Correlation between Mandibular Radiomorphometric Parameters and Gonial Angle size in Iranian Adults

Original Article

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Recieved: Mar 15, 2015
Accepted: Apr 16, 2015

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Abstract

Introdouction:
The purpose of the present study was to determine the possible relationship between gonial angle size and three mandibular morphometric parameters, namely, panoramic mandibular index (PMI), mandibular cortical width (MCW), and antegonial notch depth (AD), in digital panoramic radiographs.

Materials and methods:
PMI, MCW, and AD were calculated in digital panoramic radiographs of 370 dentulous adult subjects with a mean age of 44.2 years and a mean number of remaining teeth of 23.49 ± 7.71. The differences between the mean values of measured parameters were compared between males and females, among various age groups, and between subjects with low and high gonial angles (gonial angle of ≤120 and ≥125, respectively) .
The correlation between gonial angle size, PMI, MCW, and AD was also evaluated. T-test, ANOVA, and Pearson's correlation test were used for statistical analysis. A $P<0.05$ was considered as statistically significant.

Results:
PMI, AD, and MCW(Mandibular Cartical Width) were significantly higher in subjects with low gonial angle (LGA) than those with high gonial angle (HGA). PMI, AD, and MCW were also significantly higher in males than those in females. Significantly negative correlations between the gonial angle and PMI, AD, and MCW were also observed.

Conclusion:
The mandibular radiomorphometric parameters of PMI, AD, and ACW are related to sex and gonial angle size.

Key words:
•Mandible •Radiography •Dental •Digital •Adult

Introduction

Healthy bone with a normal regenerative capacity is essential for a successful outcome in various phases of dentistry.[1] Determining the bone quality is a very important strategy prior to the insertion of a dental implant, especially for those patients who have lost many teeth.[2]

Remodeling of the mandibular bone is a continuous process that is influenced by age, dental status, and gender.[3] Dental panoramic radiography is useful as a routine procedure in implant therapy.[1, 4-7] In some cases, not only the implant sites but also the gonial angle (GA), inferior lower cortical bone under the mental foramen, floor of the maxillary sinus, mandibular canal, and mandibular condyle are the focus of implant therapy screening.[8-13]

Factors such as age, gender, and dental status of the patient, whether they wear partial or complete dentures, and how long have worn them must determine when morphological changes of the mandible are assessed on a dental panoramic radiograph.[3, 6, 14] Generally, the loss of several teeth at the arches increases the risk for osteoporosis because of the decline in masticatory force, eventually altering the morphology of the mandibular body and GA.[1, 3, 6, 10, 15-22] Previous studies on morphometric changes in the mandible using digital panoramic radiographs obtained prior to dental implant treatments have only focused on aged, postmenopausal, and partially and completely edentulous patients.[11, 15, 23-26]

On the other hand, studies focusing on the morphological differences according to GA size are limited.[2, 27] Masticatory force is generally greater when the GA is smaller.[6, 28, 29] There is evidence that the morphology of the mandible is altered with the activity of the masseter muscle. [21]

The purpose of the present study was to evaluate the possible relationship between GA size and three mandibular radiomorphometric parameters, which include panoramic mandibular index (PMI), mandibular cortical width (MCW), and antegonial notch depth (AD) in digital panoramic radiographs of an Iranian dentulous adult population.

Materials and Methods

In this cross-sectional study, the digital panoramic radiographs of 370 adult dentulous dental patients, who were referred to the Oral and Maxillofacial Radiology Department of Yazd Dental School, were evaluated. The age range of the subjects was from 19 to 69 years.

All panoramic images were captured using a digital panoramic machine (Planmeca prolin Xc, Helsinki, Finland, 80 Kvp and 12 mA). Acceptable image quality and the absence of technical errors, bony pathology, and anomalies, as well as no previous history of trauma or surgical procedure in the maxillofacial region were considered as inclusion criteria for the evaluation of panoramic radiographs.

