

Article

Jaw Morphology and Factors Associated with Upper Impacted Canines: Case-Controlled Trial

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Featured Application: This study's findings on factors linked to impacted maxillary canines could be applied in orthodontics to develop screening methods for earlier diagnosis and potentially guide treatment plans to reduce surgical intervention needs.

Abstract: Introduction and aim: Orthodontic treatment of impacted maxillary canines is challenging and expensive. This study investigated factors associated with impaction risk and the need for surgical exposure. **Methods:** Seventy-five participants of similar age, skeletal maturity, and gender (32 impacted canines, 43 controls) were included in the case-controlled trial. Three-dimensional study models were created (Trios 3, 3Shape), and panoramic radiographs were taken. The 3D digital models were measured using software to obtain morphological characteristics of the maxilla, such as maxillary surface area (mm²) and volume (mm³). **Results:** The impacted canine group displayed a significantly higher prevalence of deep bite (OR = 5.01), hypoplastic lateral incisors (OR = 5.47), and rotated adjacent teeth (OR = 3.56) compared to the control group. The impacted canine group exhibited a smaller maxillary surface area and volume. Within the impacted canine group, factors associated with a greater need for surgical exposure included the presence of a persistent deciduous canine (OR = 10.15), a palatal canine position (OR = 7.50), and a steeper canine angulation ($p < 0.001$). **Conclusions:** These findings suggest that several signs can serve as potential predictors of increased risk for maxillary canine impaction and the need for surgical intervention. Identifying these factors can aid in early diagnosis and treatment planning for improved patient outcomes.

Keywords: maxillary canine impaction; jaw morphology; risk factors; surgical exposure of impacted tooth



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1. Introduction

Problems with the eruption of the upper canines are relatively widespread. The buds of the maxillary canines develop in the upper part of the maxilla. Compared to other teeth, they have the longest root length and the longest eruption path [1,2].

The maxillary canine is the second-most frequently impacted tooth; it is impacted slightly less frequently than the mandibular third molar. The prevalence of impacted canines in industrialized countries is between 0.82 and 2.4%. Compared to boys, impacted canines are 2.3 to 3 times more common in girls [3].

The etiology of canine impaction is unclear; it could be due to general or local factors [4,5].

General factors, diseases, and syndromes include hypopituitarism, hypothyroidism, cleidocranial dysplasia, Downs syndrome, achondroplasia, A and D hypovitaminosis, amylogenesis imperfecta, and osteoporosis [6], as well as some pathological conditions due to inflammation and ionizing radiation exposure [7]. Compared to the general conditions mentioned above, local factors are more commonly associated with impacted maxillary

canines. These include local mechanical obstructions (supernumerary tooth and odontoma), local odontogenic pathology, defects in incisor development, incorrect positions of the canine bud, and a lack of space for eruption or trauma in this area [8].

The panoramic radiograph shows the maxillary and mandibular teeth, the condyles, the maxillary sinuses, and the nasal cavity. As panoramic radiographs are widely used in clinical practice, it is one of the most recognized tools for detecting canine impactions [9–11]. Despite some disadvantages such as inaccuracy, image distortion, and the overlapping of anatomical structures, experiments and mathematical modeling have shown that panoramic radiographs can be reliably used to measure distances and angles and may allow certain predictions of possible dental impaction [12,13].

Ericson and Kuroł's diagnosis of impaction risk considers parameters such as the angle between the canine and the median line, the extent of mesiodistal overlap with neighbouring teeth, and the distance between the canine position and the occlusal line in the vertical dimension [14].

Various clinical signs and conditions such as delayed tooth maturation, hypoplasia or hypodontia of the lateral incisor, maxillary crowding, smaller transverse dimensions of the maxilla, and the absence of a vestibular canine bulge have been frequently associated with impacted maxillary canines [8,15–18].

Since the treatment of impacted canines is usually lengthy and often very challenging and may require surgical exposure of the canines, it is better to diagnose the position of the canines early and prevent their impaction [4,18]. Canine impaction can be unfavorable since it may cause resorption of the roots of neighboring teeth, most commonly lateral incisors [19]. Furthermore, impacted canines that underwent orthodontic and surgical means show higher amounts of root resorption compared to spontaneously erupted canines [20].

Our research hypothesized that several signs and conditions that are observable before the expected eruption of permanent maxillary canine are associated with canine impaction.

