ORIGINAL ARTICLE

AGE AND GENDER DIFFERENCES IN GONIAL ANGLE, RAMUS HEIGHT AND BIGONIAL WIDTH IN DENTATE SUBJECTS

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ABSTRACT

The aim of this study was to investigate the influence of age and gender differences (three mandibular parameters gonial angle, ramus height and bigonial width) in dentate Jordanian subjects using digital panoramic radiography. A total of 209 (103 males and 106 females) dentate subjects aged 11 and 69 (mean: 33.51±14.5) years participated in this study. The data were obtained by using an interview, clinical and radiographic examination. Gonial angles, ramus heights (on both sides) and bigonial widths were recorded using panoramic radiograph and measured digitally for each subject. The mean values were calculated and compared between male and female subjects and between different age groups using SPSS (V. 17). Level of significance was set at 0.05. The results of the study showed that males had higher values of the parameters compared to females. The differences in bigonial width and ramus height were statistically significant (p<0.0001). Gonial angles and bigonial widths increased with increasing age, however, ramus height increased from 11-29 years then decreased with increasing age. The morphology of the mandible changed as a consequence of age and between genders, which can be expressed as a widening of the gonial angle, increasing of the bigonial width and shortening of the ramus.

Key words: *Gonial angle, ramus height, bigonial width, digital panoramic radiography, mandible.*

INTRODUCTION

The mandible is a paired bone that develops within the mandibular arch, embedding teeth and forming an articulation of the jaw with the cranium: the temporomandibular joint (TMJ).[1,2]

Morphological changes of the mandible are thought to be influenced by the occlusal status and age of the subject. Longitudinal studies have shown that remodeling of the mandibular bone occurs with age.[3] To evaluate the morphology of the mandible, previous studies have used measurements such as gonial angle, ramus height and bigonial width.[4,19]

The gonial angle is formed by the line tangent to the lower border of the mandible and the line tangent to the distal border of the ascending ramus and condyle.[11,20] The shape of the mandibular base, especially the gonial angle, correlates with the function and shape of the muscles of mastication.[21] With age, the masticatory muscles change in function and structure, seen in decreased contractile activity and lower

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muscle density.[22] Some studies have shown a gender difference.[11,23]

The effect of the individual age and gender on the size of the gonial angle is controversial. Although some studies have shown a widening of the gonial angle with the increasing age[11,24] many articles have reported differing results.[10,23,25] Moreover, most of the studies have indicated a wider angle in female subjects[23,25,26] but this finding has not been confirmed in some other studies.[10,11] Ingervall and Thilander[27] have shown that dentate subjects with strong masseter and anterior temporal muscles have small gonial angles.

There was no significant change with regard to bigonial width or ramus breadth across age groups for either gender.[14] Ramus height, mandibular body height, and mandibular body length decreased significantly with age for both genders, whereas the mandibular angle increased significantly for both genders with increasing age.[18] Males had longer ramus height than females.[19]

Panoramic X-ray technology is commonly accessible and is used in daily clinical routine to assess mandibular vital structures.[28] A number of mandibular indices based on panoramic radiographs, and image processing and analyzing techniques have been develop to allow quantification of mandibular bone, in addition, these radiographies allow a bilateral view and are adequate to inform on vertical measurements of the mandible.[29,30] This is the main reason for using them for asymmetry evaluation of the condylar and the ramus process and for measuring vertical differences between both sides.[31] Due to the nonlinear variation that occurs by the different depths there is no controversy on the invalidity of the horizontal measurements. Therefore, Larheim et al.[32] thinks that vertical and angular measurements can be reproduced if the patient is provided with adequate equipment for head positioning.

METHODOLOGY

This cross-sectional study was carried out at the Dental Department, Prince Rashid Hospital in Irbid, Jordan. The original sample comprised all subjects who attended restorative and orthodontic clinics at Al-Hussien Hospital, King Hussien Medical Center, Royal Medical Services, Amman, Jordan from July to December 2009. The study sample consisted of 209 subjects (103 men and 106 women) aged between 11 and 69 years distributed into 6 age groups of ten-year age period each.

