Original Article

ANATOLIAN CURRENT MEDICAL

DOI: 10.38053/acmj.1909739

Anatolian Curr Med J. 2026;8(3):531-537

The role of angular parameters on panoramic radiographs in the localization of impacted maxillary canines

Anıl Demirel, Fırat Oğuz*, Sabahattin Bor

Department of Orthodontics, Faculty of Dentistry, İnönü University, Malatya, Turkiye

Cite this article as: Demirel A, Oğuz F, Bor S. The role of angular parameters on panoramic radiographs in the localization of impacted maxillary canines. *Anatolian Curr Med J.* 2026;8(3):531-537. doi:10.38053/acmj.1909739

Received: 14.03.2026 • **Accepted**: 04.05.2026 • **Published**: 22.05.2026

ABSTRACT

Aims: To evaluate whether angular measurements obtained from panoramic radiographs can be used to distinguish the buccal or palatal position of impacted maxillary canines.

Methods: This retrospective study included 200 impacted maxillary canines (100 buccal, 100 palatal). Panoramic radiographs from 2020-2025 were reviewed, and only cases with corresponding cone-beam computed tomography (CBCT) images were included. Tooth position was confirmed using CBCT. On panoramic radiographs, three angular parameters were evaluated: the angle between the maxillary canine long axis and the midline (alpha), the angle between the canine and lateral incisor long axes (beta), and the angle between the canine long axis and the occlusal plane (gamma). Group comparisons were performed using Mann-Whitney U and Kruskal-Wallis tests. Correlations were analyzed using Pearson or Spearman tests. Reliability was assessed using intraclass correlation coefficients (ICC).

Results: Significant differences were found between buccal and palatal groups for all angular measurements ($p<0.001$). Alpha and beta angles were higher in palatally impacted canines, whereas gamma values were higher in buccally impacted canines. Strong positive correlation was found between alpha and beta, while alpha-gamma and beta-gamma showed negative correlations. Intraobserver and interobserver ICC values exceeded 0.95.

Conclusions: Angular measurements on panoramic radiographs may assist in differentiating buccal and palatal impactions of maxillary canines and support clinical decision-making.

Keywords: Impacted maxillary canine, panoramic radiography, angular measurement, tooth localization

INTRODUCTION

Tooth impaction, defined as the failure of a tooth to erupt into its normal functional position, is a common developmental dental anomaly that may lead to functional, esthetic, and orthodontic complications.[1] Excluding third molars, the teeth with the highest prevalence of impaction are the maxillary canines, with the overall prevalence reported to range between 1% and 3%.[2-4] However, prevalence rates vary among populations. The prevalence of impacted maxillary canines has been reported to be 0.27% in the Japanese population,[5] whereas it rises to as high as 2.4% in the Italian population.[6] In the Chinese population, when all permanent impacted teeth excluding third molars were evaluated, impacted canines were reported to account for approximately 28.10% of these cases.[7]

The etiology of impacted maxillary canines is multifactorial, involving local obstacles, regional pathologies, developmental anomalies of adjacent teeth, and genetic predisposition.[2,8,9] Buccal and palatal impactions are thought to have different etiological mechanisms.[10,11] Crowding is generally considered the main cause of buccally impacted canines, whereas palatal impaction has been associated with the guidance theory and genetic factors.[9-11] In addition, hard tissue barriers, soft tissue lesions, or developmental pathologies may alter the eruption path and lead to impaction. Although removal of these factors may allow spontaneous eruption in some cases, most require orthodontic or surgical intervention.[2]

Accurate localization of impacted maxillary canines directly affects treatment planning and prognostic evaluation. It is important for selecting appropriate surgical and orthodontic strategies, reducing the risk of complications, and optimizing the treatment process.[12] Clinical and radiographic methods are used together in the diagnosis of maxillary canine impaction. Cone-beam computed tomography (CBCT) is widely used in dentistry and provides detailed three-dimensional information regarding hard tissues.[13] In adolescent patients, the most common indication for CBCT is impacted canines in the maxillary region.[14,15] However, CBCT has certain limitations related to its high cost and radiation exposure.[16] The radiation dose associated with CBCT is considerably higher than that of conventional two-dimensional radiographs.[17,18] Therefore, there are concerns regarding the

***Corresponding Author:** Fırat Oğuz, firat.oguz.3408@gmail.com

This work is licensed under the Creative Commons Attribution-NonCommercial-NoDerivatives 4.0 International License.

routine use of CBCT without proper justification, particularly in pediatric patients undergoing orthodontic evaluation. In this context, the development of reliable localization methods based on panoramic radiographs, which are widely used, more accessible, cost-effective, and associated with lower radiation exposure, is of clinical importance.[3] To overcome these limitations, localization methods developed on panoramic radiographs have gained importance. Traditional radiographic localization methods include the parallax method[19] and the magnification method.[20] Katsnelson et al.[21] described a new method for evaluating the position of impacted maxillary canines using panoramic radiography. In this method, the angle formed between the canine tooth and the occlusal plane was measured on panoramic radiographs, and angle values greater than 65° were reported to indicate a 26.6-fold higher likelihood of buccal impaction compared with palatal impaction. The authors suggested that because the palatal bone is thin in the sagittal direction, palatally positioned teeth cannot assume a vertical orientation and therefore tend to show a more horizontal inclination.[21]

