*Original Article*

# Evaluation of nasal septal deviation and maxillary bone and nasal airway dimensions and volumes using cone-beam computed tomography in patients with unilateral palatal canine displacement: a retrospective study

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## ABSTRACT

**Objectives:** To detect any association between palatally displaced canine (PDC) and nasal septal deviation (NSD), palatal bone thickness and volume, and nasal airway dimensions and volume.

**Materials and Methods:** A total of 92 patients were included and subdivided into two groups: group 1, unilateral PDCs (44 patients), and group 2, normally erupted canines (NDCs) (48 subjects). The following variables were measured using cone-beam computed tomography: presence and type of NSD, nasal width, inferior conchae, hard palate and nasal septum thickness, maxillary bone and nasal airway volumes.

**Results:** NSD was detected in 77% and 50% of PDC and NDC subjects, respectively. Within the PDC subjects, significant differences between the displaced and nondisplaced sides were detected. Palate thickness was increased in the canine region and reduced in the molar region. Compared with the control group, PDC subjects had reduced palate thickness and lower nasal airway volume. Two predictors were significant for predicting the odds of PDC occurrence: NSD and maxillary bone volume.

**Conclusions:** NSD is more frequent in PDC subjects. PDC subjects have reduced palate thickness and decreased nasal airway volume. In the presence of NSD, the odds of developing PDC increase by 3.35 times, and for each one-unit increase in the maxillary bone volume, the odds of developing PDC decrease by 20%. (*Angle Orthod*. 0000;00:000–000.)

**KEY WORDS:** Nasal septal deviation; Palatally displaced canine; Nasal airway volume; Maxillary bone volume

## INTRODUCTION

The nasal septum is the wall dividing the nasal cavity into symmetrical right and left sides. It supports the nose, influencing its appearance and helping to regulate airflow.[1] Any curvature of the nasal septum caused by bone or cartilage is regarded as nasal septal deviation (NSD), which is defined as the displacement, either of the bone, cartilage of the septum, or both, toward one side of the nasal cavity.[2] NSD is a common disorder with reported incidence varying between 8.8% and 75%.[1] It can be congenital or acquired. Trauma to the septum at normal birth has been suggested as a common cause for NSD.[3,4] Also, injuries during childhood, especially from contact sports, are considered the main risk factors for NSD in children and adults.[4]

The maxillary bone and nasal structures have anatomical connection during craniofacial development. The nasal septum affects nasal bone growth and hence the morphology of the face.[5] Nasal airflow was reported as one of the possible determinants of maxillary sinus growth and development.[6] Therefore, NSD, which reduces airflow in the nose, could affect maxillary volume.[7,8]

NSD may have effects on the development of the face and the maxilla, leading to asymmetries of the palatal

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region and nasal floor.[9] D'Ascanio et al.[10] found that children with NSD had reduced maxillary intermolar width. Akbay et al.[11] reported an association between posterior NSD and an increased palatal depth. However, Ballanti et al.[5] reported no association between transverse maxillary deficiencies and NSD.

Yassaei et al.[12] evaluated maxillary arch width, volume, and depth in patients with unilateral PDCs and reported that PDC subjects had reduced maxillary arch width and volume. The narrowness of the maxillary arch found in NSD subjects may affect the eruption of permanent maxillary canine teeth, which erupt around 11–13 years of age.[13] Erhamza and Akan[14] reported that 70% of subjects with a buccal ectopic canine had NSD. Although the effect of NSD on the palatal, maxillary sinus, and nasal airway dimensions and volume has been studied before,[5,10,11,14,15] no study has reported on the association between NSD and PDCs. Therefore, this study was conducted with the following objectives:

1. To investigate NSD, palate thickness and volume, and lower nasal airway dimensions and volume in subjects with unilateral PDC
2. To compare those variables between displaced and nondisplaced sides of PDC subjects and between PDC subjects and controls
3. To detect any association between PDCs and the studied variables.

## MATERIALS AND METHODS

This study was reviewed and approved by the Institutional Review Board (No. 145/132/2020) of Jordan University of Science and Technology (JUST). Cone-beam computed tomography (CBCT) images were taken between January 2014 and December 2022 and screened for the presence of unilateral PDCs. Inclusion criteria included age $\geq$18 years, nonsyndromic and noncleft patients, no history of any surgical intervention in the nose, no history of trauma, no previous orthodontic treatment, no buccal crossbites, all permanent teeth present, nonsmokers, and no presence of cysts or other pathology.

