Original Article
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The Relationship Between the Gonial Angle, Ramus Height, And the Type of Third-Molar Impaction: A Panoramic Radiographic Study

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Objectives Tooth impaction refers to the failure of a tooth to properly emerge in its expected position within a given timeframe. Several local factors influence the occurrence of tooth impaction, one of which is the specific morphometric characteristics of the mandible. The objective of this study is to examine the association between these factors and the type of impaction observed in the mandibular third molar.
Methods In this Cross-sectional study, 186 impacted mandibular third molar from patients with 20 to 30 years of age were evaluated. The mandibular third molars were categorized according to Pell and Gregory classification into A (third molar is at the same level as the occlusal plane of the second molar), B (third molar is between the occlusal plane and Cementoenamel junction (CEJ) of the second molar) and C (third molar is below the CEJ of the second molar) groups. The Chi-square test was used for statistical analysis of the data. The relation between gonial angle and ramus height with third molar impaction type was assessed using a Pearson correlation test.
Results The mean±SD for gonial angle in A, B and C groups were 121.05±6.33, 120.24±5.43 and 119.67±5.17 respectively. The mean±SD for ramus height in A, B and C groups were 58.51±5.01, 57.63±5.14 and 57.38±4.51 respectively. There was no significant relation between mandibular third molar impaction type and gonial angle and ramus height (P>0.05).
Conclusion There was no significant relationship between the gonial angle and ramus height and the type of mandibular third molar tooth impaction according to Pell & Gregory classification as well as eruption and impacted state of mandibular third molar. The results of this study can be used by dentists to assess the difficulty of mandibular third molar extraction prior to their surgeries.
Keywords Third molar; Mandible; Impacted tooth; Panoramic radiography

Introduction

Tooth impaction occurs when a tooth fails to erupt in its normal position within the expected timeframe. Various factors can contribute to tooth impaction, both local and systemic. Local factors involve limitations in the available space on the dental arch, malpositioning of the tooth. On the other hand, systemic factors are related to conditions such as Down syndrome, endocrine deficiencies, and Cleidocranial dysplasia. [1, 2]

The mandibular third molar (M3M), also known as the lower wisdom tooth, is the most commonly impacted tooth among all. The incidence of M3M impaction varies between 9.5% and 68% among different populations. [3] Certain mandibular morphometric characteristics, such as the gonial angle and ramus height, are considered local factors that contribute to tooth impaction. [4-6]

Different classification systems are used to classify the position and impaction type of mandibular third molars. The Pell and Gregory (1933) classification system is among the most prevalent, which uses second molar teeth to define impaction depth and the third molar-ramus relation. [7] The system classifies mandibular third molars into Class I, II, or III, according to their relationship with the ascending mandibular ramus, and into levels A, B, and C, based on the relative depth of the tooth in the bone concerning the occlusal plane of adjacent second molar. [8] Level A: the third molar tooth is at the same level as the occlusal plane of the second molar tooth. Level B: the third molar tooth is between the occlusal plane and the cervical region (CEJ) of the second molar tooth. Level C: the third molar tooth is below the cervical level of the second molar tooth. [6]

Previous studies have produced conflicting findings regarding the correlation between ramus height and gonial angle, prompting the necessity for more research. Some studies argue that the gonial angle does not impact the eruption status of the third molar and therefore cannot accurately predict impaction. [5, 9, 10] Conversely, other studies propose that the shape and dimensions of the ramus may contribute to impaction. [11, 12] Furthermore, the connection between the type of mandibular third molar impaction and the gonial angle remains relatively unexplored. [13] Previous studies have assessed the impaction state of the mandibular third molar using panoramic radiography. [6, 7] Jeevitha et al. indicated that this radiography can assess the third molar angulation and its relation with adjacent anatomic structures. [10] This study aims to investigate the correlation between gonial angle/ramus height and the impaction type of mandibular third molars using panoramic radiographs.

Methods and Materials

Ethical Approval:

This was a retrospective cross-sectional study. The study protocol was approved by the institutional review board of Shahid Beheshti University of Medical Sciences (code no: IR.SBMU.DRC.REC.1401.073), and it was conducted by the Declaration of Helsinki and its subsequent revisions. The study was conducted by the STROBE statement.

Sample size:

The number of samples was calculated based on using the formula n = (Zα/2+Zβ)2 *2*σ2 / d2 based on the study of Gümrükçü [14] with the probability of the level of the first type of error equal to 0.05 (α=0.05) and the power of the study 80% (β=0.2) and considering σ = 0.4 and d=0.25, the sample size was estimated to be 41. Considering that we have three presented groups, the following formula was further applied: n=41*√(3-1) =58 and at least 58 samples in each group were included.