The aim of this clinical study was to investigate the relationship between the clinical conditions of deep bite, hypoplasia of the lateral incisors, rotation of the neighbouring teeth, and infraocclusion of the ankylotic maxillary deciduous teeth to evaluate the morphology of the maxilla in patients with impacted maxillary canines to determine the relationship between local factors and the risk of canine impaction, and to identify local factors that increase the need for surgical exposure of impacted canines.

2. Materials and Methods

This case-controlled clinical study included 75 participants (43 girls, 32 boys). The participants were divided into two groups: the experimental group (with impacted canines) and the control group. The experimental group included 32 patients who were referred to the Orthos Institute for orthodontic treatment and had at least one impacted canine in their maxilla. Before inclusion into the study, and after receiving oral and written information about the clinical trial, the patients and their parents or guardians signed the informed consent form (Institutional Review Board Statement).

Thirty-two patients with at least one impacted canine without hereditary syndromes or orofacial clefts were included in the study. Forty-three patients were included in the control group. The participants in the control group were selected according to the experimental group based on the participant's gender, age, and skeletal maturity. The patients in the control group had no major orthodontic malocclusion, and their index of malocclusion was categorized as none or mild (EF values < 16 points) according to the EF index [21].

The patients underwent a detailed clinical examination, and intraoral and extraoral photographs were taken. The upper and lower dental arches were scanned with an intraoral scanner, and the bites were registered. Three-dimensional models were created with a 3Shape Trios 3 intraoral scanner (3Shape, Copenhagen, Denmark). Lateral cephalograms of the head and neck were used to assess skeletal maturity using the CVS method. Skeletal maturity was assessed based on the morphology of the second-to-fourth cervical vertebrae [22–24].

Intraoral photographs and models were used to determine the presence of a deep bite, hypoplastic lateral incisors, rotation of neighbouring teeth, or infraocclusion of the deciduous molars.

A deep bite was defined as an overbite of more than 4.1 mm, measured either during the examination with calipers or on an intraoral 3D model [25,26]. The presence of hypoplastic lateral incisors, rotation of neighbouring teeth, and deciduous teeth in the infraocclusion due to ankylosis was determined by analyzing the intraoral 3D model.

In the group of impacted canines, each impacted canine had its position (palatal or buccal), the presence of a deciduous tooth, and the angle of the impacted canine noted.

The position and presence of impacted canines were assessed on digital panoramic radiographs. The angle of the impacted canine axis (α) was measured digitally between the vertical median line and the canine axis line (Figure 1).

