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Bone Mineral Density and Radiographic Mandibular Body Height

Estera Balcikonyte, Irena Balciuniene, Vidmantas Alekna

SUMMARY

The panoramic based measurements (the total height of the mandibular body and the height from the lower border of mandible to the lower border of the mental foramen) and Mandibular Ratio index were compared to bone mineral density of the lumbar area L2-L4 by dual-energy x-ray absorptiometry (DXA) measurements in 130 women. Correlations of Mandibular Ratio indexes with parameters reflecting skeletal status measured by DXA were not statistically significant. Significant correlations between Mandibular Ratio indexes and the total height of the mandibular body ($r = 0.409$, $p<0.001$ (right side); $r =0.403$, $p<0.001$ (left side)), and with the height from the lower border of mandible to the lower border of the mental foramen ($r = -0.671$, $p<0.001$ (right side); $r = -0.709$, $p<0.001$ (left side)) were noted. The measurements of the total height of the mandibular body and the height from the lower border of mandible to the lower border of the mental foramen do not correlate significantly with dual-energy x-ray absorptiometry measurements and they should not be used as indicators of bone mineral status. The efficacy of the panoramic-based Mandibular Ratio index in diagnosing osteopenia/osteoporosis is low to moderate.

Keywords: mandible, tooth loss, alveolar bone loss, bone mineral density, osteoporosis.

INTRODUCTION

In recent years, there has been an obvious osteoporosis increase in the older population. Osteoporosis, a systemic disease in the elderly, has been watched with keen interest. The problems associated with age-related skeletal osteopenia have received much attention since the human skeleton undergoes a continuous physiological decrease in bone mass with advancing age.

Systemic loss of bone density leading to osteoporosis has long been suspected as a risk factor for loss of oral bone, including loss of the alveolar process associated with periodontal infection. A number of investigators have stated that the progressive loss of alveolar bone may be manifestation of osteoporosis [1-5].

Devices for measuring bone mineral density, bone mass, and mineral content have developed rapidly during the last 2 decades. A number of reports have been published concerning the association between diminishing total bone mass and rate of residual ridge resorption (RRR) [6, 7, 8, 9, 10, 11, 12]. The main finding has been that, at least in the first phase of alveolar resorption, general osteoporosis status affects the speed of residual ridge resorption [7, 8, 13]. The latter phase of resorption and the relation of other factors to residual ridge resorption, as compared to the general effect of osteoporosis, are still not well understood.

The number of researches presented the relationship between changes in alveolar bone height and bone mineral density in the edentulous patients. We did not find reports about the relations between the alveolar ridge height and bone mineral status in dentate patients or in patients with partial edentate.

Estera Balcikonyte *- D.D.S., ass.prof., Institute of Stomatology, Faculty of Medicine, Vilnius University, Lithuania.*
Irena Balciuniene *– M.D., PhD, Hab.Dr., Professor and Director of Institute of Stomatology, Faculty of Medicine, Vilnius University, Lithuania.*
Vidmantas Alekna *- PhD, Faculty of Medicine, Vilnius University, Lithuania. The President of Lithuanian Fund of Osteoporosis and of Lithuanian Association of Osteologists.*
Address correspondence to Dr.Estera Balcikonyte, Institute of Stomatology, Faculty of Medicine, Vilnius university, 115 Zalgirio str., 2042 Vilnius, Lithuania. E-mail: esterab@takas.lt.

The aims of this study were: (a) to determine whether bone mineral density of the lumbar area is correlated with the residual alveolar ridge height of the mandible, (b) to compare the residual alveolar ridge height of the mandible in premenopausal and postmenopausal groups and (c) to determine the influence of age to the height of mandibular body.

