Correlation between the three-dimensional root apex position and the orthodontic traction duration of mesially impacted maxillary canines

Park, Yoon Sik

Department of Dentistry

Graduate School

Yonsei University

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Advisor Choi, Sung-Hwan

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Park, Yoon Sik

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This Certifies that the Master's Thesis
of Park, Yoon Sik is Approved

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Committee Chair	**Choi, Yoon Jeong**
Committee Member	**Choi, Sung-Hwan**
Committee Member	**Kim, Harim**

Department of Dentistry
Graduate School
Yonsei University
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ABSTRACT

Correlation between the three-dimensional root apex position and the orthodontic traction duration of mesially impacted maxillary canines

This study analyzed the influence of the three-dimensional root apex position on the traction duration of mesially impacted maxillary canines, compared to the cusp tip position.

Thirty-one cases of cone-beam computed tomography were analyzed. Each normally erupted canine was mirrored across the midsagittal plane to create an image of its enantiomorph. The distances were measured between the root apices of the impacted canine and the enantiomorphic contralateral normally erupted canine, as well as between their cusp tips and tooth angulations. Each distance variable was further subdivided into vertical displacement, horizontal displacement, mesio-distal displacement, bucco-palatal displacement, while the angulation variable was divided into M-D tip difference and torque difference. The correlation between each measurement and the traction duration was analyzed.

The position of the root apex showed no significant correlation with traction duration. However, the 3D displacement, horizontal displacement, and bucco–palatal displacement of the cusp tip ($P < 0.001$), vertical displacement of the cusp tip ($P < 0.01$), and the 3D angulation difference and M-D tip difference between tooth axes ($P < 0.05$) showed significantly positive correlation with traction duration. Multiple regression analysis showed that the 3D displacement of the cusp tip explains approximately 55.4% of the variance in traction duration, increasing by 1.2 months per 1 mm.

While root apex position does not affect traction duration in mesially impacted maxillary canines, the 3D displacement of the cusp tip is a key determinant, with more significant palatal displacement and a higher vertical position associated with longer traction duration.

Key words: Mesially impacted maxillary canine; Cusp tip; Root apex; Axis; Cone-beam computed tomography; Traction duration

1. Introduction

Due to its eruption sequence, the maxillary canine is the most frequently impacted after the third molars (Choi et al., 2025). Leaving the impacted canine untreated at the appropriate time can lead to various dental complications, such as root resorption and cystic change (Kim Y. et al., 2017; Sajnani and King, 2014). Therefore, timely and proper intervention is crucial, forced eruption being a commonly used treatment approach (Stabryła et al., 2021). Forced eruption of an impacted maxillary canine often accounts for a significant portion of the total treatment time. Therefore, predicting the traction duration is essential for effective treatment planning and patient communication, as the extraction of the impacted tooth and space closure or prosthetic restoration can also be considered. In addition, providing realistic expectations about treatment duration plays a critical role in maintaining the patient's long-term compliance throughout the orthodontic treatment.

To establish reliable predictors of the traction duration, previous studies have focused mostly on the position, angulation, and overlap of the crown in relation to adjacent teeth (Bazargani et al., 2013; Fleming et al., 2009; Schubert and Baumert, 2009; Yang et al., 2022). However, there is relatively less interest in the position of the apex, even though the apex of an impacted canine also deviates from the normal position (Kim SH. et al., 2017a; Kim SH. et al., 2017b; Oh et al., 2023). Additionally, during traction, the root apex of the impacted canine moves alongside its crown (Dağsuyu İ et al., 2018). Thus, traction of an impacted canine should be considered as a correction of both the crown and root apex, implying that an abnormal root apex position could significantly influence treatment duration. Therefore, to accurately evaluate the three-dimensional position of an impacted canine, it is essential to assess both the crown and the root apex, to gain a more precise understanding of the overall displacement pattern of the impacted maxillary canine.

At present, cone-beam computed tomography (CBCT) has been introduced as a more precise tool to evaluate impacted canines. Shin et al. (2019) found the pretreatment inclination of the canine toward the midsagittal plane to be the sole factor influencing traction duration. Another study by Goh et al. (2024) found rotation to be the only factor influencing traction duration, while the vertical and horizontal displacement and angulation were not associated with traction duration. Nevertheless, rather than utilizing full three-dimensional (3D) assessment, most previous studies have typically evaluated the position of impacted canines using reference planes such as the occlusal plane or the midsagittal plane, measuring distances or angulations relative to these planes. As a result, the true complexity of the impacted tooth's spatial position may not be fully understood. To overcome these limitations, this study introduces a more refined method by mirroring the normally erupted contralateral canine across the midsagittal plane to assess the three-dimensional position of the impacted tooth. This method allows for the quantitative assessment of the displacement of the impacted canine by using its ideal position as a reference where it would have erupted under normal conditions rather than relying on conventional reference planes. The resulting measurements enable clinicians to intuitively understand the pattern and extent of the displacement based on numerical values alone.

This study aims to evaluate the influence of root apex position on the traction duration of mesially impacted maxillary canines using CBCT by incorporating a novel three-dimensional analysis method. Furthermore, this study reassesses the role of crown position, a well-established factor that affects traction duration, to provide a more comprehensive understanding of the variables that influence traction duration.

