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Is there a relationship between mandibular third molar impaction and mandibular morphology?

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Abstract

Background Panoramic radiography is widely used for initial assessment during clinical examinations. It is very useful for clinicians to predict impaction of third molar teeth via certain parameters without relying solely on personal experience. This study aims to examine the relationship between the impaction of mandibular third molar teeth and mandibular morphology. Thus, mandibular third molar tooth impaction estimation can be provided with measurements made on panoramic radiography.

Methods The study material consisted of panoramic radiographs of 330 patients. The experimental group with impacted mandibular third molar teeth included 165 patients (mean age 20.62 ± 2.89 years), and the control group with erupted mandibular third molar teeth included 165 patients (mean age 22.23 ± 4.22 years). Nine dimensional, four angular, andone1 proportional parameter were examined on panoramic radiographs via the ImageJ program. The Mann–Whitney U test, Kruskal–Wallis H test, chi–square test and correlation analysis were used for statistical analysis. Intraobserver reliability was examined via the intraclass correlation coefficient (ICC).

Results Dimensional parameters such as condyle length, coronoid length, mandibular corpus width, sigmoid notch depth, retromolar space distance, and antegonial notch depth were significantly lower in the experimental group than in the control group. The Co/Cr angle was also significantly greater in the experimental group, whereas the alpha angle was significantly greater in the other groups. The ratio of the retromolar space distance to the third molar tooth width was also significantly greater in the control group.

Conclusions Mandibular third molar tooth impaction is related to various parameters of mandibular morphology. Certain measurements taken from panoramic radiographs may provide predictions regarding the likelihood of mandibular third molar impaction.

Keywords Impaction, Mandible, Panoramic radiography, Third molar tooth

Introduction

Impaction is a term used to describe a tooth that has not erupted, remains in its position, or has only partially erupted, as identified through clinical and radiographic evaluations. Normally, two-thirds of root formations are expected for a tooth to appear; however, the term retained tooth refers to teeth that have not erupted even after the expected eruption date [1].

Etiological factors, including systemic, local, and genetic factors, contribute to teeth remaining impacted.

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When the entire dentition is evaluated, the highest frequency of impaction is observed in mandibular third molars, followed by maxillary third molars, maxillary canines, mandibular canines, mandibular first premolars, maxillary central incisors, maxillary second premolars, mandibular second premolars, and maxillary first premolars, respectively [2]. In another study not involving third molars, the most frequent impactions were found in maxillary canines, followed by maxillary and mandibular premolars [3].

The age of occurrence is a significant factor when assessing impacted teeth. In previous studies, the highest prevalence of impacted teeth was reported in those aged 20–35 years [4]. In a study carried out on 351 orthodontic patients aged between 20 and 26 years in Turkey, the impaction rate of mandibular third molars was reported to be 35.9% [5].

The orthodontist is always aware of the developing third molar and its potential impact on the dentition during and after orthodontic treatment. The etiology of third molar impaction has not been fully explained. Factors contributing to this rate included the direction of mandibular growth, the sagittal eruption of the dentition, and resorption at the anterior border of the ramus. Additionally, the increase in the condylion-symphysis dimension of the mandible has been noted to facilitate space for third molars [6]. There is a general consensus that the main factor is shortage of space.

Broadbent believed that when the third molar tooth became impacted, the mandible would not be able to achieve its full growth potential [7]. Begg claimed that there was insufficient forward movement of the dentition of modern man due to lack of attrition resulting in lack of space for the third molar [8]. Bjork demonstrated that impacted third molar teeth are associated not only with reduced growth but also with downward growth rather than forward growth [9]. Faubion's study showed that the incidence of impacted third molar teeth was reduced but not eliminated in cases treated by extraction of premolars [10].

The capability to anticipate the eruption or impaction of third molars holds significant importance in the field of clinical dentistry. If they erupt, they may be beneficial for orthodontic anchorage, prosthetic abutments, or transplantation. If they get impacted, they can cause adjacent root resorption, inflammatory process (pericoronitis), temporomandibular joint dysfunction and late incisor crowding [11]; thus prophylactic removal greatly reduces risk to a patient as opposed to extraction later in life [12]. Early germectomy may mitigate the risk of intraoperative and post-operative complications related to the surgery of a fully developed third molar, including potential nerve damage leading to paresthesia, dry socket, inflammation, bleeding, and pain [13]. Consequently, evaluating the position of the germ and the progression of mandibular third molar eruption is essential for improved patient management.