MATERIAL AND METHODS

The participants of the study were 130 healthy women aged 30.1-79.2 years (mean 60.4), living in Lithuania. The study was approved by the local committee and informed consent was obtained from all subjects. Every fifth woman consulting a doctor in the National Osteoporosis Center was recruited. None of the participants were known to have endocrine, metabolic, or skeletal disorders. None of women were on hormonal replacement therapy or taking calcitonin, bisphosphonates or fluorides except of low doses of calcium or vitamin D. Criteria for stomatological selection of the subjects was no history of serious diseases impacting oral bones. All participants had good oral health and were dentate or had partial edentate.

General osteoporosis status was determined by measuring the bone mineral density of the lumbar area L2-L4. These measurements were made by a dual-energy x-ray absortiometry, using Lunar IQ machine (Lunar Corporation, Madison, WI, USA) by the same operator. Each woman was classified into one of three (OST 1-3) groups according to the bone mineral density and into three groups (T-score 1-3) according to T-score according to WHO. T-score groups were assessed according to the following criteria: the group T-score 1 (osteoporotics) defined as T-score more than 2.5 SD below above the normal young female value, the group T-score 2 (osteopenics) defined as T-score ranging from 1 to 2.5 SD below value and the 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 a single operator. The position of the head was standardized as much as possible. Each panoramic radio-

graph was viewed by the same investigator in a blinded fashion. Height of the mandibular residual ridge was measured from the inferior border to the superior edge of the alveolar crest in the region of the mental foramen. A perpendicular line was drawn across the image of the mandible perpendicular to the horizontal axis of the mandibular body (the inferior and superior borders forming equal angles with the ruler) going trough the middle of the mental foramen. Measurements of the height of mandible were made with an odontometer. A special magnification loupe with frames (SDI, Sweden) creating a dark setting was used. On the both sides of mandible two measurements were recorded:

1. The total height of the mandibular body (the distance between lower and upper borders) (H (mm));
2. The height from the lower border of the mandible to the lower border of the mental foramen (h (mm)).

Based on these images Mandibular Ratio index (MR) was measured. MR, serving as the indicator of residual ridge resorption, was calculated as a ratio H/h according to the method of Ortman *et al.* [4] which is adaptation of a technique described by Wical and Swoope [14].

Calculations of means and standard deviations (SD) as well as correlations and differences were performed using SPSS 8.0 program. The total height of the mandibular body (H), the height from the lower border of the mandible to the lower border of the mental foramen (h) and Mandibular Ratio index (MR) were compared with the skeletal mineral status grouping (OST 1-3), T-score grouping (T-score 1-3), and the term of menopause of the subjects. The data were expressed as mean and standard deviation. Correlations between variables were established using Person correlation coefficient. The significant level was achieved with P values value <0,05.

RESULTS

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.

4.8% (n=14) of the women were in premenopausal period, 34.4% (n=100) were in physiological menopausal period and 5.5% (n=16) were in menopausal period started after gynaecological surgical treatment. Maximum term of menopauses was 420 months (the mean 138.2 months).

The means of the total height of the mandibular body (H): right side (Hr) were 17.50-40.30mm (mean value 32.31mm SD 3.95), left side (Hl) were 19.80-40.50mm (mean value 32.32mm SD 3.84).

The means of the height from the lower border of mandible to the lower border of the mental foramen (h) of right side (hr) were 8.30-17.30mm (mean value 12.38mm SD 1.93), of left side (hl) were 7.80-18.90mm (mean value 12.47mm SD 2,01).

The means of the Mandibular Ratio index (MR) of the right side (MRr) were from 1.72 to 3.94 (mean value 2.65 SD 0.45) and of the left side (MRl) were from 1.46 to 4.04 (mean value 2.65 SD 0.47).

The values of the mandibular height measurements and Mandibular Ratio index in T-score groups (T-score 1-3) and bone mineral density groups (OST 1-3) are shown in the Tables 1-3.