2. Materials and methods

2.1. Participants

This retrospective study was based on data from patients with a unilateral impacted maxillary canine who visited the Department of Orthodontics, Yonsei University Dental Hospital, between January 2018 and December 2023. In total, 273 patients were initially screened using the keyword phrase "unilateral impacted maxillary canine". Of these 273 initially screened patients, those for the final study were selected based on the following criteria. The inclusion criteria were selected to ensure that the contralateral maxillary canine erupted in its normal position: (1) an impacted canine in sectors II−V by Ericson and Kurol classification (1988) (Figure 1) to standardize the direction of displacement between the crown and root apex; (2) the presence of a normally erupted contralateral maxillary canine; and (3) the maxillary arch showing a round shape and less than 2 mm of crowding. The exclusion criteria were selected to eliminate environmental factors, such as abnormality and treatment method: (1) systemic disease, maxillofacial deformity, and history of trauma; (2) obstacles to the eruption, such as odontomas or supernumerary teeth; (3) a missing tooth or other impacted teeth, except for the canine; (4) additional rotation control after eruption (Goh et al., 2024); (5) root resorption or dilacerations of upper dentition; and (6) orthodontic treatment with extraction or transposition. Finally, of the 273 patients with unilateral canine impaction, 31 patients (21 females and 10 males) were selected according to these criteria. The average age of the selected patients was 14.8 years, ranging from 10 to 38 years. Based on a previous study, the Pearson correlation coefficient for H1 was set at 0.5, with a significance level of 0.05 and power of 80%, resulting in a minimum required sample size of 23 (G*Power, version 3.1.9.4; Franz Faul, Universität Kiel, Germany) (Yang et al., 2022). All research procedures in this study complied with the guidelines of the Declaration of Helsinki and were reviewed and approved by the Institutional Review Board of Yonsei University Dental Hospital (2−2024−0035).

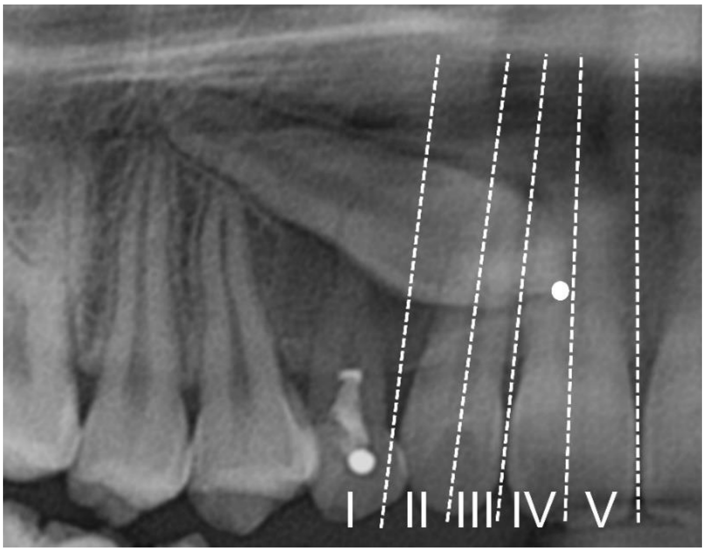


Figure 1. The classification of the anteroposterior position of the cusp tip about adjacent teeth that was used by Ericson and Kurol (1988). *Sector I*, distal part of a crown and root of the lateral incisors; *Sector II*, distal area of the lateral incisor tooth divided by the tooth axis; *Sector III*, mesial area of the lateral incisor tooth divided by the tooth axis; *Sector IV*, distal area of the central incisor tooth divided by the tooth axis; *Sector V*, mesial area of the central incisor tooth divided by the tooth axis.