Various imaging methods can be used in the diagnosis of impacted teeth. Panoramic radiography is widely used for initial assessment during clinical examinations in dentistry [14]. Predicting the potential impact of teeth is critical both for orthodontic treatment planning and for maintaining stability after orthodontic treatment. It is very useful for clinicians to predict impaction via certain parameters without relying solely on personal experience. Many studies have been done to predict the probability of third molar eruption [15–18]. Henry and Morant [19] suggested third molar space index, while Schulhof [20] used centre of ramus (Xi) point to measure the available space for eruption of the mandibular third molar. While many authors have utilized lateral cephalometric radiographs, it is noteworthy that the orthopantomogram is regarded as a more precise imaging technique for assessing the position of the third molar due to its minimal superimposition [21–23]. However, considering the variability in the findings of these studies, the sample size were small, only a few variables were tested and some subjects were less than 20 years of age when impaction was diagnosed. It was considered to conduct a study examining detailed measurements on a larger sample.

Demonstrating the differences in the size and shape of the mandible and teeth between subjects with impacted mandibular third molars and those with erupted mandibular third molars is possible. It may be possible to predict the eruption of a developing mandibular third molar by analyzing linear, angular, and proportional measurements of specific dimensions on panoramic radiographs [6].

Thus, the present study aimed to assess the relationship between the impaction of mandibular third molars and mandibular morphology via dimensional, angular, and proportional measurements on digital panoramic radiographs with a larger sample size and to recommend a measurement for clinicians that can predict third molar impaction without relying on personal experience. It was hypothesised that mandibular morphology has a significant role in the impaction and eruption of the mandibular third molar tooth.

Materials and methods

Approval for this study was granted by the Health Sciences Ethics Committee of Ankara Yıldırım Beyazıt University (date 06.10.2022-number 14). Informed consent to participate was obtained from all of the participants in the study. The study of Al-Gunaid et al. was used as a reference to determine the sample size via power analysis [15]. As a result of the power analysis, a total of 328 patients were included to ensure a test power of $(1\text{-}\beta) = 0.90$.

The study sample consisted of panoramic radiographs of 330 individuals. The inclusion criteria were no craniofacial deformities or syndromes, no previous orthodontic or orthognathic surgical treatment, the absence of congenital tooth agenesis, complete permanent dentition except for third molars, no major craniofacial asymmetry, and sufficient radiographic quality for identifying the anatomical landmarks used in this study.

The ages of the participants ranged between 18 and 31 (mean age 21.43 ± 3.7). The experimental group included 165 patients with impacted mandibular third molars (99 females, 66 males; mean age, 20.62 ± 2.89 years), whereas the control group included 165 patients with erupted mandibular third molars (110 females, 55 males; mean age, 22.23 ± 4.22 years).

Panoramic radiographs were taken via a Planmeca Promax 3D unit (Planmeca Oy, Helsinki, Finland) in the Department of Oral, Dental, and Maxillofacial Radiology. The device, featuring a focal spot size of 0.5 × 0.5 cm, operated at 50–90 kVp, 7 mA, and a pixel size of 48 μm. During the panoramic examination, the midsagittal plane centered in the rotational midline of the device and perpendicularly aligned to the floor. The Frankfort plane, that is the line passing from the superior border of the external auditory meatus to the infraorbital rim, horizontally oriented and thus parallel to the floor. A notched bite block guided the position of the maxillary and mandibular incisors. The spine was as straight as possible, and the neck extended. Patients kept the tongue pressed against the palate to avoid both overexposure and the presence of a radiolucent area representing the shadow of the air space on the upper teeth apexes. Measurements on the panoramic images were performed via ImageJ 1.48a software (version 1.38).

Anatomical landmarks identified on the panoramic radiographs (Fig. 1):

1. Orbitale (Or): The deepest point on the inferior margin of the orbit.
2. Condylion (Co): The most superior point of the mandibular condyle.
3. Coronoid (Cr): The highest point of the coronoid process.
4. Gonion (Go): The intersection point of the ramus plane and the body plane.
5. Articulare (Ar): The intersection of the posterior border of the ramus with the inferior border of the posterior cranial base.
6. Sigmoid notch (Snp): The deepest point of the mandibular sigmoid notch.
7. Pmc: The outermost point of the posterior border of the mandibular angle.
8. Arnc: The deepest point of the concavity on the anterior border of the ramus.
9. Prnc: The outermost point of the convexity on the posterior border of the ramus.
10. Imca: The most posterior convex point on the inferior border of the mandibular body.
11. Imcb: Most-anterior convex point on the inferior border of the mandibular body.
12. Mnc: The deepest point of the mandibular lower border concavity.
13. Antegonion point (Ag): The point at the antegonial notch where the ramus joins the body of the mandible.
14. Mandibular midpoint (M): The lowest and central points of the mandibular symphysis.

