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Evaluation of nasal passage and palatal morphology in patients with impacted maxillary canine: a retrospective study using cone-beam computed tomography

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Abstract

Background Anatomically, the maxilla and nasal cavity are functionally interconnected. Given the proximity of maxillary canines to these structures, impaction may affect the surrounding anatomy. This retrospective study aimed to evaluate the potential association of maxillary canine impaction with nasal passage and palatal volumes using cone-beam computed tomography (CBCT).

Methods A total of 162 CBCT scans were categorized into three equal groups, comprising 54 participants each. The first group functioned as the control, whereas the subsequent two groups comprised patients with unilateral and bilateral maxillary impacted canines. In each group, right, left, and total nasal passage and palatal volume were measured using CBCT images. All measurements were conducted using Mimics software. The data were analyzed using the Kruskal-Wallis H test for comparisons among the three groups, and the Mann–Whitney U test was used for pairwise comparisons between genders. Spearman's correlation coefficient was employed to assess the relationship between nasal passage and palatal volume.

Results The bilateral impaction group showed significantly lower nasal passage and palatal volumes compared to the control and unilateral groups. The impacted side of the unilateral group revealed reduced palatal volume compared to both the non-impacted side and the control group. The nasal passage volume on the impacted side of the unilateral group was comparable to that of both the non-impacted side and the control group. This study revealed no statistically significant correlation between nasal passage and palatal volume.

Conclusions The results indicated that bilateral maxillary canine impaction was associated with decreased nasal and palatal volumes, reflecting broader craniofacial structural changes.

Trial registration Not applicable.

Keywords Impacted canine, Nasal passage volume, Palatal volume, Cone-beam computed tomography

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Background

Maxillary canines are the second most commonly impacted permanent teeth, with a reported prevalence ranging from 1.1 to 3.3% [1, 2]. This condition is significantly more frequent in females, with a female-to-male ratio of approximately 3:1 [3]. Unilateral impaction occurs two to three times more often than bilateral impaction [4]. Palatal impactions are reported to be three times more common than buccal impactions [5, 6].

Several general and local factors can interfere with the normal development and eruption of maxillary canines or change their eruption path. These factors are generally grouped into four categories: obstruction by hard tissues, local pathologies, developmental problems of the incisors, and genetic influences [4]. Previous studies have suggested that buccal impactions are mostly related to transverse skeletal or dental deficiencies, while palatal impactions are more often associated with missing or hypoplastic lateral incisors, according to the guidance theory [7]. A narrow maxilla has also been significantly associated with palatal canine impactions in recent studies [8, 9].

The maxilla and nasal structures are closely connected from early developmental stages. At around the eighth week of gestation, the primitive nasal cavity and septum connect with the primitive mouth [10]. The roof of the oral cavity and the floor of the nasal cavity are formed by the palatine process of the maxilla and the horizontal plate of the palatine bone [11, 12]. A midline septum divides the nasal cavity into two nasal passages. Several studies have shown a strong anatomical relationship between nasal and palatal structures and craniofacial development [13–15]. To accurately diagnose these anatomical consequences, multiple imaging techniques are employed.

Traditional two-dimensional radiographs—such as panoramic, occlusal, and periapical images—have been used to locate impacted canines and evaluate related findings. However, these methods often face challenges like overlapping anatomical structures that may obscure important details [16]. Cone beam computed tomography (CBCT) provides high-resolution, three-dimensional (3D) images that overcome these limitations, such as superimposition, magnification, and distortion. Also, it improves the accuracy of angular, linear, and volumetric measurements [17].

A review of the literature revealed only one study investigating the relationship between nasal passage volume and maxillary canine impaction [18]. In that study, Osman et al. [18] reported that individuals with unilateral palatal impactions had smaller nasal airway volumes than controls. Since the oral and nasal cavities function together in maxillofacial development, most previous research has focused primarily on palatal changes. The present study aims to evaluate the potential effect of both unilateral and bilateral maxillary canine impactions on palatal and nasal morphology using CBCT. To the best of our knowledge, this is the first study to compare nasal and palatal volumes in both impaction patterns through CBCT-based volumetric analysis, offering new insights into the anatomical consequences of maxillary canine impactions. The null hypothesis of this study is that there is no statistically significant difference in nasal passage and palatal volumes among patients with unilateral or bilateral maxillary canine impactions and those in the control group.

