Can Gonial Measurements Predict Gender? A Prospective Analysis Using Digital Panoramic Radiographs

Abstract

Objective: The objective of the study was to evaluate the possible influence of Gonial measurements on sex determination.

Materials and methods: The present study consists of 188 subjects (94 males and 94 females) between 15 to 65 years of age. Suitable radiographs with visible gonial region were included in the study. GA and GI were measured according to the methods proposed by Bras & Mattila et al. [1,2] respectively. The measurements obtained were tabulated in excel sheet and subjected to statistical analysis.

Results: The mean GI was significantly higher in males (1.56 ± 0.31 mm) when compared to females (1.42 ± 0.34 mm). Hence the present sample was subjected to discriminant analysis with gender as a grouping variable, GI and GA as independent variables. Based on Wilk's lambda values Gonial index (GI) was observed to provide better sex determination when compared to Gonial angle (GA). Hence 2 different discriminant equations were obtained, one using GI alone and another one using both GI and GA.

Conclusion: The present study confirmed significant sexual dimorphism in the values of Gonial index. Males were observed to have higher GI when compared to females.

Keywords: Gonial Angle; Gonial index; Mandible; Sex determination; Panoramic radiographs

Research Article

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Introduction

The term "Gonion" is derived from the Greek word "ywvtx", i.e. angle [3]. It is a point in the extreme posterior portion of the inferior most region of mandibular angle [4]. Gonial angle (GA) is the angle between an imaginary tangential line along the inferior border of mandible and another tangent along the posterior border of ramus of mandible [5]. Gonial index (GI) is a term proposed by Bras et al. [1], which refers to the thickness of inferior cortical border of the mandible in the region of GA [1]. GA is an easily identified radiographic landmark. Mattila et al. [2] proposed that gonial angle can be easily measured in panoramic radiographs, with the same degree of accuracy as that of lateral cephalograms [1]. Further the major disadvantage of superimposition of both the sides of mandible in lateral cephalograms, made panoramic radiographs, more precise tool for measuring GA. The muscles of mastication have strong influence on these gonial angles. Ingervall et al. [6] proposed that edentulous subjects have strong masseter and anterior temporal muscle fibres, which result in small gonial angles [6]. Males tend to have strong musculature when compared to females [7]. GI is a well-known indicator of bone loss [1]. It is a well-known fact that the incidence of osteoporosis is higher in women when compared to men [8]. These basic differences in the muscle architecture and bone mass index can play crucial role in sex determination. The changes in GA were well established in dentulous and edentulous. But very few studies in the literature actually described the influence of gender on GA and GI. Hence the present study was conducted to evaluate the possible influence of sex on GA and GI, with an objective of deriving an equation for sex determination using GA and GI.

Materials and Methods

The present study consists of 188 subjects (94 males and 94 females) between 15 to 65 years of age, who were advised for Orthopantamograph (OPG) from various treatment purposes. The institutional ethical clearance was obtained prior to the conduct of study. The patient's demographic details, along with informed consent were taken at the time of examination. Patients with history of trauma, systemic diseases effecting the growth and development, clinical and radiographic evidences developmental anomalies and other bone disorders were excluded. Suitable radiographs with visible gonial region and radiographs with good anatomical details were included in the study. For each individual an OPG was taking using digital OPG machine, (Sirona XG Orthophos, Germany) with magnification factor of 1.31, under standard exposure conditions as recommended by manufacturer. The final images were obtained by accompanying software (SIDEXIS XG, version 2.5, Copyright© 2011 Sirona Dental Systems GmbH, Germany).

The following measurements were made:

a. **Gonial Angle (GA):** It was assessed by tracing one line tangent to the lower border of mandible and another line tangent to the posterior border of the ramus of mandible, which was proposed by Mattila et al. [2]. The intersection of these lines forms the gonial angle (Figure 1).