2.2. Methods

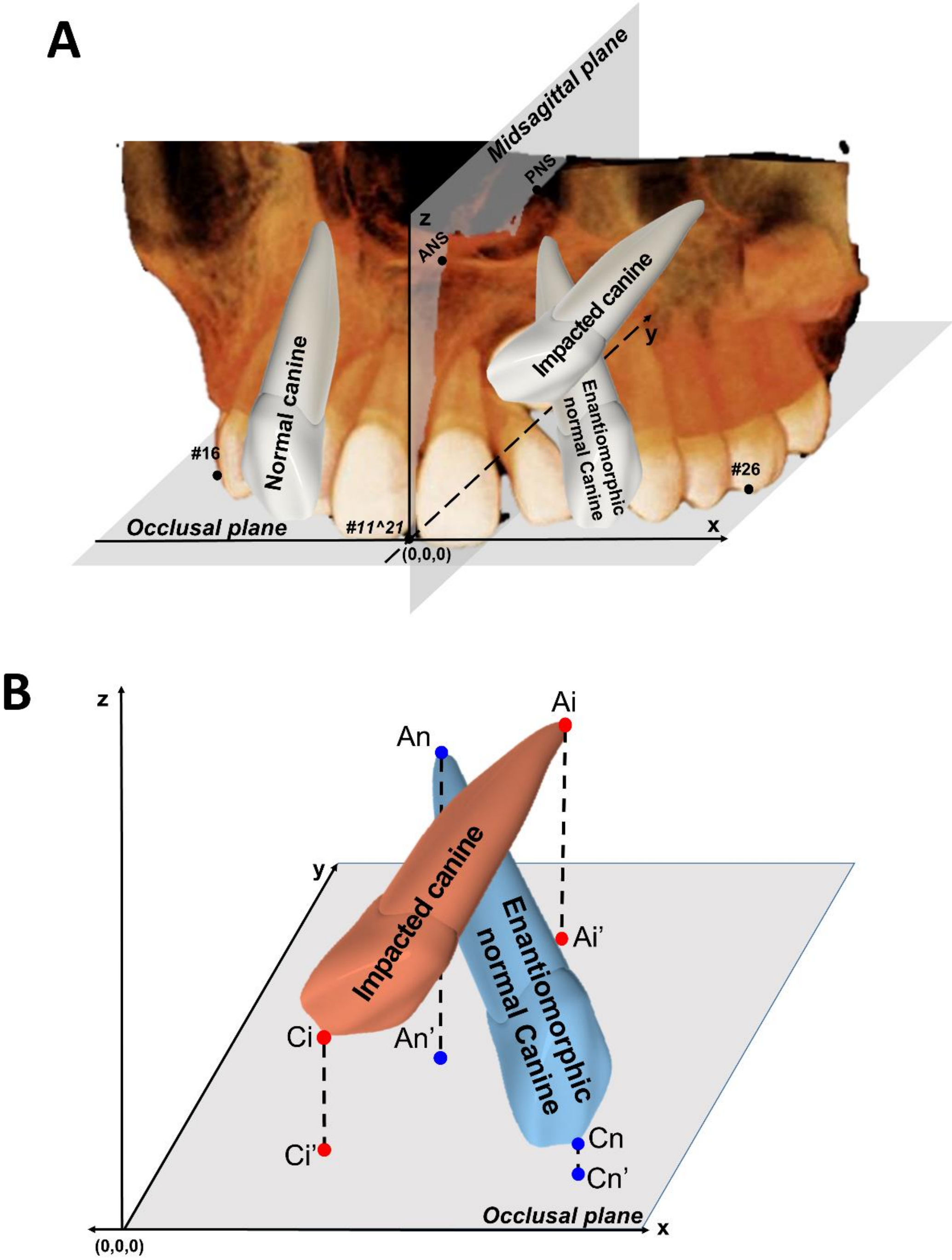
All CBCT scans were performed using uniform parametric settings at the standard operational settings of the hospital (80 kVp; 10 mA) with Alphard 3030 (Alphard Roentgen Ind., Ltd., Kyoto, Japan). CBCT data were converted and assessed using Invivo 3D Imaging software (Anatomage, San Jose, California). The software was run on a computer equipped with an Intel(R) Core(TM) i7-7700 CPU @ 3.60 GHz, integrated Intel HD Graphics 630, and 8.25 GB of RAM. For the reference plane, the occlusal plane was determined by three points: the midpoint between the incisal edges of the maxillary central incisors, and mesiobuccal cusp tips of the maxillary first molars on both sides. The midsagittal plane was perpendicular to the occlusal plane, passing ANS and PNS.

2.3. Analysis

Analyses were performed by comparing the impacted canines with the normally erupted contralateral maxillary canines by symmetrical mirroring of the normally erupted contralateral maxillary canines about the midsagittal plane (Figure 2A). The cusp tip position, root apex position, and tooth axis (the line through the cusp tip and root apex) were analyzed by linear and angular measurements, including the vertical projection of the cusp tips and root apex on the occlusal plane (Figure 2B). The position of each point on the occlusal plane by the vertical projection can be understood simply as the views from the occlusal of the CBCT 3D reconstruction. The following measurements were analyzed.

First, the 3-dimensional distance between each cusp tip and the root apex of two canines (3D displacement) was measured. The 3D displacement was divided into distance from the occlusal plane (Vertical displacement), and distance between each point of the cusp tip and root apex projected onto the occlusal plane (Horizontal displacement) (Figure 2D, Table 1). Using reference lines, the Horizontal displacement was further divided into the mesio–distal displacement (M-D displacement) and the bucco–palatal displacement (B-P displacement). These reference lines passed through each cusp tip and the root apex of the normally erupted contralateral canine that were parallel to the line passing the average point of the maxillary lateral incisor and the first premolar buccal cusp tip and root apex in the normally erupted canine quadrant (n = 31) (Figure 2E, Table 1). By this classification, unlike previous studies that usually used x-y (occlusal), y-z (midsagittal), and z-x (coronal) planes as axes, this study was conducted using three axes, the M-D axis, the B-P axis, and the Vertical axis, to allow more clinically intuitive application.