Methods

The research adhered to the Helsinki Declaration and obtained ethical approval from the Near East University Scientific Research Evaluation Ethics Committee (YDU/2024/122–1826). This retrospective study analysed CBCT images taken from patients who presented with various dental complaints in the Faculty of Dentistry, Department of Dentomaxillofacial Radiology, from 2007 to 2024. Prior to imaging, written informed consent was signed by all patients or their legal guardians.

Collection of the data

In this study, CBCT scans were conducted using two different systems. The NewTom 3G system (Quantitative Radiology s.r.l., Verona, Italy) operated at 120 kVp and 3–5 mA, with a scan duration of 36 s and a 6 or 9 inch field of view (FOV). This system used isotropic voxels and featured an axial slice thickness of 0.3 mm. During scanning, patients were positioned supine, laser beams were used to adjust the head position, and they were instructed to keep their mouths closed in a natural occlusion position, remaining motionless throughout the procedure. Conversely, in the Sirona Orthophos SL 3D system (Dentsply Sirona, Bensheim, Germany), imaging parameters ranged from 60 to 90 kVp and 3–16 mA, with a scan period of 14 s and a voxel size of 0.08 mm. The FOV was set at 110 mm × 100 mm. For these scans, patients were positioned vertically. A bite block device was used to maintain a bite with their anterior teeth, and laser beams were utilized to adjust the head position, ensuring the beam divided the head into two symmetrical sections. Patients were required to remain motionless during the scanning. All data were saved in the DICOM (Digital Imaging and Communications in Medicine) format.

The inclusion criteria for this study were as follows: patients aged 12 years or older, availability of high-quality CBCT scans, and clearly observable regions of interest on the CBCT images. The impaction groups included patients with either unilateral or bilateral maxillary impacted canines, with no other impacted teeth present,

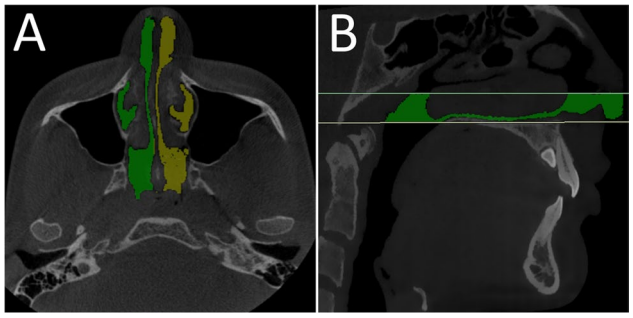


Fig. 1 Segmentation of the nasal passage by Mimics software: (**A)** Axial section showing the right (yellow) and left (green) side nasal passage segmentation; (**B)** Sagittal CBCT section showing the superior and inferior borders of the nasal passage

except third molars. The control group was obtained from patients whose CBCT images were obtained for various dental reasons. The control group was selected retrospectively from the same population using the same inclusion and exclusion criteria without impacted teeth (excluding third molars) to minimize selection bias. Patients were excluded from the study if they had any of the following conditions: a history of maxillofacial trauma; presence of odontomas, cysts, or tumors in the regions assessed; cleft lip and/or palate; craniofacial syndromes; congenital nasal deformities; a diagnosis of obstructive sleep apnea; age under 12 years; absence of the region of interest in the imaging field; patient- or device-related imaging artifacts; or poor image quality.

Sample size calculation

The power analysis indicated that, with an effect size of 0.25, classified as moderate by Cohen's criteria, a power (1-β Error Probability) of 0.80, and a Type I error rate (α) of 0.05, a minimum total sample size of 159 participants was required to achieve statistical significance.