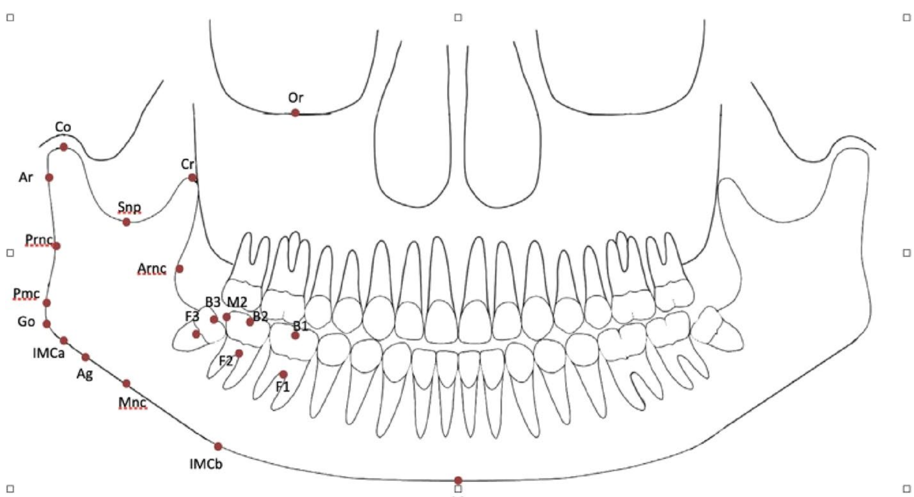

Fig. 1 Anatomical landmarks used in the study

15. F1: The midpoint of the occlusal fossa of the mandibular first molar.
16. B1: The furcation point of the mandibular first molar.
17. F2: The midpoint of the occlusal fossa of the mandibular second molar.
18. B2: The midpoint of the occlusal fossa of the mandibular second molar.
19. F3: The midpoint of the occlusal fossa of the mandibular third molar.
20. B3: The furcation point of the mandibular third molar.
21. M2: Distal contact point of the mandibular second molar.

Reference planes used in the study (Fig. 2):

1. Orbital plane: A plane passing through the bilateral orbital points.
2. Co-Cr plane: A plane passing through the condylion and coronoid points.
3. Snp plane: A tangent drawn parallel to the orbital plane from the deepest point of the sigmoid notch.
4. Mandibular plane: A tangent drawn along the inferior border of the mandibular body passing through the two most convex points (IMCa and IMCb).
5. Z plane: A line perpendicular to the sigmoid notch plane and tangent to the anterior descending border of the mandibular ramus.
6. First molar axis: A plane passing through the midpoint of the first molar occlusal surface and its furcation midpoint.
7. Second molar axis: A plane passing through the midpoint of the second molar occlusal surface and its furcation midpoint.
8. Third molar axis: A plane passing through the midpoint of the third molar occlusal surface and its furcation midpoint.

Dimensional measurements performed in the study (Fig. 3):

1. Condyle length (Co-Snp): the distance from the condylion to the sigmoid notch plane along the long axis of the condylar process.
2. Coronoid length (Cr-Snp): The distance between the coronoid point and the sigmoid notch plane.
3. Ramus height (Co-Go): The distance between the condylion and gonion points.
4. Ramus width (Arnc–Prnc): The distance between the most convex points of the anterior and posterior walls of the ramus.
5. Mandibular body length (Go-M): The distance between the gonion and menton points.
6. Sigmoid notch depth: The distance from the condyle–coronoid plane to the deepest point of the sigmoid notch.
7. Retromolar space: The distance between the distal contact point of the mandibular second molar and the Z plane.
8. Mandibular third molar width: The distance between the mesial and distal surfaces of the third molar.
9. Antegonial notch depth: The distance from the plane passing through the anterior and posterior convex points of the mandibular body to its innermost point.

