

Research Article

Maxillary arch and sinus dimensions in patients with unilateral labial and palatal maxillary canine impaction: a CBCT study

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Abstract: Maxillary canine impaction is one of the most common orthodontic problems, which may be associated with alterations of the dental arch and adjacent maxillary structures. Cone-beam computed tomography (CBCT) allows three-dimensional assessment of the impacted canine, dental arch and maxillary sinus. **Objective:** The aim of the study was to compare maxillary arch dimensions and maxillary sinus measurements between patients with unilateral labially impacted maxillary canines, and patients with unilateral palatally impacted maxillary canines and healthy controls. **Methods:** This retrospective cross-sectional comparative study included 75 CBCT scans divided into 3 groups of 25 scans each, 25 labial impactions, 25 palatal impactions and 25 controls. Arch circumference, arch length, intermolar width, inter-first-premolar width and palatal depth were measured. Both sides were measured for the anteroposterior (AP) and mediolateral (ML) dimensions of the maxillary sinus. Comparisons between groups were performed with one-way ANOVA or Kruskal-Wallis tests and paired t-tests or Wilcoxon signed rank tests for side-to-side comparisons. **Results:** The labial group was younger than the palatal and control groups ($p=0.001$). The groups also differed in sex distribution ($p=0.010$). There was no significant difference for arch circumference ($p=0.454$), arch length ($p=0.300$), intermolar width ($p=0.694$), inter-first-premolar width ($p=0.375$) and palatal depth ($p=0.294$). The right and left sinus AP and ML measurements and the bilateral mean measurements were not significantly different among the three groups. AP and ML measurements in the labial group did not show difference between impacted and contralateral sides ($p=0.449$ and $p=0.213$). Similar findings were seen for the palatal group ($p=0.404$ and $p=0.918$). **Conclusions:** There was no statistically significant difference in the measured general arch dimensions or linear maxillary sinus dimensions associated with unilateral labial or palatal maxillary canine impaction. There may be small local anatomical changes around the impacted tooth that should be taken into consideration when formulating diagnosis and treatment planning.

Keywords: Cone-beam computed tomography; Impacted canine; Maxillary arch; Maxillary sinus; Orthodontics

INTRODUCTION

Maxillary canine impaction is one of the most frequent problems in orthodontic practice. The maxillary canines are one of the most commonly impacted teeth after the third molars. The frequency and location of impaction vary between different populations, but the reported prevalence is usually about 1-3%. Unilateral impaction is more common than bilateral and a higher prevalence among females have been reported in several studies. The location of the impacted canine is different, too. In many Caucasian populations palatal impaction is more common, whereas a greater proportion of labial or buccal impaction has been reported in some other populations. These differences suggest that genetic background, local

anatomy, and environmental factors could all play a role. [1,2]

Maxillary canine impaction is believed to be the result of a variety of factors. Two main theories, guidance theory and genetic theory, have been put forth to explain palatally displaced canines. The genetic theory links canine impaction with inherited dental features such as differences in the number, size and shape of teeth. According to the guidance theory, the erupting canine usually follows the distal surface of the root of the lateral incisor. When the lateral incisor is missing, small or malformed, this eruption path can be disrupted. Labial impaction would seem to have a somewhat different

pattern and is more often associated with lack of space and crowding within the dental arch. The differences between labial and palatal impactions justify treating them as separate entities for investigation rather than all impacted canines being grouped together. [1,3]

The maxillary canine is an important tooth both from an esthetic and functional point of view. Failure of normal eruption may be associated with loss of arch space, displacement of adjacent teeth, changes in inclination of adjacent teeth, cyst formation and root resorption. Also, the position and severity of impaction can affect the difficulty and duration of orthodontic treatment. Goh et al. found that patients with palatal and labial or mid-alveolar impacted canines had longer treatment duration than controls and that longer treatment was related to greater displacement and rotation of the impacted tooth. Therefore, a good knowledge of the position of the tooth and the surrounding maxillary anatomy is important in the planning of the orthodontic treatment. [1,4]