Second, the three-dimensional angulation between two canines was measured (3D angulation difference). The 3D angulation difference was divided into the difference of the canine angulation to the occlusal plane (torque difference), and the canine axis difference projected onto the occlusal plane (M-D tip difference), which could be considered the mesio–distal angular displacement, known as M-D tip (Figure 2C, Table 1).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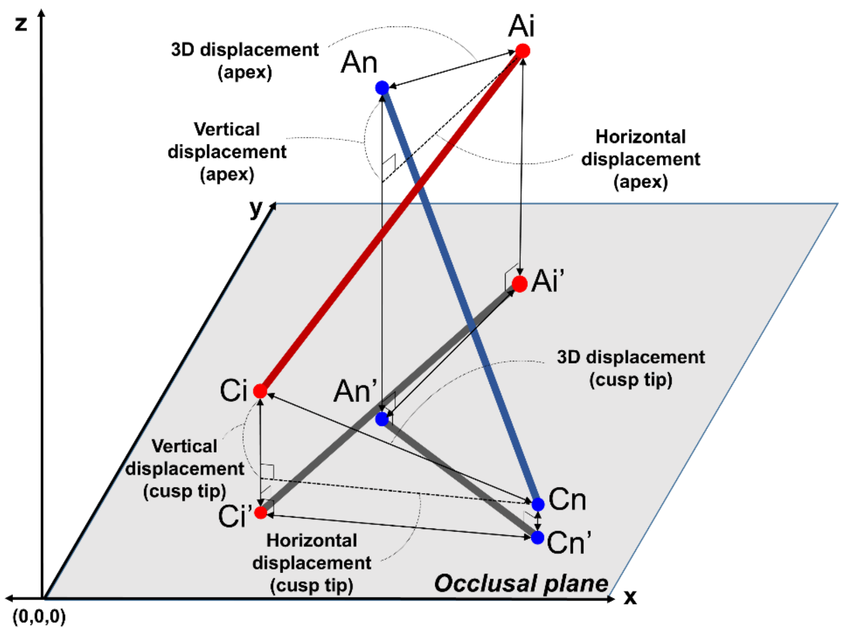
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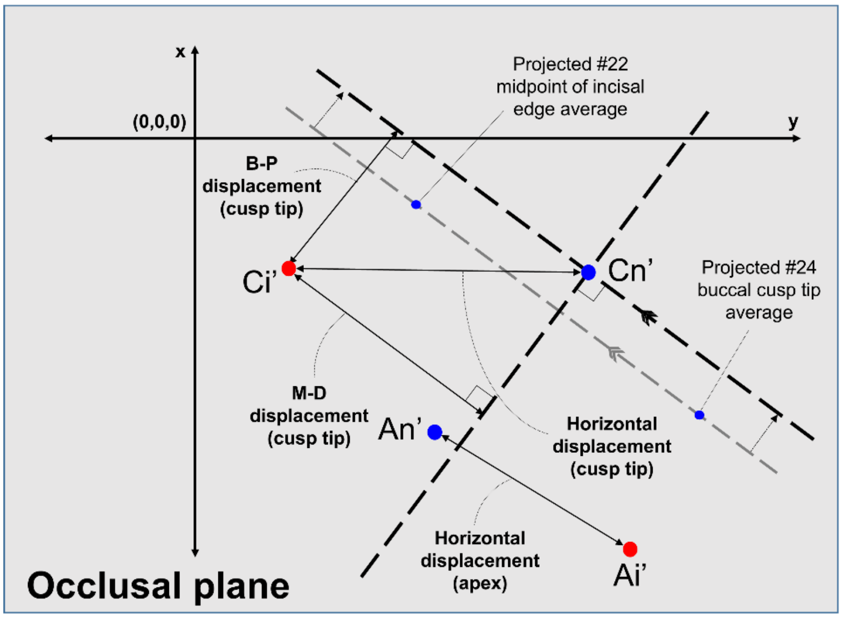
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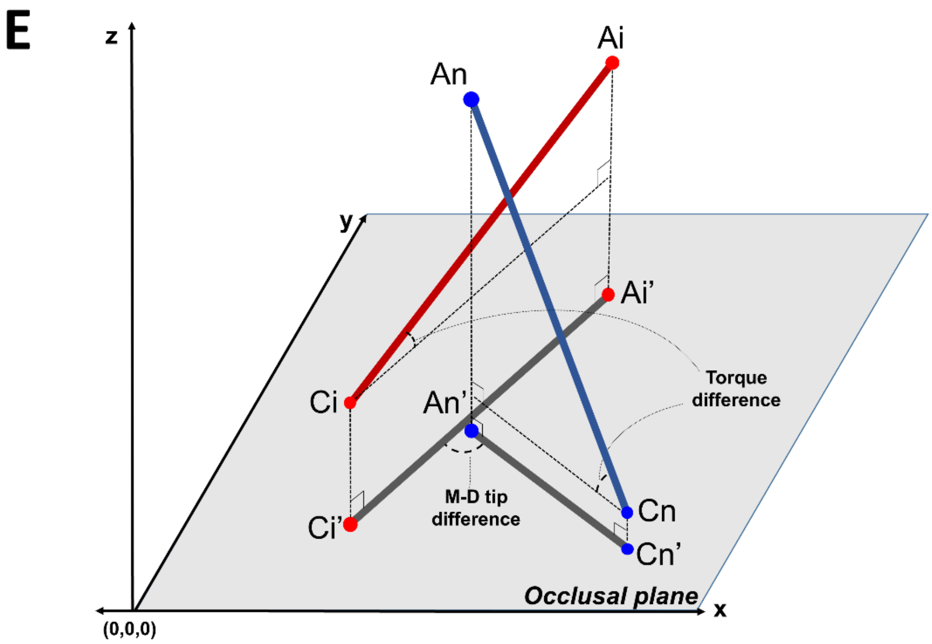