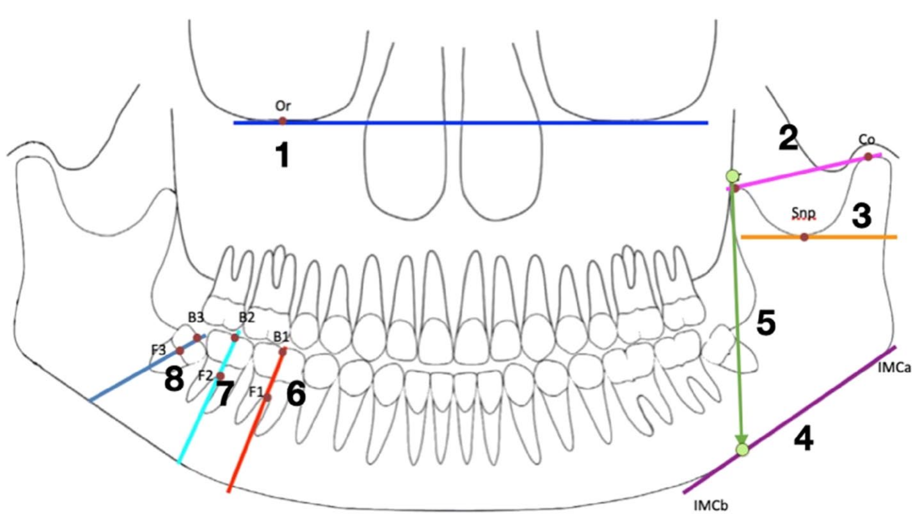

Fig. 2 Reference planes used in the study

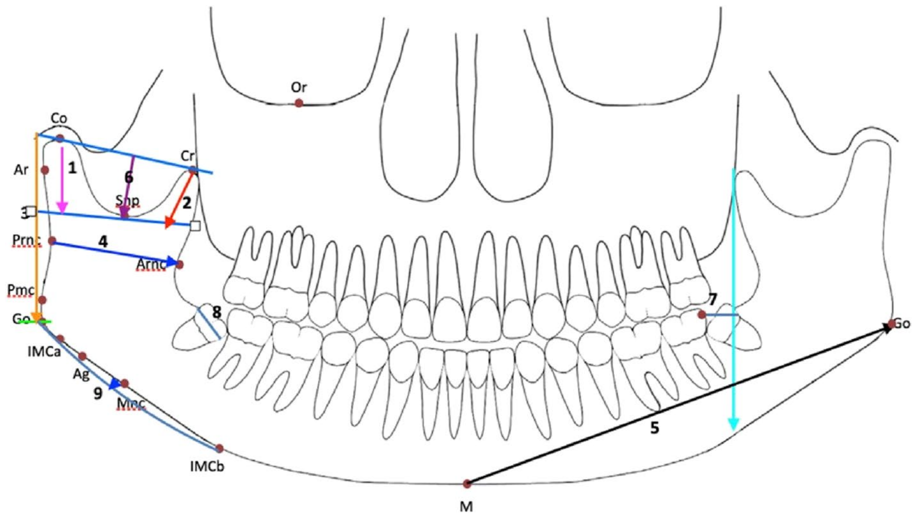

Fig. 3 Dimensional measurements performed in the study

Angular measurements performed in the study (Fig. 4):

1. Co-Cr angle: The angle between planes passing through the condylar and coronoid processes.
2. Gonial angle (Ar-PMC and IMCa-IMCb): The angle between the ramus plane and the mandibular plane.
3. Alpha angle (L8-MP): The angle between the long axis of the mandibular third molar and the mandibular plane.
4. Gamma angle: The angle between the long axis of the mandibular second molar and the mandibular plane.
5. Inclination of the mandibular first molar (L6-MP): The angle between the long axis of the mandibular first molar and the mandibular plane.
6. Beta angle: The angle between the long axes of the mandibular third molar and the mandibular second molar.

Proportional measurement performed in the study:

1. The retromolar space/mandibular third molar width ratio (Ret/3. M): The ratio of the retromolar space to the width of the mandibular third molar.

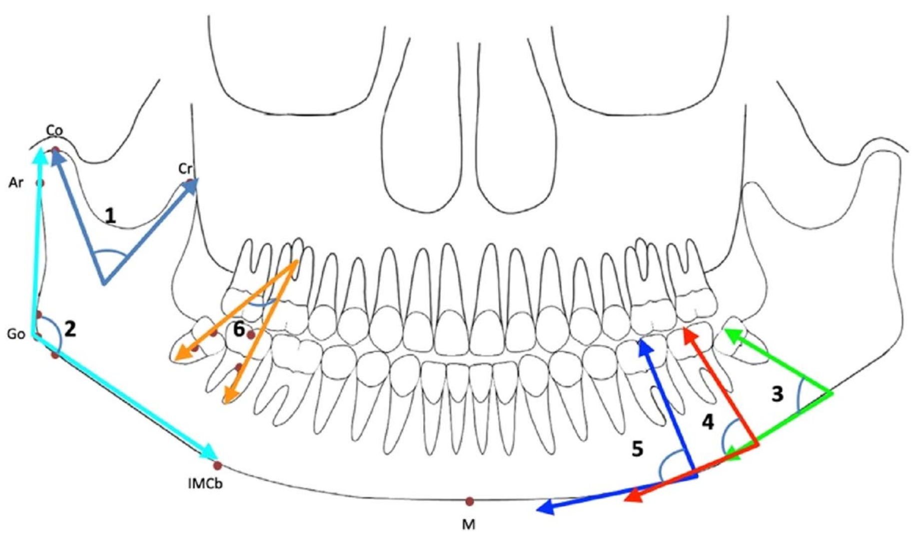

Fig. 4 Angular measurements performed in the study

All measurements in this study were conducted by the same researcher (G.İ), ensuring consistency and minimizing potential fatigue-related errors. To increase the measurer's visual sensitivity, a 10-min rest period was implemented between the measurements, and a maximum of five radiographs were measured each day. To maintain standardization, measurements were performed in the same room under natural daylight, utilizing images downloaded in JPEG format to a MacBook Air computer (Retina, 13-inch, 2020).

Statistical analysis

Data analysis was conducted via the SPSS 22 software package. The Mann–Whitney U test was used for comparisons between two nonnormally distributed groups, and the Kruskal–Wallis H test was used for comparisons among three or more groups. Relationships among categorical variables were examined via chi-square analysis, and correlations among variables were evaluated via the correlation test.