Several studies using CBCT have evaluated whether or not canine impaction is associated with differences in maxillary arch dimensions, but the results are not completely consistent. Sharhan et al. found that patients with unilateral or bilateral impacted canines had smaller intermolar, interpremolar and intercanine widths, shorter arch length and smaller arch perimeter than controls. Sokmen et al. also reported decreased alveolar and dental widths in the premolar area on the side of palatal impaction. These findings suggest that canine impaction may be associated with reduced transverse development or reduced available arch space. [1,3]

Other studies have reported a different pattern. Saade et al. reported that the widths of first-premolar, second-premolar and first-molar were greater in patients with unilateral palatally displaced canines than in matched controls. Firincioglugulari et al. observed that patients with labially impacted canines had a decreased mid-root palatal width and smaller intermolar width, and both labial and palatal impaction groups had a reduced arch perimeter compared with controls. These differences could be related to the type of impaction, age, sex, ethnic background, sampling, presence of retained primary teeth, and differences in measurement landmarks. Therefore, separate evaluation of the labial and palatal impaction may give better understanding of its relation to maxillary arch morphology. [2,5]

The maxillary sinus is another anatomical structure that might be related to an impacted maxillary canine. It is a large air-filled cavity in the maxilla and its floor lies in close proximity to the alveolar process. The closest relationship is usually with the premolar and molar roots, but an ectopically placed canine may also be in close

proximity to the sinus. Oz et al. reported changes in sinus volume after orthodontic movement of impacted canines using CBCT to compare sinus volumes on the impacted and contralateral sides. Additionally, Abu Alhaija et al. evaluated the maxillary sinus height, width and volume in patients with unilateral palatal and buccal displaced canines which support the significance of investigating the sinus morphology in relation to the position of the displaced canine. [6,7]

Recent studies have shown that the correlation between dog impaction and the size of the maxillary sinus is not clear. Kurnaz et al. investigated patients with unilaterally palatally impacted canines using semiautomatic 3D segmentation. The maxillary and molar basal widths were smaller on the impacted side, but there was no significant difference in the sinus volume between the impacted and non-impacted sides. Horacek et al. also demonstrated that CBCT can provide reproducible linear and volumetric measurements of the maxillary sinus and impacted canine in different anatomic planes. [8,9]

CBCT is useful in this type of investigation as it gives three dimensional views without the superimposition seen in conventional two dimensional radiographs. It provides precise localization of impacted canines, assessment of the neighboring teeth, maxillary bone, dental arch and maxillary sinus in axial, coronal and sagittal planes. This allows for a full assessment of anatomical changes that may be related to canine impaction. [3,8]

However, few studies have measured maxillary arch dimensions and maxillary sinus measurements simultaneously, distinguishing unilateral labial and palatal impactions and comparing both with healthy controls. Previous results of transverse arch dimensions and sinus studies have been inconsistent, mainly limited to palatal impaction or only the contralateral side as a control. This results in the need for a study to evaluate both arch and sinus morphology with one standardized CBCT approach. [5,6,8,10]

The aim of this study was to quantitatively evaluate and compare the maxillary arch dimensions and maxillary sinus parameters in patients with unilateral labially impacted maxillary canines, patients with unilateral palatally impacted maxillary canines and healthy controls using cone-beam computed tomography (CBCT). The study was conducted on arch circumference, arch length, intermolar width, inter-first-premolar width, palatal depth and bilateral maxillary sinus AP and ML dimensions. Further comparison was made between impacted and contralateral sides.

MATERIALS AND METHODS

This retrospective cross-sectional comparative study was carried out in Erbil, Kurdistan Region of Iraq. Existing cone-beam computed tomography (CBCT) scans previously obtained for clinical and diagnostic purposes were reviewed. No new CBCT examination was performed for the purpose of the present study. The study compared maxillary arch dimensions and maxillary sinus measurements between patients with unilateral labially impacted maxillary canines, patients with unilateral palatally impacted maxillary canines and subjects with normally erupted maxillary canines.