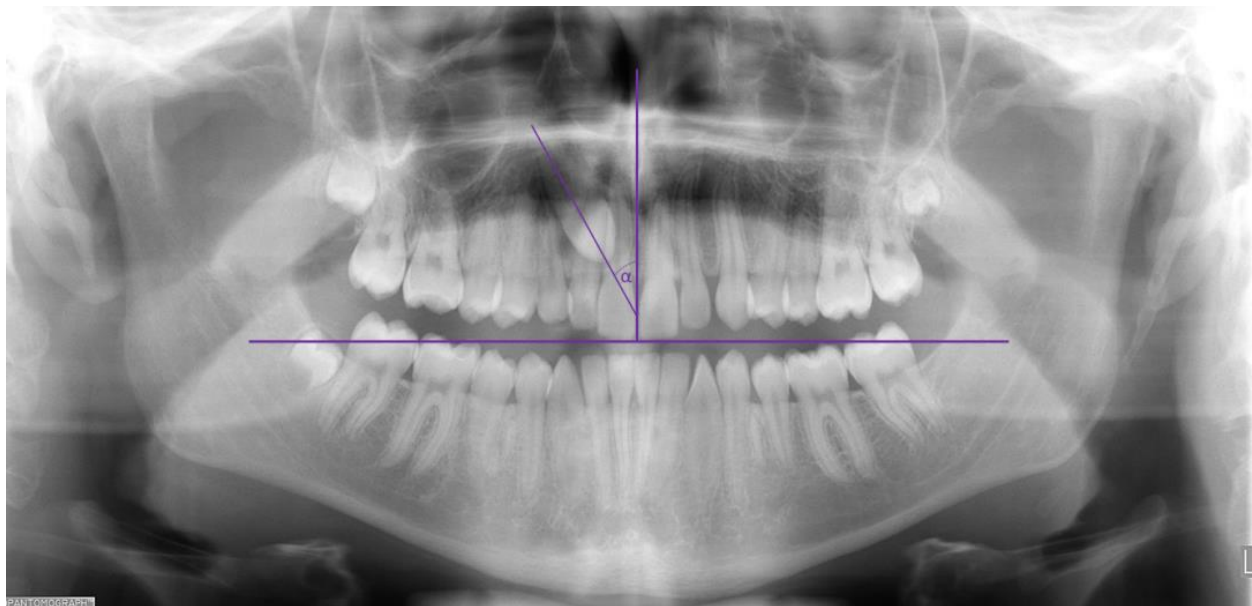


Figure 1. Measurement of impacted maxillary canine axis angle (α).

The measurements were performed by the same person twice, 1 week apart. The mean values of the two measurements were considered as the final measured values.

Based on the analysis of 3D study models of the maxilla, the surface area, the projection area, and the volume of the maxilla were determined. To determine the surface area and volume of the maxilla, we imported the 3D study models in digital form into a customized program for analyzing the morphological features of the jaws based on Rapid Form™ 2006 software (Inus Technology Inc., Seoul, Republic of Korea). The software, which uses a high-quality polygonal mesh, enables precise visualization and calculation of the selected surface and volume of the jaw. The program was developed in collaboration between the University of Ljubljana and Cardiff University and adapted for the analysis of morphological features, and described in an article by Primožič et al. [27]. The method has been used in several studies so far and is considered an established method for the assessment of morphological features. It has already been described in detail [28–31].

Three-dimensional models of the maxilla made it possible to measure morphological features by measuring the projection of the surface of the palatal vault and the volume of the palate. The surface area and volume of the maxilla were determined twice at different locations: the anterior segment of the maxilla between teeth 14 and 24 and the entire maxilla between teeth 16–26. First, we determined the gingival plane, which was delineated by reference points at the junction of the marginal gingiva with the center of the mesio-distal width of the dental crowns on the palatal side of the maxillary teeth (gingival points). The gingival plane was defined by the gingival points.

The distal plane was defined by two points placed on the most distal part of the crown of the maxillary left and right first permanent molar or first permanent premolar, and the distal plane was defined by these distal points perpendicular to the gingival plane. By defining all these boundaries, the RapidForm™ 2006 software provided results in terms of mm² (surface area and projection area) and mm³ (volume).

Statistical Analysis

Data were collected using Microsoft Office Excel spreadsheets (Microsoft, Redmond, WA, USA). Statistical analyses were performed using SigmaPlot 14.0 software (Systat, Palo Alto, CA, USA). p -value ≤ 0.05 was considered statistically significant. Sample size was calculated for the association of risk factors and differences in palatal morphology between the two groups. A dedicated sample-size calculation tool was used to differentiate the impacted canine and control group with chi-square and t -tests. Assuming a power of the test of 0.80 and a level of statistical significance at 0.05 (alpha), the study would require a total of 42 participants to reach the level of statistical significance for differences in morphology of maxilla and a total of 30 participants to obtain statistically significant difference in odds of impaction when considering intraoral conditions.

The experimental group and the control groups were described using descriptive statistics. To test for differences between them, the variables were analyzed for normal distribution using the Shapiro–Wilk test. In the case of a non-normal distribution, the non-parametric version of the statistical test was used.

Differences between the sexes were tested using the chi-square test; differences between the groups in terms of age and skeletal maturity were tested using the Student t -test.

The chi-square test and Fisher's exact test were used to compare the frequency of intraoral disorders such as deep bite, hypoplastic lateral incisor, rotation of the neighbouring tooth, or infraocclusion of the deciduous tooth between the experimental group and the control group. Odds ratios (OR) with 95% confidence intervals (CI) were determined. The relationship was represented graphically in a bar chart. The symbol * indicates a p -value ≤ 0.05 .

Morphological characteristics (palatal surface, projection area, and palatal volume) of the maxilla between the groups were compared using the Mann–Whitney test and the t -test. The results are shown graphically in a box plot. The center box represents the interquartile range, the dotted line the sample mean, and the solid line the median. The whiskers represent the 5th and 95th percentiles of the sample.