Method error

To evaluate reliability, panoramic radiographs of 30 randomly selected patients were remeasured by the same researcher under the same conditions 20 days after the initial measurements. Intraobserver reliability was analyzed via the ICC method.

Results

Intraobserver reliability revealed very high consistency (ICC = 0,792–0.983.) It was concluded that the researcher's measurements were consistent and that the reliability of the measurements was confirmed.

There were significant differences between the groups in terms of the condylar length, coronoid length, ramus length, mandibular corpus width, sigmoid notch depth, retromolar space distance, antegonial notch depth, and alpha angle ($p < 0.05$). Compared with those in the experimental group, individuals in the control group presented significantly greater values for these parameters (Table 1).

There was no significant difference between the groups in terms of ramus width, third molar width, gamma angle, or first molar inclination ($p > 0.05$) (Table 1). However, there was a significant difference in the Co/Cr angle values between the groups ($p < 0.05$). Individuals in the experimental group had significantly greater Co/Cr angle values (Table 1).

In the present study, all the parameters were evaluated to establish a cutoff value. Using the data from the measurements, an ROC analysis was conducted for the angle variable between the Co-Cr points, resulting in a significant threshold value. The cutoff value for the Co/Cr angle was determined to be 76.34° (Table 2) (Fig. 5).

Discussion

This study investigated the contribution of mandibular morphology to the impaction of mandibular third molar teeth. The sample size significantly affects the reliability of a study. In this study, panoramic radiographs of 330 patients were analyzed. The sample sizes of previous studies varied between 81 and 240 [15, 16]. The sample size of the 330 patients in the present study was considerably larger than that in previous studies.

The age of individuals is another crucial factor in evaluating mandibular third molar impaction. The ages of the patients were considered, ensuring that they were close to the reported eruption age of third molars in the literature [17, 18]. Massler et al. reported that the eruption of third molar begins between the ages of 17 and 21 [24]. Uzamış et al. reported that in the Turkish population, the mandibular third molar germ can be observed as early as age 7 [25]. Schersten et al. reported the optimal age for investigating the incidence of impacted mandibular third molars to be between 20 and 25 [26]. On the basis of this information, the mean age was 21.43 ± 3.47 years in the present study, with most of the root formation being completed.

In orthodontics, the accuracy and reliability of measurements are critically important, especially with respect to the precision of the software used for measurements. In the present study, ImageJ (version 1.38) was employed for the measurements on panoramic radiographs. The software was freely downloaded from https://imagej.nih.gov/ij/download.html. The digital radiographic images were converted to JPEG (Joint Photographic Experts Group) format for transfer into ImageJ software and saved on a MacBook Air (Retina, 13-inch, 2020). The literature indicates that JPEG compression using standard values does not result in diagnostically significant loss in panoramic images [27]. It performs geometric transformations such as scaling, rotation, and translation [28, 29].

In routine clinical practice, dentists commonly use digital panoramic radiographs to obtain both an initial overall diagnosis of the patient's oral health and a more in-depth examination of third molar teeth. Its rapid processing, low cost, minimal radiation dose, and ability to provide a bilateral view of the mandible make it an ideal radiographic technique for evaluating the dimensional and angular parameters of the mandible [30]. There are different opinions regarding measurements made on panoramic radiographs, but studies generally report that angular measurements and vertical length calculations are reliable [31, 32]. A study comparing panoramic radiographs with lateral cephalometric radiographs for length measurements indicated that the measurements obtained from panoramic radiographs were as reliable as those from lateral cephalometric radiographs [31]. Considering

Table 1 Comparison of dimensional, angular, and proportional measurements in experimental and control groups