Figure 1: The radiographic representation of the Gonial angle (GA) obtained by measuring the angle between the tangents drawn at the lower border of mandible and the posterior border of the ramus of mandible.

b. Gonial Index (GI): It was measured as the mandibular cortical width on the bisectrix of the angle between the two tangent lines forming gonial angle which was proposed by Bras et al. [1]. GA and GI were measured on left side of all radiographs (Figure 2).

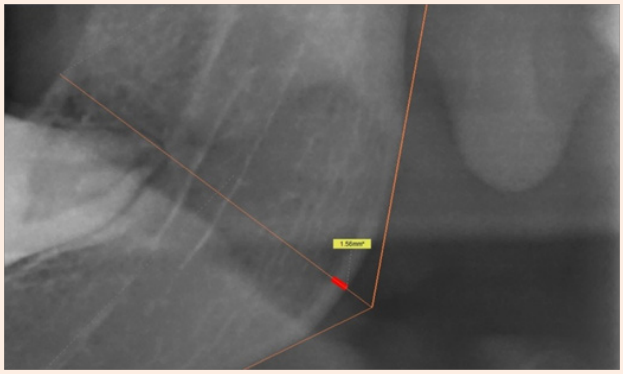

Figure 2: The radiographic representation of Gonial index measurement, which is obtained by measuring the thickness of mandibular cortex at thebisectrix of the Gonial angle.

The measurements obtained were tabulated in excel sheet and subjected to statistical analysis (SPSS version 16.01, SPSS.inc, Chicago, 1989-2007).The mean and standard deviations of these measurements were compared between males and females using t-test. The data was subjected to discriminant function analysis, with sex as classifying variable and GA and GI as independent variables. Thus obtained equation was evaluated for its reliability in gender differentiation.

Results

A total of 188 individuals were studied (94 males & 94 females) with age range of 15 to 65 years. The measurements were made by an experienced oral radiologist. They included Gonial angle (GA) and the Gonial index (GI) in the Orthopantamograph (OPG). A subset of 30 randomly chosen radiographs was revaluated by the same oral radiologist within a span of 3 weeks. The Cohen's Kappa coefficients obtained for GA and GI are 0.913 and 0.892 respectively, which was found to be almost perfect agreement Table 1. The mean GI was significantly higher in males (1.56 ± 0.31) when compared to females (1.42 ± 0.34). But no significant difference was observed in the mean values of GA. Hence the present sample was subjected to discriminant analysis with gender as a grouping variable, GI and GA as independent variables. Wilk's lambda is an interesting value which depicts the degree of sexual dimorphism, a variable can provide. These values were tabulated in Table 2 for GA and GI respectively. Gonial index (GI) was observed to provide better sex determination when compared to Gonial angle (GA). Based on the above results, 2 different discriminant equations were obtained. First equation was obtained using GI alone (D = [3.030 X GI] - 4.525). The second discriminant equation was obtained using both GI and GA as independent variables (D = [2.542 X GI] - [0.067 X GA] + 4.426). In these equations "D" represents discriminant score, which aids in sex prediction. The cut-off value calculated in both the equations was "0".

A greater value of D (D>0) would definitely represent male sex and a value less than zero would indicate female sex. The more extreme the D value moves from the cut-off value, the higher will be the probability, that the predicted sex would be correct. The obtained discriminant equations were applied to the given sample and the overall accuracy rates were calculated for both equations in Tables 3 & 4. The results obtained in the study confirmed that the equation 2 using GA and GI has successfully identified 64.9% males & 61.7% females, with an overall accuracy rate of 63.3% (Table 3). These results were much superior when compared to the equation 1 using GI alone where 53.2% of males and 60.6% of females were identified correctly with an overall accuracy rate of 56.9% (Table 4).

