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RESEARCH ARTICLE

Mandibular Gonial Angle Measurement as a Predictor of Gender-A Digital Panoramic Study

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Abstract:

Objective:

The present study is intended for properly assessing, comparing, and evaluating the contemporary measurements of gonial angle using digital panoramic radiography. In addition, this research evaluates the importance of mandibular gonial angle in gender determination.

Materials and Methods:

Technically, this is a retrospective cross-sectional study, where the study sample was composed of 590 (295 males and 295 females) patients undergoing digital panoramic radiography in the College of Dentistry in University of Science & Technology of Fujairah, Fujairah, UAE. These patients had been prescribed panoramic radiographs based on different factors. As a generally adopted procedure, bilateral gonial angle measurements were carried out, results were recorded, and their predictability as a determinant of gender was assessed. ANOVA and t-test procedures were utilized for statistical analysis of the collected data.

Results:

The analysis of the present study confirmed a statistically significant difference between the right and left sides of the gonial angle in both genders. Further, the mean comparison exposed a variation between males and females, based on gonial angle values; females have a statistically significant higher mean angle values than males. Based on the analysis, the present study concludes that this difference between males and females from both sides suggests that the gonial angle helps in sex identification.

Conclusion:

It has been concluded that gender significantly influences the gonial region and has great potential to be used as a forensic tool in gender determination. Digital panoramic radiography is a good study tool and it can be used to determine the morphology of the mandible.

Keywords: Forensic dentistry, Gonial angle, Digital panoramic radiography, Gender prediction, Mandibular measurements, Random sampling procedure.

Article History

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1. INTRODUCTION

In order to calculate age and recognize gender from the remains of human beings, accurate measurement and assess-

ment of gonial angle values are required. Assessment of the anatomic gonial angle values according to age and gender has been analyzed before [1 - 10] as panoramic radiography (orthopantomography), a useful tool to measure the gonial angle [11 - 14] that offers similar results to lateral radiography [11].

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However, previous studies on the current area of interest show mixed results as some of the studies [1, 15 - 17] suggest that gonial angle values can be used for determining age and gender, while some [6, 18, 19] hold the idea that there is no statistically significant relationship between gonial values, age, and gender.

For the proper assessment of the mandibular and maxillary vital structure, practitioners most commonly and frequently advise panoramic radiographs (OPGs). This is considered the all-inclusive approach for imaging the number of different dental disorders in one film. It is authentic and a higher degree of prescription suggests that it can be successfully used for studying any morphological variations that are normally observed with changes in ages and has a correlation with gender. If the head positioning is kept constant and standardized, then a suitable duplicability in terms of vertical and angular variables for group comparisons is obtained [20 - 23]. Furthermore, it has been documented in the earlier studies that irrespective of the fact that the horizontal measurement is not much reliable, angular measurement is still carried out in the OPG process with significant reliability.

Because the left side and right side of our body play different roles, this study proposes the hypothesis that the right side gonial angle is significantly different from the left, further; there is a different type of correlation between gender and each side. To evaluate this relationship, a retrospective cross-sectional study was carried out of panoramic radiography patients visiting the dental clinic of the University of Science and Technology of Fujairah. Digital panoramic radiographs were traced and evaluated in order to support the research. The study was conducted to better understand the alteration in the gonial region to correlate with gender determination.

2. MATERIALS AND METHODS

To conduct the current study, we selected the College of Dentistry, University of Science & Technology of Fujairah, Fujairah, United Arab Emirates. Using a simple random sampling procedure, a total of 590 digital panoramic radiographs from the Asian patient's database stored at the Department of Oral and Maxillofacial Radiology were selected. These patients were visiting the dental clinic in University of Science & Technology of Fujairah and thus were evaluated and included in the study. A general consent form was signed by all the participants of the study, which indicates their approval as their information might be used in the clinical research projects. Based on gender, the study sample was categorized into two groups *i.e.* 295 males (with an average age of 37.4 with SD 10.3) and 295 females (with an average age of 32.9 with SD 10.7) (Table 1). Having 590 subjects delivered greater than 86% power of the sample to detect the differences between male and female.