		Group						Mann Whitney U Test		
		n	Mean	Median	Minimum	Maximum	ss	Mean Rank	U	*p*
Dimensional measurements										
Condylar length	Experimental	165	17.10	16.99	8.92	25.08	3.18	150.76	11180	0.006
	Control	165	18.17	17.91	10.71	25.31	3.16	179.33		
	Total	330	17.64	17.54	8.92	25.31	3.21			
Coronoid length	Experimental	165	11.64	11.27	5.67	21.87	2.91	148.51	10809	0.002
	Control	165	12.55	12.60	6.55	25.24	2.76	181.59		
	Total	330	12.10	11.97	5.67	25.24	2.87			
Ramus length	Experimental	165	63.10	62.09	48.89	77.13	6.18	149.92	11042	0.004
	Control	165	65.33	65.24	53.16	82.02	6.09	180.17		
	Total	330	64.22	63.84	48.89	82.02	6.22			
Ramus width	Experimental	165	28.70	28.49	21.46	38.08	3.03	160.43	12776	0.382
	Control	165	28.90	28.97	18.23	38.26	3.05	169.60		
	Total	330	28.80	28.86	18.23	38.26	3.04			
Mandibular corpus width	Experimental	165	91.79	91.41	70.51	111.63	6.86	145.57	10324.5	0.0001
	Control	165	94.52	94.73	80.29	111.06	6.40	184.55		
	Total	330	93.16	93.10	70.51	111.63	6.76			
Sigmoid notch depth	Experimental	165	12.13	12.09	6.72	19.10	2.31	144.28	10111	0.0001
	Control	165	12.89	12.86	8.45	16.69	1.64	185.85		
	Total	330	12.51	12.41	6.72	19.10	2.04			
Retromolar space distance	Experimental	165	6.27	6.08	2.91	12.09	1.56	87.22	697	0.0001
	Control	165	10.92	11.06	6.41	15.91	1.66	243.25		
	Total	330	8.60	8.55	2.91	15.91	2.83			
Antegonial notch depth	Experimental	165	2.08	2.07	.89	3.62	.52	154.04	11722	0.036
	Control	165	2.68	2.20	1.03	3.37	6.05	176.02		
	Total	330	2.38	2.18	.89	3.37	4.30			
3rd molar width	Experimental	165	11.43	11.34	8.74	14.25	1.16	160.40	12771	0.379
	Control	165	11.51	11.59	8.32	14.80	1.05	169.63		
	Total	330	11.47	11.50	8.32	14.80	1.10			
Angular measurements										
Co/Cr angle	Experimental	165	79.85	77.93	57.56	123.77	11.07	187.31	9849	0.0001
	Control	165	75.55	74.14	56.81	116.05	10.11	142.55		
	Total	330	77.70	76.40	56.81	123.77	10.80			

Table 1 (continued)

		Group						Mann Whitney U Test		
		n	**Mean**	**Median**	**Minimum**	**Maximum**	**ss**	**Mean Rank**	**U**	***p***
Gonial angle	Experimental	165	117.98	117.59	104.23	133.25	5.49	159.33	12594	0.278
	Control	165	118.49	118.66	81.40	141.04	6.94	170.71		
	Total	330	118.23	118.26	81.40	141.04	6.25			
Alpha angle	Experimental	165	65.08	63.66	18.64	112.36	19.37	115.55	5371.5	0.0001
	Control	165	84.47	84.69	50.12	113.72	10.27	214.75		
	Total	330	74.77	78.50	18.64	113.72	18.27			
Gamma angle	Experimental	165	87.78	87.76	72.50	107.37	6.79	164.91	13514.5	0.986
	Control	165	87.88	87.57	70.78	107.33	6.26	165.09		
	Total	330	87.83	87.61	70.78	107.37	6.52			
1st molar inclination	Experimental	165	86.99	87.50	68.31	100.27	5.21	156.89	12192	0.121
	Control	165	87.60	87.80	12.83	99.45	7.59	173.16		
	Total	330	87.30	87.71	12.83	100.27	6.51			
Proportional measurements										
Ret/3rd M. ratio	Experimental	165	.54	.50	.20	.90	.15	86.97	655.5	0.0001
	Control	165	.99	1.08	.60	1.40	.16	243.50		
	Total	330	.77	.80	.20	1.40	.28			

Table 2 ROC Analysis for Co/Cr Angular Measurement

	Area Under the Curve	*p*	Asymptotic 95% Confidence Interval		Cut-off	For Impacted Tooth			
			Lower Bound	Upper Bound		Sensitivity	Specificity	PPV	NPV
Co/Cr Angle	0.636	0.0001	0.576	0.696	76.34	56.4	62.2	60	58.6

these advantages, panoramic radiographs were preferred in the present study to guide clinicians in assessing the impaction status of mandibular third molars.

The measurements of condylar and coronoid length, ramus height, mandibular corpus width, and antegonial notch depth were significantly greater in the control group (Table 1). This result aligns with those reported by Al-Gunaid et al. [15]. However, in contrast with the studies carried out by Capelli et al. and Hassan et al., these differences could be attributed to variations in measurement techniques [32, 33].

Studies on impacted mandibular third molars in the literature suggest that retromolar space measurement influences the likelihood of tooth impaction [31, 34, 35]. In this study, the retromolar space was significantly larger in the control group (mean: 10.92 ±1.56 mm) than in the experimental group (mean: 6.27 ±1.66 mm) (Table 1). Richardson noted a strong association between a decrease in this space and the impaction of mandibular third molars [6]. Studies on the retromolar space generally reported it to be larger in the control group [31, 36, 37]. Studies have reported insufficient retromolar space in most patients with impacted mandibular third molars [38, 39]. Legović et al. concluded that sufficient space does not guarantee the normal development of mandibular third molars [40]. They suggested that this space can serve as a reference around the age of 18, when most of the remodeling of the ramus is complete and the third molars are ready to erupt. In orthodontics, the retromolar space is considered an important parameter for predicting third molar eruption, planning distal movement of the mandibular dental arch, and making extraction decisions during orthodontic treatment.