All dentate subjects with full set of natural permanent teeth (with the exclusion of third molars), class I skeletal relationship with average vertical proportions and no transverse discrepancies, no systemic bone disease and clear panoramic radiographs with visible structure for the measurements were included in this study. Partially or completely edentulous and dentate subjects with class II or class III skeletal relationships (those with vertical and transverse discrepancies) were excluded from the study. In addition, all distorted, unclear and invisible panoramic radiographs were discarded.

The data were obtained by using an interview (including general health and self-reported diseases), as well as clinical and radiographic examination. All subjects gave verbal consent to participate in the study. The study protocol was approved by the Head of Dental Specialty in the Department of Dentistry and Ethical Committees of the Royal Medical Services. Clinical examination was carried out with the patient seated in an upright position and the head was in the natural position. It was performed by one orthodontist. Thereafter, a digital panoramic radiograph was taken using Orthopos XG Plus (Model: 5884999d3352, SN: 03024, Sirona, Siemens, Germany). The exposure parameters 64 kV and 8 mA were selected.

Panoramic radiographs were performed by one trained dental radiology technician. All digital panoramic radiographs were measured digitally using Sidexis next Generation software (Version 1.52; Sirona, Siemens, Germany), on Dell Inspiron (N 5010, China) personal computer.

Gonial angles were measured using a method described by Mattila et al.[33] A line was digitally traced on the panoramic radiographs tangential to the most inferior points at the gonial angle and the lower border of the mandibular body and another line tangential to the posterior borders of the ramus and the condyle. The intersection of these two lines formed the gonial angle, which was measured on the right and left sides of the mandible. Ramus heights were measured using a method described by Saini et al.[19] A line represented the ramus extended from the most superior lateral point to the most inferior lateral point on the ramus tangent. Ramus height was measured on both sides on each panoramic radiograph. Bigonial width is the distance between both Gonia (Go). Gonian is the most inferior, posterior and lateral point on the external angle of the mandible.[14] It was measured horizontally from the right to left gonia. (Fig 1).

Measurements were performed by one orthodontist examiner who was trained to use the same reference points required for obtaining the measurements of the angles and linear distances on each radiograph. For each parameter, 3 readings were taken and the mean was calculated.

STATISTICAL ANALYSIS

The analyses were performed using SPSS version 17 (SPSS Inc., Chicago, IL, USA). Paired samples t-test was carried out to compare the right and left sides. Mann-Whitney U-test was used to compare the means of the gonial angle, ramus height and bigonial width between male and female subjects. Independent samples 2-tailed t-test was used to compare the means of the gonial angle, ramus height and bigonial width between different age groups. Level of significance was set at 0.05.

RESULTS

Age and sex distribution of subjects are shown in Table 1. The mean age of all subjects was 33.51±14.50, although the mean age of males was higher than that of females but the differences were not statistically significant.

Table 2 shows gender differences in gonial angle, ramus height and bigonial width on both sides. The mean of the gonial angle and ramus height on the right side were slightly higher than those on the left side (124.35±3.47; 51.85±5.67 and 124.23±3.36; 50.49±5.70); respectively. However, these differences were not statistically significant. In addition, males have higher values of the gonial angle, ramus height and bigonial width compared to female counterparts. Gender differences in gonial angle were not significant, but statistically significant gender differences ($p<0.0001$; paired t-test), were recorded in bigonial width and ramus height. (Table 3).

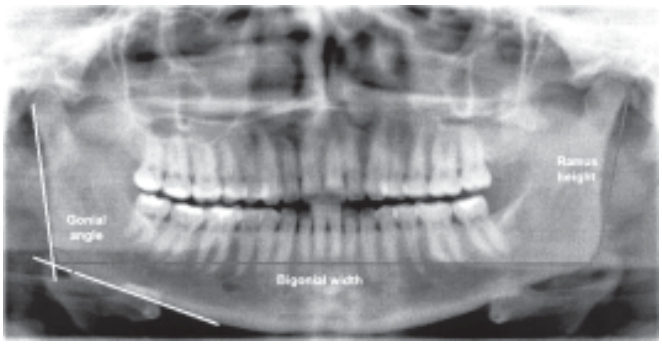

Fig 1: Measurements of the Gonial angle, Ramus width and Bigonial width on panoramic radiographs

Table 4 sows the mean values of ramus height, bigonial width and gonial angle in 6 different age groups. Gonial angles and bigonial widths increased with increasing age, however, Ramus height increased in the second and third decayed then decreased with increasing age. Paired sample t-test analysis showed that statistically significant differences in ramus height were recorded between two age groups; 11-19 and 60-69 age groups and the other groups. Bigonial width significantly different between the age groups 11-19 and 20-29 and the other age groups. However, statistically significant differences in gonial angle between 60-69 age group and the other groups; and between 11-19 and 50-59 age groups were recorded (Table 5).

