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Original research

Does tooth loss in the mandibular posterior region have an effect on the mental index and panoramic mandibular index?

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Purpose

Mental index (MI) and panoramic mandibular index (PMI) are important radiomorphometric indices used for assessing the quality of the mandibular bone. The aim of this study was to investigate the possible effect of mandibular posterior tooth/teeth loss in young adults on the MI and PMI (superior panoramic mandibular index: PMI-s, and inferior panoramic mandibular index: PMI-i).

Materials and Methods

Digital panoramic radiographs belonging to 253 patients aged between 18-35 years old were examined. According to the inclusion criteria of the study, a patient and control group was formed. The patient group (n=46) included individuals having at least one extracted tooth in the posterior region of the mandible, and the control group (n=45) included full dentate patients. The MI and PMI (PMI-i and PMI-s) were calculated bilaterally for all of the individuals.

Results

No significant difference was found between the MI, PMI-i and PMI-s indices of the patient group and the control group among both genders (p>0.05).

Conclusion

The mandibular premolar and/or molar teeth loss in young adults did not lead to any change in the MI, PMI-i and PMI-s indices among both genders.

Keywords: *Mandible; mental index; panoramic mandibular index; panoramic radiography; tooth loss*

Introduction

Bone metabolism, skeletal mineral status, the extraction of teeth, surgical procedures, occlusal forces transmitted by prosthesis, physical and muscular activity, presence of teeth, different types of denture support, thickness of the mandibular bone, body mass index, and drug intake are factors reported to influence bone mineral density (1).

Panoramic radiographs are commonly used in dental practice for radiographic assessment. Studies have reported that these radiographs could be used to predict local bone loss in patients. Such an evaluation could be performed with specially designed radiomorphometric indices.

The mental index (MI) and the panoramic mandibular index (PMI) are among these radiomorphometric indices (2-4). The MI defines the cortical width in the mental foramen region. It is calculated as the distance of the mandibular cortex on the line perpendicular to the inferior border of the mandible in the middle of the mental foramen (2). The PMI evaluates the cortical thickness of the mandible normalized for the mandibular size. The PMI is assessed as superior (PMI-s) and inferior (PMI-i) panoramic mandibular indices. This index is calculated by dividing the cortex thickness to the distance of the superior and inferior

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margin of the mental foramen to the inferior border of the mandible separately (3).

The jaws undergo continuous alveolar ridge atrophy after the extraction of teeth. This process happens more severely in the mandible than the maxilla (5). Some studies have investigated the effect of the age, gender, edentulism, dental status, and residual alveolar ridge resorption on the radiomorphometric indices in adults and the elderly (6-9). In this study, we tested the null hypothesis that teeth loss in the mandibular posterior region does not have an effect on the MI and PMI in young adults.

Materials and Methods

Population characteristics

The present study protocol was approved by the ethical committee of Gazi University (2017-368). The digital panoramic radiographs present in the archive of the Oral and Dentomaxillofacial Radiology department in the time period of January-May 2017 belonging to patients aged 18-35 years old were evaluated in this study. Informed consent was routinely obtained from all the patients prior to the radiographic examinations. The anamnesis data recorded in the system was assessed and non-medicated individuals free from systemic diseases or trauma were chosen. According to this, a total of 253 digital panoramic radiographs were present in the archive. Out of these 253 digital panoramic radiographs, individuals having at least one extracted tooth in the posterior region of the mandible; excluding the third molars, were accepted into the patient group. Subsequently, the patient group was divided into three sub-groups: 1-Patients having missing teeth on the right side of the posterior mandible 2-Patients having missing teeth on the left side of the posterior mandible, and 3-Patients having missing teeth both on the right and left side of the posterior of the mandible. After this, the individuals having no missing teeth in the mandible and maxilla; excluding the third molars in both jaws, were accepted into the control group. Ninety-one panoramic radiographs out of 253, provided these criteria. Forty-six of these belonged to the patient group (25 males, 21 females), and 45 (22 males, 23 females) belonged to the control group. The four radiographs belonging to the patient group and the four radiographs belonging to the control group were excluded from the study due to undefined mental foramen and /or inferior mandibular cortex borders.