The total height of the mandibular body and the height from the lower border of mandible to the lower border of the mental foramen in all women did not correlate with the age and the term of menopause. There were no significant differences between the total height of the mandibular body, the height from the lower border of mandible to the lower

Table 1. *The values of the mandibular height measurements and Mandibular Ratio indexes in the T-score groups.*

T-score Groups		Hr	Hl	hr	hl	MRr	MRl
1	N	29	29	29	29	29	29
	Mean	31.1310	31.0000	12.0483	11.9655	2.6366	2.6472
	Std. Deviation	4.4571	3.9092	1.7630	1.7249	.4333	.5187
2	N	94	94	94	94	94	94
	Mean	32.8394	32.7989	12.5681	12.6149	2.6547	2.6602
	Std. Deviation	3.6374	3.8044	1.9937	2.0948	.4731	.4587
3	N	7	7	7	7	7	7
	Mean	30.1143	31.2714	11.3571	12.7714	2.6557	2.4943
	Std. Deviation	4.6592	2.8975	1.2960	1.8509	.3141	.4121
Total	N	130	130	130	130	130	130
	Mean	32.3115	32.3154	12.3869	12.4785	2.6507	2.6484
	Std. Deviation	3.9545	3.8419	1.9302	2.0115	.4547	.4684

Table 2. *The values of the mandibular height measurements and Mandibular Ratio indexes in the bone mineral density groups.*

OST groups		Hr	Hl	hr	hl	MRr	MRl
1	N	38	38	38	38	38	38
	Mean	30.6289	30.6895	11.9263	12.0921	2.6182	2.6087
	Std. Deviation	4.3593	3.5816	1.7876	2.0254	.4246	.5281
2	N	74	74	74	74	74	74
	Mean	33.3068	33.0311	12.8135	12.7824	2.6265	2.6357
	Std. Deviation	3.5071	3.9313	1.9386	2.0266	.4434	.4286
3	N	18	18	18	18	18	18
	Mean	31.7722	32.8056	11.6056	12.0444	2.8189	2.7844
	Std. Deviation	3.6798	3.0539	1.8067	1.7893	.5454	.4952
Total	N	130	130	130	130	130	130
	Mean	32.3115	32.3154	12.3869	12.4785	2.6507	2.6484
	Std. Deviation	3.9545	3.8419	1.9302	2.0115	.4547	.4684

Table 3. *The values of the mandibular height measurements and Mandibular Ratio indexes in normal, osteopenic and osteoporotic subjects.*

		Hr	Hl	hr	hl	MRr	MRl
Osteoporosis	**N**	14	14	14	14	14	14
	Mean	32.5143	32.7643	11.6071	11.7071	2.8586	2.8550
	Std. Deviation	3.5229	3.1373	1.8235	1.7726	.5092	.4705
Osteopenia	**N**	100	100	100	100	100	100
	Mean	32.3650	32.3070	12.4600	12.6390	2.6384	2.6037
	Std. Deviation	3.8042	3.8019	1.9236	2.0114	.4487	.4326
Normal	**N**	16	16	16	16	16	16
	Mean	31.8000	31.9750	12.6125	12.1500	2.5456	2.7469
	Std. Deviation	5.2807	4.7640	2.0192	2.1282	.4144	.6292
Total	**N**	130	130	130	130	130	130
	Mean	32.3115	32.3154	12.3869	12.4785	2.6507	2.6484
	Std. Deviation	3.9545	3.8419	1.9302	2.0115	.4547	.4684

Table 4. *Correlations between radiological measurements of the height of mandible and the bone mineral density of lumbar area, age, and menopausal term.*