Study groups

The study consisted of a total of 162 patients, categorized into three groups of 54 individuals each. The first group was the control group, which did not include any subjects with impacted canines. The second group comprised individuals with unilateral, and the third group consisted of those with bilateral impacted canines.

Measurement methods and anatomical boundaries

The axial images were converted into DICOM files with a 512 × 512 matrix format and subsequently imported into Mimics Medical INK 25.0 (Materialise, Leuven, Belgium) software. All volume measurements were performed using this program, which is specifically designed for three-dimensional reconstruction and voxel-based volumetric analysis. Dedicated tools within the software were used for segmentation, region growing, and final volume calculation.

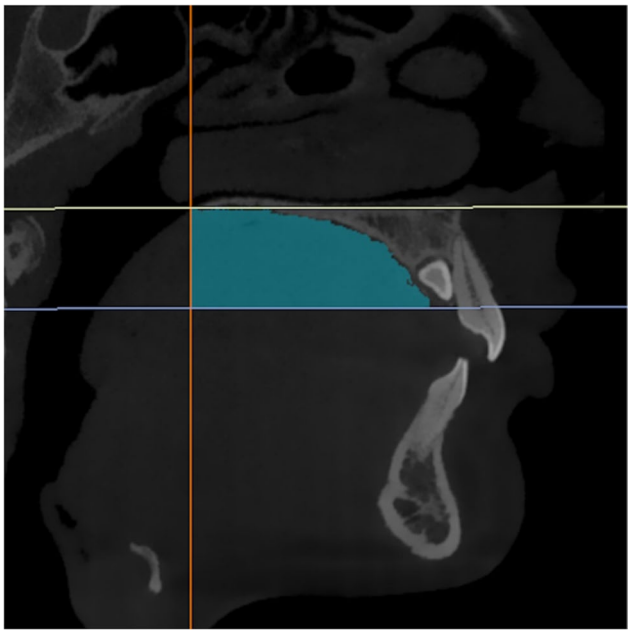


Fig. 2 Sagittal CBCT section showing the segmentation of the palate

The parameters assessed in this study were the volumes of the palatal and nasal passages. The anatomical boundaries of the nasal passages were defined based on the limits described by El and Palomo [14, 15] as follows: the nasal septum served as the dividing structure between the right and left nasal passages. The superior border was identified as the last slice in which the nasal septum intersected with the posterior wall of the nasopharynx (Fig. 1A). The inferior border was defined as a plane extending from the anterior nasal spine (ANS) to the posterior nasal spine (PNS), reaching the posterior wall of the nasopharynx. The anterior border was delineated by the nostrils, and the posterior border by the posterior wall of the nasopharynx (Fig. 1B).

According to Yassei et al. [9], the anatomical boundaries of the palatal region were defined as follows: the ANS–PNS line was used to separate the right and left sides of the palate. The superior border was defined as the highest point of the palatal vault in the sagittal view. The inferior border was a plane parallel to the ANS–PNS plane, originating at the cemento-enamel junction (CEJ) of the central incisor. The anterior border was delineated by a curve connecting the highest point of the palatal vault to the CEJ of the central incisor, following the natural curvature of the hard palate. The posterior border was defined as a plane drawn from the PNS, perpendicular to the inferior border (Fig. 2).

The nasal passage and palatal volumes were initially traced manually on axial, sagittal, and coronal slices to ensure accurate segmentation. Subsequent refinement

of these volumes was performed using the 'edit masks' tool of the software, in accordance with the specifications outlined. The dynamic region growing capability was first employed in Mimics software, enabling the extension of a mask from a selected point without the necessity of thresholding. Subsequently, the 'smart expand' tool was utilised to automatically fill the nasal passage (Fig. 1) and palate areas (Fig. 2), generating a 3D mask of these anatomical structures. The 'Crop Mask' function was used to limit the image processing to the designated area. Ultimately, the total volume was calculated using the software's 'calculate part' tool (Fig. 3), which utilised voxel addition to present the results in cubic millimetres. In each group, right, left, and total nasal passage and palatal volumes were measured. The collection of all data and measurements was conducted by an observer (S.T.H) using Mimics software, and volume measurements were performed twice by the same observer, one month later.