A total of 75 eligible CBCT scans were included and evenly divided into 3 groups. Group A included 25 subjects with a unilateral labially impacted permanent maxillary canine, Group B included 25 subjects with a unilateral palatally impacted permanent maxillary canine and Group C included 25 control subjects with normally erupted maxillary canines and Class I occlusion.

The inclusion criteria for the impaction groups were: single unilateral impacted permanent maxillary canine; complete eruption of permanent dentition except third molars; no previous orthodontic treatment; diagnostic quality CBCT scan covering the complete maxilla and both maxillary sinuses. Control subjects had bilateral erupted maxillary canines, class I occlusion, no history of maxillary canine impaction, no previous orthodontic treatment, and adequate cone beam computed tomography (CBCT) coverage of the maxilla and both maxillary sinuses. Patients were excluded if there was a history of facial trauma involving the maxilla, cleft lip or palate, major craniofacial anomaly, previous maxillofacial surgery affecting the study area, maxillary lesions or tumors, or marked maxillary sinus pathology. Studies with poor image quality, large artifacts, or incomplete coverage were also excluded.

In each subject, the age, sex, side of impaction and the position of the impacted canine were recorded. Multiplanar CBCT views were used to assess the position of each affected canine. Axial, coronal, sagittal and cross-sectional images were used to assess the position of the crown and root of the canine in relation to the dental arch and alveolar process. When the crown of the canine was mostly positioned on the palatal side of the dental arch and alveolar process, it was classified as palatally impacted, and when the crown was mostly positioned toward the buccal or labial side, it was classified as labially impacted.

Before measurement, the CBCT datasets were aligned in standardized anatomical planes. Axial, coronal and sagittal views were adjusted to maintain the same orientation between subjects. Scans were excluded if the

landmarks could not be identified with sufficient resolution.

The measurements of the maxillary arch used in the final analysis were arch circumference, arch length, intermolar width, inter-first-premolar width and palatal depth. The arch perimeter was the curved length of the maxillary dental arch. Arch length was measured from the anterior midline to a posterior reference line. Measurements of intermolar and inter-first-premolar widths were taken between identical bilateral landmarks on the teeth. Palatal depth was measured vertically from the chosen palatal reference plane. All linear measurements were in millimeters.

Maxillary sinuses were assessed individually. The final analysis included maximum anteroposterior (AP) depth and mediolateral (ML) width at the right and left sides. The sinus measurements on the impacted side were compared with the sinus measurements on the non-impacted side in unilateral canine impaction patients. Right and left sinus measurements were analyzed in the control group using the same methodology.

The data were entered in a coded data sheet and analyzed using SPSS. Continuous variables were expressed as mean and standard deviation if they were approximately normally distributed and as median and interquartile range if they were skewed. Categorical variables were summarized as counts and percentages. The inferential analysis was preceded by a check for normality.

When assumptions for parametric analysis were satisfied, comparisons of continuous measures among the 3 study groups were made using one-way analysis of variance (ANOVA). For variables not normally distributed, the Kruskal-Wallis test was used. Categorical variables were compared using the chi-square test or the Fisher exact test when appropriate. For the comparison of impacted and contralateral side within patients, the paired t-test was used when the paired differences were normally distributed and the Wilcoxon signed-rank test was used for the non-normally distributed paired data. The labial and palatal groups were compared for side-to-side differences by the independent t-test or Mann-Whitney U test, as appropriate. All statistical tests were two-sided. A p value <0.05 was considered significant.

The study used existing clinical CBCT records, so no additional radiation exposure was given for research purpose. The ethics committee and administrative permission were obtained before access to the records was given. All CBCT records were de-identified prior to analysis; electronic data were stored in a secure location with restricted access to the authorized research team.

RESULTS

Characteristics of the Study Groups

The mean age of the total study sample was 24.36 ± 8.58 years. Age was not normally distributed in all groups; therefore, the Kruskal-Wallis test was used. The median age was 19 years in the labial impaction group, 25 years in the palatal impaction group, and 27 years in the control group. There was a statistically significant difference in age among the three groups ($p=0.001$).