Maxillary canines were considered as palatally displaced if they appeared palatal to a line connecting the roots of adjacent teeth at any level of the canine crown and nondisplaced if they were erupted normally in the dental arch (Figure 1). A total of 92 patients were included in the study and subdivided into two groups:

- Group 1 (PDC): unilateral PDCs in 44 patients (34 females, 10 males; 26 on the right side, 18 on the left side; average age 25.30 $\pm$ 3.37 years). Of the total PDC subjects, 19 had Class I, 15 Class II, and 10 Class III skeletal malocclusion (based on ANB angle), and 7 subjects had a reduced, 21 subjects had a normal, and 16 subjects had an increased maxillary/mandibular plane (max/mand°) angle.
- Group 2 (NDC control): normally erupted canines on both sides in 48 subjects (37 females and 11 males; average age 28.00 $\pm$ 4.50 years). The CBCT images for this group used as control subjects were taken to assess the treatment decision for impacted third molars. Of the total NDC subjects, 25 had Class I, 9 Class II, and 14 Class III skeletal malocclusion (based on ANB angle) and 8 subjects had a decreased, 23 subjects had a normal, and 17 subjects had an increased max/mand° plane angle.

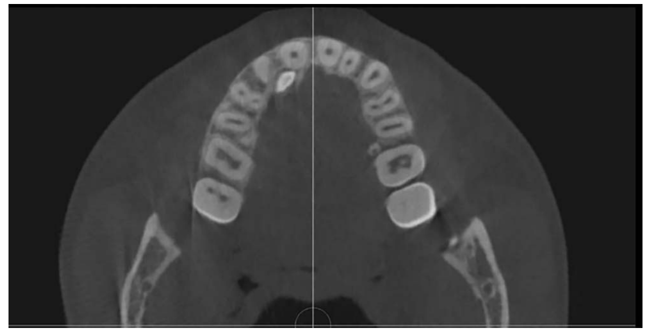

**Figure 1.** Palatally displaced canine.

### CBCT Images

A CS 9500 Cone Beam 3D System (Carestream Health, Rochester, NY, USA) with a flat panel detector located at the Dental Teaching Center/JUST was used. The CBCT images were 0.2-mm slices of a medium field of view (FOV), where the maxillofacial area was examined at a tube voltage of 90 kV, current of 10 mA, and an exposure time of 8.01 seconds. The imaging area was a cylinder with a height of 15 cm and a diameter of 9 cm, providing 0.2-mm cubic voxels. CBCT parameters were standardized, and patient position was identical in all CBCT scans. Examinations were performed by 360° rotation, with each patient in an upright position and Frankfort horizontal plane parallel to the ground.

CBCT coronal, axial, and sagittal views were used for linear measurements. The right and left sides were separated and measured individually. The 3D reconstruction view was used to aid in assessing the volume of the included structures. "View control" was changed to view the nasal cavity and palate clearly separated from adjacent dental and bony structures by choosing the proper threshold. To measure the volume, the palatal bone and nasal cavity were separated from adjacent structures using the volume render tool on all of the different views. Their outlines were traced following the inner bony surface. Subsequently, the "volume