Statistical analysis

Statistical analyses were conducted using SPSS version 21. The Kruskal–Wallis H test was used for comparisons among three or more groups, as the data did not meet the assumptions of normality. Gender differences in nasal passage and palatal volumes were evaluated using the Mann–Whitney U test. The relationship between nasal passage and palatal volumes was evaluated using Spearman's correlation. A significance level of 0.05 was established, and p-values less than 0.05 were considered statistically significant.

Error of the method

The intraclass correlation coefficient (ICC) was employed to assess the reliability of the first and second measurements. All CBCT images were analysed, and volume measurements were repeated after one month. The ICC values ranged between 0.999 and 1, showed high reproducibility, with no significant variations detected between the two sets of measurements by the observer.

Results

The gender distribution and chronological age of the study groups are presented in Table 1.

The bilateral group exhibited significantly lower mean total palatal volumes compared to both the control and unilateral groups ($p < 0.05$). The impacted sides in both the unilateral and bilateral groups showed reduced palatal volumes relative to the non-impacted side of the unilateral and control group, whereas the non-impacted sides displayed palatal volumes comparable to those of the control group, as detailed in Table 2.

In both unilateral and bilateral impacted canine groups, the mean palatal volumes of the impaction side were determined to be 4408.62 mm^3 for the buccally impacted canines and 4738.71 mm^3 for the palatally impacted canines. No statistically significant difference was observed based on the location of impaction.

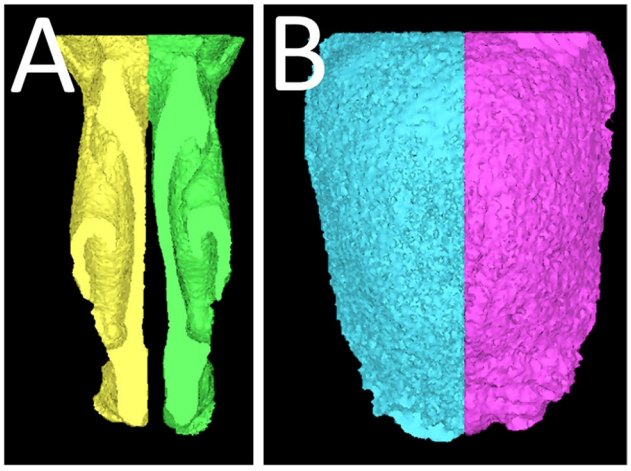


Fig. 3 3D calculation of the: (**A**) Right (yellow) and left (green) nasal passage volume; (**B**) Right (blue) and left (purple) palatal volume

Table 1 Demographic characteristics of the three study groups

Groups	Gender		Mean Age (Year) ± standard deviation
	Female (*n*)	Male (*n*)	
Control	33	21	27.3 ± 12.5
UIC	38	16	27.7 ± 13.3
BIC	31	23	28.7 ± 15.9

UIC Unilateral Impacted Canine, *BIC* Bilateral Impacted Canines

The bilateral impaction group had the lowest volumes in the left, right, and total nasal passages compared to other groups ($p < 0.05$), indicating a considerable impact of bilateral canine impaction on nasal passage volumes. The nasal passage volume on the impacted side in unilateral impaction cases was comparable to that on the non-impacted side and the control group, suggesting that unilateral impaction did not significantly influence nasal passage volume ($p > 0.05$), as demonstrated in Table 3.

Gender-based comparisons revealed no statistically significant differences in nasal passage or palatal volumes between male and female patients within any groups ($p > 0.05$), as illustrated in Table 4.

A highly significant positive relationship was noted between the volumes of the right and left palate, as well as between the volumes of the right and left nasal passages across all three groups ($p = 0.001$). No statistically significant relation was found between nasal passage and palatal volume ($p > 0.05$), as shown in Table 5.