Discussion

Sex determination of unidentified human remains is a crucial part in forensic medicine; in situations where the whole body of the deceased is not found [9]. The skeletal component that is most often investigated for sex determination is mandible. Because of its dense layer of compact bone, it is highly durable and well preserved. When skeletal sex determination was considered, radiometric analysis of radiographs was found to be the best possible methods in terms of accuracy and reproducibility [10]. Hence we have considered OPGs for evaluation of Gonial values in our study. Keen et al. [10] proposed that after tooth extraction, there will be chronic and progressive resorption of residual alveolar ridge, which finally results in widened gonial angle [11]. Israel proposed that as age advances and as the dentulous status slowly transforms to edentulous, the equilibrium between the elevator and depressor muscles will be lost [12]. This statement was supported by Kasai et al. [13] study where he found a significant difference in the morphology of superior masseter muscle between dentulous and edentulous subjects [14]. But interestingly such presentation was not observed in the present study. We did not find any significant correlation between age and gonial angle in both males and females. This can be attributed

to the fact that we have confined the study only to complete dentulous mandibles. Obviously the change in the mandibular angle would be least in such conditions.

Jensen et al. [14] found a significant difference in the gonial angle between males and females [14]. Casey et al. [3] proposed that, usually males have 3-5° greater gonial angles than female [3]. However the present study showed no significant difference in the mean gonial angles between males and females. This presentation was further supported by similar results in studies conducted by Raustia, Upadhyay & Güngör et al. [15-17] stated that there were no significant differences between the right and left gonial angles [18]. Hence in the present study only left gonial measurements were taken into consideration inorder to minimize the discrepancy based on sides and to obtain the maximum possible sexual dimorphism. Gonial index (GI) is an excellent device to investigate the changes in cortical thickness at gonial angle (GA). Bras et al. [4] reported that osteoporosis in women has a significant effect on GI [4]. Kribbs et al. [18] concluded that systemic osteoporosis has a classic presentation of thinner cortex at Gonion [18]. Osteoporosis is more common in women because they have less bone tissue than men and experience a rapid phase of bone loss due to hormonal changes at menopause. Hence in the present study we observed a significant difference in GI values between males and females. Kribbs et al. [18] insisted upon the importance of GI value, whose value less than 1mm is an excellent indicator of metabolic bone loss [18]. In the present study the GA values were observed to be 121degrees, 124 degrees in males and females respectively. Whereas GI values were observed to be 1.54 and 1.45mm respectively. These results buoyed the importance of GI in predicting gender. However, better results were obtained when both GI and GA were taken into account.

Table 1: Mean Values Estimation in Males And Females (T-Test).

	Sex	N	Mean	Std. Deviation	Std. Error Mean	p-value
Gonial Angle	Males	94	121.995	7.7358	0.7979	0.058
	Females	94	124.361	9.2387	0.9529	
Gonial Index	Males	94	1.5627	0.31168	0.03215	0.005*
	Females	94	1.4243	0.34747	0.03584	

Table 2: Wilk's Lambda values for parameters.

	Wilks' Lambda	F	Sig.
Gonial Angle	0.981	3.624	0.058
Gonial Index	0.957	8.264	0.005*

Table 3: Reliability of obtained formula in the present sample data

Equation 2:	Sex	Predicted Group Membership			Functions at Group Centroids
		Males	Females	Total	
D = [2.542 X GI] – [0.067 X GA] + 4.426	Males	61	33	94	0.255
	%	64.9	35.1	100	
	Females	36	58	94	-0.255
	%	38.3	61.7	100	

63.3% of original grouped cases correctly classified

Table 4: Reliability of obtained formula in the sample data.

Equation 1:	Sex	Predicted Group Membership			Functions at Group Centroids
		Males	Females	Total	
D = [3.030 X GI] – 4.525	Males	50	44	94	0.21
	%	53.2	46.8	100	
	Females	37	57	94	-0.21
	%	39.4	60.6	100	

56.9% of original grouped cases correctly classified

Conclusion

The present study confirmed significant sexual dimorphism in the values of Gonial index. Males were observed to have higher GI when compared to females. Even though many methods are available for sex determination, most of them are used only as an adjunct, because the probability of sex determination varies from method to method. Hence there is a need for evaluating all the possible methods and establishing a comprehensive and contemporary database of these methods, for increasing the prospect of identifying the correct sex. The results in the present study have supported the use of GA and GI as an adjunct tool for sex determination.

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