**Table 1.** Variables and the Methods Used to Measure Them

| Variable | Figure | Definition |
|---|---|---|
| Canine displacement | Figure 1 | Palatally displaced canine: canines appearing palatal to a line connecting the roots of adjacent teeth at any level of canine crown. Coronal plane set at the posterior margin of the hard palate and sagittal plane in the midline of the hard palate. |
| Presence, type, and direction of nasal septal deviation (NSD) | | Lateral and coronal views with soft tissue and teeth view control were chosen to do these measurements as follows:<br>The axial line was placed at the level of the infraorbital line. The presence of septal deviation was identified by screening the nasal septum from the anterior to posterior borders of the nasal septum. Then, the type of nasal septum deviation was determined from coronal and axial views based on Mladina's classification system.[19] The direction of the deviation was recorded as right or left.<br>Type I: Mild anterior deviation of the vertical ridge without reaching the nasal dorsum<br>Type II: Moderate anterior deviation of the vertical ridge reaching the nasal dorsum<br>Type III: Posterior vertical deviation of the vertical ridge at the level of middle turbinate<br>Type IV: S-shaped deviation that involves the anterior and the posterior areas of the vertical ridge (a combination of type 2 and 3, each at one side)<br>Type V: manifests as a horizontal deformity on one side of the nose with the other being flat<br>Type VI: manifests as a bilateral involvement of the septum with dislocation of one side and deviation of the other side<br>Type VII: represented as a combination of two or more types |
| Nasal width (mm) | Figure 2 | Volume render (coronal view) with soft tissue and teeth view control and full half-coronal clipping and 2D measurements were chosen. The coronal plane is set at the infraorbital rim and the sagittal plane in the midline. |
| | Upper limit | Measured as the distance in millimeters from the nasal septum to the lateral border of the nose measured at the level of the infraorbital rim. |
| | Lower limit | Measured as the distance in millimeters from the nasal septum to the lateral border of the nose measured at the level of the nasal floor. |
| Thickness of inferior conchae (mm) | Figure 3 | Coronal views with soft tissue and teeth view control were chosen to do these measurements as follows: the coronal line was set at level of canine area and the sagittal plane placed in the midline. Measured as the distance in millimeters from the inner and outer border of the inferior conchae in both canine and molar areas. |
| Palate thickness (mm) | Figure 4 | A coronal view with soft tissue and teeth view control were chosen. Coronal plane set at the canine area and the sagittal plane in the midline of the hard palate. Measured at 5-mm distance lateral to the midline per side in canine and molar areas. |
| Maxillary bone volume (mm)$^3$ | Figure 5 | Volume render (frontal view) with soft tissue and teeth view control and full half coronal clipping were chosen initially. The outline of maxillary bone were traced and isolated, following the outline of the bony maxilla(upper limit: ANS-PNS, lower limit: alveolar crest) using the free hand sculpture. Any other structures showing when maxillary bone is viewed from the different sections were trimmed. Maxillary bone volume was calculated by Invivo dental Anatomage software. |
| Nasal airway volume (mm)$^3$ | Figure 6 | Volume render (frontal view) with soft tissue and teeth view control and full half coronal clipping were chosen initially. The outline of the nasal airway (upper limit is the infraorbital line and lower is the nasal floor) was traced and isolated following the outline of the bony maxilla using the free-hand sculpture. Any other structures showing when the maxillary bone is viewed from the different sections were trimmed. Nasal airway volume was calculated by Invivo dental Anatomage software. |
| HP length | Figure 7 | Sagittal view with soft tissue and teeth view control was chosen. The distance in millimeters between the anterior nasal spine and posterior nasal spine was measured. |
| Nasal septum thickness | Figure 8 | Coronal views with soft tissue and teeth view control were chosen to do these measurements as follows: The coronal line was set at level of canine area and sagittal plane placed in the midline. The width of the nasal septum was measured at this level of the level of the nasal floor in both the canine and molar areas. |

measurement" option was used to calculate the total volume.

The DICOM files were imported into InVivo software dental version 6.0.5 (Anatomage, San Jose, Calif) for secondary reconstruction and further investigation. CBCT images were evaluated over a period of 4 months by one calibrated examiner (Dr Osman). The volumetric accuracy of the CBCT scanner was evaluated in previous studies by the same author.[16] The upper limit of the CBCT was determined by a line passing through the infraorbital rim.

The presence of NSD was evaluated manually by moving through the nasal septum and its borders. The evaluation was conducted using axial and coronal