In this context, it is important to determine the diagnostic value of angular assessments performed on panoramic radiographs for identifying the position of impacted canines. However, current evidence indicates that the diagnostic accuracy of angular measurements in distinguishing buccal and palatal impactions of maxillary canines remains limited, and the combined use of different angular parameters has not been sufficiently investigated. Although previous studies have reported that increased gamma angle values are associated with buccal impaction,[21] relying solely on this parameter may lead to potential diagnostic errors and may be insufficient for identifying palatal impactions. In contrast, the alpha and beta angles, which reflect the orientation of the canine relative to the midline and adjacent teeth, may provide complementary diagnostic information, particularly for palatal localization. Therefore, the combined evaluation of multiple angular parameters may help reduce diagnostic errors and improve localization accuracy, especially in borderline or ambiguous cases. This approach may also contribute to more accurate preliminary assessment in clinical practice and support more selective use of advanced imaging modalities.

Accordingly, the aim of the present study was to evaluate whether the angular relationships of impacted maxillary canines with the midline, the long axis of the lateral incisor, and the occlusal plane on panoramic radiographs can serve as meaningful indicators for determining whether the tooth is positioned buccally or palatally. The null hypothesis (H_0) of this study was that there is no significant relationship between these angular measurements and the position of the impacted maxillary canine, and that these parameters do not have discriminative value for clinical localization.

METHODS

Ethics

The study was conducted with the approval of the İnönü University Health Sciences Researches Ethics Committee (Date: 10.02.2026, Decision No: 2026/9385). All procedures were carried out in accordance with the ethical rules and the principles of the Declaration of Helsinki.

Study Design and Patient Selection

For the study material, panoramic radiographs and CBCT of patients with impacted maxillary canines who applied to the Department of Orthodontics, Faculty of Dentistry, İnönü University, for orthodontic treatment between 2020 and 2025 were retrospectively reviewed.

Individuals in the permanent dentition period who had unilateral or bilateral impacted maxillary canines, who had both panoramic radiographs and CBCT images available for diagnostic evaluation, and whose radiographs were of sufficient quality were included in the study. In addition, only cases in which the occlusal plane could be identified on panoramic radiographs and the relevant reference teeth (maxillary lateral and central incisors) were clearly visible were included. Individuals with a history of maxillofacial trauma, those with any syndrome or anomaly that could affect craniofacial development, and cases in which the maxillary lateral incisor used as a reference tooth was congenitally missing or presented structural anomalies were excluded from the study, as these factors could affect the reliability of the measurements.

A power analysis was performed using G*Power software (v3.1, Universität Düsseldorf, Germany) to determine the sample size. Assuming a medium effect size (Cohen's d=0.50), α=0.05, and a power (1-β) of 0.95, a minimum of 88 samples per group (176 in total) was required. A total of 200 impacted maxillary canines (100 buccal and 100 palatal) were included in the study to ensure an adequate sample size against possible data loss and measurement errors. The positions of the teeth were confirmed using archived CBCT images, which had been previously obtained for definitive diagnosis, and all images were retrospectively retrieved from the archive to avoid additional radiation exposure.

Procedure

According to the determined criteria, an archive screening was performed and the eligible panoramic radiographs were exported for analysis. All panoramic radiographs were obtained using the same imaging device (Planmeca Proline XC, Helsinki, Finland). To ensure standardization, all panoramic images had been acquired according to the manufacturer's instructions with patients in an upright position. The anterior teeth were positioned in the bite block notch for proper occlusal alignment, and the Frankfort horizontal plane was aligned parallel to the floor. Patients had been instructed to keep their lips closed, place the tongue against the palate, and remain still during exposure. Consistent head positioning and standardized imaging protocols were used to minimize magnification and distortion, with exposure parameters set at 18 s, 66 kVp, and 5 mA.

The exported panoramic images were transferred to Blender software (v5.0.1, Blender Foundation, Amsterdam, the Netherlands) for alpha, beta, and gamma angle measurements. All measurements were performed by a single researcher (A.D.) with five years of orthodontic experience.

The panoramic radiographs were randomly selected, and the angular measurements for each tooth were recorded. The examiner was blinded to the buccal or palatal position of the teeth. To ensure measurement consistency, all evaluations were performed under standardized conditions using the same software environment and image display settings. The examiner followed a consistent protocol for landmark identification and angle measurements throughout the study.

For the alpha angle, the long axis of the maxillary canine was determined by connecting the crown and the root apex, and the angle between this axis and the midline was measured (**Figure 1**). For the beta angle, the angle between the long axes of the maxillary canine and the lateral incisor, each defined by connecting the crown and the root apex, was measured (**Figure 2**).