The labial impaction group was significantly younger than the palatal group (adjusted $p=0.014$) and significantly younger than the control group (adjusted $p=0.003$). No significant difference was found between the palatal and control groups.

Out of the 75 subjects, 51 (68.0%) were female and 24 (32.0%) were male. Females represented 22 of 25 patients (88.0%) in the labial impaction group, 12 of 25 (48.0%) in the palatal group, and 17 of 25 (68.0%) in the control group. The difference in sex distribution among the groups was statistically significant ($p=0.010$).

The labial group included 12 right-sided impactions (48.0%) and 13 left-sided impactions (52.0%). The palatal group included 15 right-sided impactions (60.0%) and 10 left-sided impactions (40.0%). There was no statistically significant difference in the distribution of the impaction side between the labial and palatal groups ($p=0.571$).

Table 1. Demographic characteristics of the study groups

Variable	Labial impaction (n=25)	Palatal impaction (n=25)	Control (n=25)	p-value
Age, years, median (IQR)	19 (15-24)	25 (21-27)	27 (22-34)	0.001*
Female, n (%)	22 (88.0%)	12 (48.0%)	17 (68.0%)	0.010**
Male, n (%)	3 (12.0%)	13 (52.0%)	8 (32.0%)	
Right impaction, n (%)	12 (48.0%)	15 (60.0%)	-	0.571***
Left impaction, n (%)	13 (52.0%)	10 (40.0%)	-	

*Kruskal-Wallis; **Chi-square; ***Fisher's exact; IQR: interquartile range.

Comparison of Maxillary Arch Dimensions

The mean arch circumference $\pm$ SD was 82.49 ± 6.09 mm in the labial impaction group, 80.92 ± 4.66 mm in the palatal impaction group, and 82.63 ± 5.13 mm in the control group. One-way ANOVA showed no statistically significant difference among the three groups ($p=0.454$).

The mean arch length $\pm$ SD was 23.70 ± 2.67 mm in the labial group, 22.96 ± 2.14 mm in the palatal group, and 23.93 ± 1.97 mm in the control group. There was no significant difference among the three groups ($p=0.300$).

The mean intermolar width $\pm$ SD was 52.05 ± 3.59 mm in the labial group, 52.11 ± 3.77 mm in the palatal group, and 52.84 ± 3.47 mm in the control group. One-way ANOVA showed that the difference was not statistically significant ($p=0.694$).

The inter-first-premolar width was not normally distributed in the labial group. Therefore, the Kruskal-Wallis test was used. The median inter-first-premolar width was 42.9 mm in the labial group, 40.8 mm in the palatal group, and 42.0 mm in the control group. No statistically significant difference was found among the groups ($p=0.375$).

The mean palatal depth $\pm$ SD was 19.64 ± 2.35 mm in the labial group, 19.71 ± 2.26 mm in the palatal group, and 20.56 ± 2.26 mm in the control group. The difference among the three groups was not statistically significant ($p=0.294$). Overall, none of the measured maxillary arch dimensions showed a statistically significant difference between patients with labial canine impaction, patients with palatal canine impaction, and control subjects.

Table 2. Comparison of maxillary arch dimensions among the three groups

Maxillary arch measurement	Labial impaction (n=25)	Palatal impaction (n=25)	Control (n=25)	p-value
Arch circumference (mm), mean $\pm$ SD	82.49 $\pm$ 6.09	80.92 $\pm$ 4.66	82.63 $\pm$ 5.13	0.454*
Arch length (mm), mean $\pm$ SD	23.70 $\pm$ 2.67	22.96 $\pm$ 2.14	23.93 $\pm$ 1.97	0.300*
Intermolar width (mm), mean $\pm$ SD	52.05 $\pm$ 3.59	52.11 $\pm$ 3.77	52.84 $\pm$ 3.47	0.694*
Inter-first premolar width (mm), median (IQR)	42.9 (39.8-43.8)	40.8 (39.0-43.5)	42.0 (39.9-44.4)	0.375**
Palatal depth (mm), mean $\pm$ SD	19.64 $\pm$ 2.35	19.71 $\pm$ 2.26	20.56 $\pm$ 2.26	0.294*

*One-way ANOVA; **Kruskal-Wallis; IQR: interquartile range.