Figure 2. Mirroring process and illustrations of measurements used in the analysis: A, Mirroring process. The normally erupted contralateral canine is reflected along the midsagittal plane, to compare with the impacted canine; B, Landmarks of the impacted canine and the enantiomorphic normally erupted canine. Cn, the cusp tip of the enantiomorphic normally erupted contralateral canine; An, apex of the enantiomorphic normally erupted contralateral canine; Ci, the cusp tip of the impacted canine; Ai, the apex of the impacted canine. Points marked with (') indicate the corresponding landmarks projected perpendicularly onto the occlusal plane; C, Illustration of the 3D displacement, vertical displacement, and horizontal displacement; D, Illustration of the horizontal displacement, B-P displacement, and M-D displacement on the occlusal plane; E, Illustration of the torque difference and M-D tip difference (see Table 1).

Table 1. Definitions of impacted canine measurements

Measurements	Definition
Cusp tip displacement	
3D displacement	Distance from Ci to Cn
Vertical displacement	Difference between the distance of Ci and Ci' and that of Cn and Cn'
Horizontal displacement	Distance from Ci’ to Cn'
M-D displacement	Mesio-distal distance from Ci’ to Cn' using reference line passing the average point of the maxillary left lateral incisor and first premolar buccal cusp tip
B-P displacement	Bucco-palatal distance from Ci’ to Cn' using reference line passing the average point of the maxillary left lateral incisor and first premolar buccal cusp tip
Apex displacement	
3D displacement	Distance from Ai to An
Vertical displacement	Difference between the distance of Ai and Ai' and that of An and An'
Horizontal displacement	Distance from Ai’ to An'
M-D displacement	Mesio-distal distance from Ai’ to An' using reference line passing the average point of the maxillary left lateral incisor and first premolar apex
B-P displacement	Bucco-palatal distance from Ai’ to An' using reference line passing the average point of the maxillary left lateral incisor and first premolar apex
Canine angulation difference	
3D angulation difference	Angulation from an axis passing Ci and Ai to an axis passing Cn and An
M-D tip difference	Angulation from an axis passing Ci’ and Ai’ to an axis passing Cn’ and An’
Torque difference	Difference between angulation of the axis passing Ci and Ai and occlusal plane and that of the axis passing Cn and An and occlusal plane

Cn: cusp tip of the enantiomorphic normally erupted contralateral canine; An: apex of the enantiomorphic normally erupted contralateral canine; Ci: cusp tip of the impacted canine; Ai: apex of the impacted canine; Points marked with (’) indicate the corresponding landmarks projected perpendicularly onto the occlusal plane.

2.4. Traction duration

Medical records and clinical data were used to calculate treatment duration by applying orthodontic force to the impacted canine after the surgical opening to engage a 0.016 × 0.022-in stainless steel wire in 0.018-in slot bracket on the maxillary dental arch. This meant that the impacted canine was sufficiently aligned. If the stainless steel wire was not used as the main arch wire for the treatment, the debonding period was used as the end-point of the traction.

2.5. Statistical Analysis

All statistical analyses were conducted using IBM SPSS software for Windows, version 27.0 (IBM Korea, Seoul, Republic of Korea). Intra-examiner reliability was assessed using intra-class correlation coefficients based on two sets of measurements performed by a single researcher (Y.S. Park) with a 2-week interval. The researcher was blinded to the traction duration of each case during the measurement process to minimize potential measurement bias. All intra-class correlation coefficient values exceeded 0.9 ($P < 0.001$), indicating high consistency of the measurements. Pearson correlation coefficient and stepwise multiple linear regression analysis were used to determine correlations between the measurements of cusp tip displacement, apex displacement, canine angulation difference, and traction duration.

3. Results

Table 2 summarizes the distribution of impacted canines according to sector classification based on panoramic radiographs. Using CBCT images, impacted canines were categorized relative to the lateral incisor root, with 12 cases classified as buccal impaction and 19 as palatal impaction (Table 2). Figure 3 illustrates the vertical projection of cusp tips and apices on the occlusal plane. The cusp tips of impacted canines were palatally located near the lateral incisor, while their apices were palatally positioned near the first and second premolars.