TABLE 1: AGE AND SEX DISTRIBUTION OF SUBJECTS

	Males (103)	Females (106)	Total (209)	t-test	p-value
Mean age	34.35	32.36	33.51	13.14	0.99
(SD)	(14.19)	(13.98)	(14.50)		(NS)
Age range	11-66	11-69	11-69		
10–19	24	26	50		
20–29	15	23	38		
30–39	24	23	47		
40–49	27	16	43		
50–59	8	11	19		
60–69	5	7	12		
Total	103	106	209		

NS: Not significant

TABLE 2: GENDER DIFFERENCES IN GONIAL ANGLE, RAMUS HEIGHT AND BIGONIAL WIDTH ON RIGHT AND LEFT SIDES

		Male	Female	Mean
Ramus height	Right	54.02 (5.87)	49.77 (4.62)	51.85 (5.67)
	Left	52.62 (6.03)	48.44 (4.52)	50.49 (5.70)
	Mean	53.22 (5.82)	49.11 (4.45)	51.12 (5.55)
Bigonial width		206.61 (15.26)	198.13 (11.20)	202.28 (13.98)
Gonial angle	Right	124.38 (3.63)	124.31 (3.21)	124.35 (3.47)
	Left	124.33 (3.57)	124.08 (3.36)	124.23 (3.36)
	Mean	124.36 (3.48)	124.21 (3.17)	124.28 (3.28)

TABLE 3: PAIRED T-TEST TABLE FOR RIGH-LEFT SIDE OF RAMUS HEIGHTS AND GONIAL ANGLES AND MANN-WHITNEY U-TEST FOR GENDER DIFFERENCES IN GONIAL ANGLE, RAMUS HEIGHT AND BIGONIAL WIDTH

	Mean	SD	Std Error mean	df	t-test	P-value	Sig. (2-tailed)
Rt–Lt side differences							
Rt-Lt Rami	0.604	0.752	0.050	208	11.603	0.405	NS
Rt-Lt Gonial angles	-0.0268	2.580	0.179	208	-0.150	0.881	NS
Gender differences							
Ramus height	5.773	5.829	0.574	102	10.051	0.000	*
Bigonial width	9.015	12.648	1.246	102	7.234	0.000	*
Gonial angle	-0.0218	3.920	0.386	102	-0.057	0.955	NS

NS: Not significant, * p<0.0001

TABLE 4: MEAN VALUES OF RAMUS HEIGHT, BIGONIAL WIDTH AND GONIAL ANGLE IN RELATION TO AGE GROUPS

Age	Ramus height			Bigonial width			Gonial angle		
range	Male	Female	Total	Male	Female	Total	Male	Female	Total
11–19	46.116	45.837	45.976	189.625	186.574	188.100	122.639	121.821	122.230
20–29	53.874	53123	53.499	204.975	199.645	202.310	123.243	122.837	123.040
30–39	53.571	52.972	52.272	208.060	204.121	206.091	124.453	122.633	123.543
40–49	53.209	52.858	53.034	210.521	205.614	208.465	124.328	123.659	123.994
50–59	53.124	52.816	52.970	211.125	206.869	208.695	125.361	123.719	124.540
60–69	52.560	50.761	5.661	211.316	207.172	207.149	127.817	127.258	127.537