To evaluate local factors that might be associated with impaction, the experimental group was further stratified, and impacted teeth were compared with non-impacted maxillary canines. The chi-square test was used to compare the effects of the presence of a persistent deciduous tooth on the probability of impaction. The Mann–Whitney test was used to compare the angle of the canine axis.

Impacted canines requiring surgical exposure were compared with impacted canines treated by non-surgical means. The risk of the need for surgical exposure was compared. The influence of the presence of a persistent deciduous tooth was tested with a chi-square test, and the odds ratio for the need for surgical exposure was calculated. Univariate logistic regression was used to model the relationship between the need for surgical intervention and canine axis angle.

The relationship between maxillary morphological characteristics, skeletal maturity, and intraoral factors was tested with linear regression and a Mann–Whitney test to exclude possible interactions between the variables.

3. Results

Seventy-five participants were included in the study. There were no statistically significant differences in age, gender, or skeletal maturity between the experimental and control groups (Table 1).

Table 1. Contingency table of the number of participants in experimental and control group: their age, gender, and skeletal maturity. There were no statistically significant differences. (m= male; f = female).

	Impacted Canine	Control Group	
Frequency (N)	32	43	
Age (years)	13.845 ± 1.678	13.085 ± 1.782	$p = 0.0653$ (<i>t</i> -test)
Gender	13 m 19 f	19 m 24 f	$p = 0.942$ (Chi-square test)
Skeletal maturity (CS)	4.241 ± 1.347	3.645 ± 1.518	$p = 0.114$ (<i>t</i> -test)

There was a significant difference between the group with impacted canines and the control group in terms of the presence of a hypoplastic lateral incisor ($p = 0.004$). If a patient had a hypoplastic lateral incisor, its odds for maxillary canines were 5.47 times higher.

In the impacted canine group, 21 participants had a rotated tooth adjacent to the impacted canine, while 15 participants in the control group had a rotated lateral incisor or first premolar. There was a significant difference in the prevalence of deep bites between the groups ($p = 0.017$). If the patient had a rotated tooth next to the canine, its odds for maxillary canine impaction were 3.56 times higher.

In the impacted canine group, three participants with impacted canines had infraocclusion/ankylosis of the deciduous tooth in the maxillary arch, and that applied to one participant in the control group. There was no statistically significant difference in the presence of deciduous teeth in the infraocclusion/ankylosis between the groups ($p = 0.304$). The significance of the test was low (<0.70). Further data can be found in Table 2, and the results are shown graphically in Figure 2.

Table 2. Intraoral conditions, associated with canine impaction compare the presence of deep bite, hypoplastic lateral incisors, rotation of adjacent teeth, and infraocclusion of deciduous teeth in the maxilla between the impacted canine group to the control group.

	Impacted Canine Group	Control Group	
Deep bite	Present (N)	17	8
	<i>expected (N)</i>	10.76	14.23
	Not present (N)	14	33
	<i>expected (N)</i>	20.23	26.76
			* $p = 0.004$ (chi-square test) OR = 5.01 95% CI: 1.76–14.28
Hypoplastic lateral incisor	Present (N)	15	6
	<i>expected (N)</i>	9.04	11.95
	Not present (N)	16	35
	<i>expected (N)</i>	21.95	29.04
			* $p = 0.004$ (chi-square test) OR = 5.47 95% CI: 1.79–16.70
Rotation of adjacent tooth	Present (N)	21	15
	<i>expected (N)</i>	15.50	20.50
	Not present (N)	10	26
	<i>expected (N)</i>	15.50	20.50
			* $p = 0.017$ (chi-square test) OR = 3.56 95% CI: 1.36–9.35
Infraocclusion/Ankylosis of deciduous tooth	Present (N)	3	1
	<i>expected (N)</i>	1.69	2.31
	Not present (N)	27	40
	<i>expected (N)</i>	28.31	38.69
			$p = 0.304$ (Fisher exact test) OR = 4.44 95% CI: 0.44–45.04

* Statistically significant, $p < 0.05$.