For the gamma angle, the angle between the long axis of the maxillary canine and the occlusal plane was calculated. The occlusal plane was defined as a horizontal line passing through the buccal cusp tips of the maxillary molars and incisors (**Figure 3**).

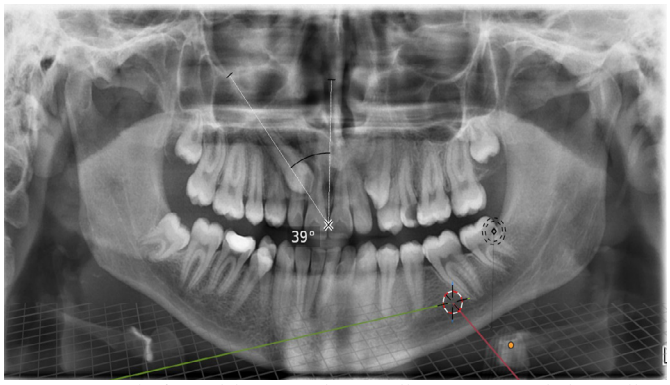

Figure 1. Angle formed between the maxillary canine and the midline (alpha angle)

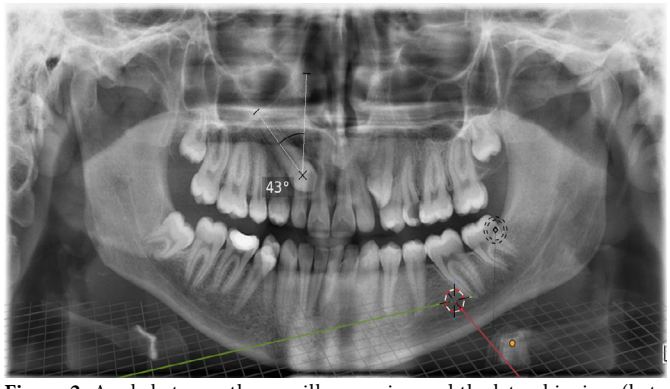

Figure 2. Angle between the maxillary canine and the lateral incisor (beta angle)

Intraobserver reliability was assessed by repeating the measurements on 25 randomly selected panoramic radiographs after a two-week interval by the same researcher (A.D.). Interobserver reliability was evaluated by having the same 25 panoramic images independently measured by a second researcher (F.O.) with seven years of orthodontic experience. All obtained data were recorded in Excel software (Microsoft Office 365, Redmond, WA, USA).

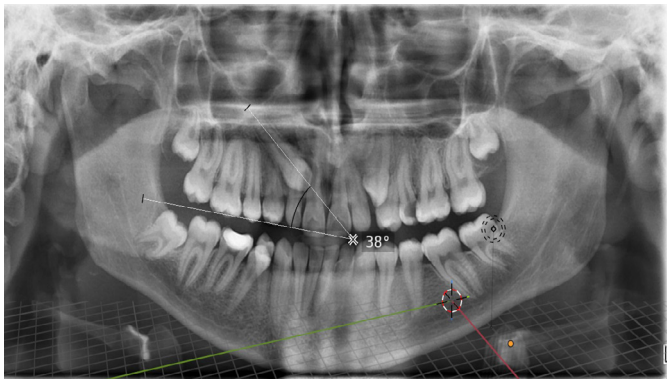

Figure 3. Angle between the maxillary canine and the occlusal plane (gamma angle)

Statistical Analysis

All data analyses were performed using RStudio software (Version 2026.01.1+403; Posit Software, Boston, MA, USA). The normality of continuous variables was assessed using the Shapiro-Wilk test. Descriptive statistics were presented as mean±standard deviation, median, and interquartile range (Q1-Q3). The Mann-Whitney U test was used to compare angular measurements between buccally and palatally positioned impacted canines. Comparisons among the four subgroups defined by tooth number and position (13B, 13P, 23B, and 23P) were performed using the Kruskal-Wallis test, and Bonferroni-adjusted post hoc analyses were applied for significant results. Relationships among angular measurements were evaluated using Pearson or Spearman correlation analyses, as appropriate. Measurement reliability was determined using the intraclass correlation coefficient (ICC), and agreement between methods was assessed using Bland-Altman plots. Bonferroni correction was applied to control the type I error rate in multiple comparisons. The level of statistical significance was set at $p<0.05$.

RESULTS

A total of 200 impacted maxillary canines (100 buccal, 100 palatal) were included. Median alpha, beta, and gamma values were 14.00, 19.50, and 67.00 in the buccal group, and 42.00, 47.00, and 41.50 in the palatal group (**Table 1**, **Figure 4**).

Table 1. Comparison of angular measurements between buccally and palatally impacted maxillary canines (median, Q1-Q3)

Position	n	Alpha (median, Q1-Q3)	Beta (median, Q1-Q3)	Gamma (median, Q1-Q3)
Buccal	100	14.00 (9.25-21.25)	19.50 (8.52-33.25)	67.00 (58.00-71.00)
Palatal	100	42.00 (28.75-50.00)	47.00 (35.00-56.00)	41.50 (33.00-53.00)

Mann-Whitney U test results showed significant differences between buccal and palatal groups for all angular measurements (alpha: U=1683.000; beta: U=1729.500; gamma: U=8344.000; $p<0.001$). Alpha and beta angles were higher in palatally impacted canines, whereas the gamma angle was higher in the buccal group. Effect sizes were large (r=0.565-0.578) (**Table 2**).