All the panoramic radiographic images were acquired using Planmeca ProMax[®] 3D Max panoramic machine (Planmeca Oy, Helsinki, Finland). Exposure parameters were ranging from 64-68 kVp, 6.3-10 mA, and 0.19 s according to the patient's age and size. The adopted inclusion criterion of the present study is significantly matched by all the selected images for analysis.

2.1. Inclusion Criteria

- Those images were selected that were with high panoramic standard quality and were free from any kind of exposure and positioning errors.
- If all factors and parameters are clearly visible on the image obtained through the digital panoramic radiographic process and that for gonial angle a clear tracing can be observed.

2.2. Exclusion Criteria

- Individuals giving a history of orthognathic surgery.
- Individuals with the Temporomandibular Joint Disorder (TMD).
- Syndromes affecting the face/jaw.
- Patient with gross facial asymmetry.
- Any type of general and domestic syndromes that could possibly influence the development of the craniofacial region.
- Any history of facial trauma.
- History of any other major surgery and/ or radiotherapy related to head and neck.
- Mixed dentition.
- Evident radiographic error.

Using the JPG file format, all the required digital panoramic images were saved and for linear and angular measurement they were exported to Planmeca Romexis[®] software. Following the well-developed procedure, panoramic landmarks were located, identified, and marked on the selected radiograph using the calibration. A single examiner determined the gonial angle measurements and they were undertaken as described by Upadhyay *et al.* 2012 [24] measuring between 2 tangents from the gonion; whereas the one campaigning overbearingly with the posterior edge of the mandibular ramus while the other anteriorly along the inferior edge of the body of the jaw bone (Fig. 1). For obtaining an average value, a consensual measurement was performed both for the right and left-hand sides of the radiograph.

3. RESULTS

3.1. Statistical Analysis

A type of pilot study prior to collecting data for the whole sample was carried out, in which the reliability of the measure was tested by an expert through data from 25 subjects. Following this, data from the targeted study sample were collected and coded in Statistical Software for Social Sciences (IBM SPSS Inc, Chicago, III) for further analysis. One sample and paired sample t-test were carried out to determine the differences between the right and left sides of the gonial angle in both genders and to determine the differences between the same sides of the gonial angle in both genders. The study group consisted of 590 digital panoramic radiographs (295 males and 295 females). The reliability analysis for all the dependent variables under study was calculated by using Cronbach's Alpha, and in our case, it was equal to 0.843, which can be considered as good.

Table 1. Descriptive statistics: The average age for males, females and overall.

Gender		N	Range	Min.	Max.	Mean		Std. Deviation
		Statistic	Statistic	Statistic	Statistic	Statistic	Std. Error	Statistic
F	Age	295	44	16	60	32.91	.781	10.676
M	Age	295	49	16	65	37.41	.565	10.296
Overall	Age	590	49	16	65	35.79	.467	10.645

Table 2. One-sample statistics - Descriptive statistics.

Dependent Variable		Mean	Std. Error	95% Confidence Interval	
				Lower Bound	Upper Bound
Right Side (590)		123.198	0.315	122.581	123.816
Left Side (590)		124.347	0.307	123.745	124.95
Right Side (295)	Male	122.2	0.445	121.326	123.074
	Female	124.197	0.445	123.323	125.07
Left Side (295)	Male	123.403	0.434	122.551	124.255
	Female	125.292	0.434	124.439	126.144

Table 3. Paired samples test: The difference between the right and left side of the gonial angle in both genders.

Gender		Paired Differences					t-Value	Differences	Significant Difference (2-tailed)
		Mean	Std. Deviation	Std. Error Mean	95% Confidence Interval of the Difference				
					Lower	Upper			
Male	Right side - Left side	-1.203	4.801	.280	-1.754	-.653	-4.305	294	.000
Female	Right side - Left side	-1.095	6.541	.381	-1.844	-.345	-2.875	294	.004

Table 4. Male & female ANOVA for the left side and the right side measurements.

