72656	1.739384	5.583333	15.66667
Females					
20–29 years	96	10.20486	1.309151	7.166667	13.41667
30–39 years	68	10.49265	1.306059	7.000000	14.08333
40–49 years	79	10.56224	1.423467	7.833333	14.16667
50–59 years	78	10.64744	1.600692	7.250000	15.33333
60–69 years	74	10.70833	1.859007	4.750000	14.83333
> 70 years	72	10.59606	1.973844	6.250000	16.16667

14, 15, 18, 20, 21]. Although it is generally believed that bone mass decreases with age [5], normal ranges of radiomorphometric indices, especially in males, are discussed infrequently [5, 14]. The most extensive material on this issue was gathered in the course of the OSTEODENT project — 671 female patients aged 45 to 70 years, [4, 8] — as well as by Gulsahi et al. [6], who examined panoramic radiographs of 1863 Turkish patients over 20 years of age. In our own material, with the aim of estimating the variability of panoramic radiomorphometric parameters in Polish patients, X-rays of 877 subjects were included — 467 females and 410 males.

Saglam [13] evaluated 192 panoramic radiographs of dentate and edentulous patients, and stated that mandibular height was greater in males than in females. The H value was also significantly greater in dentate patients than in the edentulous ones in the quoted study. In dentate women mean mandibular height equalled 37.5 ± 3.5 mm, while in the remaining female subjects it was 18.7 ± 6.1 mm. In the present paper the group of edentulous patients was not numerous (42 subjects) and, due to this disproportion, was not analysed separately. In the studied Polish subjects the mandibular height differed significantly in both genders ($p = 0.00$) and was greater in men. Age correlated negatively with the H parameter ($r = –0.3688$ and $r = –0.3645$, respectively for the right and the left sides of the mandible).

The distance between the inferior mandibular cortex and the lower margin of the mental foramen (h) (i.e. the part of mandibular body below the mandibular nerve canal) remains at approximately the same height throughout adult life [3]. This may be the reason why there was no evident correlation between the h parameter on the right and left sides ($r = 0.049$ and $r = 0.019$, respectively). However, a statistically significant difference in the h value in males and females ($p = 0.00$) was determined in this study.

In literature we could find only two peer-reviewed papers in worldwide circulation discussing practical

Table 7. Descriptive statistics of the left side h parameter regarding age and gender

Age group	No.	Mean	Standard deviation	Minimum	Maximum
Total					
20–29 years	158	11.20517	1.648994	7.250000	16.00000
30–39 years	149	11.57606	1.729555	7.250000	15.50000
40–49 years	154	11.23864	1.672893	7.166667	16.41667
50–59 years	148	11.43694	1.599161	7.250000	15.25000
60–69 years	132	11.28725	1.809067	4.583333	15.16667
> 70 years	136	11.52635	1.995847	6.166667	17.08333
Males					
20–29 years	62	12.18817	1.665637	9.166667	16.00000
30–39 years	81	12.31893	1.653269	8.333333	15.50000
40–49 years	75	11.93111	1.563734	8.333333	16.41667
50–59 years	70	12.06310	1.517241	8.250000	15.00000
60–69 years	58	11.81178	1.580103	8.833333	15.16667
> 70 years	64	12.05859	1.730884	8.250000	17.08333
Females					
20–29 years	96	10.57031	1.294011	7.250000	13.75000
30–39 years	68	10.69118	1.371958	7.250000	14.00000
40–49 years	79	10.58122	1.506927	7.166667	14.58333
50–59 years	78	10.87500	1.463896	7.250000	15.25000
60–69 years	74	10.87613	1.879769	4.583333	15.08333
> 70 years	72	11.05324	2.105553	6.166667	16.41667

Table 8. Differences between h values regarding patient gender — Student's t test results (statistically significant differences marked with an asterisk)

Variable	Gender	No.	Mean	SD	Student's t test results	P	Degrees of freedom	F test value	P of the F test
h right side	Females	467	10.52123	1.58816	12.06889	0.00*	875	1.009317	0.924602
	Males	410	11.81565	1.58082					
h left side	Females	467	10.76356	1.61441	11.96638	0.00*	875	1.003719	0.967459
	Males	410	12.07215	1.61741					

applications of panoramic radiomorphometric indices in Polish patients [5, 22]. However a potential weakness of these studies is the relatively small number of examined subjects (30 and 35 patients, respectively) in comparison with 877 subjects in the present study.

Drozdzowska et al. [5] evaluated 30 healthy postmenopausal women aged 48 to 71 years. In this study group the h parameter was constant, and the mean value equalled 12.3 ± 2 mm. Our own results were comparable: 11.13 ±1.17 mm on the right and 11.38 ± 1.74 mm on the left side of the mandible.

The other available paper on the issue of panoramic radiomorphometric indices in Polish patients was published by Zmysłowska et al. [22], who evaluated panoramic radiographs of 35 edentulous patients, aged 51 to 89 years, who were users of prosthetic appliances. These authors estimated MR indices bilaterally. The mean values reached 1.64 ± ± 0.36 on the right side of the mandible and 1.61 ±

± 0.32 on the left side, without statistically significant difference (p = 0.8). In their opinion, mandibular ridge resorption was not age-dependent (p = = 0.6 on the right and p = 0.8 on the left side), but the small size of the study group did not allow definite conclusions to be drawn. These authors noted negative correlation between the duration of edentulousness and MR index, but only unilaterally (r = –0.33, p < 0.05 on the right side of the mandible).

CONCLUSIONS

1. Gender influenced the mandibular height values as well as the distance between the inferior margin of the mental foramen and the inferior mandibular cortex.
2. The distance between the inferior mandibular cortex and the inferior limit of the mental foramen was similar in all age groups, while the mandibular height tended to be lower in older age groups.
3. When age and gender were discussed simultaneously, the highest values of the H parameter were observed in the age group 30–39 years in both genders. In older age groups the mandibular height decreased gradually, but the decline was more pronounced in females.
4. The elaborated norms of panoramic radiomorphometric parameters in Polish patients may serve as a source of comparison for radiological and clinical applications.

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