Comparison of Maxillary Sinus Dimensions Among the Three Groups

For the right maxillary sinus, the mean AP dimension $\pm$ SD was 34.17 $\pm$ 3.67 mm in the labial group, 34.42 $\pm$ 3.21 mm in the palatal group, and 35.76 $\pm$ 3.78 mm in the control group. There was no significant difference among the three groups (p=0.246).

The right sinus ML measurement was not normally distributed in all groups. The median right ML dimension was 21.5 mm in the labial group, 23.4 mm in the palatal group, and 26.4 mm in the control group. The control group showed a higher median value, but the difference did not reach statistical significance (Kruskal-Wallis test, p=0.053).

For the left maxillary sinus, the mean AP dimension $\pm$ SD was 33.38 $\pm$ 3.72 mm in the labial group, 33.88 $\pm$ 3.74 mm in the palatal group, and 35.56 $\pm$ 3.65 mm in the control group. Although the control group showed a slightly higher value, the difference was not statistically significant (p=0.098).

The median left sinus ML dimension was 22.7 mm in the labial group, 24.9 mm in the palatal group, and 26.4 mm in the control group. No statistically significant difference was found among the groups (p=0.458).

The bilateral mean AP dimension $\pm$ SD was 33.77 $\pm$ 3.58 mm in the labial group, 34.15 $\pm$ 3.30 mm in the palatal group, and 35.66 $\pm$ 3.58 mm in the control group. There was no significant difference among the groups (p=0.136). The bilateral mean ML dimension also showed no significant difference among the three groups, with median values of 21.85 mm, 24.05 mm, and 26.40 mm, respectively (p=0.171).

Table 3. Comparison of maxillary sinus dimensions among the three groups

Sinus measurement	Labial impaction (n=25)	Palatal impaction (n=25)	Control (n=25)	p-value
Right sinus AP (mm), mean $\pm$ SD	34.17 $\pm$ 3.67	34.42 $\pm$ 3.21	35.76 $\pm$ 3.78	0.246*
Right sinus ML (mm), median (IQR)	21.5 (20.6-25.0)	23.4 (20.7-25.7)	26.4 (21.6-27.6)	0.053**
Left sinus AP (mm), mean $\pm$ SD	33.38 $\pm$ 3.72	33.88 $\pm$ 3.74	35.56 $\pm$ 3.65	0.098*
Left sinus ML (mm), median (IQR)	22.7 (21.9-24.8)	24.9 (21.3-26.4)	26.4 (21.3-27.6)	0.458**
Bilateral mean AP (mm), mean $\pm$ SD	33.77 $\pm$ 3.58	34.15 $\pm$ 3.30	35.66 $\pm$ 3.58	0.136*
Bilateral mean ML (mm), median (IQR)	21.85 (20.95-24.30)	24.05 (21.00-25.30)	26.40 (22.10-27.90)	0.171**

*One-way ANOVA; **Kruskal-Wallis; AP: anteroposterior; ML: mediolateral; IQR: interquartile range.

Comparison of the Impacted Side With the Contralateral Side

In the labial group, the mean AP dimension $\pm$ SD was 33.62 $\pm$ 3.59 mm on the impacted side and 33.93 $\pm$ 3.84 mm on the contralateral side (p=0.449). The mean ML dimension $\pm$ SD was 22.96 $\pm$ 3.49 mm on the impacted side and 23.53 $\pm$ 3.59 mm on the contralateral side (p=0.213).

In the palatal group, the mean AP dimension $\pm$ SD was 33.96 ± 3.31 mm on the impacted side and 34.34 ± 3.67 mm on the contralateral side ($p=0.404$). The mean ML dimension $\pm$ SD was 23.67 ± 4.12 mm on the impacted side and 23.62 ± 4.33 mm on the contralateral side ($p=0.918$).