TABLE 5: DIFFERENCES BETWEEN SIX AGE GROUPS IN RAMUS HEIGHT, BIGONIAL WIDTH AND GONIAL ANGLE

		11–19	20–29	30–39	40–49	50–59
Ramus height	20–29	†				
	30–39	†	NS			
	40–49	†	NS	NS		
	50–59	†	NS	NS	NS	
	60–69	†	*	*	*	*
Bigonial width	20–29	**				
	30–39	**	*			
	40–49	***	*	NS		
	50–59	***	*	NS	NS	
	60–69	***	**	NS	NS	NS
Gonial angle	20–29	NS				
	30–39	NS	NS			
	40–49	NS	NS	NS		
	50–59	*	NS	NS	NS	
	60–69	***	**	*	*	*

(2-tailed t-test)
NS: Not significant, * p<0.05, ** p<0.01, *** p<0.001, † p<0.0001

DISCUSSION

This study was performed to assess the measurement of gonial angle, ramus height and bigonial width on digital panoramic radiographs and compare between gender and different age groups in dentate subjects with Class I skeletal relationship among Jordanian population.

The mean age of all subjects was 33.51±14.50, although the mean age of males was higher than that of females but the differences were not statistically significant. A wide age range was selected, so that the effect of aging on the different parameters can be investigated.

Several studies have reported that panoramic radiographs are reproducible and accurate for the linear and angular measurements on mandibles.[20,26,35] Larheim and Svanaes[36] have found that the gonial angle assessed from a panoramic film was almost identical that measured on the dried mandible.

The panoramic radiographs in the present study were made by one experienced dental radiographer using the same panoramic unit and all digital measurements were performed by one orthodontist. Although the panoramic radiographs have some limitations, like difficulties in controlling the distortion and magnification of the images, there is an important advantage of this technique is that they are often a part of the routine examination of patients, thus their use for research purpose does not involve the patient in any additional exposure or cost, and they are a very god source for the retrospective studies.[26,35] Shahabi et al[37] concluded that panoramic radiography can be used to determine the gonial angle as accurately as a lateral cephalogram. Furthermore, in panoramic radiography the right and left gonial angles can be measured easily without superimposition of anatomic landmarks, which occurs frequently in a lateral cephalogram.

In this study, three parameters were evaluated; ramus height, bigonial width and gonial angle. Ramus height and bigonial width represent the vertical and horizontal dimensions, respectively. However, gonial angle formed by the intersection of vertical with antero-posterior dimensions. The implication of these 3 mandibular parameters evaluate the base of cranium in 3 directions; vertical, horizontal and antero-posterior dimensions is of great importance to evaluate the morphology of the mandible and demonstrate gender differences and influence of aging process on the remodeling changes of mandibular bone. In this study, the mean values of the gonial angle and ramus height on the right side were slightly higher than those on the left side. However, these differences were not statistically significant and it might be explained by variation in the size and shape of the mandible among people. These findings were in accordance with previous studies.[3,33,37-39]

It has been stated that panoramic radiographs were accurate in determining the gonial angle and there was no significant difference between the right and left sides in panoramic radiography.[36] On the contrary, some researchers found that the gonial angle on the right side was significantly smaller than on the left possibly because of more use of the right side. In their study, most subjects reported that they chewed more often on the right side. Unfortunately, in this study the habit of chewing was notrecorded.[2,40]

In this study, male subjects had higher values of the gonial angle, ramus height and bigonial width compared to female counterparts. Gender differences in gonial angle were not significant, but statistically significant gender differences ($p<0.0001$) were recorded in bigonial width and ramus height. These results are in agreement with previous studies[11,37] who did not find any statistically significant gender differences in the gonial angle determined from the digital panoramic radiographs. In addition, they found that the gender had little effect on the size of the gonial angle. However, other researchers have shown that statistically significant larger gonial angles in female subjects compared to the males.[2,23,25,26] These findings concerning gender differences may be explained by the fact that, on average, men have greater masticatory force than women.

Regarding the mandibular angle, studying a Chinese population, Xi and Ainamo25 found an average value of 122.4° in the young population and 122.8° among the elderly. The variation found may be due to the ethnic group, the different morphometric technique used, or also to specific aspects such as the biomechanics and physiology characterizing and differentiating the groups of people studied.