The following angular and liner measurements were conducted using the Romexis software (Planmeca-Romexis- Helsinki-Finland)

1. GA: The angle formed between the mandibular plane and the ramus line (letter A in Figure 1)
2. PMI: The ratio of the thickness of the mandibular cortex below the mental foramen (MCW) to the distance between the inferior border of the mental foramen and inferior border of mandible (C/B ratio in Figure 1)
3. MCW: Mandibular cortical width along the mental foramen (letter A in Figure 1)
4. AD: The perpendicular distance from the deepest point of the antegonial notch to the mandibular plane (letter D in Figure 1)

Only the radiographs exhibiting GA that were <120 (low GA) or >125 (high GA) on both sides of the mandible were used in the present study. Only cases of alveolar bone resorption <3/5 of the root length were included in the present study. For statistical analysis, the t-test and ANOVA were used to determine the differences in the mean values of the measured parameters between males and females, various age groups, and between the subjects with low and high GAs. The significance of the correlations between GA size and other parameters were assessed using the Pearson's correlation test. SPSS version 11.5 (Chicago, USA) was used and a P value of <0.05 was considered as statistically significant.

Results

A total of 370 panoramic radiographs of 185 males and 185 females with a mean age of 44.2 years were included in the present study. The mean number of remaining teeth was 23.49 ± 7.71.

Table 1 shows the mean number of remaining

teeth in the subjects. No statistically significant differences between the mean number of remaining teeth in males and females were observed. However, the mean number of remaining teeth decreased with increasing age.

Table 1: Gender and dental status of the patients

Gender	Number	Mean number of remaining teeth ± SD
Female	185	23.59 ± 7.86
Male	185	23.39 ±7.58
Total	370	23.49 ± 7.71

Table 2 shows that the amount of MCW, AD, and PMI were significantly higher in men than that in women (P = 0).

Table 3 shows the comparison between the mean values of three measured radiomorphometric parameters in various age groups. Statistically significant differences between PMI and MCW in different age groups were observed (P = 0). PMI and MCW decreased with aging. Post hoc analysis (Tukey test) showed significant differences only between 19-29- and 60-69-year-old patients. Table 4 lists the mean values of the

Table 2. Comparison of the mean values of each parameter between men and women

Gender	Number	Mandibular cortical width (mm)	Antegonial notch depth (mm)	Panoramic mandibular index
Female	185	3.722 ± 0.848	2.880 ± 0.573	0.269 ± 0.102
Male	185	4.744 ± 0.906	3.119 ± 0.590	0.304 ± 0.097
Total	370	4.233 ± 1.014*	3.000 ± 0.593***	0.287 ± 0.101**
P value	-	*0.000	*0.000	*0.000

*P = 0.000, **P = 0.000, ***P = 0.000

Table 3 Comparison of the mean values of each parameter in different age groups

Age Range	Number	Mandibular cortical width (mm)	Antegonial notch depth (mm)	Panoramic mandibular index
19–29	75	4.572 ± 0.935	2.948 ± 0.547	0.335 ± 0.166
30–39	75	4.440 ± 0.782	3.003 ± 0.637	0.295 ± 0.07
40–49	74	4.195 ± 0.924	2.996 ± 0.592	0.286 ± 0.080
50–59	72	4.156 ± 1.117	2.960 ± 0.511	0.267 ± 0.068
60–69	74	3.796 ± 1.125	3.093 ± 0.645	0.251 ± 0.063
P value	-	*0.000	0.604	*0.000

*Significant p value < 0.05

Table 4. Comparison of the mean values of each parameter between subjects with low and high gonial angles

Gonial angle type	Number	Mandibular cortical width (mm)	Antegonial notch depth (mm)	Panoramic mandibular index
LGA	182	4.681 ± 0.950	3.367 ± 0.594	3.367 ± 0.594
HGA	188	3.799 ± 0.880	2.645 ± 0.382	2.645 ± 0.382
P value		*0.000	*0.000	*0.000