Imaging protocols

The digital panoramic radiographs were obtained with a machine (Sirona Dental Systems, Bensheim, Germany), operating at 66 kVp, 8 mA, with a 0.5 mm focal spot and an exposure time of 14 seconds with standard positioning according to the manufacturer's recommendation. The magnification factor of the machine was 1:25. The panoramic images were in a JPEG format with a resolution of 1935x1054 pixels, 96 dpi and 24 bits. All the measurements were carried out using Image J 1.48v software (National Institutes of Health, USA). All the radiographic evaluations were done on a 20-inch LCD monitor with a resolution of 1600×900 operating at 32-bits (HP 2011x, Hewlett-Packard Company USA) in a quiet room with subdued ambient lighting.

Radiographic evaluation

The evaluation of the radiographs was made independently by two Oral and Maxillofacial Radiology experts. The MI and PMI were measured on the panoramic radiographs. The measurements were made according to the following criteria: The MI was calculated as the distance of the mandibular cortical thickness on the line perpendicular to the bottom of the mandible in the middle of the mental foramen both for the right and the left side (10) (Figure 1). The PMI was calculated as both PMI-s and PMI-i for the right and left side as (3-11): PMI-s: mandibular cortical thickness/distance from the superior margin of the mental foramen to the inferior border of the mandible. PMI-i: mandibular cortical thickness/ distance from the inferior margin of the mental foramen to the inferior border of the mandible (Figure 2). Where possible, all the measurements in the control group were made on both the left and right sides. At least two weeks later, both observers repeated their measurements on 40 digital panoramic radiographs (20 patient group, 20 control group) to evaluate the intra-observer agreement level.

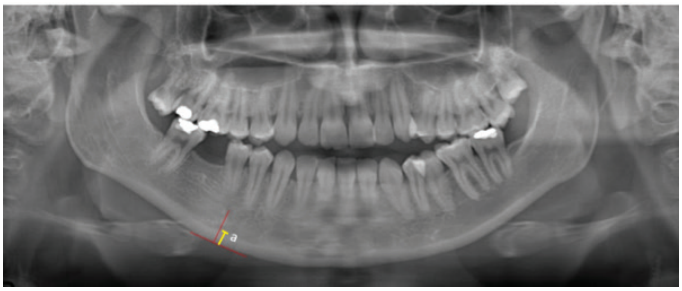

Figure 1. *Mental Index (MI). Length of "a" in mm.*

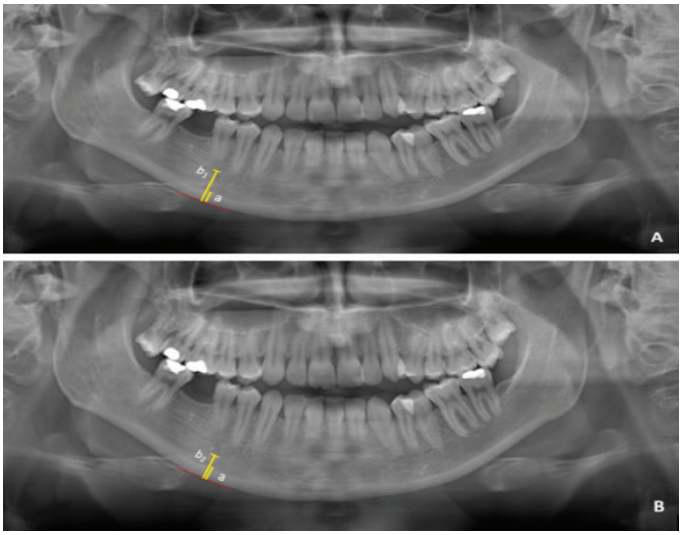

Figure 2. *Panoramic Mandibular Index (PMI). PMI-s = ratio of a/b_1 (A), PMI-i = ratio of a/b_2 (B).*