When tooth number and position were evaluated together, four subgroups were defined (13B, 13P, 23B, and 23P). Kruskal-Wallis test results showed significant differences among the

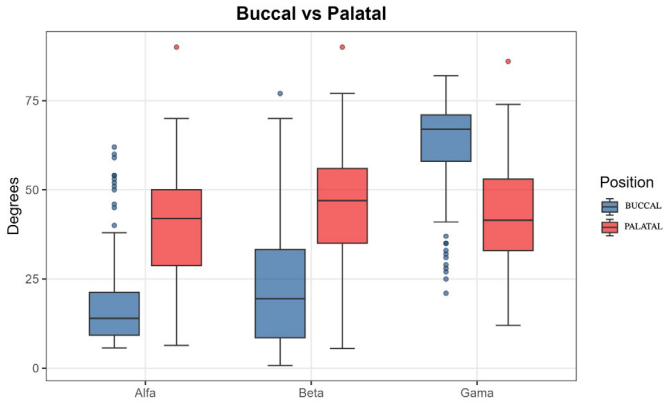

Figure 4. Boxplot comparison of alpha, beta, and gamma angular measurements between buccally and palatally impacted maxillary canines

Table 2. Comparison of angular measurements between buccally and palatally impacted maxillary canines using the Mann-Whitney U test

Angle	Test	Statistic	p value	Effect size
Alpha	Mann-Whitney U	1683.000	<0.001***	r=0.573
Beta	Mann-Whitney U	1729.500	<0.001***	r=0.565
Gamma	Mann-Whitney U	8344.000	<0.001***	r=0.578

***p<0.001

groups for all angular measurements (alpha: H=66.562; beta: H=65.555; gamma: H=68.162; p<0.001). Post hoc analysis indicated that these differences were attributable to position rather than tooth number, with no significant differences between teeth in the same position (p>0.05).

Correlation analysis showed a strong positive relationship between alpha and beta (r=0.844) and strong negative correlations of gamma with both alpha (r=-0.931) and beta (r=-0.813) (p<0.001) (**Table 3**). In subgroup analyses, correlations were stronger in the palatal group. In the buccal group, alpha-beta (r=0.634) and beta-gamma (r=-0.530) showed moderate correlations, whereas alpha-gamma remained strongly correlated (r=-0.772) (**Table 3**, **Figure 5 A-B**).

Table 3. Correlation analysis of alpha, beta, and gamma angular measurements in the total sample and according to impaction position

Group	Variables	Method	r	p value	Interpretation
All data	Alpha vs beta	Spearman	0.844	<0.001***	Strong
	Alpha vs gamma	Spearman	-0.931	<0.001***	Strong
	Beta vs gamma	Spearman	-0.813	<0.001***	Strong
Buccal	Alpha vs beta	Spearman	0.634	<0.001***	Moderate
	Alpha vs gamma	Spearman	-0.772	<0.001***	Strong
	Beta vs gamma	Spearman	-0.530	<0.001***	Moderate
Palatal	Alpha vs beta	Pearson	0.872	<0.001***	Strong
	Alpha vs gamma	Pearson	-0.913	<0.001***	Strong
	Beta vs gamma	Pearson	-0.820	<0.001***	Strong