Table 2. Classification of cusp tips by sectors

	Cusp tip		**Buccal / Palatal**	
Sector	**Number (n)**	**Percentage of Total** (%)	**Buccal**	**Palatal**
II	7	22.6%	2	5
III	11	35.5%	6	5
IV	9	29.0%	4	5
V	4	12.9%	0	4

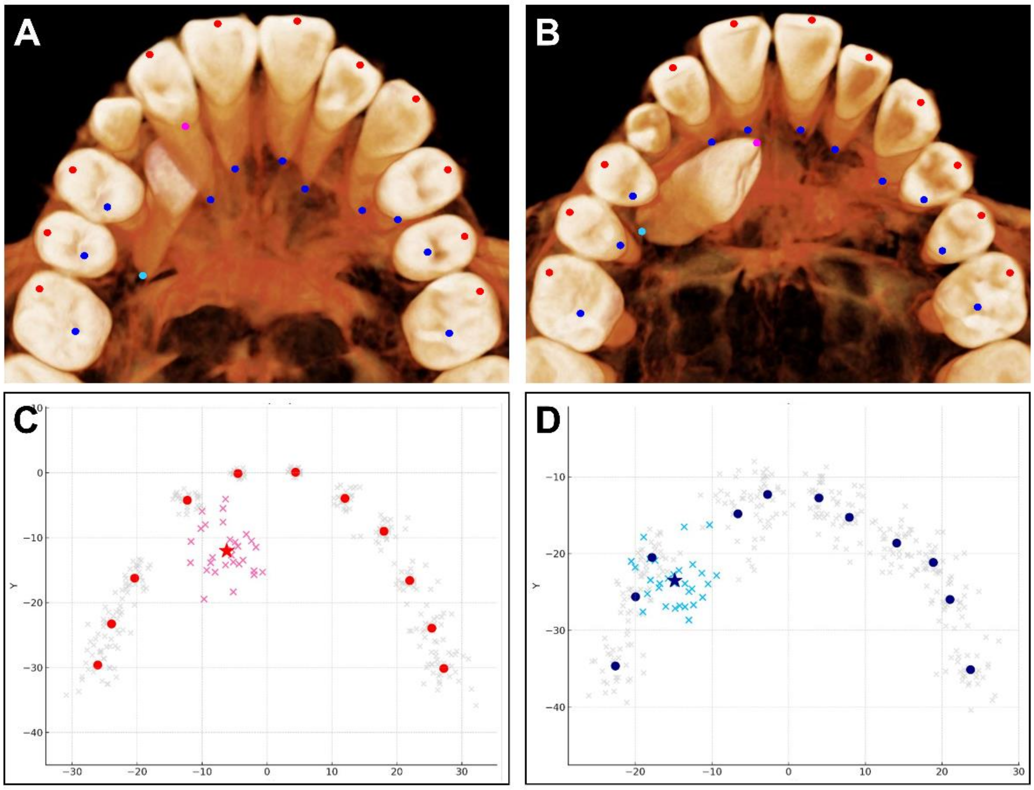

Figure 3. 3D and 2D projected occlusal views of the cusp tips and root apices: For cusp tips of the whole dentition, the midpoint of the incisor edge for incisors, the buccal cusp tip for bicuspids, and the mesio-buccal cusp tip was used for molars. The average point of the multiple root apices was used for the apex. A, Example of a buccal impacted canine with cusp tip and apex point tracing of the entire dentition; B, Example of a palatal impacted canine with cusp and apex point tracing of the entire dentition; C, Projection of cusp tip points onto the occlusal plane from 31 participants. Gray X marks denote all cusp tip positions, except for the impacted canines; red points denote the average cusp tip position of each tooth, except for the impacted canines; pink X marks denote the cusp tip points of the impacted canines; and red stars denote the average cusp tip position of the impacted canines; D, Projection of apex points onto the occlusal plane. Gray X marks denote all root apex positions, except for the impacted canines; Blue points denote the average apex position of each tooth, except for the impacted canines; Light blue X marks denote the apex positions of the impacted canines; Blue star denotes the average apex position of the impacted canines.

The average treatment duration was 17.7 months, ranging from 6 to 30 months. Pearson correlation analysis showed that the 3D displacement, horizontal displacement, and B-P displacement of the cusp tip ($P < 0.001$), and the vertical displacement of the cusp tip ($P < 0.01$) were significantly positively correlated with the traction duration. However, none of the apex displacement measurements were significantly correlated with the traction duration. Nevertheless, 3D angulation and M-D tip difference between tooth axes ($P < 0.05$) were significantly positively correlated with the traction duration (Table 3). The mean values of cusp tip displacement parameters were more than twice those of the corresponding apex displacement parameters, except for the M-D displacement, which showed similar values.

Table 3. Correlation between impacted maxillary canine position and traction duration

Measurements	Mean [± SD]	r	*P value*
Cusp tip displacement (mm)			
3D displacement	16.5 [±3.7]	0.754	<0.001***
Vertical displacement	10.2 [±2.9]	0.496	0.005**
Horizontal displacement	12.6 [±3.8]	0.675	<0.001***
M-D displacement	5.0 [±2.5]	0.006	0.973
B-P displacement	11.1 [±4.3]	0.658	<0.001***
Apex displacement (mm)			
3D displacement	7.8 [±2.3]	-0.021	0.910
Vertical displacement	4.2 [±2.8]	-0.041	0.829
Horizontal displacement	6.0 [±2.4]	-0.013	0.944
M-D displacement	3.3 [±2.3]	0.244	0.186
B-P displacement	4.3 [±2.5]	-0.158	0.396
Canine angulation (°)			
3D angulation difference	38.3 [±16.0]	0.442	0.013*
M-D tip difference	57.1 [±22.6]	0.449	0.011*
Torque difference	20.2 [±13.7]	0.178	0.338

P-values were calculated using the Pearson correlation coefficient
* Significance at the 0.05 level. ** Significance at the 0.01 level. *** Significance at the 0.001 level.