Discussion

The aim of this study was to delineate the changes in nasal passage and palatal volume related with impacted maxillary canine and to determine the association

Table 2 Comparison of palatal volume in control and impacted groups

Palatal Volume (mm^3)		Group			Kruskal-Wallis H Test		
		n	Mean	Standard deviation	*p*	Post hoc	*p*
Total	1 = Control	54	11707.47	2276.04	< 0.001*	3 – 1	< 0.001*
	2 = UIC	54	10656.71	1828.23		1–2	0.01*
	3 = BIC	54	9144.60	2277.10		3 – 2	< 0.001*
Right	1 = Control	54	5854.64	1135.81	< 0.001*	1–2	< 0.001*
	2 = UIC (Side wIC)	31	5020.94	802.62		1–4	< 0.001*
	3 = UIC(Side woIC)	23	5478.56	1076.40		2–3	0.049*
	4= BIC	54	4552.67	1116.87		4 – 3	0.002*
Left	1 = Control	54	5852.83	1145.05	< 0.001*	1–2	0.002*
	2 = UIC (Side wIC)	23	4931.52	1007.43		2–3	0.003*
	3 = UIC (Side woIC)	31	5818.75	883.97		1–4	< 0.001*
	4 = BIC	54	4591.93	1167.77		4 – 3	< 0.001*

UIC Unilateral Impacted Canine, *BIC* Bilateral Impacted Canines, *wIC* With Impacted Canine, *woIC* Without Impacted Canine

*Significant at $p<0.05$

Table 3 Comparison of the nasal passage volume in control and impacted groups

Nasal Passage Volume (mm^3)		Group			Kruskal-Wallis H Test		
		n	Mean	Standard deviation	*p*	Post hoc	*p*
Total	1 = Control	54	13769.81	2557.15	< 0.001*	3 – 1	< 0.001*
	2 = UIC	54	13033.31	2565.43			
	3 = BIC	54	10115.45	2612.54		3 – 2	< 0.001*
Left	1 = Control	54	6847.58	1403.55	< 0.001*	4 – 1	< 0.001*
	2 = UIC (Side wIC)	23	6191.71	1277.21		4 – 2	0.002*
	3 = UIC (Side woIC)	31	6824.91	1537.87		4 – 3	< 0.001*
	4 = BIC	54	5079.66	1448.01			
Right	1 = Control	54	6922.23	1365.11	< 0.001*	4 – 1	< 0.001*
	2 = UIC (Side wIC)	31	6554.46	1348.66		4 – 2	< 0.001*
	3 = UIC (Side woIC)	23	6375.18	1422.42		4 – 3	< 0.001*
	4 = BIC	54	5035.79	1402.12			

UIC Unilateral Impacted Canine, *BIC* Bilateral Impacted Canines, *wIC* With Impacted Canine, *woIC* Without Impacted Canine

*Significant at $p<0.05$

Table 4 Comparison of total palatal and nasal passage volumes in males and females within the group

	Total Volume (mm^3)		Group			Mann-Whitney U Test
			n	Mean	Standard deviation	*p*
Control	Palatal	Female	33	11673.92	1959.10	0.950
		Male	21	11760.19	2753.58	
	Nasal Passage	Female	33	13590.19	2477.61	0.600
		Male	21	14050.35	2345.34	
UIC	Palatal	Female	38	10792.61	1831.54	0.520
		Male	16	10333.94	1837.81	
	Nasal Passage	Female	38	12885.01	2459.46	0.495
		Male	16	13385.53	2854.04	
BIC	Palatal	Female	31	9165.10	2277.41	0.979
		Male	23	9116.96	2327.57	
	Nasal Passage	Female	31	10005.94	2445.97	0.786
		Male	23	10263.06	2871.39	

UIC Unilateral Impacted Canine, *BIC* Bilateral Impacted Canines

Table 5 The correlation between nasal passage and palatal volume within and between groups