In the control group, the right and left sinus measurements were also very similar. AP dimensions $\pm$ SD were 35.76 ± 3.78 mm on the right and 35.56 ± 3.65 mm on the left ($p=0.862$), while ML dimensions $\pm$ SD were 25.28 ± 3.53 mm and 24.98 ± 3.58 mm, respectively ($p=0.337$). Overall, all p-values were greater than 0.05, showing that canine impaction was not associated with a significant change in AP or ML sinus dimensions on the impacted side.

Table 4. Comparison of maxillary sinus dimensions between impacted and contralateral sides

Group and measurement	Impacted/right side, mean $\pm$ SD (mm)	Contralateral/left side, mean $\pm$ SD (mm)	Mean difference $\pm$ SD (mm)	p-value
Labial impaction - AP (n=25)	33.62 ± 3.59	33.93 ± 3.84	-0.31 ± 2.03	0.449*
Labial impaction - ML (n=25)	22.96 ± 3.49	23.53 ± 3.59	-0.57 ± 2.24	0.213*
Palatal impaction - AP (n=25)	33.96 ± 3.31	34.34 ± 3.67	-0.39 ± 2.28	0.404*
Palatal impaction - ML (n=25)	23.67 ± 4.12	23.62 ± 4.33	0.05 ± 2.30	0.918*
Control - AP (n=25)	Right: 35.76 ± 3.78	Left: 35.56 ± 3.65	0.19 ± 2.00	0.862**
Control - ML (n=25)	Right: 25.28 ± 3.53	Left: 24.98 ± 3.58	0.30 ± 1.53	0.337*

*Paired t-test; **Wilcoxon signed-rank. For impaction groups, difference = impacted side minus contralateral side. For controls, difference = right side minus left side.

Comparison of Side-to-Side Changes Between Labial and Palatal Impaction

For the AP dimension, the mean difference was -0.31 ± 2.03 mm in the labial group and -0.39 ± 2.28 mm in the palatal group. There was no significant difference between the two groups ($p=0.901$).

For the ML dimension, the mean difference was -0.57 ± 2.24 mm in the labial group and 0.05 ± 2.30 mm in the palatal group. This difference was also not significant ($p=0.338$).

The absolute AP difference was 1.20 mm in the labial group and 1.50 mm in the palatal group ($p=0.712$). The absolute ML difference was 1.70 mm and 1.80 mm, respectively ($p=0.923$). Overall, all p-values were greater than 0.05, showing that the amount of sinus side-to-side difference was similar in patients with labial and palatal canine impaction.

Table 5. Comparison of sinus side-to-side differences between labial and palatal impaction groups

Side-to-side measurement	Labial impaction (n=25)	Palatal impaction (n=25)	p-value
AP difference, mean $\pm$ SD (mm)	-0.31 ± 2.03	-0.39 ± 2.28	0.901*
ML difference, mean $\pm$ SD (mm)	-0.57 ± 2.24	0.05 ± 2.30	0.338*
Absolute AP difference, median (IQR), mm	1.20 (0.50-2.20)	1.50 (0.60-3.00)	0.712**
Absolute ML difference, median (IQR), mm	1.70 (1.00-2.40)	1.80 (0.60-2.70)	0.923**

*Independent t-test; **Mann-Whitney U test; AP: anteroposterior; ML: mediolateral; IQR: interquartile range.

DISCUSSION

The aim of the present study was to compare maxillary arch and maxillary sinus dimensions in patients with labially impacted canines, palatally impacted canines and healthy controls using CBCT. Women made up 68.0% of the total sample. No significant difference was observed also in the side of impaction between the labial and palatal groups ($p=0.571$). This result is in agreement with the study done by Ali et al., Iraq, 2021, where impacted

maxillary canines were more common in females and Right and left impactions were almost equally distributed, 48.2% and 51.8% respectively. It is also close to Firincioglulari et al., North Cyprus, 2024, who reported that 57.8% of their unilateral canine impaction patients were females and no significant association between impaction position and side. Also, Eid et al., Egypt, 2025 reported that there was no significant right-left difference in impacted teeth ($p=0.63$). Similar female predominance is also reported in orthodontic literature from Nepal.