***p<0.001

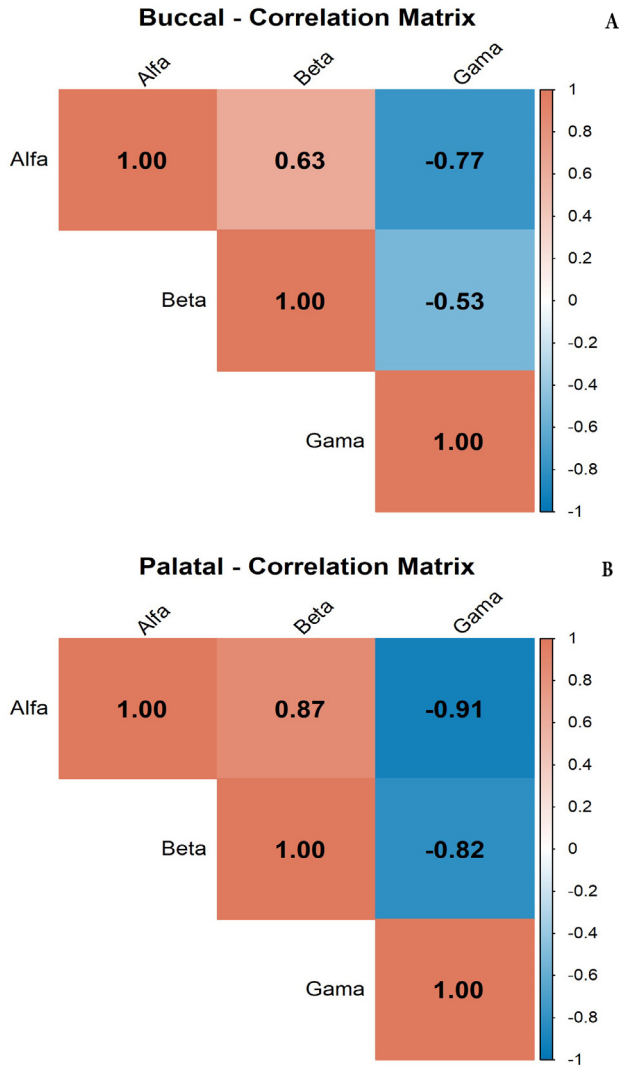

Figure 5 (A-B). Heatmap correlation matrices showing the relationships between alpha, beta, and gamma angular measurements in buccal and palatal impacted maxillary canines. Positive correlations are shown in blue and negative correlations in red

ROC analysis demonstrated good and comparable diagnostic performance for all angular parameters (AUC: alpha=0.832, beta=0.827, gamma=0.834) (**Figure 6**). The distribution patterns of angular measurements showed clear differences between buccal and palatal groups, with higher alpha and beta values in palatal impactions and higher gamma values in buccal impactions. Optimal cut-off values (alpha≥24°, beta≥30°, gamma ≤55°) demonstrated effective group discrimination, with balanced sensitivity and specificity, indicating their potential clinical applicability (**Figure 7**).

Measurement reliability was assessed using intraobserver and interobserver analyses on 25 samples. All ICC values exceeded 0.95, indicating excellent agreement (intra-observer: gamma=0.989, alpha=0.995, beta=0.998; interobserver: 0.987, 0.990, 0.959).

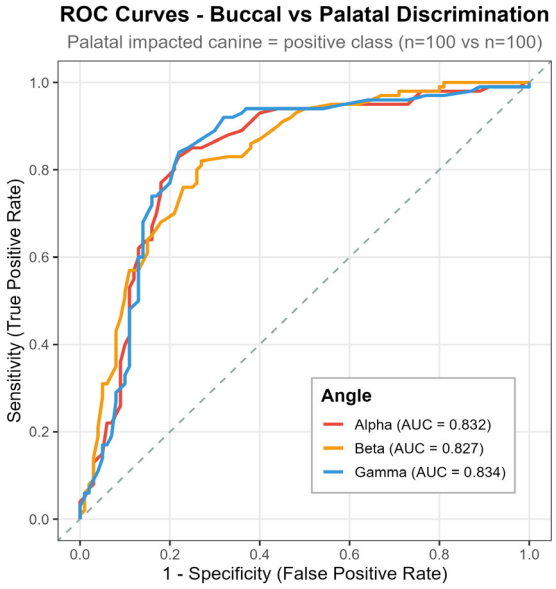

Figure 6. ROC curves of alpha, beta, and gamma angles for discriminating buccal and palatal impacted maxillary canines

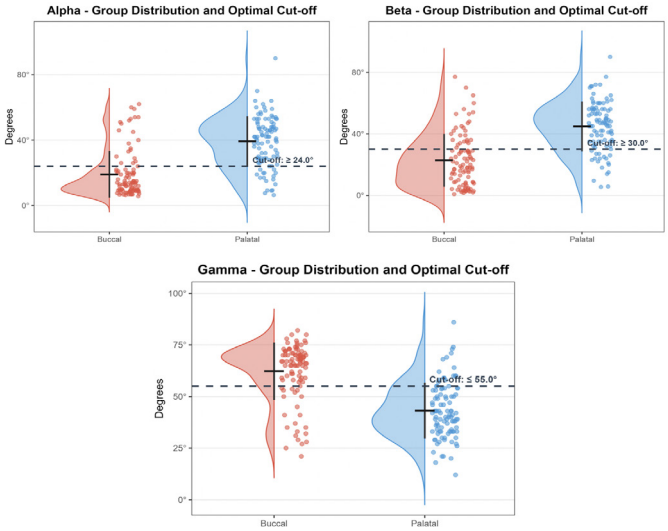

Figure 7. Distribution of alpha, beta, and gamma angles according to buccal and palatal impaction, with optimal cut-off values indicated by dashed lines

DISCUSSION

In this study, it was evaluated whether the angular relationships of impacted maxillary canines with the midline, the long axis of the lateral incisor, and the occlusal plane on panoramic radiographs constitute meaningful indicators for determining whether the tooth is positioned buccally or palatally. Since statistically significant differences were identified between the groups, the null hypothesis was rejected.