Statistical analysis

IBM SPSS Statistics 23 software (IBM Corp. Released 2015. IBM SPSS Statistics for Windows, Version 23.0. Armonk, NY, USA) was used in the present study. The normality of the data was assessed with the Kolmogrov Smirnov and Shapiro-Wilk

tests before the analysis of the index measurements. When the data showed a normal distribution, the parametric t-test was used and when not, the Mann Whitney-U test was used for the analysis of the indices. The first and second measurements of the two observers showed a normal distribution. The paired t-test and Pearson correlation coefficient were therefore used for the evaluation of the intra-observer agreement level. Any difference between the genders was assessed with the t-test. Confidence level was set to 95% and $p<0.05$ was considered significant.

Results

The mean age of the patient group was 27.61 (Sd:4.86) and the control group was 27.04 (Sd:4.67). The descriptive statistics and gender distribution of the age and p-values regarding the t-tests are given in Table 1.

3-premolars+molars. Any difference between these tooth groups was analyzed with the ANOVA test. Depending on the test results, no significant differences between tooth groups for the MI (p=0.144), PMI-s (p= 0.719), PMI-i (p=0.945).

The difference between the first and second measurements of the first and second observer for the MI was non-significant. ($p = 0.356 > 0.05$; $p = 0.481 > 0.05$, respectively) The intra-observer agreement for the MI was found to be $r = 0.943$ and $r = 0.652$ for the first and second observer respectively according to the 95% confidence interval. No significant difference was detected between the first and second measurements of the first and second observer for the PMI-s ($p = 0.301 > 0.05$; $p = 0.610 > 0.05$, respectively). The intra-observer agreement for the PMI-s was found to be $r = 0.922$ and $r = 0.680$ for the first and second observer respectively according to the 95% confidence interval. The difference between the first and second measurements of the first and second observer for the PMI-i was non-significant ($p = 0.944 > 0.05$; $p = 0.964 > 0.05$, respectively). The intra-observer agreement for the PMI-i was found to be $r = 0.921$ and $r = 0.627$ for the first and second observer respectively according to the 95% confidence interval. No significant difference was detected for the measurements made for the MI, PMI-s and PMI-i for the right side, the left side, and the total for both observers ($p > 0.05$). The correlation coefficients for the inter-observer agreement level were statistically significant ($p < 0.05$).

Table 1. *Descriptive statistics of gender distribution regarding age and statistical analysis results according to t-test.*

Groups	Gender	N (%)	Mean (Sd)	p-value	95% Confidence Interval of the Difference	
					Lower	Upper
Control	Female	23 (51.1%)	27.83 (5.25)	0.256	-4.400	1.203
	Male	22 (48.9%)	26.23 (3.94)			
	Total	45 (100%)	27.04 (4.68)			
Patient	Female	21 (45.7%)	29.00 (3.92)	0.075	-5.387	0.267
	Male	25 (54.3%)	26.44 (5.32)			
	Total	46 (100%)	27.61 (4.86)			

Sd: Standard deviation

Table 2. *Descriptive statistics of the extracted tooth/teeth according to location and gender.*

	Female N (%)	Male N (%)	Total N (%)
Right-Side	8 (42%)	11 (58%)	19 (41%)
Left-Side	3 (27%)	8 (73%)	11 (24%)
Bilateral	10 (62%)	6 (38%)	16 (35%)

Nineteen (41%) of the extracted teeth belonged to the right side, 11 (24%) belonged to the left side, and 16 (35%) belonged to the bilateral sides of the posterior region of the mandible. The details are given in Table 2. The most frequent extracted teeth were the first molars on both sides of the mandible among both genders. None of the first premolars were extracted. The descriptive statistics of the extracted tooth/teeth and gender are given in Table 3.