The present study showed that older subjects had significantly larger gonial angle and bigonial width and smaller ramus than younger ones. The findings are probably because of the generally altered mandibular basal bone morphology associated with decreased masticatory muscle functioning as a result of aging. In addition, the decrease in ramus height with age might be explained by the anterior-rotation of the mandible. These results confirmed a widening of the gonial angle and increasing bigonial width with age has also been noted in earlier studies.[3,25]

Thus, results in this study support a multifactorial model of structural variation in the shape and size of the mandible among people, which can be explained by the action of biomechanical forces, and by biochemical

alterations of the bone tissue with age, causing the reshaping of the mandible bone-joint components and dramatically influencing the morphological characteristics. Gonial angles and bigonial widths increased with increasing age, however, ramus height increased in the second and third decayed then decreased with increasing age. This could be explained by the fact that the vertical growth continues through the life but subsides to adult level in the late 20s for males and early 20s for females.[10]

Statistically significant differences in ramus height were recorded between two age groups; 11-19 and 60-69 age groups and the other groups. Bigonial width significantly different between the age groups 11-19 and 20-29 and the other age groups. However, statistically significant differences in gonial angles between 60-69 age group and the other groups; and between 11-19 and 50-59 age groups were recorded. Alvaran et al[41] reported that males had significantly ($P<0.001$) wider arches than females, and that older subjects had significantly wider bigonial width than younger. On the other hand, Hesby et al[42] found that the differences in the transverse mandibular basal bone between gender and with increasing age, measured as bigonion were not significant.

It has been concluded that mandibular basal bone morphology changes as a consequence of aging process, which can be expressed as widening of the gonial angle and shortening of the ramus.[25] The gonial angle is a representative of mandible morphology and its increase may cause the face to appear older.[3,43]

The findings highlight the importance of prosthetic rehabilitation of the masticatory system to maintain good functioning of the masticatory muscles. However, it has been reported that the average angle of the body and the ramus of the mandible did not change from the time one reached adulthood to at least 70 years of age, except when there was extensive tooth loss,[23,44] In addition, Show et al[18] reported that there was no significant change with regard to bigonial width or ramus breadth across age groups for either gender. Ramus height, mandibular body height, and mandibular body length decreased significantly with age for both genders, where as the mandibular angle increased significantly for both genders with increasing age.[45] Because of a relatively small sample size and limited participation rate, the present study does not represent Jordanian population as a whole. Another disadvantage was that the dental status was based mainly on panoramic radiography. Therefore, the information of tooth to tooth contacts and chewing habits were not available.

Future research should be performed to investigate other mandibular parameters in Class II and Class III skeletal relationships and other types of malocclusion using other radiographic angulations' images such as lateral cephalometric views. In addition, the effect of tooth to tooth contacts and chewing habits should also be performed. Even though panoramic radiographs provide information on the vertical dimensions of craniofacial structures, clinicians should be vigilant when predicting skeletal cephalometric parameters from panoramic radiographs, because of their lower predictability. Also, further research to compare mandibular parameters between partially and completely edentulous subjects and the influence of tooth loss and edentulousness between genders and among different age groups may be needed before the results of this study can be applied on the general population.

CONCLUSIONS

The mean values of the gonial angle and ramus height on the right side were slightly higher than those on the left side but the differences were not statistically significant. Males have higher values of the gonial angle, ramus height and bigonial width compared to female counterparts. Gender differences in gonial angle were not significant, but statistically significant gender differences ($p<0.0001$; paired t-test) were recorded in bigonial width and ramus height. Gonial angles and bigonial widths increased with age, however, Ramus height increased in the second and third decayed then decreased with age. Statistically significant differences in ramus height were recorded between two age groups; 11-19 and 60-69 age groups and the other groups. Bigonial width significantly different between the age groups 11-19 and 20-29 and the other age groups. However, statistically significant differences in gonial angle between 60-69 age group and the other groups; and between 11-19 and 50-59 age groups were recorded.

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REFERENCES

1 Ramaesh T, Bard. The growth and morphogenesis of the early mouse mandible: a quantitative analysis. J Anat 2003; 203: 213-22.

2 De Sousa JC, Machado FA, Porto Silva, PA, Cardinot TM, Babinski MA. Correlation of the gonial angle with condylar measurements on dry mandible: a morphometric study for clinical-surgical and physiotherapeutic practices. Eur J Anat 2006; 10: 91-96.