*Significant p value < 0.05

three anatomical parameters (MCW, AD, and PMI) in subjects with low and high GAs. All parameters were significantly higher in the LGA group than that observed in the HGA group (P = 0). Pearson correlation coefficient showed a negative correlation between the three parameters and the GA size in both males and females. Table 5 represents the correlation coefficients between GA and the other variables. Negative correlations between GA size and all three measured morphometric parameters (MCW, AD, and PMI) were detected. Positive correlations were observed between PMI and AD, PMI and MCW, and MCW and AD (P = 0).

Table 5. Correlation coefficient between size of gonial angle and each variable

Parameters	Gonial angle	Panoramic mandibular index	Mandibular cortical width
Panoramic mandibular index	-	-	–
Pearson correlation coefficient	−0.302	–	–
P value	0.000	–	–
Number	370	–	–
Mandibular cortical width	-	–	–
Pearson correlation coefficient	−0.364	0.269	–
P value	0.000	0.000	–
Number	370	370	–
Antegonial notch depth	–	–	–
Pearson correlation coefficient	−0.495	0.372	0.472
P value	0.000	0.000	0.000
Number	370	370	370

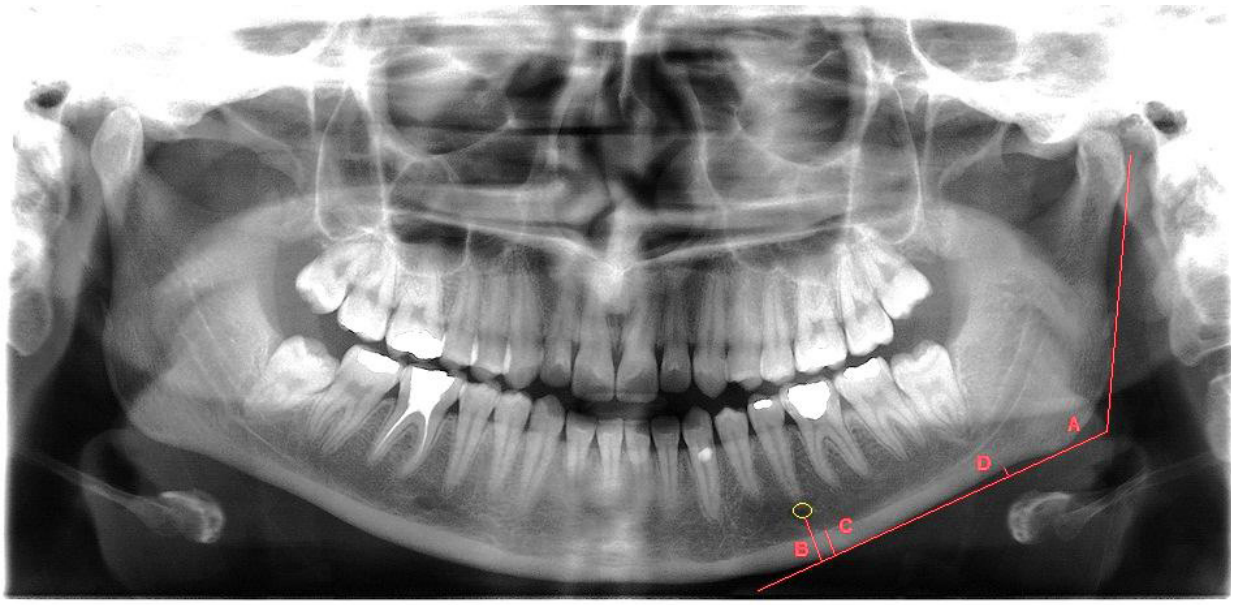

Figure1. Radiomorphometric parameters that were measured

A = Gonial angle, the angle formed between the mandibular plane and ramus line (GA)
C to B Ratio C/B = Panoramic mandibular index (PMI)
C = Mandibular cortical width (MCW)
D = Antegonial notch depth (AD)