Accurate determination of the position of impacted maxillary canines is important for treatment planning and prognostic evaluation. Accordingly, several studies have investigated different methods for identifying tooth position.[19,22,23]

Clark19 described the parallax method for determining whether teeth are positioned buccally or palatally. This method requires either two periapical radiographs taken at different angles or the combined use of a panoramic radiograph and an anterior maxillary occlusal radiograph. In the magnification method, which requires only a panoramic radiograph, teeth impacted in the palatal region have been reported to appear larger on panoramic images than those located in the buccal region.[20] Mason et al.[23] evaluated these two localization methods and reported that 76% of impacted canines were correctly localized using the parallax method, whereas 66% were correctly localized using the magnification method. These studies have reported that the parallax and magnification methods can be used for the localization of impacted canines; however, their accuracy is limited, particularly for buccally positioned teeth. While the parallax method requires additional radiation exposure, the magnification method may be affected by variable magnification and distortion inherent to panoramic images.

Angular analyses performed on panoramic radiographs have been reported in the literature to be helpful in determining whether impacted maxillary canines are positioned buccally or palatally.[21,24] Katsnelson et al.[21] measured the angle between 130 maxillary canines and the occlusal plane on panoramic radiographs and reported that values greater than 65° were associated with a nearly 27-fold greater likelihood of buccal, rather than palatal, impaction. In a study conducted on 60 patients, Sümer et al.[24] observed that when the gamma angle exceeded 60°, the probability of buccal localization of the impacted maxillary canine increased. Similarly, in the present study, evaluation of the gamma angle revealed a highly significant difference between buccally and palatally impacted canines ($p<0.001$). The mean gamma angle was 62.22° in the buccal group and 43.16° in the palatal group. Furthermore, ROC analysis demonstrated that the gamma angle showed good diagnostic performance, with an optimal cut-off value of ≤55° for predicting palatal impaction. This threshold provided a balanced sensitivity and specificity, indicating its potential clinical utility as a supportive parameter in distinguishing buccal and palatal positions. However, this cut-off should be interpreted with caution and not be considered a substitute for three-dimensional imaging when precise localization is required.

On the other hand, An et al.[25] reported that the angulation method is not a reliable approach for localizing impacted maxillary canines on panoramic radiographs and that the magnification method demonstrates higher accuracy. Similarly, Dinu et al.[26] in their review of radiographic methods, concluded that panoramic radiography alone is insufficient for reliable localization of impacted maxillary canines. These discrepancies may be attributed to the smaller sample size and the evaluation of only a single angular parameter in previous studies. In contrast, the present study analyzed three different angular parameters using a larger dataset.

In the present study, statistically significant differences were found between buccally and palatally impacted canines in terms of alpha and beta angles ($p<0.001$). The alpha (39.18°) and beta (44.77°) values were higher in the palatal group compared to the buccal group (19.02° and 22.78°, respectively). These findings suggest that palatally positioned canines exhibit greater angular deviation relative to the midline and the long axis of the adjacent lateral incisor. In contrast, the lower alpha and beta values observed in buccally positioned

teeth indicate a more vertical orientation and a more parallel alignment with the adjacent tooth axis. Correlation analysis revealed a strong positive relationship between alpha and beta angles, whereas strong negative correlations were observed between alpha-gamma and beta-gamma angles. This suggests that as the orientation of the canine relative to the midline and adjacent tooth axis increases, the angle formed with the occlusal plane changes in the opposite direction. Overall, these findings indicate that angular measurements obtained from panoramic radiographs are interrelated and collectively reflect the position of impacted canines. While previous studies have primarily focused on the gamma angle, the present study demonstrates that alpha and beta angles also provide significant diagnostic information. In addition, ROC analysis revealed that alpha and beta angles demonstrated good diagnostic performance, with optimal cut-off values of ≥24° and ≥30°, respectively. These thresholds may provide practical reference points for clinical estimation of canine position. The gamma angle reflects the relationship of the canine with the occlusal plane, whereas the alpha angle represents inclination relative to the midline and the beta angle reflects angular deviation relative to the adjacent lateral incisor. Therefore, incorporating alpha and beta angles into the evaluation may allow for a more comprehensive assessment of buccal or palatal impaction.

Although there are studies in the literature evaluating the alpha and beta angular values of impacted maxillary canines on panoramic radiographs, these studies did not focus on localization. Laurenziello et al.,[27] in their study assessing factors that may be involved in the occurrence of impacted maxillary canines, examined various angular and linear parameters on panoramic and cephalometric radiographs. They also evaluated the relationship between impaction and the alpha angle, which represents the angle formed between the canine tooth and the midline, and reported that the angular position of the canine on panoramic radiographs may be an important parameter in assessing the risk of impaction. Topsakal et al.,[28] in a study using CBCT images, reported that increases in alpha and beta angles were associated with the level of complexity of impacted maxillary canines. Guarnieri et al.[29] investigated whether root resorption in teeth adjacent to impacted maxillary canines could be evaluated using findings obtained from panoramic radiographs. When the mean values of angular measurements were examined according to the presence of root resorption, they observed differences and ultimately reported that the variable with the greatest predictive effect for root resorption was the beta angle, whereas the alpha and gamma angles were not statistically significant. Similarly, Razeghinejad et al.,[30] in a study aiming to evaluate root resorption in teeth adjacent to impacted maxillary canines, examined CBCT images. In that context, measurements such as the angular position of the canine tooth, the angular relationship between the canine and the lateral incisor, and the distance to the midline were evaluated, and the relationships of these parameters with lateral incisor root resorption were investigated.