Inclusion and exclusion Criteria:

The samples of this study comprised the panoramic radiographs of patients referred to the Oral and Maxillofacial Radiology Department of Shahid Beheshti Medical University in Tehran, Iran. The inclusion criteria consist of good quality of the image, having at least one impacted mandibular third molar patient's age 20-30 because the average age for the eruption of the third molars is 20 years. [9] Radiographic images with pathologic diseases in the third molar region and without the second molar were excluded. Overall, 186 mandibular third molar cases of 111 patients (71 females and 40 males) were selected to be included in this study.

Panoramic Radiograph assessments:

All panoramic radiographs were taken between April 2022 and November 2022 by an experienced radiologic technologist using a Panoramic X-ray machine (Soredex Cranex-D, Finland). The exposure parameters were 50–84 kV,5–16 mA and Exposure time was 17.6s. The Radiographs were then imported to ScanoraLite software (4.2, Soredex, Helsinki, Finland) for analysis, tracing and measurement. The gonial angle, the ramus height and the M3M impaction type based on the Pell and Gregory classification (levels A, B, C) were obtained using the software features. (Table1) (Figure1). In addition, classification based on Impaction and eruption was also conducted. (Figure2) In this regard, level A was considered as erupted, whereas levels B and C were considered as impacted.

Table 1- The Pell–Gregory classification

A	M3M is at the same level as the occlusal plane of the 2nd molar
B	M3M is between the occlusal plane and CEJ of the 2nd molar
C	M3M is below the CEJ of the 2nd molar

Figure 1: The Pell–Gregory classification

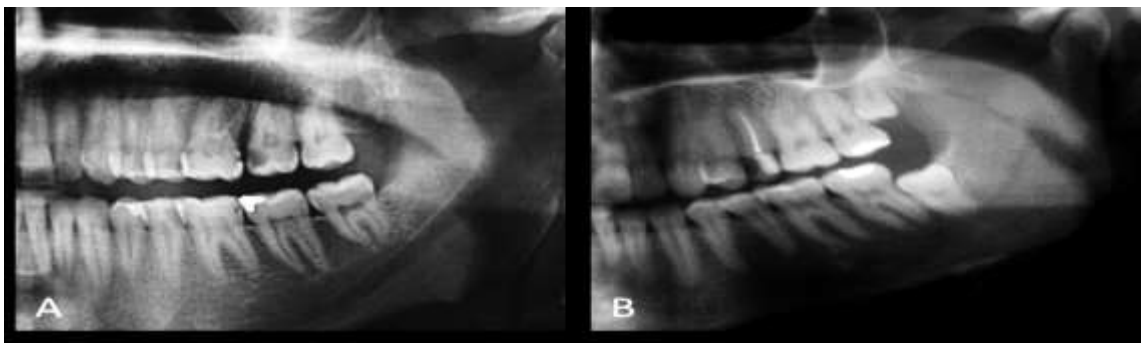

Figure 2: Classification of third molar into two categories of (A) Erupted and (B) Impacted.

The gonial angle and ramus height were measured with the digital protractor and ruler in panoramic images and recorded. The gonial angle was measured as the angle between the posterior border of the ramus (Ar–Go) and the lower border of the mandible or MP (Go–Me) (Figure 3). [15] To measure the mandibular ramus height, the bisection line

between the mandibular ramus and the body line was drawn. Then the ramus height was measured as the distance from the highest point on the top of the condyle to the point where the bisection line crosses the mandible angle (Figure 4). [16] All measurements were performed by a skilled oral and maxillofacial radiologist.

Other study variables were recorded including patients' age and gender.

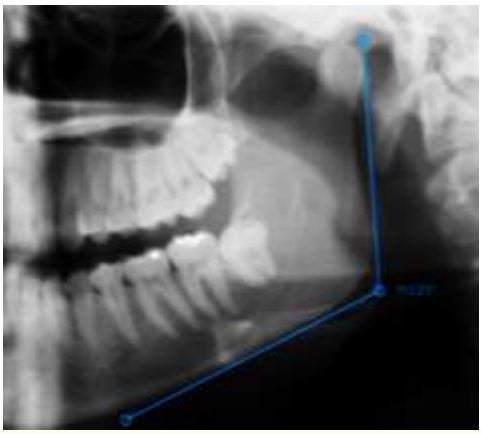

Figure 3: Cropped panoramic shows gonial angle measurement on the left side of mandible.