Discussion

Various panoramic radiomorphometric indices have been used in assessing mandibular bone density. According to Ferriera et al., antegonial indices and GA have the least accurate correlation with bone density, whereas MCW and PMI present the most accurate relationship with bone density.[30]

The present study clarified the relationship between three anatomical morphometric parameters (PMI, MCW, and AD) and GA size. Age and gender distribution of each parameter were also examined. These radiomorphometric parameters have been extensively used in previous studies, especially those related to low bone mineral density.[7]

All of the panoramic radiographs examined in the present study were captured using the same radiograph machine, and the same software that was recommended by the manufacturer. In this manner, discrepancies in magnification caused by variations in the settings of different machines were avoided.

The inter-observer and intra-observer findings of the present study were in agreement, which was similar to those of other previous studies.[3]

Previous studies have also investigated the relationship between masticatory force and mandible morphology. It is believed that the masseter muscle in low GA jaw applies a greater force to the mandible than a high GA jaw.[2]

MCW is one of the most important parameters in the diagnosis of osteoporosis. [1, 7, 9, 13, 24, 26] The increase in MCW in LGA patients corresponds to the forces of the masticatory muscles. Gulsahi et al. previously showed that an edentulous individual with MCW of <3 mm was at a higher risk for osteoporosis.[1]

The mean MCW value of the males and females in the present study was 4.744 and 3.722, respectively. However, Osato et al. reported that the mean MCW of males and females was 5.15 and 4.565, respectively.[2] These discrepancies might have resulted from variable magnification factors for different radiographic machines.

During mandibular growth, the mandibles of subjects with a deep AD developed more vertically in contrast to those with a shallow AD, which had a larger mandibular body that induced a more horizontal mode of development. Remodeling of the jaw exists during the lifetime of an individual and is more affected by masticatory forces.[31]Because of the higher masticatory force, patients with low GA had a deeper AD than those with a high GA.[2] In the present study, AD measurements in HGA were lower than that observed in LGA. These findings were in agreement with the results of Osato et al.[2], whereas these were in contrast to the observations of Dutra et al.[3]

PMI is the morphometric index that was first proposed by Benson et al.[9] for the assessment of the mandible in postmenopausal women. Benson et al. reported that the mean PMI value significantly decreased with increasing age in black and Hispanic compare to white women, whereas the mean PMI of white men increased with advancing age.[9] Ledgerton et al. demonstrated that the PMI underwent a very gradual reduction with age until the sixth decade, when the mean value sharply declines. They also suggested that ethnic origin is the most probable reason for differences in age-related patterns of PMI. [24] PMI is an important index used in the diagnosis of osteoporosis, as well as in determining bone mineral density.[23]

The present study determined that individuals with LGA had significantly larger PMIs than those with HGA, because the PMI reflected the results of the MCW. Our finding agreed with the observations of previous studies.[2, 27]

Gender dimorphism was observed in all three parameters. PMI, AD, and MCW were significantly greater in men than in women. Saglam et al.[32], Dutra et al.[3], and Osato et al.[2] also reported higher AD and MCW in men, although Osato et al.[2] and Yuzugullu et al.[26] disagreed with the concept of sexual dimorphism in PMI. Because PMI is usually evaluated among women, data related to differences between genders were limited.[9, 24, 33] In the present study, the mean PMI of men and women was 0.304 and 0.269, respectively. The observed differences between genders may be attributable to the fact that women are more susceptible to develop osteoporosis than men, and the mean PMI of osteoporotic individuals is generally lower than those without osteoporosis.

Considering age differences, we observed that PMI and MCW values decreased with increasing age. However, we did not detect any relationship

between GA size and aging. This finding is in contrast with the results described by Ohm et al.[34] and Merrot et al.[35], wherein GA increases with advanced aging and edentulism. This discrepancy could have resulted from our inclusion of subjects with dentulous jaws only, as well as the small population size of dentulous individuals who presented changes in GA size despite their advancing age.