3 Huumonen S, Sipila K, Haikola B, Taipio M, Soderholm A-L, Remes-Lyly T, et al. Influence of edentulousness on gonial angle, ramus and condylar height. Journal of Oral Rehabilitation 2010; 37: 34-38.

4 Tracy WE, Savara BS, Brant JWA. Relation of height, width and depth of the mandible. The Angle Orthodontist 1965; 35(4): 269-77.

5 Stephen H, Wei Y. Craniofacial width dimensions. The Angle Orthodontist 1970; 40(2): 141-47.

6 Spolyar JL. Head positioning error in cephalometric radiography. The Angle Orthodontist 1987; 57(1): 77-88.

7 Owen III AH. Frontal facial changes with the Frankel appliance. The Angle Orthodontist 1988; 58(3): 257-87.

8 Raghavan R, Sidhu SS, Kharbanda OP. Craniofacial pattern of parents of children having cleft lip and/or cleft palate anomaly. The Angle Orthodontist 1994; 64(2): 137-44.

9 Nanda RS, Ghosh J, Bazakidou E. Three-dimensional facial analysis using a video imaging system. The Angle Orthodontist Volume 1996; 66(3): 181-88.

10 Raustia AM, Salonen MA. Gonial angles and condylar ramus height of the mandible in complete denture wearers-a panoramic radiograph study. J Oral Rehabil. 1997; 24: 512-16.

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

12 Young DV. Rinchuse DJ, Pierce CJ, Zullo T. The craniofacial morphology of bruxers versus nonbruxers. The Angle Orthodontist 1999; 69(1): 14-18.

13 Baccetti T, Franchi L, Cameron CG, McNamara Jr JA. Treatment timing for rapid maxillary expansion Orthod 2001; 71: 343-50.

14 Lux CJ, Conradt C, Burde D, Komposch G. Dental arch widths and mandibular-maxillary base widths in Class II Malocclusions between early mixed and permanent dentitions. The Angle Orthodontist 2003; 73(6): 674-85.

15 Saglam AA, Sanli G. Condylar asymmetry measurements in patients with temporomandibular disorders. J Contemp Dent Pract. 2004; 5: 59-65.

16 Yavuz I, Ikbal A, Baydas B, Ceylan I. Longitudinal posteroanterior changes in transverse and vertical craniofacial structures between 10 and 14 years of age. The Angle Orthdontist 2004; 74(5): 624-29.

17 Anghinoni ML, Magri AS, Di Blasio A, Toma L, Sesena E. Midline mandibular osteotomy in an asymmetric patient. The Angle Orthodontist 2009; 79(5): 1008-14.

18 Shaw RB Jr, Katzel EB, Koltz PF, Kahn DM, Girotto JA, Langstein HN. Aging of the mandible and its aesthetic implications. Plastic and Reconstructive Surgery 2010; 125(1): 332-42.

19 Saini V, Srivastava R, Rai RK, Shamal SN, Singh TB, Tripathi SK. Mandibular ramus: an indicator for sex in fragmentary mandible. Journal of Forensic Sciences 2011; 56: 13-16.

20 Ceylan G, Yanikoglu N, Yilmaz AB, Ceylan Y. Changes in the mandibular angle in the dentulous and edentulous states. J Prosthet Dent 1998; 80: 680-84.

21 Ronning O, Barnes SA, Pearson MH, Pledger DM. Juvenile chronic arthritis: a cephalometric analysis of the facial skeleton. Eur J Orthod. 1994; 16: 53-62.

22 Raustia AM, Salonen MA, Pyhtinen J. Evaluation of masticatory muscles of edentulous patients by computed tomography and electromyography. J Oral Rehabil. 1996; 1: 11-16.

23 Casey DM, Emrich LJ. Changes in the mandibular angle in the edentulous state. J Prosthet Dent. 1988; 59: 373-80.

24 Fish SF. Change in the gonial angle. J Oral Rehabil. 1979; 6: 219-27.

25 Xie Q, 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: 477-82.

26 Sakar O, Sulun T, Ispirgil E. Correlation of the gonial angle size with residual ridge resorption in edentulous subjects. Balk J Stom, 2008; 12: 38-41.