No significant difference was observed between age and the measurements made for all the indexes for both observers ($p > 0.05$). When all the groups (right side, left side, and bilateral) were assessed, no significant difference was found between the MI, PMI-s, and PMI-i from the patient group and the control group ($p > 0.05$). The extracted teeth were divided into three groups as: 1-premolars, 2-molars and

Table 3. *Descriptive statistics of the extracted tooth/teeth according to tooth/teeth type and gender.*

Teeth No	Female N (%)	Male N (%)	Total N (%)
44	-	-	-
45	2 (4%)	3 (6%)	5 (7%)
46	15 (5%)	15 (5%)	30 (39%)
47	4 (67%)	2 (33%)	6 (8%)
34	-	-	-
35	3 (5%)	3 (5%)	6 (8%)
36	12 (48%)	13 (52%)	25 (33%)
37	3 (75%)	1 (25%)	4 (5%)

Table 4. *Comparison of the mean index values of the control group (a) and patient group (b).*

	Groups	Mean (Sd)	p-value	95% Confidence Interval of the Difference	
				Lower	Upper
Right-MI	Control	10.60 (1.64)	0.336	-0.374	1.085
	Patient	10.25 (1.70)			
Right-PMI (sup)	Control	0.27 (0.06)	0.659	-0.018	0.029
	Patient	0.27 (0.05)			
Right-PMI (inf)	Control	0.34 (0.08)	0.697	-0.037	0.025
	Patient	0.34 (0.07)			
Left-MI	Control	10.25 (1.98)	0.712	-0.660	0.962
	Patient	10.10 (1.74)			
Left-PMI (sup)	Control	0.27 (0.08)	0.817	-0.021	0.027
	Patient	0.26 (0.05)			
Left-PMI (inf)	Control	0.32 (0.07)	0.514	-0.041	0.021
	Patient	0.33 (0.07)			
Total-MI	Control	10.43(1.81)	0.356	-0.375	1.085
	Patient	10.17 (1.71)			
Total-PMI (sup)	Control	0.27 (0.07)	0.698 (mw)	-0.074	0.034
	Patient	0.27 (0.05)			
Total-PMI (inf)	Control	0.32 (0.07)	0.460 (mw)	-0.037	0.025
	Patient	0.33 (0.07)			

Table 5. *Comparison of the mean index values of the control group (a) and patient group (b) according to gender.*

a. Control Group	Gender	Mean (Sd)	p-value	95% Confidence Interval of the Difference	
				Lower	Upper
Right-MI	Female	10.57 (1.64)	0.901	-0.987	1.117
	Male	10.64 (1.69)			
Right-PMI (sup)	Female	0.28 (0.06)	0.272	-0.055	0.016
	Male	0.27 (0.05)			
Right-PMI (inf)	Female	0.35 (0.08)	0.209	-0.078	0.017
	Male	0.32 (0.06)			
Left-MI	Female	9.77 (1.66)	0.111	-0.235	2.206
	Male	10.76 (2.18)			
Left-PMI (sup)	Female	0.27 (0.06)	0.507	-0.048	0.024
	Male	0.26 (0.06)			
Left-PMI (inf)	Female	0.33 (0.07)	0.625	-0.054	0.035
	Male	0.32 (0.07)			

a. Patient Group	Gender	Mean (Sd)	p-value	95% Confidence Interval of the Difference	
				Lower	Upper
Right-MI	Female	9.82 (1.74)	0.144	-0.275	1.821
	Male	10.60 (1.62)			
Right-PMI (sup)	Female	0.29 (0.23)	0.097	-0.060	0.003
	Male	0.26 (0.06)			
Right-PMI (inf)	Female	0.36 (0.07)	0.067	-0.078	0.002
	Male	0.32 (0.06)			
Left-MI	Female	9.77 (1.77)	0.259	-0.470	2.206
	Male	10.38 (1.69)			
Left-PMI (sup)	Female	0.27 (0.06)	0.536	-0.048	1.697
	Male	0.26 (0.05)			
Left-PMI (inf)	Female	0.34 (0.08)	0.512	-0.043	0.022
	Male	0.33 (0.06)			

As a main result, no significant difference was found between the MI, PMI-s, and PMI-i of the patient group and control group for the right side and the left side of the mandible. In addition, bilateral teeth loss did not influence the indices ($p > 0.05$). No significant difference was observed between females and males ($p>0.05$). The details are given in Tables 4 and 5.