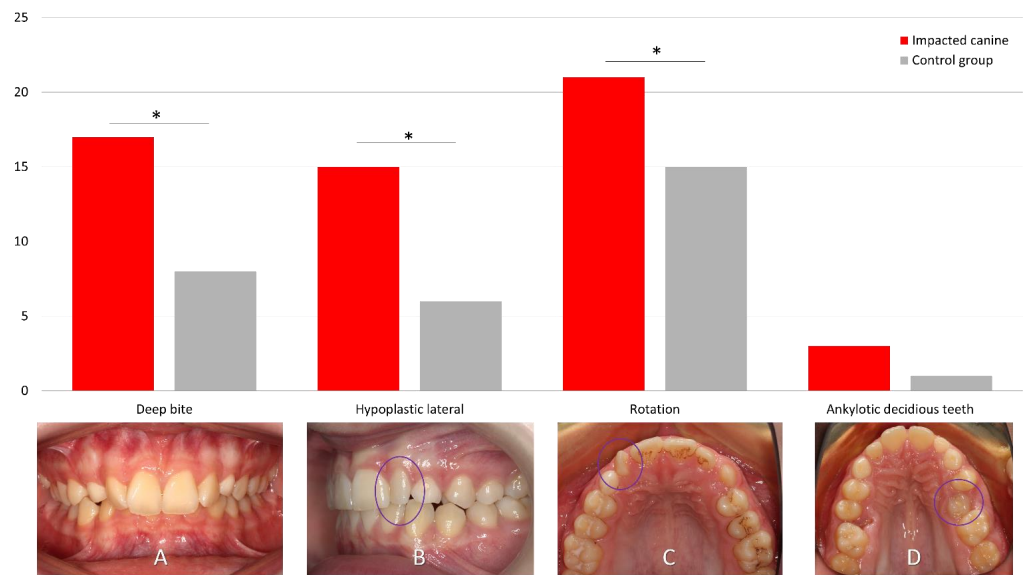


Figure 2. The group with impacted canines was more likely to have (A) a deep bite, (B) a hypoplastic lateral incisor, and (C) a rotated neighbour. However, patients with (D) ankylotic deciduous teeth do not have a higher risk of impaction. * marks a statistically significant difference ($p < 0.05$).

3.1. Morphological Features of Maxilla

Morphological characteristics of the upper jaw were measured on 3D study models and were compared between the impacted canine and control groups.

The palatal surface of both upper arch surfaces (with posterior delimitation distal to first molars 6-6) and the surface of the anterior part of the upper jaw (with delimitation distal to first premolars 4-4) were significantly smaller in the impacted canine group compared to the control group, per the Mann–Whitney test, $p < 0.001$.

The projection surface of the anterior palate (4-4) was significantly smaller in the impacted canine group compared to the control group (t -test, $p = 0.0198$), while there was no statistically significant difference in the projection surface of the palate (6-6); t -test, $p = 0.136$. Results are presented in boxplots (Figure 3).

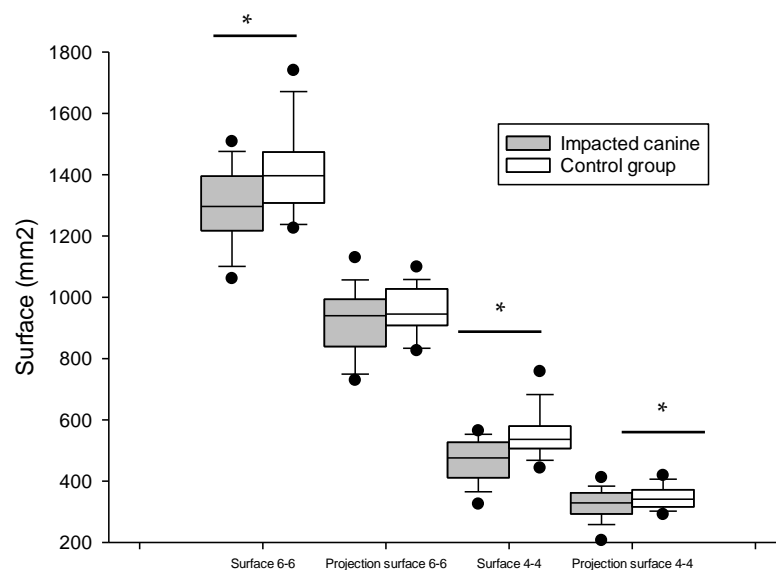


Figure 3. Surface and projection surface comparison between impacted canine and control groups. * $p < 0.05$.

Both palatal volume (6-6) and volume of the anterior palate (4-4) were significantly smaller in the impacted canine group compared to the control group (Mann–Whitney test, $p < 0.001$)—Figure 4.