27 Ingervall B, Thilander B. Relation between facial morphology and activity of masticatory muscles. J Oral Rehabil. 1974; 1: 131-47.

28 Juodzbalys G, Wang HL, Sabalys G. Anatomy of mandibular vital structures. Part II: Mandibular incisive canal, mental foramen and associated neurovascular bundles in relation with dental implantology. J Oral Maxillofac Res. 2010; 1(1): 2-10.

29 Arifin AZ, Asano A, Taguchi A, Nakamoto T, Ohtsuka M, Tanimoto K. Computer-aided system for measuring the mandibular cortical width on panoramic radiographs in osteoporosis diagnosis. Proc of SPIE 2005; 5747: 813-21.

30 Watanabe PCA, Issa JPM, Oliveira TM, Moteiro SAC, Iyomasa MM, SCH Siessere S Morphodigital study of the mandibular trabecular bone in panoramic radiographs. Int J Morphol 2007; 25(4): 875-80.

31 Yanez-Vico RM, Iglesias-Linares A, Torres-Lagares D, Gutierrez-Perez JL, Solano-Reina E. Diagnostic of craniofacial asymmetry. Literature review. Med Oral Pathol Oral Cir Bucal. 2010; 15(3): 494-98.

32 Larheim TA, Svanaes DB, Johannessen S. Reproducibility of radiographs with the ortho-pantomograph 5: tooth-length assessment. Oral Surg Oral Med Oral Pathol. 1984; 58: 736-41.

33 Mattila K, Altonen M, Haaviko K. Determination of the gonial angle from the orthopantomogram. Angle Orthod. 1977; 47: 107-110.

34 Profit WR, Fields HW. Contemporary orthodontics. 3rd ed. 2000; Mosby, St Louis: Ch 6, pp: 159, 172-73.

35 Wilding RJC, Levin I, Pepper R. The use of panoramic radiographs to measure alveolar bone areas. J Oral Rehabil, 1987; 14: 557-67.

36 Larheim TA, Svanaes DB. Reproducibility of rotational panoramic radiography: Mandibular linear dimensions and angles. Am J Orthod Dentofac Orthop 1986; 90: 45-51.

37 Shahabi M, Ramazanzadeh B-A, Mokhber N. Comparison between the external gonial angle I panoramic radiographs and lateral cephalograms of adult patients with Class I malocclusion. Journal of Oral Science 2009; 51(3): 425-29.

38 Altonen M, Haavikko K, Mattila K. Developmental position of lower third molar in relation to gonial angle and lower second molar. Angle Orthod 1977; 47: 249-55.

39 Krisjane Z, Urtane I, Krumina G, Bieza A, Zepa K, Rogvska I. Condylar and mandibular morphological criteria in the 2D and 3D MSCT imaging for patients with Class II division I subdivision malocclusion. Stomatologia Baltic Dent Max-fac J 2007; 9: 67-71.

40 Bakke M, Holm B, Kensen BL, Michler L, Moller E. Unilateral, isometric bite force in 8-68-year-old women and men related to occlusal factors. Scand J Dent Res 1990; 98: 149-58.

41 Alvaran N, Roldan SI, Buschan.

42 G PH. Maxillary and mandibular arch widths of Colombians. Am J Orthod Dentofacial Orthop 2009; 135(5): 649-56.

43 Hesby RM, Marshall SD, Dawson KA, Casko JS, Franciscus RG, Southard TE. Transverse skeletal and dentoalveolar changes during growth. Am J Orthod Dentofacial Orthop 2006; 130(6): 721-31.

44 Bayat M, Ja'farian M, Ghassemi Habashi O. Correlation between gonial angle and different variables after bilateral sagittal split ramus osteotomy. Journal of Dentistry, Tehran University of Medical Sciences 2006; 3(1): 19-23.

45 Israel H. The failure of aging or loss of teeth to drastically alter mandibular angle morphology. J Dent Res 1973; 52: 83-90.

46 Akcam MO, Altiok T, Ozdiler E. Panoramic radiographs: a tool for investigating skeletal pattern. Am J Orthod Dentofacial Orthop 2003; 123: 175-81.