	Correlation						
	Volume (mm^3)		**Right Palatal**	**Total Palatal**	**Left Nasal Passage**	**Right Nasal Passage**	**Total Nasal Passage**
Control	Left Palatal	*r*	0.989*	0.995*	0.232	0.076	0.189
		p	0.000	0.000	0.091	0.585	0.171
	Right Palatal	*r*		. 996*	0.241	0.087	0.202
		p		0.000	0.080	0.532	0.143
	Total Palatal	*r*			0.237	0.082	0.190
		p			0.084	0.556	0.168
	Left Nasal Passage	*r*				0.679*	0.925*
		p				0.000	0.000
	Right Nasal Passage	*r*					0.890*
		p					0.000
UIC	Left Palatal	*r*	0.667*	0.917*	0.144	0.019	0.148
		p	0.000	0.000	0.300	0.894	0.286
	Right Palatal	*r*		0.894*	−0.025	0.005	0.042
		p		0.000	0.860	0.971	0.764
	Total Palatal	*r*			0.063	0.013	0.108
		p			0.650	0.925	0.438
	Left Nasal Passage	*r*				0.610*	0.893*
		p				0.000	0.000
	Right Nasal Passage	*r*					0.878*
		p					0.000
BIC	Left Palatal	*r*	0.987*	0.995*	0.089	0.166	0.121
		p	0.000	0.000	0.521	0.230	0.382
	Right Palatal	*r*		0.997*	0.101	0.165	0.130
		p		0.000	0.468	0.232	0.349
	Total Palatal	*r*			0.087	0.164	0.119
		p			0.533	0.235	0.389
	Left Nasal Passage	*r*				0.631*	0.885*
		p				0.000	0.000
	Right Nasal Passage	*r*					0.905*
		p					0.000

UIC Unilateral Impacted Canine, *BIC* Bilateral Impacted Canines

*Significant at $p<0.05$

between these impacted teeth. The null hypothesis was rejected for the bilateral impaction group, which exhibited significantly reduced total palatal and nasal passage volumes compared to both the control and unilateral groups. In contrast, it was only partially rejected for the unilateral impaction group, which showed reduced total palatal volume, while nasal passage volumes remained comparable to those of the non-impacted side and the control group.

Given the critical role of maxillary canines in facial aesthetics and functional dynamics [19], untreated cases may have substantial implications on facial asymmetry [9]. In the field of dental diagnostics, the imaging of impacted maxillary canines presents a significant challenge that is critical for devising effective treatment plans. Traditionally, two-dimensional (2D) imaging modalities (panoramic, occlusal, and periapical radiography) have been utilized to evaluate the position and status of impacted canines. While 2D imaging offers valuable insights and is widely accessible, it often falls short in providing the detailed spatial orientation necessary to fully appreciate complex impactions. In contrast, 3D imaging technologies like CBCT have revolutionised the diagnostic approach by offering comprehensive views that include precise localization and the relationship of impacted canines to surrounding structures [20]. CBCT also facilitates the performance of volumetric measurements.

Previous research has utilized digital dental models [21, 22] and CBCT [9, 23, 24] for performing three-dimensional palatal volume evaluations in subjects with impacted canines. The present study revealed that overall palatal volumes were significantly reduced in the bilaterally impacted group (9144.6 mm^3) in comparison to the unilaterally impacted group (10656.71 mm^3) and the control group (11707.47 mm^3). The unilateral group exhibited significant differences in palatal volume measurements on the impacted side (right or left) compared to the non-affected side and the control groups. These

results align with prior research, albeit with variations in study designs and measurement specifics that underscore the impact of maxillary canine impaction on reduced palatal volume. Tang [21] used dental model analysis on a sample of 31 patients with impacted canines and 31 controls, reported a decrease in palatal volume associated with impacted canines; however, the specifics regarding unilateral versus bilateral impactions and whether measurements were of total or unilateral palatal volume were not detailed. Similarly, Bizzarro [22] found that in comparison to the 30 control group, both bilateral and unilateral 30 buccal impactions result in reduced total palatal volume using a dental model. Nonetheless, Bizzarro's [22] study did not evaluate the palatal volume distinctly for the bilateral and unilateral groups, which makes the comparison with our findings difficult. Dadgar et al. [23] and Yassaei et al. [9] evaluated the individuals with 47 and 45 unilateral impacted maxillary canines, respectively, using CBCT. Both studies used Mimics Medical software (version 21.0) and found that the palatal volume on the impacted side was less than that on the healthy side, consistent with our findings.