No significant difference was found in terms of third molar width. The mean width was 11.51 ±1.05 mm in the control group and 11.43 ±1.16 mm in the experimental group (Table 1). The general view is that the larger the mesiodistal width of the third molar is, the lower the likelihood of eruption. Even in patients with sufficient retromolar space, an increased mesiodistal width due to various factors can increase the probability of impaction. Verma et al. and Behbehani et al. reported a negative correlation between the width of the third molar and its likelihood of eruption [34, 37]. Like this study, Al-Gunaid et al., Hattab and Alhaija, and Qamruddin et al. reported no significant difference in the width of the third molar tooth between the groups [31, 36, 41]. The results achieved in this study align with the literature.

Capelli [32], stated that the impaction of third molars is associated with a vertical component of mandibular growth. The change in the position of the third molars seems to be associated with the idea of continuous mandibular growth, which is responsible for enlargement of the retromolar region up to the age of 20.

In a study examining the relationship between the Co/Cr angle and mandibular third molar impaction, Al-Gunaid et al. reported a significantly greater Co/Cr angle in the impacted group [41]. Similarly, this study revealed that the Co/Cr angle was significantly greater in the impacted group. This hints that sigmoid notch depth is more likely to be more in depth in the control group [41]. This finding might be due to more backward and forward slope of the anterior and posterior borders of the ramus in the impacted group.

ROC analysis in this study revealed a threshold value of 76.34° for the Co/Cr angle (Fig. 5). The Co/Cr angle was found to be 76.34° or greater in the experimental group with impacted mandibular third molars. The results of the ROC analysis, an AUC of 0.636 suggests that this cutoff value provides meaningful contribution in terms of the test's sensitivity and specificity.

An AUC value above 0.5 indicates that the test cannot be considered completely random, and it possesses some discriminatory power. Moreover, the sensitivity of 56.4% and specificity of 62.2%, achieved with a cutoff value of 76.34, might be considered partially sufficient for clinical applications. The positive predictive value (PPV) and negative predictive value (NPV) derived from the selected cutoff value can provide valuable references for assessing the clinical significance of this test. In other words, the cutoff value for the Co/Cr angle used in this study is highlighted as a value determined through a previously unexplored approach or perspective.

This cutoff value is considered to be an important parameter for clinicians in predicting the impaction status of mandibular third molars. Similarly, Qamruddin et al. also gave a value range for the estimation of impaction. The probability of eruption of the lower third

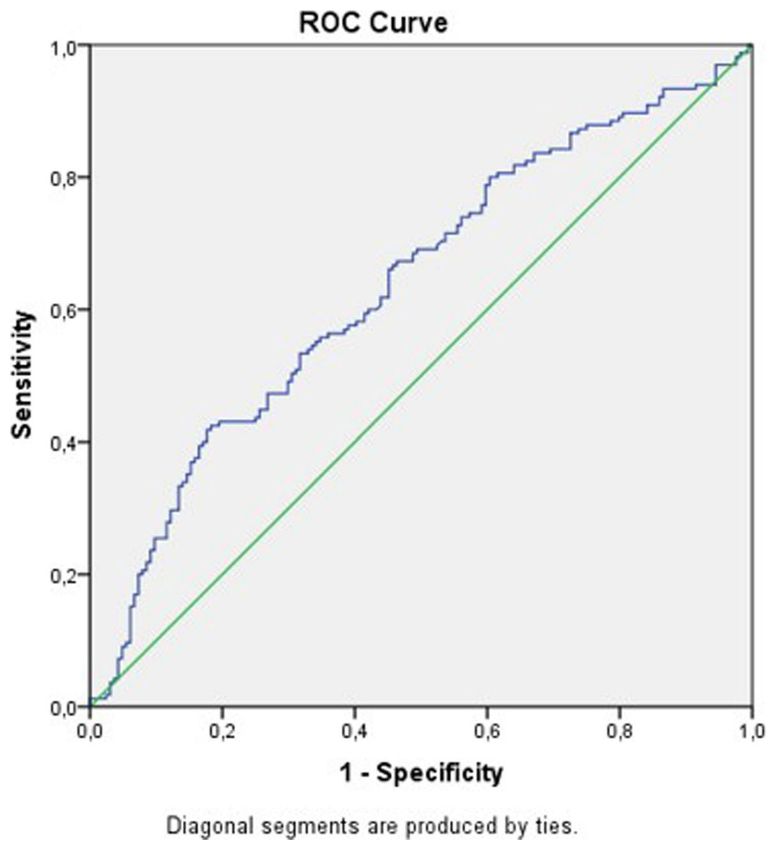

Fig. 5 ROC curve developed for Co/Cr angular measurement

molar increases if retromolar space measured from anterior edge of ramus and centre of rumus point is 13 mm and 25 mm respectively, provided the space/width ratio is greater than 1 and angulation is also vertical [36]. The Co/Cr angle cutoff value we found in our study is an easier and more practical angle. By using this angle, early prediction of mandibular third molar impaction can be achieved and early removal of those mandibular third molars which are unlikely to erupt in a normal position can prevent the associated pathology, surgical complications and relapse after orthodontic treatment.