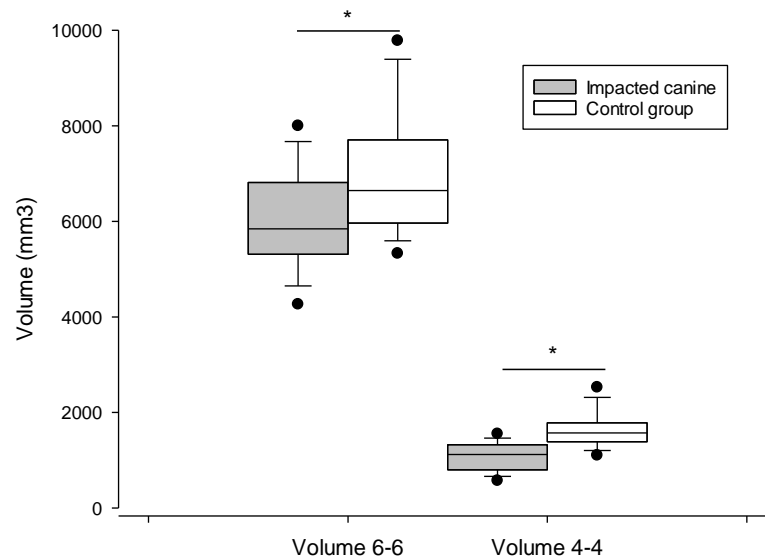


Figure 4. Comparison of palatal volume between impacted canine and control group. * $p < 0.05$.

3.2. Relationship between Local Factors and Canine Impaction

The experimental group was stratified, and the side of the impacted canine was compared to the side without the impacted maxillary canine. The canine was significantly more likely impacted if there was persistent deciduous canine present (chi-square test, $p < 0.001$), or if the canine axis angle was steeper (Mann–Whitney test, $p < 0.001$). Results are presented in Table 3.

Table 3. Comparison of occurrences of persistent deciduous maxillary canine and canine axis angle in impacted and non-impacted canines within the experimental group.

		Impacted	Non-Impacted	
Deciduous canine	Present (N)	33	4	* $p < 0.001$ (chi-square test) OR: 47.44 95% CI: 10.75–209.36
	expected (N)	21.39	15.61	
	Not present (N)	4	23	
	expected (N)	15.61	11.39	
Canine axis angle	Median	40°	0°	* $p < 0.001$ (Mann-Whitney test)
	Interquartile range (25–75%)	32.5–49°	0–5°	

* Statistically significant, $p < 0.05$.

3.3. Association between Local Impaction Risk Factor and Need for Surgical Exposure

The impacted canine group was further stratified based on the need for surgical exposure of the impacted canine (Table 4).

Impacted maxillary canines that required surgical exposure had significantly more persistent deciduous canines present (chi-square test; $p < 0.001$), and the impacted canines with the need for surgical exposure were significantly more palatally located (chi-square test; $p < 0.001$).

Table 4. Comparison of the presence of local risk factors for impaction and need for surgical exposure of impacted canines.

		Need for Surgical Exposure	No Need for Surgical Exposure	
Deciduous canine	Present (N)	24	14	* $p < 0.001$ (chi-square test) OR: 10.15 95% CI: 2.988–35.84
	Not present (N)	16.44	20.55	
Location of impacted canine	Palatal (N)	4	22	* $p < 0.001$ (chi-square test) OR: 7.5 95% 2.43–23.14
	Buccal (N)	11.55	14.44	
Canine axis angle	Median	21	10	* $p < 0.001$ (Mann-Whitney test)
	Interquartile range (25–75%)	13.78	17.22	
		7	25	
		14.22	17.78	
		39°	5°	
		30.5–49°	0–31°	

* Statistically significant, $p < 0.05$.

Impacted canines that needed surgical exposure had significantly higher canine axis angles (Mann–Whitney test; $p < 0.001$). The relationship between the impacted canine axis angle with the need for surgical exposure was modelled with univariate logistic regression with the equation:

$$\text{Logit } p = -2.011 + (0.0676 * \text{Canine axis angle } (^{\circ}))$$

Univariate logistic regression model showed that each degree of increased canine axis angle increases the odds of surgical exposure need by 1.067 times (95% CI: 1.034–1.107; logistic regression; $p < 0.001$).