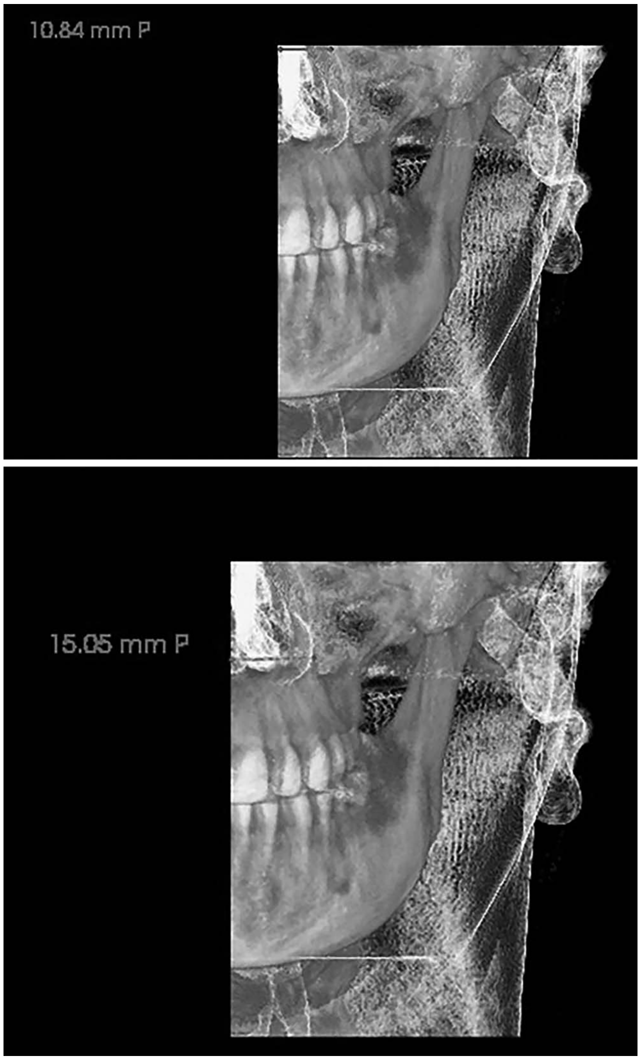


**Figure 2.** Upper and lower nasal width.

sections of each CBCT, and the presence and type of NSD was according to the Mladina's classification.[17] Definitions of the variables investigated and the methods used to measure them are shown in Table 1 and illustrated in Figures 2 to 8.

### Error of the Method

A random sample of 10 CBCT images was remeasured after a 2-week interval. All measurements were repeated by the same examiner under the same conditions to test intraexaminer reliability.

### Statistical Analysis

Statistical analysis was performed using the Statistical Package for Social Science (SPSS) computer software (SPSS 28). Normality of data was assessed using the Shapiro-Wilk test and indicated that the data were not normally distributed. The Wilcoxon signed-rank test was applied to detect differences between the right and left sides within the same group. Differences between the two study groups were assessed using chi-square and Mann-Whitney *U* tests for categorical and nominal variables, respectively. The odds ratio was presented using binary logistic regression analysis to determine the association between maxillary canine displacement (dichotomized to either NDCs or PDCs) and the studied variables. The level of significance was set at $P \leq .05$.

## RESULTS

No significant intraexaminer differences were noted. The kappa coefficients were 1.00 for all categorical data, and Dahlberg errors ranged from 0.67 mm for thickness of the inferior conchae to 3.09 $mm^3$ for lower nasal airway volume.

Distribution of the subjects in the two groups regarding the side of canine displacement and the type and direction of NSD is shown in Table 2.

There was a statistically significant association (strong association $\phi = .282$) between the presence of NSD and PDCs ($\chi^2 = 7.33$, $P = .006$). NSD was detected in 77.3% and 50% of PDC and NDC subjects, respectively. In the PDC group, 50% of canines were displaced on the same side of NSD and 25% were displaced on the opposite side. The type of NSD did not differ between PDC and nondisplaced canine subjects (.446).

In the PDC group, significant differences between the displaced and nondisplaced sides were detected (Table 3). On the displaced side, palate thickness lateral to the midline was increased in the canine region ($P = .004$) and reduced in the molar region ($P = .034$). In the NDC group (Table 3), the differences in the right and left sides were found. The thickness of the inferior conchae in the molar region was increased ($P < .000$), the thickness of the palate lateral to midline in the molar region was reduced ($P = .003$), and the lower nasal airway volume was larger ($P = .022$) on the right side compared with the left side.

Mann-Whitney *U* standardized test statistics of the PDC and NDC subjects are shown in Table 4. The displaced side of the PDC group (group 1) was compared with the average values of the right and left sides in group 2 (control), and significant differences were detected. In group 1, the palate thickness was reduced ($P = .048$) and the lower nasal airway volume was reduced ($P = .049$) compared with the control group.

Two predictor variables were significant for predicting the odds of PDC occurrence (Table 5): the presence of NSD ($P = .026$) and the maxillary bone volume ($P = .042$). In the presence of NSD, the odds of developing PDC increased by 3.35 times. Also, for


**Figure 3.** Thickness of inferior conchae.

each one-unit increase in the maxillary bone volume, the odds of developing PDC decreased by 20%.

## DISCUSSION

The nasal septal cartilage acts as a key facial growth center.[18] Hence, as the maxillary bone and the nasal structures have anatomical connection during craniofacial development, deviated septal growth may contribute to the development of facial asymmetry.[9]

It has been reported that NSD can cause a significant reduction in palatal dimensions.[19] While the relationship between NSD and the presence of the canine in an ectopic buccal position has been assessed previously,[14] there has been no study reporting on the possible association between NSD and PDCs. Therefore, this study was conducted to determine whether there was an association between PDC and NSD, palatal bone thickness and volume, and lower nasal airway dimensions and volume.