-	-	Sum of Squares	Df	Mean Square	F	Sig.
Left Side	Between Groups	525.846	1	525.846	9.471	.002
	Within Groups	32647.925	588	55.524	-	-
	Total	33173.771	589	-	-	-
Right Side	Between Groups	588.002	1	588.002	10.072	.002
	Within Groups	34325.797	588	58.377	-	-
	Total	34913.798	589	-	-	-

Table 2 documents the descriptive statistics for the study sample. Data were presented as a number of sample, mean, standard error, and a 95% confidence interval of the mean of both right and left sides of the gonial angle for each gender.

The average of the gonial angle for the right side and left side for all the subjects was 123.198 and 124.347, respectively, precisely the average R side for the male was 122.2 while for the female was 124.197, also the average for the L side was 123.403 for the male and 125.292 for the female. This shows that the R side and the L side gonial angle for the female was greater than the male in both cases.

Based on the gender, Paired sample t-test was used to compare the mean value for both sides of the gonial angle (Table 3). A comparison between the right and the Left side gonial angles was performed, and it was found that there was a

statistically significant difference between the two sides in both male and female. That is why we cannot depend on the average of the right and left side for each gender.

In consequence, we came up with an idea to compare the right side gonial angle of the female with the right side of the male and do the same for the left side gonial angle (Table 4).

The analysis of variance ANOVA table gave the above results for left side and right side measurements for both groups; the outputs suggest that there is a statistically significant difference between groups with an exact probability value of 0.002. This leads us to conclude that with a 95% confidence interval if a measurement of the Left side is obtained in the range of 122.48 and 124.33 then the participant must be male. Similarly, an interval obtained between 124.51 and 126.07 with a confidence level of 95% will suggest a

female. Further, an interval obtained between 121.28 and 123.12 with a confidence level of 95% for the right side will suggest that the participant is male and otherwise it must be female.



Fig. (1). Measurement of the gonial angle on the digital panoramic radiograph.

4. DISCUSSION

A critical review of the previous literature on the current area of interest revealed that a number of studies have been conducted for analyzing the difference between the values of male and female gonial angles; however, very insignificant research has been carried out regarding analyzing the gender assessment on the basis of values obtained for the gonial angle. This study extends that the existing morphology of the jaw bones can be used for the categorization of genders.

The analysis and study of sex determination are simultaneously important for forensic investigations and for regional differences and population history [25]. In addition to that, determination of the correct age has become an important duty of medicolegal officers in light of the contemporary increasing crimes.

It has been observed that in the entire human body, the two highly sexual dimorphic parts are mandibular condyle and ramus because these are the parts that experience maximum morphological changes in size and restriction during the life span [26]. Based on the above analysis, for the determination of gender, the current study has selected the mandibular gonial angle measurement procedure.

The present study was attempted for assessing the importance of mandibular gonial angle as an aid in sex determination. The study sample was composed of 590 OPGs among which 295 were male and 295 female participants. Based on the fact that OPGs have been accepted as an authentic and reliable procedure for the measurement of angular parameters, this procedure has been selected prior to lateral cephalograms. Similarly, it has been proved that it is not affected by the magnification error and by the coinciding disadvantage of the lateral cephalograms. Further, regardless of its untrustworthiness in horizontal measurement, angular measurements can be carried out with high accuracy and reliability in OPG. Similarly, it has also been proved that an insignificant slight misalignment of the head, which is frequently observed in daily life, cannot significantly influence vertical calculations in the posterior mandible or maxilla, or in the anterior mandible, and minor anteroposterior changes and

inclines are linked with a difference of less than 2% for mandibular measurements in the vertical plane [27]. Consequently, we can conclude that the method used in the present study is considered reliable for the determination of the gonial angle. Moreover, the comparison can be made easy for the left and right sides of the parameters.