Eid et al. [24] analysed the influence of impaction location by comparing the palatal volume between 15 patients with palatal impactions and 15 with buccal impactions using Materialise Magics 3D Print Suite software. Interestingly, Eid [24] noted no significant difference in palatal volume among individuals with buccally impacted canines, although it was reported a decrease in cases of palatal impactions. This discrepancy may be due to differences in the local effects of impaction based on its buccal or palatal orientation, suggesting that the impaction location might have differentially influenced the surrounding anatomical structures. Conversely, in the present study, the mean volume of the palate for patients with buccally impacted canines was 4408.62 mm^3, whereas for those with palatally impacted canines, it was slightly higher at 4738.71 mm^3. This could be attributed to our sample selection and research design. The research by Eid et al. [24] focused exclusively on unilateral impactions. However, in the present study, a significant number of canines impacted buccally were observed in the bilateral impaction group, suggesting that the bilateral impaction might exert a greater influence on the palatal architecture. Although no significant differences were observed, the palatal volume in the bilateral impacted group on both the right and left sides was reduced compared to the unilateral group.

Numerous studies have evaluated the changes in nasal cavity width related to various types of canine impaction. Alshehri et al. [25] reported significant differences in nasal cavity width between patients with unilateral ($n = 35$) and bilateral ($n = 24$) canine impactions. Specifically, the nasal cavity was found to be significantly wider in unilateral cases compared to the bilateral impaction group. Conversely, Kim et al. [26] and Yan et al. [7] investigated the nasal cavity widths in both buccally and palatally impacted groups, finding no statistically significant variations. These studies included both bilateral and unilateral cases but did not divide the data for bilateral and unilateral impactions, a variable thought to potentially influence the outcomes.

The measurement of nasal passage volume was determined by the superior and inferior borders established according to the methods employed by El and Palomo [27], who evaluated the reliability of three automatic airway volume measurement software programs. It was revealed that each software demonstrated lower reliability in measuring nasal passage volume. While manual segmentation provides the utmost accuracy, it is considerably more time-intensive and unsuitable for clinical use. El and Palomo [14, 15] conducted two distinct studies using the InVivoDental program to examine airway volume, encompassing both nasal and oropharyngeal airways. While our study utilized the same anatomical borders, our measurements, obtained by the Mimics program with manual segmentation, were found to be higher than those in all previous studies. It is important to note that the primary aim of the present study was not to determine accurate mean volumes within our study group but to evaluate the influence of unilateral and bilateral maxillary canine impactions on nasal passage volume. In another study, Weissheimer et al. [28] evaluated the upper airway volume using six different programs and found that OsiriX, Dolphin3D, Mimics, and ITK-Snap software exhibited comparable performance and greater accuracy than InVivoDental and Ondemand3D software. Notably, their findings indicated that volume measurements acquired with InVivoDental were slightly lower than those obtained with Mimics and other programs.

In 1962, Moss [29] published the Functional Matrix Theory, proposing that craniofacial growth and development are not solely a consequence of the skeletal system's independent evolution but are significantly influenced by the surrounding soft tissues and spaces. The head is a complex region where multiple functions, such as respiration, vision, olfaction, and digestion, are coordinated. Each function is facilitated by a specific functional cranial component consisting of two elements: a functional matrix and a supportive skeletal unit. Functional matrices, which include muscles, glands, neurovascular bundles, and teeth, interact directly with their corresponding microskeletal units. These interactions affect morphological changes through active deposition and resorption processes, hence effectively modifying the size, shape, and form of these micro-skeletal units based on operational demands [30]. Respiration and digestion

are the two essential functions of the facial region, closely related, with the roof of the oral cavity functioning as the nasal cavity floor. The correlation between respiratory function and craniofacial development has long been a subject of considerable attention and debate. Despite this, the relationship between nasal passage volume and palatal volume remains understudied in the existing literature. Moshajari et al. [31] studied the association between nasopharyngeal and palatal volume in 93 patients with various facial morphological patterns and identified no significant correlation between the two. Contrary to this study, Miranda-Viana M. et al. [32] highlighted a significant association between the hard palate dimensions and the volumes of various upper airway compartments. Specifically, measurements obtained in the first premolar region revealed that both the width and height of the hard palate correlated significantly with the total volume of the upper and nasopharyngeal airway.