Limitations

This study has some limitations. First, it had a retrospective design, and the data were obtained from a single center. In addition, the use of panoramic radiographs for angular measurements may introduce distortion and magnification effects inherent to two-dimensional imaging, which can influence measurement accuracy. This may lead to difficulties in accurately determining the long axes of the teeth and result in deviations in angular measurements. In particular, minor variations in head positioning, superimposition, and imaging of structures outside the focal trough may further reduce measurement accuracy. Nevertheless, the buccal or palatal positions of the impacted maxillary canines were confirmed using CBCT images. Future studies with larger sample sizes and study designs that evaluate different imaging methods together may contribute to a more comprehensive understanding of the localization of impacted maxillary canines. In addition, the use of artificial intelligence assisted tools for measuring these parameters may enable faster and more efficient assessments.

CONCLUSION

The findings of this study indicate that angular assessments on panoramic radiographs may provide diagnostically valuable information for distinguishing between buccal and palatal positions of impacted maxillary canines. Increased alpha and beta values may indicate palatal localization, whereas increased gamma values may suggest buccal positioning. Notably, the marked difference in gamma angle between buccally and palatally impacted canines suggests that this parameter may serve as a useful adjunctive parameter in clinical evaluation.

These measurements may serve as a preliminary assessment tool, particularly in cases where immediate use of advanced imaging modalities is not required, contribute to treatment planning, and support a more selective indication for CBCT, thereby helping to reduce unnecessary radiation exposure.

ETHICAL DECLARATIONS

Ethics Committee Approval

The study was conducted with the approval of the İnönü University Health Sciences Researches Ethics Committee (Date: 10.02.2026, Decision No: 2026/9385).

Informed Consent

As this was a retrospective study, formal written informed consent was not required and was therefore not obtained. This retrospective study used pre-existing anonymized patient data. No additional intervention was performed, and there was no direct patient contact. The study was approved by the Ethics Committee, and the requirement for written informed consent was waived by the ethics committee.

Peer Review Process

This manuscript was subject to external peer review.

Conflict of Interest

The authors declare no conflicts of interest related to this study.

Financial Disclosure

The authors received no financial support for the conduct or publication of this research.

Author Contributions

Concept: AD, FO; Design: AD, SB; Control: FO, SB; Data Collection and/or Processing: AD, FO; Analysis and/or Interpretation: AD, FO, SB; Literature Review: AD, FO, SB; Article Writing: AD, FO, SB; Critical Review: AD, FO, SB.