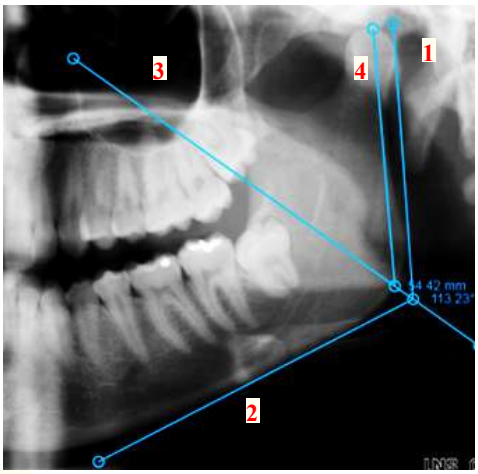

Figure 4: Ramus height measurement on the left side of the panorex using the bisection method. Lines 1 and 2 are the tangents of the mandibular ramus and the body, respectively. Line 3 is the bisection line dividing the angle between the two tangents in half. Line 4 is used to measure the ramus height and goes from the gonial angle (where line 3 crosses the curvature of the angle of the mandible, i.e., point gonion) to the highest point on the top of the condyle, i.e., point condyle (16).

Also, the type of mandibular third molar impaction was determined based on the Pell & Gregory classification in relation to the occlusal plane of the second molar tooth in panoramic images. [17] In this study, to compare the variables of gonial angle and ramus height between impacted and erupted teeth, the Class A group was considered as erupted and the other two groups were considered as impacted teeth group. [18]. To confirm the validity using Intra observer agreement, among the analyzed samples, 16 samples were randomly selected and after 30 days, all the variables were re-examined.

Statistical Analysis

The Shapiro–Wilk normality test was applied to the data and revealed normal distribution (Table 2).

Table 2- Result of Shapiro–Wilk normality test for ramus height and gonial angle. (P value>0.05)

Variable	Class	P value
Gonial Angle	A	0.214
	B	0.551
	C	0.250
Ramus Height	A	0.744
	B	0.262
	C	0.109

The statistical analysis was performed using Statistical Package for Social Science (SPSS) 23.0 (SPSS Inc., Chicago, Illinois, USA). To evaluate the results between the three groups of A, B and C, the data were analyzed using ANOVA variance analysis and the statistical significance was considered $p<0.05$. An Independent T-test was used to assess the relation between gonial angle/ramus height and classification of impacted and erupted third molars. Pearson correlation between age and gonial angle/ramus height was equal to r = -0.16, P value = 0.028 and r = 0.025, P value = 0.74 respectively.

Results

Intra-Operator Reliability

Measures for the first and second replicates were recorded and intra-class correlation coefficients (ICC) were established for all measurements. Most measures demonstrated a high degree of reliability between the first and second replicates with ICC values 0.82 for ramus height and 0.95 for gonial angle (Table 3).

Table 3- Result of intra-operator reliability for ramus height and gonial angle. (ICC: intra-class correlation coefficients)

	ICC	95% Confidence Interval for Mean	
		Lower Bound	Upper Bound
Ramus Height	0.816	0.550	0.931
Gonial Angle	0.954	0.873	0.984

Demographic data

The study samples included 186 impacted mandibular third

molars, 111 panoramic radiographs taken from 111 patients who met the inclusion criteria. The study group consisted of 71 (64%) females and 40 (36%) males. The total mean age±SD of included patients was 23.35± 3.14 years. Mean Ramus height was significantly higher in male than in female whereas mean gonial angle was significantly higher in female than in male (P<0.05). A significant negative relationship was seen between age and gonial angle (P=0.028).

Quantitative Assessments:

The distribution of patients in terms of age and gender according to the Pell & Gregory classification is listed in (Table 4).

Table 4- Age and gender distributions according to Pell & Gregory Classification

	Pell & Gregory A	Pell & Gregory B	Pell & Gregory C
Mean age±SD	23.67±3.39	23.81±3.16	22.58±2.75
Female (N)	43	48	29
Male (N)	19	14	33

The minimum, maximum and mean values of ramus height and gonial angle within A, B and C groups are listed in Tables 5 and 6. There was no statistically significant difference between Pell & Gregory class A, B and C in terms of both gonial angle (p value= 0.396) and ramus height (p value= 0.674) according to the ANOVA test.

Table 5- Comparative analysis of gonial angle measurements in different classes: An investigation using one way ANOVA

Variable	Class	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum	F-value	P- Value
					Lower Bound	Upper Bound				
Gonial Angle	A	62	121.05	6.33	119.45	122.66	110.23	136.16	0.93	0.39
	B	62	120.24	5.43	118.86	121.62	106.07	133.81		
	C	62	119.67	5.17	118.36	120.98	110.63	132.61		
	Total	186	120.32	5.66	119.50	121.14	106.07	136.16		

Table 6- Comparative study of ramus height measurements in different classes: insights from descriptive statistics and one way ANOVA analysis.