		Age	OST groups	T-score groups	Menopause term	Hr	Hl	hr	hl	MRr	*MRI*
Age	**Pearson Correlation**	1.000	-.490***	-.487***	.753***	-.045	-.034	.072	.068	-.120	-.081
	Sig. (2-tailed)	.	.000	.000	.000	.609	.703	.414	.441	.173	.359
	N	130	130	130	130	130	130	130	130	130	130
OST groups	**Pearson Correlation**	-.490***	1.000	1.000***	-.424***	.049	.113	.013	.030	.043	.036
	Sig. (2-tailed)	.000	.	.000	.000	.576	.202	.879	.732	.623	.687
	N	130	130	130	130	130	130	130	130	130	130
T-score groups	**Pearson Correlation**	-.487***	1.000***	1.000	-.422***	.051	.115	.012	.028	.047	.038
	Sig. (2-tailed)	.000	.000	.	.000	.561	.194	.890	.748	.597	.666
	N	130	130	130	130	130	130	130	130	130	130
Menopause term	**Pearson Correlation**	.753***	-.424***	-.422***	1.000	-.037	-.008	-.015	.031	-.006	-.033
	Sig. (2-tailed)	.000	.000	.000	.	.673	.924	.863	.730	.948	.713
	N	130	130	130	130	130	130	130	130	130	130
Hr	**Pearson Correlation**	-.045	.049	.051	-.037	1.000	.729***	.336***	.197**	.409***	.304***
	Sig. (2-tailed)	.609	.576	.561	.673	.	.000	.000	.025	.000	.000
	N	130	130	130	130	130	130	130	130	130	130
Hl	**Pearson Correlation**	-.034	.113	.115	-.008	.729***	1.000	.251***	.313***	.314***	.403***
	Sig. (2-tailed)	.703	.202	.194	.924	.000	.	.004	.000	.000	.000
	N	130	130	130	130	130	130	130	130	130	130
hr	**Pearson Correlation**	.072	.013	.012	-.015	.336***	.251***	1.000	.428***	-.671***	-.232***
	Sig. (2-tailed)	.414	.879	.890	.863	.000	.004	.	.000	.000	.008
	N	130	130	130	130	130	130	130	130	130	130
hl	**Pearson Correlation**	.068	.030	.028	.031	.197**	.313***	.428***	1.000	-.257***	-.709***
	Sig. (2-tailed)	.441	.732	.748	.730	.025	.000	.000	.	.003	.000
	N	130	130	130	130	130	130	130	130	130	130
MRr	**Pearson Correlation**	-.120	.043	.047	-.006	.409***	.314***	-.671***	-.257***	1.000	.454***
	Sig. (2-tailed)	.173	.623	.597	.948	.000	.000	.000	.003	.	.000
	N	130	130	130	130	130	130	130	130	130	130
MRl	**Pearson Correlation**	-.081	.036	.038	-.033	.304***	.403***	-.232***	-.709***	.454***	1.000
	Sig. (2-tailed)	.359	.687	.666	.713	.000	.000	.008	.000	.000	.
	N	130	130	130	130	130	130	130	130	130	130

** OST: bone mineral density; T-score: SD decrease from peak bone mass; Hr: the total height of the mandibular body of right side of the mandible; Hd: the total height of the mandibular body of left side of the mandible; hd: the height from the lower border of mandible to the lower border of the mental foramen of the right side of the mandible; hl: the height from the lower border of mandible to the lower border of the mental foramen of the left side of the mandible; MRr: (Hr/hr) mandibular ratio of the right side of the mandible; MRl: (Hl/hl) mandibular ratio of the left side of the mandible.*

*** Correlation is significant at the 0.01 level (2-tailed).*

**** Correlation is significant at the 0.05 level (2-tailed).*

border of the mental foramen, and the Mandibular Ratio indexes in the bone mineral density groups (OST1-3). Also the measurements of the jawbone height and the index of residual ridge did not indicate significant correlation in the T-score groups (T-score 1-3). The index of Mandibular Ratio correlated with the total height of the mandibular body (H) ($r = 0.41$, $p<0.001$) and the height from the lower border of mandible to the lower border of the mental foramen (h) ($r = -709$, $p<0.001$). The results of correlations are shown in the Table 4.

DISCUSSION

For many years the gradual resorption of the alveolar bone was thought to be due only to local factors such as the loss of the functional influence of the teeth on the surrounding tissues, direct loading of the alveolus by complete dentures, continuous wearing of ill-fitting dentures, and periodontal disease. Currently the literature suggests a relationship between systemic bone loss from osteoporosis and the resorption of the edentulous alveolar ridge [6, 13,

15]. Many (but not all) studies have shown a relation between skeletal density and oral bone density, crestal height, or residual ridge resorption.