Discussion

Mandibular bone quality may be influenced by age, sex, and dental status (9). According to our results, we did not find any difference between the MI, PMI-s, and PMI-i values for the subjects aged between 18 and 35 years old. The increase of age from 18 to 35 did not lead to a difference in the mean MI, PMI-s, and PMI-I index values. This means that these indices were not influenced by age in young adults. It was reported that there was an age-related decrease for the MI values in the females and males (3,6,8,9). Previous studies investigated the interactions of the radiomorphometric indices with age and loss of dentition (8,12,13). Zlataric et al. (14) evaluated the MI values in middle aged and elderly individuals and showed that MI values decreased in both genders until 78 years. Ledgerton et al. (8) reported that in British women, MI underwent a gradual reduction until the sixth decade, and then decreased sharply. They also reported that PMI-s and PMI-i were negatively correlated with age and that there was a significant difference between the index values between ages <55 and >65 years old. The difference between our results and these studies could be related to the difference in the age groups. We evaluated young adults and others evaluated middle aged adults and older in their studies. Middle aged adults and older adults could be affected by osteoporosis, which is reported to decrease the MI and PMI values (15-17).

To the best of our knowledge, there are limited studies concerning the effect of tooth loss on MI and PMI in young adults. In our study we found that tooth/teeth loss did not have any effect on the MI, PMI-s and PMI-i values in young adults. Moradi et al. (12) reported no effect of tooth loss on MI and PMI among adults and older patients. In their study, the dental status of the patients was classified as full dentate, partially dentate (having all teeth except molars), and completely dentate. Mostafa et al. (13) evaluated the effect of edentulism on the MI and PMI. They recorded both maxillary and mandibular dentitions (excluding third molars) as full dentition, partial dentition (any tooth missing), and complete edentulous. According to their results, they found no effect of dentition on the indices. In our study, we only evaluated the right, the left, and the bilateral mandibular posterior region according to one or more extracted teeth and did not divide the individuals into the groups mentioned in the two studies above. We also gave detailed information regarding the extracted tooth type, extracted tooth number, and location of the extracted tooth. However, as this was a retrospective radiographic study, we were unable to obtain the information regarding the time period since the tooth/teeth have been extracted. Although the age groups and dental status were classified differently, our results showed a similarity with both studies. According to the results of our study and the other studies conducted on different age groups, one may conclude that edentulism; both among young individuals and older individuals, does not have an effect on these indices. When a tooth/teeth are extracted from the jaws, the structure and function of the muscles of the mastication change. Thus, the atrophy in the insertion regions of these muscles may happen. However, these results may be related to the phenomena of 'no atrophy occurring in the inferior cortex of the mandible and mental foramen regions due to tooth extraction' (13,18).

Panoramic radiographs are available in most dental clinics. It is an easy radiographic technique to perform. The resultant image shows the maxillary and mandibular teeth and the mandible and maxillae. The cortical border of the mandible and foramen mentale is also visible. One disadvantage is that in some cases the inferior and the superior border of the foramen mentale and inferior mandibular cortex borders cannot be visible enough for the selection of the points to be measured. In our study the four radiographs belonging to the patient group and the four radiographs belonging to the control group were excluded due to undefended mental foramen and /or inferior mandibular cortex borders.