Variable	Class	N	Mean	Std. Deviation	95% Confidence Interval for Mean		Minimum	Maximum	F-value	P-Value
					Lower Bound	Upper Bound				
Ramus Height	A	62	58.15	5.01	56.88	59.42	47.25	69.93	0.39	0.67
	B	62	57.63	5.14	56.33	58.94	42.10	67.90		
	C	62	57.38	4.51	56.23	58.53	44.71	67.46		
	Total	186	57.72	4.88	57.01	58.43	42.10	69.93		

The correlation between gonial angle/ramus height and mandibular third molar impaction is presented in Table 7. No significant relationship was detected (P>0.05).

Table 7- Comparative analysis of gonial angle and ramus height in impacted and erupted dental

Variable	Condition	N	Mean	Std. Deviation	P- Value
Gonial Angle	Impacted	124	119.96	5.29	0.24
	Erupted	62	121.05	6.33	
Ramus Height	Impacted	124	57.51	4.82	0.4
	Erupted	62	58.15	5.00	

Discussion

Tooth impaction is the failure of eruption in the expected time as defined by Peterson. [19] Numerous studies have been conducted to figure out the correlation between morphometric features and tooth impaction. [12, 18] This study aimed to measure the gonial angle and the mandibular ramus height on a panoramic image to investigate their

correlation with mandibular third molar impaction type according to the Pell & Gregory classification. Previous studies have indicated that the main etiological factor for M3M impaction is contributed by the bony obstruction to the pathway of eruption [10] therefore, this study aimed to assess the relation between mandibular structures and the type of impaction.

Age and gender

In the present study, age had an inverse relationship with the gonial angle, but no significant relationship was found between age and ramus height. Ramus height is larger in men and gonial angle in women. In a study by Leversha et al. [20] in 2016 to determine the relationship between gender and age with the gonial angle and ramus height, the results regarding age were contrary to the present study, this controversy could be due to the different ethnicity within the studies. Leversha et al. also indicated that the size of the gonial angle and the ramus height increased with age which is consistent with our study.

Gonial angle and ramus height within different impaction classifications.

In this study, there was no significant difference between the three classes of the Pell & Gregory in terms of gonial angle and ramus height measurement. The result was in line with Merve Gonca et al. who found that there were no differences in mandibular morphology between classes A, B, and C, however; class C exhibited unique characteristics in terms of impaction angle compared to the other two classes. [18]

Our finding disagrees with the result of Gümrükçü [14], who reported that gonial angle and ramus height are significantly different in Pell & Gregory Classification types. According to the results of her study, the ramus height was found to be highest in Class A and lowest in Class C. Also, the highest gonial angle was found in Class A and the lowest in Class B.

This difference may be a result of the different measurement techniques used. In 2021 Gümrükçü et al. [14] measured the gonial angle on cephalometric radiographs, whereas in our study it is done on panoramic images. Similarly, in the mentioned study the ramus height is measured as the distance between the lateral edge point of the condyle and the lateral edge point of the ramus on the panoramic image, but in this study the ramus height is determined using the bisection method on panoramic radiograph.

Also, our result is not in line with that of Barone et al. in which the morphometric analysis by CBCT scans showed that a lower gonial angle was related to a reduced retromolar space, favoring the development of the M3M in a complete bone impaction, with a horizontal position and closer to the inferior alveolar nerve (IAN). [21]

Another study, by Demirel et al. found no correlation between third molar angulation and gonial angle. However, the C2 sub-group of the Pell-Gregory classification exhibited the higher average gonial angle value although it was not statistically significant. [7]

Gonca et al. found that there were no differences in mandibular morphology between classes A, B, and C, however; class C exhibited unique characteristics in terms of impaction angle compared to the other two classes. [18]

Study limitations:

This study assessed selected, most informative parameters in the mandible (gonial angle and ramus height) and their relation to M3M impaction type. However, future studies can include all important parameters such as soft tissue condition and another patient characteristic on impaction type.

Conclusion

This study found that there was no significant relationship between the gonial angle and ramus height and the type of mandibular third molar tooth impaction in the population analyzed. The results of this study can be used by oral and maxillofacial surgeons and dentist to assess the difficulty of mandibular third molar extraction prior to their surgeries.

Conflict of Interest

No Conflict of Interest Declared

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