A stepwise multiple regression analysis was conducted using thirteen measurements mentioned above to identify significant predictors of the traction duration. This statistical method involved the iterative inclusion and exclusion of variables based on the F-statistic, with an entry probability of less than 0.05 and a removal probability greater than 0.10. This analysis revealed that the 3D displacement of the cusp tip is the only factor included in the model, explaining 55.4% of the variation in traction duration, and was statistically significant (F = 37.236, *P* < 0.001). Additionally, for every 1 mm increase in the 3D displacement of the cusp tip, the traction duration increased by approximately 1.2 months, on average (Table 4).

Table 4. Multiple linear regression analysis of factors affecting traction duration

Variables (scale)	**Unstandardized coefficient**		**Standardized coefficient**	**t**	***P* value**
	B	**Standard error**	**β**		
(Constant)	-2.392	3.331		-0.718	0.478
Cusp tip 3D displacement	1.211	0.196	0.754	6.187	<0.001***
F (*p*)			38.274***		
Adjusted R^2			0.554		
Durbin-Watson			1.582		

Analysis was conducted using the stepwise method to select significant predictors.
*** Significance at the 0.001 level.

4. Discussion

To improve the intuitiveness of the analysis, this study introduced a novel 3D approach that compared the impacted canine with its contralateral normally erupted canine. This method enabled the exact displacement in terms of both displacement distance and angulation to be measured. The variables in this study were divided into three major categories: cusp tip displacement, apex displacement, and canine angulation. The correlation between these variables and traction duration was analyzed. No variable related to apex displacement demonstrated a statistically significant relationship with traction duration. This finding aligns with previous studies, which reported no association between the apex and treatment outcomes by 2D analysis such as the anterior–posterior and bucco–palatal positions (Fleming et al., 2009; Gullu and Cakmak Ozlu, 2024; Vasović et al., 2025). Although one study suggested that root–cortex contact may prolong treatment by approximately three months, apex position alone appears to have limited predictive value for traction duration (Amuk et al., 2021). However, since the 3D angulation difference and M-D tip difference of the impacted tooth demonstrated a significant correlation with traction duration, the apex position may be clinically considered even though the apex position alone is not associated with the traction duration.

Unlike the apex, the cusp tip displacement related variables showed strong correlation, except for the M-D displacement. This suggests that the crown position of the impacted canine is a key factor influencing traction duration. Several factors may explain this finding. First, the displacements of the cusp tips are nearly twice as large as those of the apex in all directions, except mesiodistally (Table 3). The position of the root apex is mostly influenced by the location of the tooth germ, and as it is due to genetic factors, there will be a relatively high degree of occurrence of bilateral impacted canines (Becker et al., 2015). Since this study only included unilateral impaction, which are more likely due to eruption path abnormality or space deficiency rather than genetic factors, the actual displacement of the root apex appeared to be at approximately half the cusp tip displacement. Therefore, as the expected displacement range is more extensive at the cusp tip, it will likely be the decisive factor contributing to increased traction duration. Second, the modality of orthodontic traction typically involves surgically exposing the crown and attaching an appliance to apply traction to a single point on the crown. Consequently, following crown displacement, correction of the apex occurred as a secondary movement. In addition, unlike the apex, the adjacent teeth make the crown of the impacted canine move only partially in response to the orthodontic force. Furthermore, there is a histological difference between crown and root apex. The dental follicle around the crown is damaged during the surgical opening, and the tissue surrounding the crown becomes fibrotic during the healing, finally hindering the movement of the crown. In contrast, the presence of the periodontal ligament around the root may facilitate more favorable physiological movement.

When cusp tip 3D displacement was divided into vertical displacement and horizontal displacement, both showed a significant correlation with traction duration. Further analysis of horizontal displacement by separating the mesio–distal (MD) and bucco–palatal (BP) directions revealed that only the B-P displacement showed a significant correlation. Additionally, the B-P displacement is 2.2 times greater than the M-D displacement, which mainly influences horizontal displacement. As a result, traction duration is more influenced by the palatal displacement of the cusp tip and its vertical impaction depth.

Previous studies commonly used panoramic radiographs to assess the initial crown position of impacted canines, and the traction duration was reported to be associated with factors such as anteroposterior position, vertical position, and canine angulation (Grisar et al., 2021; Kim et al., 2012; Schubert and Baumert, 2009). Also, each CBCT-based study identified a different single factor related to increased traction time, such as the pretreatment inclination of the canine toward the midsagittal plane, rotation of the impacted canine, and the sectors close to the midline (Shin et al., 2019; Goh et al., 2024; Arriola-Guillén et al., 2019). The results of all previous CBCT studies differ from this study, and these discrepancies are likely due to the analyzing method and the differences in the sample selection criteria. This study adopted the novel method, using expected normally erupted position. So, the differences in positional assessment criteria will result in these discrepancies. For example, using axis to the midsagittal plane versus the axis to the expected normally erupted canine may lead to different results due to individual anatomic variations. Additionally, since the traction duration of the impacted canine is influenced by multiple factors, minimizing the effects of these variables is essential for identifying a more accurate relationship between the tooth position and traction duration. For example, cases requiring de-crowding, extraction, and additional rotation control were not considered (Goh et al., 2024). Although these strict criteria reduced the sample size in this study, they allowed for more consistent analysis of the effect of displacement on treatment duration, while minimizing the influence of other confounding factors.