Conclusion

This research demonstrated that the mandibular radiomorphometric parameters of MCW, AD, and PMI are related to GA sizes and sexual dimorphism. In addition, aging was a significant factor that affected both MCW and PMI. In terms of age, the sex and GA size of elderly individuals should be considered during assessment prior to implant therapy.

Acknowledgment

The authors would like to thank the Vice-Chancellor of Shahid Sadouqi University of Medical Science for supporting this research study (Grant 2749). This article is based on the thesis of Dr. Yasaman Sabaghzadegan.

Conflict of interest

The authors have nothing to declare.

References

1.Gulsahi A, Yüzügüllü B, İmirzalıoğlu P, Genç Y. Assessment of panoramic radiomorphometric indices in Turkish patients of different age groups, gender and dental status. Assessment. 2014;37(5).

2.Osato S, Kuroyama I, Nakajima S, et al. Differences in 5 anatomic parameters of mandibular body morphology by gonial angle size in dentulous Japanese subjects. Ann Anat 2012;194(5):446-51.

3.Dutra V, Yang J, Devlin H, Susin C. 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.

4.Horner K, Devlin H, Harvey L. Detecting patients with low skeletal bone mass. J Dent 2002;30(4):171-5.

5.Zechner W, Watzak G, Gahleitner A, et al. Rotational panoramic versus intraoral rectangular radiographs for evaluation of peri-implant bone loss in the anterior atrophic mandible. Int J Oral Maxillofac Implants 2002;18(6): 873-8.

6.Xie Q-F, Ainamo A. Correlation of gonial angle size with cortical thickness, height of the mandibular residual body, and duration of edentulism. J PROSTHET DENT 2004;91(5):477-82.

7.Hastar E, Yilmaz HH, Orhan H. Evaluation of mental index, mandibular cortical index and panoramic mandibular index on dental panoramic radiographs in the elderly. European J Dent 2011;5(1):60.

8.Bras J, Van Ooij C, Abraham-Inpijn L, et al. Radiographic interpretation of the mandibular angular cortex: A diagnostic tool in metabolic bone loss: Part I. Normal state. Oral Surg Oral Med Oral Pathol 1982;53(5):541-5.

9.Benson BW, Prihoda TJ, Glass BJ. Variations in adult cortical bone mass as measured by a panoramic mandibular index. Oral Surg Oral Med Oral Pathol 1991;71(3):349-56.

10.Xie Q, Wolf J, Soikkonen K, Ainamo A. Height of mandibular basal bone in dentate and edentulous subjects. ACTA ODONTOL 1996;54(6):379-83.

11.Knezović Zlatarić D, Čelebić A, Lazić B, et al. Influence of age and gender on radiomorphometric indices of the mandible in removable denture wearers. COLLEGIUM ANTROPOL 2002;26(1):259-66.

12.Vazquez L, Saulacic N, Belser U, Bernard JP. Efficacy of panoramic radiographs in the preoperative planning of posterior mandibular implants: a prospective clinical study of 1527 consecutively treated patients. CLIN ORAL IMPLAN RES2008;19(1):81-5.

13.Taguchi A, Sugino N, Miki M, et al. Detecting young Japanese adults with undetected low skeletal bone density using panoramic radiographs. Dentomaxillofac Radiol 2011 Mar; 40(3):154-9. doi: 10.1259/dmfr/30045588. 14. Yanıkoğlu N, Yılmaz B. Radiological evaluation of changes in the gonial angle after teeth extraction and wearing of dentures: a 3-year longitudinal study. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2008;105(6):e55-e60.

15.Taguchi A, Tanimoto K, Suei Y, Wada T. Tooth loss and mandibular osteopenia. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 1995;79(1):127-32.