4. Discussion

The results of the case-controlled study show that patients with impacted canines are more likely to have smaller maxillary dimensions, a deep bite, hypoplastic lateral incisors, or rotated teeth adjacent to the canines. The presence of a persistent deciduous canine and a larger canine axis angle are local risk factors that increase the likelihood of canine impaction. In patients with impacted canines, there is a greater need for surgical exposure if persistent deciduous teeth are present, if the impacted canine is palatal, or if its axial angle is greater.

The majority of impacted canines (59%) belonged to female participants, suggesting that maxillary canines are more common in girls, which has been previously reported in several reports [3,14]. However, since the design of our study is the case control, we cannot fully confirm this. The control group matched the experimental group in terms of gender, age, and skeletal maturity and might, therefore, not be representative of the general population in this respect.

The palatal location of impacted maxillary canines was present in 83.8% of canines, while six impacted canines were located buccally, which is comparable to the results of other studies [3,14,32]. Problems with the eruption of maxillary maxillary canines are relatively common; they may be influenced by either intraoral conditions or local risk factors [33]. The impaction of maxillary canines is often associated with various intraoral conditions, such as a deep bite, a hypoplastic later incisor, rotation of neighbouring teeth, or ankylosis of deciduous teeth [8,33].

The results of our study show that patients with impacted canines have a deep bite significantly more often. A deep bite was present in 54.8% of the participants in the experimental group. A similar association was also found in previous studies: Al Nimri reported that 44% of patients with impacted canines also had a deep bite, while Basdra reported 33.5% [34,35]. This association is explained by the guidance theory: the roots of

the retroinclined maxillary incisors are more buccal, and the root tips of the lateral incisors are often more mesial so that these roots cannot guide the eruption of the canine, which can get displaced palatally and possibly impacted. In addition, there may be a common genetic factor that causes a deep bite with retro-inclination of the incisors and impaction of the canines [36].

The prevalence of hypoplastic lateral incisors in the general population is approximately 1.8% and varies by race, ethnicity, and gender [37]. In our experimental group, hypoplastic lateral incisors were present in 48.3% of participants, which is a slightly higher prevalence compared to other studies in which hypoplastic lateral incisors were found in 17–18% of participants with impacted maxillary canines [34,38].

We found that the odds of impaction were 3.5 times higher when the tooth adjacent to the impacted canine was rotated. The lateral incisor and the first premolar erupt close to the canine. On average, the lateral incisor erupts 3 years and the first premolar 1 year before the canine. If neighbouring teeth erupt in an improper position of the root, their root tips may tip into the eruption path of the canine and block its normal eruption [8,39]. Conversely, an impacted canine can exert pressure on the roots of neighbouring teeth and cause spontaneous orthodontic tooth movement, which manifests as tipping and/or rotation.

Some authors investigated whether the ankylosis of the deciduous tooth that leads to infraocclusion is related to the impaction of the maxillary canine [15,38]. In the present study, the comparison between the groups did not confirm this hypothesis. It is important to mention that the number of participants with ankylotic deciduous teeth was very low (1 or 2), which is reflected in the very low power of the statistical test.

When comparing the maxillae based on the 3D morphological features, we found that the palate of the group with impacted canines was significantly smaller. The volume of the palate, the surface area of the palate, and the projection area of the anterior palate (4-4) were significantly smaller in the experimental group. The projection area of the entire palate (6-6) showed a similar pattern but did not reach the level of statistical significance ($p = 0.136$). The different results between the palatal surface and projection surface parameters indicate a possible role of the vertical dimension of the maxilla in the impaction of the upper canines, as the projection surface (in contrast to the palatal surface) is only influenced by the transversal width and sagittal height. Several authors have emphasized the possible role of the vertical dimension in the impaction of maxillary canines [40,41]. In contrast to our study, previous studies have used linear measurements instead of using 3D measures such as surface area and volume. The advantage of this 3D measurement technique is that it reduces the likelihood of measurement errors due to local model peculiarities or defects on a 3D model.