REFERENCES

1. Pop MA, Bucur SM, Porumb A. Permanent canine impaction: a systematic review of incidence, distribution, and etiology. *Medicina*. 2026;62(4):681. doi:10.3390/medicina62040681
2. Becker A, Chaushu S. Etiology of maxillary canine impaction: a review. *Am J Orthod Dentofacial Orthop*. 2015;148(4):557-567. doi:10.1016/j.ajodo.2015.06.013
3. Mohammad RJ. Orthodontic evaluation of impacted maxillary canine by panoramic radiograph-a literature review. *J Med Dent*. 2021;9:220-227.
4. Minhas S, Wu TH, Kim DG, Chen S, Wu YC, Ko CC. Artificial intelligence for 3D reconstruction from 2D panoramic X-rays to assess maxillary impacted canines. *Diagnostics (Basel)*. 2024;14(2):196. doi:10.3390/diagnostics14020196
5. Takahama Y, Aiyama Y. Maxillary canine impaction as a possible microform of cleft lip and palate. *Eur J Orthod*. 1982;4(4):275-277. doi:10.1093/ejo/4.4.275
6. Sacerdoti R, Baccetti T. Dentoskeletal features associated with unilateral or bilateral palatal displacement of maxillary canines. *Angle Orthod*. 2004;74(6):725-732. doi:10.1043/0003-3219(2004)074<0725:DFAWUO>2.0.CO;2
7. Hou R, Kong L, Ao J, et al. Investigation of impacted permanent teeth except the third molar in Chinese patients through an X-ray study. *J Oral Maxillofac Surg*. 2010;68(4):762-767. doi:10.1016/j.joms.2009.04.137
8. Baccetti T. A controlled study of associated dental anomalies. *Angle Orthod*. 1998;68(3):267-274. doi:10.1043/0003-3219(1998)068<0267:ACSOAD>2.3.CO;2
9. Peck S, Peck L, Kataja M. The palatally displaced canine as a dental anomaly of genetic origin. *Angle Orthod*. 1994;64(4):249-256. doi:10.1043/0003-3219(1994)064<0249:WNID>2.0.CO;2
10. Jacoby H. The etiology of maxillary canine impactions. *Am J Orthod*. 1983;84(2):125-132. doi:10.1016/0002-9416(83)90176-8
11. Counihan K, Al-Awadhi EA, Butler J. Guidelines for the assessment of the impacted maxillary canine. *Dent Update*. 2013;40(9):770-777. doi:10.12968/denu.2013.40.9.770
12. Behera S, Pyne A, Mahawar N, Tandon R. Management of ectopically placed and impacted canine based on their position: a case series. *Asian J Oral Health Allied Sci*. 2023;13(1):33. 10.25259/AJOHAS_25_2022
13. Alqerban A, Jacobs R, Fieuws S, Willems G. Comparison of two cone beam computed tomographic systems versus panoramic imaging for localization of impacted maxillary canines and detection of root resorption. *Eur J Orthod*. 2011;33(1):93-102. doi:10.1093/ejo/cjq034
14. Hajem S, Brogårdh-Roth S, Nilsson M, Hellén-Halme K. CBCT of Swedish children and adolescents at an oral and maxillofacial radiology department. A survey of requests and indications. *Acta Odontol Scand*. 2020;78(1):38-44. doi:10.1080/00016357.2019.1645879
15. Hidalgo Rivas JA, Horner K, Thiruvenkatachari B, Davies J, Theodorakou C. Development of a low-dose protocol for cone beam CT examinations of the anterior maxilla in children. *Br J Radiol*. 2015;88(1054):20150559. doi:10.1259/bjr.20150559
16. Scarfe WC, Farman AG, Sukovic P. Clinical applications of cone-beam computed tomography in dental practice. *J Can Dent Assoc*. 2006;72(1):75-80.
17. Theodorakou C, Walker A, Horner K, et al. Estimation of paediatric organ and effective doses from dental cone beam CT using anthropomorphic phantoms. *Br J Radiol*. 2012;85(1010):153-160. doi:10.1259/bjr/19389412
18. Kadesjö N, Lynds R, Nilsson M, Shi XQ. Radiation dose from X-ray examinations of impacted canines: cone beam CT vs two-dimensional imaging. *Dentomaxillofac Radiol*. 2018;47(3):20170305. doi:10.1259/dmfr.20170305
19. Clark CA. A method of ascertaining the relative position of unerupted teeth by means of film radiographs. *Proc R Soc Med*. 1910;3(Odontol Sect):87-90. doi:10.1177/003591571000301012
20. Sudhakar S, Patil K, Mahima VG. Localization of impacted permanent maxillary canine using single panoramic radiograph. *Indian J Dent Res*. 2009;20(3):340-345. doi:10.4103/0970-9290.57381
21. Katsnelson A, Flick WG, Susarla S, Tartakovsky JV, Miloro M. Use of panoramic x-ray to determine position of impacted maxillary canines. *J Oral Maxillofac Surg*. 2010;68(5):996-1000. doi:10.1016/j.joms.2009.09.022
22. Nagpal A, Pai KM, Setty S, Sharma G. Localization of impacted maxillary canines using panoramic radiography. *J Oral Sci*. 2009;51(1):37-45. doi:10.2334/josnusd.51.37
23. Mason C, Papadakou P, Roberts GJ. The radiographic localization of impacted maxillary canines: a comparison of methods. *Eur J Orthod*. 2001;23(1):25-34. doi:10.1093/ejo/23.1.25
24. Sumer AP, Duran H, Uzun C, Sumer M, Cankaya S. Panoramik radyograflarda gömülü maksiller kanin lokalizasyonunun değerlendirilmesi. *Selçuk Univ Dis Hek Fak Derg*. 2013;22(2):68-71.
25. An S, Wang J, Li J, et al. Comparison of methods for localization of impacted maxillary canines by panoramic radiographs. *Dentomaxillofac Radiol*. 2013;42(8):20130129. doi:10.1259/dmfr.20130129
26. Dinu Ş, Todor L, Zetu IN, et al. Radiographic methods for locating impacted maxillary canines. *Rom J Morphol Embryol*. 2022;63(4):599-606. doi:10.47162/RJME.63.4.01
27. Laurenziello M, Montaruli G, Gallo C, et al. Determinants of maxillary canine impaction: retrospective clinical and radiographic study. *J Clin Exp Dent*. 2017;9(11):e1304-e1309. doi:10.4317/jced.54095
28. Topsakal KG, Gökmen Ş, Uçaker YE, Öztürk T, Yağci A. Assessment of the positional and morphological differences of unilaterally impacted canines: a cross-sectional study. *J Stomatol Oral Maxillofac Surg*. 2024;125(4S):101920. doi:10.1016/j.jormas.2024.101920
29. Guarnieri R, Cavallini C, Vernucci R, Vichi M, Leonardi R, Barbato E. Impacted maxillary canines and root resorption of adjacent teeth: a retrospective observational study. *Med Oral Patol Oral Cir Bucal*. 2016;21(6):e743-e750. doi:10.4317/medoral.21337
30. Razeghinejad MH, Bardal R, Shahi S, Mortezapoor E, Mostafavi M. Volumetric evaluation of maxillary lateral incisor root resorption due to positional variations of impacted canine. *Int J Dent*. 2022;2022:2626222. doi:10.1155/2022/2626222