MI and PMI are indices used worldwide. They are both repeatable and reproducible on digital panoramic images (19). They are easy to interpret as they rely on the measurement of the specific points on panoramic radiographs. The measurements could be done with digital rulers on digital panoramic images or they could be done with digital calipers on conventional radiographs. One problem with the MI is that the result is a direct linear measurement made on the panoramic radiograph; thus, one could not compare the MI values of the panoramic images taken with different machines as the magnification value differ among panoramic machines. The PMI is the ratio of two linear measurements thus, the differences in magnification between the different panoramic machines does not affect the results, and a comparison between the images is possible (6,13). At this point, the PMI differs from the MI. We found no significant difference between the genders in terms of tooth/teeth loss. Thus, we can conclude that gender does not influence early tooth/teeth extraction on the MI and PMI-s and PMI-i. Our results show a similarity with Mostafa et al. (13).

Gender is an important factor affecting the bone metabolism. Osteoporosis is seen more frequently among females due to hormonal changes in menopause. Osteoporosis is a pathology affecting the skeletal system. It is characterized by 'low bone mass, compromised bone strength, and microarchitectural deterioration predisposing to an increased risk of fracture'. Osteoporosis is the most common metabolic bone disease seen among individuals (20). Studies report that the thickness of the inferior cortex of the mandible may be useful to predict the bone mass from panoramic radiographs with these indices (9). Radiomorphometric indices and their relationship to gender and age are studied. The cortical bone in the mental region is significantly thinner in individuals with osteoporosis. PMI and MI may be used as an indicator of bone mineral changes (15-17).

Tooth or teeth extraction on the mandibular posterior region either on the right or left side or both sides did not influence the MI or PMI-s and PMI-i. Dölekoğlu et al. (21) investigated the effect of disorders affecting the skeletal metabolism among total edentulous patients and reported that the PMI-i and PMI-s did not differ significantly on the right or left side of the mandible.

Conclusion

According to this radiographic study mandibular premolar and/or molar teeth loss did not have any effect on the MI, PMI-s and PMI-i among young adults in both genders.

Türkçe Öz: *Alt çene arka bölgedeki diş kaybinin mental indeks ve panoramik mandibular indeks üzerindeki etkileri. Amaç: Mental indeks (MI) ve panoramik mandibular indeks (PMI) mandibulanın kemik kalitesini değerlendirmek için kullanılan önemli radyomorfometrik indekslerdir. Bu çalışmanın amacı genç erişkinlerde alt çene arka bölgedeki diş / dişlerin kaybının MI ve PMI (süperior panoramik mandibular indeks: PMI-s ve inferior panoramik mandibular indeks: PMI-i) üzerine etkisinin araştırılmasıdır. Gereç ve yöntem: 18-35 yaşları arasındaki 253 hastaya ait dijital panoramik radyografiler incelendi. Çalışmanın dahil edilme kriterlerine göre hasta ve kontrol grubu oluşturuldu. Mandibula posterior bölgesinde en az bir eksik dişe sahip olan bireyler hasta grubunu (n = 46), tüm dişleri mevcut olanlar kontrol grubunu (n = 45) oluşturdu. Tüm bireyler için MI ve PMI (PMI-i ve PMI-s) hesaplandı. Bulgular: Hasta grubu ve kontrol grubunda her iki cinsiyet arasında MI, PMI-i ve PMI-s indeksleri arasında anlamlı bir fark bulunamadı (p> 0.05). Sonuç: Genç erişkinlerde mandibular premolar ve molar diş veya dişlerin kaybı, her iki cinsiyette de MI, PMI-i ve PMI-s indekslerinde herhangi bir değişikliğe yol açmamıştır. Anahtar Kelimeler: Mandibula; mental indeks; panoramik mandibular indeks; panoramik radyografi; diş kaybı*

Ethics Committee Approval: The study protocol has been approved by the ethical committee of Gazi University (project no:2017-368).

Informed Consent: Informed consent was waived due to the retrospective nature of this study.

Peer-review: Externally peer-reviewed.

Author contributions: GA, ZA and KG participated in designing the study. GA and ZA participated in generating the data for the study. GA and ZA participated in gathering the data for the study. OK participated in the analysis of the data. ZK wrote the majority of the original draft of the paper. GA and ZA participated in writing the paper. All authors approved the final version of this paper.

Conflict of Interest: The authors have no conflicts of interest to declare.

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