The stepwise multiple linear regression analysis demonstrated a predictive power of 55.4%, higher than that reported in previous studies (Goh et al., 2024; Shin et al., 2019). From the regression analysis, the following regression model can be constructed:

Duration of traction (month) = −2.40 + 1.20 × Cusp tip 3D displacement (mm), adjusted $R^2 = 0.554$

Notably, traction duration is predicted to increase by approximately 1.2 months for every 1 mm increase in the 3D displacement of the cusp tip. Unlike the Pearson correlation analysis, the multiple linear regression model identified the 3D displacement of the cusp tip to be the most significant predictor ($P < 0.001$). This suggests that other variables may share explanatory power with the 3D displacement, diminishing their significance when analyzed together. Even though a predictive power of 55.4% is higher than previous studies, the current model can still explain only more than half of the variability in traction duration, which represents underlying limitation of this study. There can be several additional factors that are difficult to quantify. First, proximity and interference between impacted canine and the roots of adjacent teeth can complicate the traction. Additionally, the rate of the movement of the individual impacted tooth may vary depending on factors such as the bone volume and density, age, systemic health, or genetic predisposition. Finally, the type of treatment method and patient compliance can affect the traction duration.

This study has further limitations. First, the analysis was limited to mesially impacted maxillary canine. Although this made the direction of canine displacement standardized for the uniformity of the sample, the cases with distal or inverted impactions were excluded. Second, to control for variables, cases with root resorption, supernumerary teeth, and extraction treatment were excluded, which consequently led to a small sample size. This may also limit the applicability of the findings to all impacted canines. Nevertheless, results of this 3D analysis method based on an assumed normal eruption position, which predicts the traction duration by cusp tip 3D displacement as the sole variable, offer a practical advantage by allowing clinicians to easily calculate the traction duration in practice. Additionally, in the future, integrating deep learning or artificial intelligence technology with these data could enable more straightforward prediction of traction duration using only CBCT data.

5. Conclusions

This study used a novel 3D approach comparing the impacted canine with its enantiomorphic contralateral normally erupted canine to evaluate the influence of root apex and cusp tip position on the traction duration. The following results could be concluded:

1. Apex displacement was found to not be associated with the traction duration of impacted maxillary canines.
2. The key factor for longer traction duration was an increase in 3D displacement of the cusp tip, with an increase of approximately 1.2 months per 1 mm.
3. The 3D displacement of the cusp tip showed that more palatally positioned and higher vertically positioned cusp tips required longer traction time.

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Abstract in Korean

근심으로 매복된 상악 견치 치근첨의 3 차원적 위치와 교정적 견인 기간 간의 상관성

본 연구는 근심으로 매복된 상악 견치에서 치관첨의 위치 대비 치근첨의 3 차원적 위치와 교정적 견인 기간 간의 상관성을 분석하였다.

총 31 명 환자의 콘빔 전산화 단층 촬영 영상을 분석하였다. 각 정상 맹출한 견치를 정중 시상면을 기준으로 거울상을 생성한 후, 반대측의 상악 매복 견치와의 위치를 서로 비교하였다. 분석 항목으로는 매복 견치와 반대측 정상 맹출한 견치의 거울상 간의 치근첨 간 거리, 치관첨 간 거리, 그리고 치축 각도 차이를 측정하였다. 거리 변수는 수직적, 수평적, 근원심측 및 협구개측 변위로 나누어 평가하였으며, 치축 각도는 교합평면에 대한 각도 차이 및 근원심적 각도 차이로 세분화하였다. 각각의 변수와 견인 기간 간의 상관성을 피어슨 상관 계수와 다중선형 회귀분석을 이용해 평가하였다.

치근첨의 위치는 견인 기간과 유의미한 상관관계를 보이지 않았으나, 치관첨의 3 차원적 변위, 수평적 변위, 협구개측 변위 ($P < 0.001$), 수직적 변위 ($P < 0.01$), 그리고 치축의 3 차원적 각도 차이 및 근원심적 각도 차이 ($P < 0.05$)는 견인기간과 통계적으로 유의한 상관성을 보였다. 다중선형 회귀분석 결과, 치관첨의 3 차원적 변위가 1 mm 증가할수록 치료기간은 약 1.2 개월씩 증가하는 것으로 나타났으며, 이는 대략 55.4%의 설명력을 보였다.

본 연구를 통해 치근첨의 위치는 근심으로 매복된 상악 견치의 견인 기간에 영향을 미치지 않는다는 사실을 확인하였다. 반면, 치관첨의 3 차원적 변위는 견인 기간과 가장 유의한 상관관계를 보였으며, 특히 치관첨이 수직적으로 높고 구개측 변위량이 클수록 치료 기간이 증가하는 경향을 보였다.

핵심되는 말 : 근심 매복 상악 견치, 치관첨, 치근첨, 치축, 콘빔 전산화 단층 촬영, 견인기간