It is important to mention that the differences in measurements were very small but were statistically significant. This may be due to the alterations in the making of the x rays or in the manual measurements, which may reduce the credibility of the measurements

Based on gender differences, the present study confirmed a statistically significant difference in gonial angles. The study explicitly revealed that females had statistically significantly higher gonial angles than males. The gender differences were statistically significant in the gonial angle where males have a lower value than females. Findings of the current study are in line with the results of the previous relevant studies [1, 16, 28, 29] which reach the same conclusion; females have a higher gonial angle, this specific result might be due to the remarkable impact of masticatory forces [1]. Particularly, it is observed that an individual with relatively higher masticatory forces has a small gonial angle; men mostly have greater masticatory force than women [30]. On average, bones in male skeleton are relatively thick and large than females; however, this is not universal, because a number of factors other than gender, such as better nutrition and heavy physical activity, determine bone size and thickness [9]. This might also be due to gender hormonal differences; testosterone in males and estrogen in females affect bone metabolism, thereby showing visible changes in radiographs, and contributing to the development of craniofacial morphologic differences between genders. On average, males have greater masticatory force than females which influences the bone size. Literature suggests that muscular tension is the most important determinant of bone formation and in mandible, the mixture of elevating muscles during masticatory movement exerts tension throughout the ramus [31].

Conversely, other researchers found that males showed statistically significant higher mean gonial angle values than females as mentioned in a previous study [32], and others did not find any statistically significant differences between both sexes [27, 33]. A study found that females have a downward and backward rotation in the mandible and males have a forward rotation in the mandible. Hence, the gonial angle values in females are higher than in males. Two factors, such as gender hormonal differences that affect bone metabolism or mastication muscles might be responsible for this difference in the gonial angles. The present study confirmed a significant difference between right and left gonial angles in both sexes, which proved the intrinsic nature of the irregularity of the human mandible. The findings are further supported by the fact that the jaw bone could be physiologically asymmetric, in case malformation is not found or even if the skull base is asymmetric.

The analysis suggests that the final physical design of any completely developed mandible is observed due to the genetic determination, which exposes them as a result of the working

environment. Further, the multifaceted design of the jaw bone suggests that it can be used for a number of purposes.

CONCLUSION

Human identification has always been a significantly important task for society. Summing up the above discussion revealed that the outcomes of the current work are in line with the previous relevant literature; using values of gonial angles is significantly important and helpful in the determination of gender. Further, this can be equally used as an important forensic tool in investigations regarding gender identification. The study explicitly revealed that females had statistically significantly higher gonial angles than males. There are two factors responsible for this difference in gonial angles. The first one is gender hormonal differences and this can be described in terms of different concentrations and secretion of different hormones to illustrate that estrogen affects bone metabolism in females while in males, testosterone is the effective factor in bone remodeling. The second factor is that mastication muscles might be responsible for this difference in gonial angles; this can be described as subjects with maximum masticatory force have a small gonial angle since powerful muscles will bend the lower border of the mandible against the ramus, and on average, men have greater masticatory force than women. In this study, we found that there is a significant difference between the right gonial angles of females and the right and also the left gonial angles of males and this can be considered as a determinant for gender.

ETHICAL APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by Ethical committee of University of Science & Technology of Fujairah, Fujairah, UAE. (Reference Number GDF-2017/18-03-S).

HUMAN AND ANIMAL RIGHTS

No animals were used in this research. All research procedures on humans were followed in accordance with the ethical standards of the committee responsible for human experimentation (institutional and national), and with the Helsinki Declaration of 1975, as revised in 2013. (<http://ethics.iit.edu/ecodes/node/3931>)

CONSENT FOR PUBLICATION

All the participants of the study signed a general consent form.

AVAILABILITY OF DATA AND MATERIALS

The datasets analyzed during the current study are available from the corresponding author upon request.

FUNDING

None.

CONFLICT OF INTEREST

The authors declare no conflict of interest, financial or otherwise.

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