These findings indicate that sex may be associated with occurrence of canine impaction, while the side of the right or left does not seem to have a definite impact. [5,11-13]

In the present study, no significant differences were observed in maxillary arch dimensions among the labial, palatal and control groups. The arch circumference was 82.49 ± 6.09 mm, 80.92 ± 4.66 mm, and 82.63 ± 5.13 mm ($p=0.454$). There was also no significant difference in arch length, intermolar width, inter first premolar width and palatal depth. This result was similar to Firincioguluri et al., North Cyprus, 2024, who found no significant group differences in palatal depth or arch length. However, they reported smaller arch perimeter in both labial and palatal impaction groups and lower intermolar width in labial group. Sharhan et al, China, 2022 also observed smaller intermolar, interpremolar, intercanine widths, arch length and arch perimeter in subjects with canine impaction compared to controls. In contrast, Saade et al, USA, 2023 found that patients with unilateral palatally displaced canines had wider first premolar, second premolar and first molar widths than controls. Turkey, 2024 Sokmen et al. Narrower first premolar region and decreased arch perimeter on the palatal impaction side These differences between studies may relate to different measurement points, differences in age and sex, sample size and measurement of the whole dental arch or only the affected quadrant. [1-3,5]

Some previous studies showed differences and there is not a single pattern of maxillary arch form associated with canine impaction. Some studies found smaller dimensions, and some wider dimensions. The three groups in our study had very similar intermolar widths, with means of 52.05 mm, 52.11 mm and 52.84 mm. Thus the position of the dog may not be sufficient to cause a great change in the total width of the maxillary arch. Kurnaz et al., Turkey, 2026 found a smaller posterior maxillary basal dimension on the side of palatal impaction, but this was primarily a local side-to-side change rather than a general reduction in all maxillary measurements. This may explain why studies of quadrant or local bone measurements can detect differences not seen with measurement of the entire arch. [1-3,5,8]

The present study also did not show any significant difference in maxillary sinus AP and ML dimensions among the three groups. Mean ($\pm$ SD) AP values were $33.77 (\pm 3.58)$ mm in the labial group, $34.15 (\pm 3.30)$ mm in the palatal group and $35.66 (\pm 3.58)$ mm in controls ($p=0.136$). There was also no significant difference in the bilateral ML measures ($p=0.171$). Controls had a higher right ML measurement but the p-value was a bit close to the significance level ($p=0.053$), but still above 0.05. This finding is in accordance with Kurnaz et al., Turkey, 2026 who reported almost similar sinus volumes in the

palatally impacted and non impacted sides with no significant difference. Similarly, no significant difference in sinus volume after treatment was reported by Horacek et al., Czech Republic, 2023. These findings suggest that the presence of an impacted canine does not always cause a significant modification of the size of the maxillary sinus. [8,9]

Other studies, however, have reported changes in sinus. Oz et al., Turkey, 2017 reported that the maxillary sinus on the impacted side could be significantly smaller before treatment, but after eruption of the canine, there was no significant difference between the affected and contralateral sides. Recently, Kumari et al., India, 2025 reported a significantly smaller pretreatment sinus volume on the impacted side $10,970.67 \pm 805.37$ mm³ vs. $12,698.00 \pm 791.86$ mm³ on the non-impacted side ($p<0.001$). This difference was absent after orthodontic treatment ($p=0.468$). Their finding partly differs from that in the present study. One possible explanation is that the present study measured linear AP and ML dimensions, whereas these studies measured complete three-dimensional sinus volume. A sinus may be similar in AP and ML dimensions but differ in overall volume due to changes in height, sinus floor shape, or local contour. [7,14]