Paranasal sinuses and the nasal passage are important components of the upper respiratory tract. Previous research demonstrated a decrease in maxillary sinus capacity associated with unilateral canine impaction in a palatal position [33, 34]. Despite the close relationship between maxillary canines and nasal morphology, only one article, Osman et al. [18], examined the correlation between nasal airway volume and impacted canine teeth. They evaluated the CBCT images of 48 patients without an impacted canine and 44 patients with a palatally unilateral impacted canine, discovering that the impaction group exhibited reduced nasal passage volume than the control group, using InVivo Dental version 6.0.5 (Anatomage, San Jose, Calif). Although our study observed a slight reduction in nasal passage volume on the impacted side of the unilateral group, this decrease was not statistically significant. However, the bilateral group demonstrated significantly lower nasal passage volumes compared to other groups.

In the light of these findings, the reduction in nasal and palatal volumes observed in the bilateral impaction group may suggest more pronounced anatomical limitations compared to unilateral or non-impacted cases. This reduction could potentially influence airway function and maxillofacial growth, thereby affecting both treatment outcomes and long-term patient health. These results underscore the importance of early detection of bilateral maxillary canine impaction, enabling clinicians to evaluate potential airway or skeletal constraints and to implement timely, comprehensive interventions. Treatment planning should be individualized, taking into account these anatomical differences to optimize functional and esthetic outcomes. Furthermore, cases of this nature may benefit from a multidisciplinary approach, particularly when anatomical restrictions co-exist with functional complaints such as compromised breathing or maxillary constriction.

This study had some limitations due to its retrospective design. It was not feasible to assess nasal functions or determine whether patients exhibited clinical symptoms such as oral breathing tendencies. The retrospective design restricted access to complete medical histories of patients who underwent CBCT, which impeded a thorough analysis of potential correlations between medical backgrounds and occurrences of impacted canines.

Conclusions

This study demonstrated that maxillary canine impaction, particularly when bilateral, is associated with significant reductions in nasal passage and palatal volumes. The findings underscore the anatomical significance of canine impaction in craniofacial development. These volumetric differences, identified through CBCT-based three-dimensional analysis, may indicate underlying anatomical and developmental constraints with potential implications for breathing patterns and maxillofacial growth.

Abbreviations

CBCT	Cone-Beam Computed Tomography
3D	Three-Dimensional
DICOM	Digital Imaging and Communications in Medicine
ANS	Anterior Nasal Spine
PNS	Posterior Nasal Spine
CEJ	Cemento-Enamel Junction
ICC	Intraclass Correlation Coefficient
2D	Two-Dimensional
UIC	Unilateral Impacted Canine
BIC	Bilateral Impacted Canines
wIC	With Impacted Canine
woIC	Without Impacted Canine

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Authors' contributions

Şerife Tuğçe Hasoğlan contributed to conceptualization, data collection, formal analysis, visualization, original draft preparation, and manuscript review and editing; Seçil Aksoy contributed to conceptualization, methodology, formal analysis, visualization, validation, original draft preparation, and manuscript review and editing; Kaan Orhan contributed to methodology, validation, project administration and supervision; Beste Kamiloğlu contributed to project administration and supervision.

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Data availability

No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate

The study was designed retrospectively and received ethical approval from the Near East University Scientific Research Evaluation Ethics Committee (YDU/2024/122–1826). The research was conducted in accordance with the

Helsinki Declaration. Informed consent was obtained from all participants and their legal guardians, allowing for the collection and use of their data.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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