We tested a possible interaction between the morphological characteristics of the maxilla and the intraoral conditions. The tests revealed no significant interaction between a deep bite, hypoplastic lateral incisor, or rotation of the neighbouring teeth with the 3D morphology of the maxilla. We can conclude that the 3D morphological features of the maxilla are an independent sign associated with the maxillary maxillary canines. Cacciatore et al. analyzed 3D models and found that the maxillae of participants with impacted canines were significantly narrower in the transverse dimension and shorter in the sagittal direction, while the vertical height of the palate was not significantly different [40]. However, Shahin et al. measured the vertical height of the palate on CBCT images and concluded that both the anterior and posterior heights of the palate were smaller in the groups with impacted canines [41]. A recent systematic review measuring CBCT images confirmed that the width of the impacted side was narrower, and palatal volume was smaller when impacted canines were present [42]. These findings are consistent with the results of our study. According to Leifert, a narrow apical base of the maxilla and a lack of space in the maxilla may be the cause of canine displacement, which may lead to impaction [43].

The results of our study show that in the presence of a persistent primary canine, the odds of impacted permanent canines are higher. This is consistent with a study by Bazargani et al. that confirmed a causal relationship between the prolonged presence of a

deciduous canine and the impaction of a permanent canine. They found that the risk of spontaneous eruption of permanent canines was significantly higher when primary canines were extracted in time [44].

We found that a higher axis angle of the canines increased the risk of impaction. In a previous study, canines with an axis angle greater than 31° were reported to have a higher risk of impaction [45].

Within the group of impacted canines, we investigated the association between the need for surgical exposure of the impacted maxillary maxillary canine and local risk factors.

The canine axis angle was significantly higher in canines requiring surgical exposure, with a mean value of 39° . We have confirmed that the need for surgical exposure is significantly higher when a permanent canine is present, or the impacted canine is positioned palatally. Similarly, Naumova et al. found that the need for surgical exposure of the canine was higher when the impacted canine was located in Sector 4 (the canine crown overlapped with the lateral incisor and the distal half of the central incisor) or the canine axis angle was greater than 30° [9].

The present study included is limited in its design. Since it is a case-controlled design, it cannot provide data on gender distribution since gender was a controlled trait. It only evaluated the canine axis angle and did not consider its vertical and mesiodistal position [14]. However, it is important to note these are related; impacted canines with more mesial and superior positions often exhibit larger axis angles. Furthermore, the present study, utilizing 3D model analysis, noted a possible involvement of vertical dimension in maxillary canine impaction. However, the used methods are not able to provide information on whether the vertical deficiency is limited to the maxilla only or if it is a part of the facial skeletal pattern. However, the role of vertical dimension remains disputable [40,41]. An analysis of the lateral cephalogram could provide further explanations.

Cicek et al., in their study, did report several skeletal cephalometric parameters to be associated with canine impaction, especially bilateral maxillary with Class III and lower canine axis angle in the Class II skeletal pattern [46]. The results of our study show that intraoral conditions such as a deep bite, a hypoplastic lateral incisor, and rotation of the neighbouring tooth are associated with a higher risk of impaction of the maxillary canine. As these can be identified before the expected eruption of the maxillary canine and are very easy and inexpensive to identify, they could be used as an indicator of risk for the maxillary canine impaction.

Early diagnosis and timely interceptive measures such as the extraction of the primary canine may prevent impaction of the maxillary canine and, thus, reduce the need for complex, lengthy, and costly treatment, which can be a burden for the patient, a therapeutic challenge for the therapists, and a significant expense for the public health system [47–49].

5. Conclusions

The study showed that patients with impacted canines were significantly more likely to have a deep bite, hypoplastic lateral incisors, and rotated adjacent teeth. Patients with impacted canines had smaller maxillary volumes and surfaces. The presence of a deciduous tooth, palatal position, and a steeper canine axis angle are local factors that increase the risk of impaction and the need for surgical exposure.

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Institutional Review Board Statement: Subjects provided their informed consent for inclusion before they participated in the study. The study was conducted in accordance with the Declaration

of Helsinki. The study proposal was reviewed by the Institutional Review Board. Ethical review was waived by the Institutional Review Board (number 006/2023) for this study since it was a non-intervention study, and no additional diagnostic or therapeutic interventions any different from the standard procedure according to the doctrine of the profession were employed.

Informed Consent Statement: Informed consent was obtained from all subjects involved in the study.

Data Availability Statement: Data are available on request due to restrictions. Part of the data contains sensitive personal information and is, therefore, protected by the national and EU (GDPR) laws. However, data that could not compromise the privacy of research participants may be available from the corresponding author (AG) upon reasonable request.

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