The most commonly investigated parameter in the literature concerning third molar impaction is the gonial angle [15, 31]. In this study, there was no significant difference in the gonial angle measurements between the groups (Table 1). Mummolo et al., Ganss, and Richardson reported greater gonial angle values in the control group [6, 16, 35], whereas Hattab and Alhaija, Al-Gunaid reported greater gonial angles in the experimental group [31, 41]. Behbehani suggested that a smaller gonial angle might be related to an increased likelihood of mandibular third molar impaction [34]. Mollaoğlu et al. found no significant difference between the gonial angle and mandibular third molar impaction in their study [39]. In contrast, Verma et al. suggested a weak negative correlation between the Gonial angle and eruption [37]. Hattab and Alhaija reported that patients with smaller and more vertical gonial angles had a higher rate of mandibular third molar impaction [31]. Begtrup et al. found no significant correlation between the gonial angle and third molar eruption, indicating that the gonial angle is not a reliable measurement for determining third molar impaction [42]. Kaur et al. reported that the gonial angle exhibits minimal variation, suggesting that it cannot provide information about third molar eruption [43].

The alpha angle can offer insights into the likelihood of tooth eruption. In this study, the alpha angle was significantly greater in the control group. This result is consistent with those reported by Uthman et al., who suggested that an alpha angle of 80°–81° is required for eruption of the mandibular third molar [44]. Additionally, Mattila et al. claimed that the closer the beta angle is to parallel, the greater the likelihood of third molar eruption [45]. Verma et al. found a strong positive correlation between the angle of the third molar with the mandibular plane and its eruption [37]. Richardson[6] noted that narrower angles increase the distance the third molar must travel during eruption, making it more challenging, especially if space is limited [6].

Similar to previous studies, there was no significant difference in the Gamma angle between the groups in this study. Sandhu et al., Uthman et al., and Haaviko identified the gamma angle as the least variable parameter and suggested that it does not provide insights into the eruption of mandibular third molars [43–45].

Another significant parameter related to mandibular third molar impaction is the ratio of the retromolar space distance to the width of the third molar. In this study, this ratio was significantly greater in the control group. This finding aligns with the study carried out by Al-Gunaid et al. and is comparable to the values reported by Hattab and Alhaija, likely due to similarities in the inclusion criteria [31, 41]. In this study, the control group's ratio ranged between 0.6 and 1.4 mm. Hattab and Alhaija, suggested that when the ratio of the retromolar space to the mesiodistal width of the third molars is at least one, 69% of third molars erupt [31]. The observed differences are thought to result from the use of different measurement techniques across studies. Qamruddin et al. found that the retromolar space/third molar width ratio was 0.82 ± 0.34 mm in the experimental group and 1.22 ± 0.20 mm in the control group [36]. When the ratio was less than one, an increased likelihood of impaction was observed, which is consistent with the results obtained in this study.

One of the limitations when conducting our study was the difficulty in obtaining a larger homogeneous sample size in the study sample. Although the size used is much more than to that of previous studies analysed, we consider that an increase in the number of sample size could help us improve our results. Further research using a contemporary approach such as cone beam computed tomography to elucidate the difference between groups is recommended. The findings reported here could also be used in a longitudinal growth study as a suggestion for further researchs. A longitudinal growth study allows researchers to examine the development of teeth over time and find patterns that may suggest a higher risk of teeth being impacted. This proactive strategy could result in earlier interventions and improved outcomes for patients.

Conclusion

The impaction of the mandibular third molar tooth is associated with various parameters of mandibular morphology.

- The measurements of condylar and coronoid length, ramus length, mandibular corpus width and antegonial notch depth were significantly greater in the control group.
- No significant difference was found between the control and experimental groups in terms of third molar tooth width, gonial angle, or gamma angle.
- The retromolar space, the alpha angle, and Ret/3.rd M ratio was significantly greater in the control group.
- The Co/Cr angle was significantly greater in the experimental group. A cutoff value of 76.88° was defined for the Co/Cr angle in this study. Patients with values above this threshold are more likely to have their third molar teeth remaining impacted.
- The Co/Cr angle cutoff value is considered as an important parameter for clinicians in predicting the impaction of mandibular third molars without solely relying on personal experience.

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Authors' contributions
G.İ and O.UA led the primary study and drafted the manuscript. G.İ conducted data analysis, interpretation, and visualization. O.UA designed the main study framework and revised the manuscript. All authors read and approved the final manuscript.

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Data availability
The datasets used and/or analysed during the current study are available from the corresponding author on reasonable request.

Declarations

Ethics approval and consent to participate
All the procedures of the study were in accordance with the Declaration of Helsinki and approved by Health Sciences Ethics Committee of Ankara Yıldırım Beyazıt University (date 06.10.2022-Approval no 14). Informed consent to participate was obtained from all of the participants in the study.

Consent for publication
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Competing interests
The authors declare no competing interests.

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