Von Wowern & Kollerup [16] reported that osteoporotic edentulous women show a higher degree of maxillary, but not significantly higher degree of mandibular, atrophy than normal women. Klemetti *et al.* conducted a number of studies on the relationship between indicators of osteoporosis and oral bone loss. These investigators studied the height of the residual ridge and bone mineral density (BMD) of the trabecular bone of the mandible assessed by quantitative computed tomography (QCT) in 74 of 355 menopausal women. They compared mandibular BMD to BMD of the lumbar spine and femur which was measured by dual-energy x-ray absortiometry (DXA). Their study showed that the BMD of the spine and femur correlated well to each other, but not to the BMD of the trabecular bone of the mandible. Residual ridge height did not correlate strongly with any BMD values [17].

On the other hand, according to Hirai *et al.* [1] suggested in the study of 44 female and male edentulous patients aged 81.1 years that osteoporosis strongly affects reduction of the residual ridge. The height of the residual ridge edentulous ridge in these patients was significantly correlated ($r = -0.42$, $P<0.01$) with severity of osteoporosis. In another report, Klemetti studied 355 edentulous postmenopausal women and determined number of teeth, time of last extraction, and height of alveolar ridges. Time of tooth loss and number of teeth were not correlated with generalized bone density, but clinical height was related to bone density in some regions [18]. A subsequent study reported on alveolar crest height, duration of edentulous, and BMD in five different regions of the mandible in 77 post-menopausal women. This study showed that after tooth loss, BMD of the trabecular, but not cortical, regions of the mandible was lower. The authors postulate the mechanism to be the mechanical stress caused by remaining natural teeth rather than the damage following use of maxillary dentures [19]. They also considered time since last tooth loss in four cortical regions within this cohort of 77 partially or totally edentate post-menopausal women. Density of the cortical bone on the lingual and buccal sides, and distal from the mental foramen, was significantly higher among those who had been edentate 12 to 23 years, but not in those edentate less than 12 or over 23 years compared to dentate subjects. The authors suggest that muscular activity during different phases of edentulousness regulates the bone mineral density in those attachment regions [20]. Ortman *et al.* [4] maintained that percentage of patients with severe residual ridge resorption increases with edentulous time status.

In our study correlations of Mandibular Ratio indexes (MR) with parameters reflecting skeletal status measured by DXA were not statistically significant. We noted only two significant correlations of mandibular ratio: with the total height of the mandibular body ($r = 0.409$, $p<0.001$ (right side); $r = 0.403$, $p<0.001$ (left side)) and with the height from the lower border of mandible to the lower border of the mental foramen ($r = -0.671$, $p<0.001$ (right side); $r = -0.709$, $p<0.001$ (left side)). The ability of mandibular variables indicates the changes of bone mass were generally low. We suppose that possible reason was the fact that all our women were partial or total dentated. It is well known that the jaws undergo a continuous alveolar ridge atrophy after extraction of teeth and the use of full dentures. This atrophy is about four times greater in the edentulous mandible than in maxilla [21].

Factors influencing the interpretation of the data include underlying population studied and method of determining oral bone loss. The populations studied vary on important characteristics such as prevalence of edentulousness, gender, and underlying prevalence of severe osteopenia. These factors play a role in determining the relation between osteoponia and oral bone loss. Limitation of our study could be: quite small number of osteoporotic patients with T-score < -2.5 and the lack of edentulous women. These results are open-ended at the moment. In next articles we shall discuss about resent results and findings.

CONCLUSIONS

The measurements of the total height of the mandibular body, also of the height from the lower border of mandible to the lower border of the mental foramen do not correlate significantly with DXA measurements and they should not be used as indicator of skeleton status. The efficacy of the panoramic-based mandibular ratio index in diagnosing osteopenia or osteoporosis is low to moderate.

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