16.Devlin H, Karayianni K, Mitsea A, et al. Diagnosing osteoporosis by using dental panoramic radiographs: the OSTEODENT project. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2007;104(6):821-8.

17.Vlasiadis KZ, Skouteris CA, Velegrakis GA, et al. Mandibular radiomorphometric measurements as indicators of possible osteoporosis in postmenopausal women. Maturitas 2007;58(3):226-35.

18.Hirai T, Ishijima T, Hashikawa Y, Yajima T. Osteoporosis and reduction of residual ridge in edentulous patients. J

PROSTHET DENT 1993;69(1):49-56.

19.Bairam LR, Miller WA. Mandible bone resorption as determined from panoramic radiographs in edentulous male individuals aged 25–80 years. Gerodontology 1994;11(2):80-5.

20.Ceylan G, Yaníkoglu N, Yílmaz AB, Ceylan Y. Changes in the mandibular angle in the dentulous and edentulous states. J PROSTHET DENT 1998;80(6):680-4.

21.Jonasson G, Kiliaridis S. The association between the masseter muscle, the mandibular alveolar bone mass and thickness in dentate women. Arch Oral Biol 2004;49(12):1001-6.

22.Dutra V, Devlin H, Susin C, et al. Mandibular morphological changes in low bone mass edentulous females: evaluation of panoramic adiographs. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2006;102(5):663-8.

23.Klemetti E, Vainio P, Lassila V, Alhava E. Trabecular bone mineral density of mandible and alveolar height in postmenopausal women. Eur J Oral Sci 1993;101(3):166-70.

24.Ledgerton D, Horner K, Devlin H, Worthington H. Radiomorphometric indices of the mandible in a British female population. Dentomaxillofac Radiol 1999;28(3):173-81.

25.Jonasson G, Bankvall G, Kiliaridis S. Estimation of skeletal bone mineral density by means of the trabecular pattern of the alveolar bone, its interdental thickness, and the bone mass of the mandible. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2001;92(3):346-52.

26.Yüzügüllü B, Gulsahi A, Imirzalioglu P. Radiomorphometric indices and their relation to alveolar bone loss in completely edentulous Turkish patients: a retrospective study. J PROSTHET DENT 2009;101(3):160-5.

27.Nakajima S, Osato S. Association of gonial angle with morphology and bone mineral content of the body of the adult human mandible with complete permanent dentition. Ann Anat

2013;195(6):533-8.

28.Ringqvist M. Isometric bite force and its relation to dimensions of the facial skeleton. Acta Odontol Scand . 1973;31(1):35-42.

29.Sondang P, Kumagai H, Tanaka E, et al. Correlation between maximum bite force and craniofacial morphology of young adults in Indonesia. J Oral Rehabil 2003;30(11):1109-17.

30.Leite AF, de Souza Figueiredo PT, Guia CM, et al. Correlations between seven panoramic radiomorphometric indices and bone mineral density in postmenopausal women. Oral Surg Oral Med Oral Pathol Oral Radiol Endod 2010;109(3):449-56.

31.Lambrechts A, Harris A, Rossouw P, Stander I. Dimensional differences in the craniofacial morphologies of groups with deep and shallow mandibular antegonial notching. Angle Orthod 1996;66(4):265-72.

32.Sağlam A. The vertical heights of maxillary and mandibular bones in panoramic radiographs of dentate and edentulous subjects. Quintessence Int .

Quintessence Int 2002 Jun;33(6):433-8. 33. Horner K, Devlin H. The relationship between mandibular bone mineral density and panoramic radiographic measurements. J Dent 1998;26(4):337-43.

34.Ohm E, Silness J. Size of the mandibular jaw angle related to age, tooth retention and gender. J Oral Rehabil 1999;26(11):883-91.

35.Merrot O, Vacher C, Merrot S, et al. Changes in the edentate mandible in the elderly. Surg Radiol Anat 2005;27(4):265-70.