A key finding of the present study was the similarity between impacted and contralateral sides within the same patient. AP measurements of the labial group were 33.62 ± 3.59 mm in the impacted side and 33.93 ± 3.84 mm in the other side ($p=0.449$) and ML measurements were 22.96 ± 3.49 mm and 23.53 ± 3.59 mm ($p=0.213$). Similarly, the palatal group did not show any significant difference between the sides in AP and ML dimensions. This result was similar to Kurnaz et al. Turkey, 2026 who reported no significant difference in sinus volume between palatal impaction and non-impaction sides. However Eid et al., Egypt, 2024 showed that there may be local skeletal changes around impacted canines. They found differences in local maxillary bone and palatal measurements between the affected and unaffected sides. Thus, canine impaction can cause local changes in the bone but not necessarily affect the overall linear dimensions of the maxillary sinus as a whole. [8,10]

This is also supported by Light et al., 2022 who found that unilateral canine impaction was associated with changes in the inclination of adjacent incisor roots, mainly on the side of the impacted canine with little effect on the opposite side. Therefore, the effect of canine impaction may be more localized around the canine, adjacent roots and alveolar bone rather than a general change in the whole maxilla or maxillary sinus. This could explain why the present study found very small AP and ML side-to-

side differences even when impacted canines are known to affect surrounding structures. [10,15]

The degree of sinus asymmetry was also similar when labial and palatal impactions were directly compared. The AP side-to-side difference in labial group was -0.31 ± 2.03 mm, and in palatal group was -0.39 ± 2.28 mm ($p=0.901$). The corresponding differences for ML were -0.57 ± 2.24 mm and 0.05 ± 2.30 mm ($p=0.338$). Therefore, neither impaction position resulted in greater sinus asymmetry. This is different from Kumari et al., India, 2025 who found a difference in sinus volume based on buccal or palatal canine position and reported a greater change in sinus volume following treatment of palatally impacted canines. Again this difference may be due to the use of three dimensional volume in their study versus linear measurements in the present work. Their study was also prospective and evaluated changes after orthodontic traction, whereas our study was cross-sectional and evaluated the anatomy before treatment. [14]

The present study did not show major differences in general arch or sinus dimensions, but CBCT is still important for patients with impacted maxillary canines. Ngo et al. , USA, 2018 Strong association between the location of impacted canines on panoramic radiographs and their actual labial or palatal location on CBCT. Certain canine positions were associated with root resorption. Ali et al., Iraq, 2021 also showed that impacted maxillary canines can cause root resorption of adjacent incisors. Goh et al., Australia, 2024 also found an association between canine displacement, rotation and apical shape and a longer orthodontic treatment. These results suggest that the clinical importance of CBCT is not just to measure arch or sinus size. It also helps the orthodontist to find the exact position of the canine, its relation with the neighboring roots and the sinus, possible complications and the expected difficulty of treatment. [4,11,16]

There are some limitations in the current study. This was a retrospective study with 25 subjects in each group . The distribution of the groups was not equal in regard to age and sex, the labial group being younger and having more females. Also, the final analysis used linear AP and ML sinus dimensions, rather than full three-dimensional sinus volume. These factors may impact the ability to detect small anatomical differences. Larger, age- and sex-matched groups and full 3D sinus segmentation in future studies will help elucidate the relationship between canine impaction and maxillary anatomy.

CONCLUSION

The measured maxillary arch dimensions were not significantly different in labial impaction, palatal impaction and control groups. The maxillary sinus AP and ML dimensions were also not different among the three

groups. There was no significant difference between the impacted and contralateral side for labial or palatal impaction. These results show that unilateral canine impaction does not produce a significant change in the general linear dimensions of the maxillary arch or sinus, although small local changes around the impacted tooth may still exist.

RECOMMENDATIONS

Larger sample size studies with similar age and sex distribution among the groups should be included in the future. In addition to AP and ML dimensions, we suggest measuring the total 3D maxillary sinus volume and sinus height. Local bone width and volume around the impacted canine should also be studied because changes may be confined to the affected region. Prospective studies before and after orthodontic traction are recommended to ascertain whether treatment alters the size of the maxillary sinus. CBCT should continue to be used for diagnosis and treatment planning when detailed three-dimensional assessment is needed.

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