In this study, 77% of the PDC subjects presented with NSD, compared with 50% in the control group. In PDC subjects, types 1 and 7 were the most frequent, whereas types 3 and 7 most common in the controls. Comparison of NSD results in the current study with previous studies was not possible as no

**Figure 4.** Thickness of hard palate.

previous study evaluated NSD in PDC subjects. This association may be related to a common etiology between the 2 entities, as NSD may be caused by genetic factors.[20]

The 50% prevalence of NSD in the control group was less than the 86.6% and 89.3% reported by others[17,21] but similar to that reported by Salihoglu et al.,[22] who showed that almost half of their patients had NSD. On the other hand, a lower prevalence was reported by Yildirim and Okur[23] (34.9%) with type 1 NSD as the most common type. Racial differences, sample size differences, and variability in the methodology used to classify NSD may explain such inconsistencies.

In the PDC group, palate thickness lateral to the midline was increased in the canine region and reduced in the molar region on the displaced side compared with the nondisplaced side. The increased palate thickness in the molar area may be related to palate morphology, upper airway, and maxillary sinuses.[24]

In the NDC group, the right and left sides were asymmetric and differed in the thickness of the inferior conchae and palate in the molar region and in the

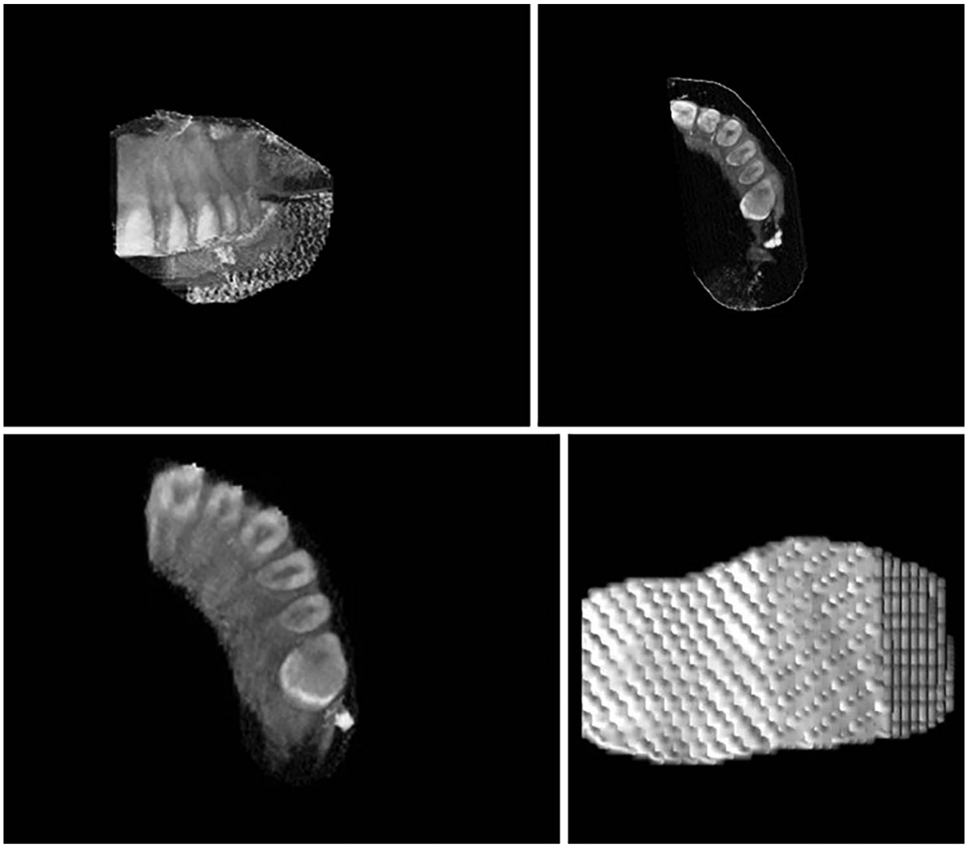

**Figure 5.** Maxillary bone volume.

nasal airway volume. Dental arch asymmetry is present in most individuals, and those with a malocclusion tend to have more asymmetry.[25,26] The NDC group in the present study included subjects with different malocclusions, and 50% of them presented with NSD, which may explain the right- and left-side asymmetry found in the current study.

In theory, as the maxillary canine tooth germ is located close to the lateral wall of the nasal cavity, the width of the nasal cavity between displaced and

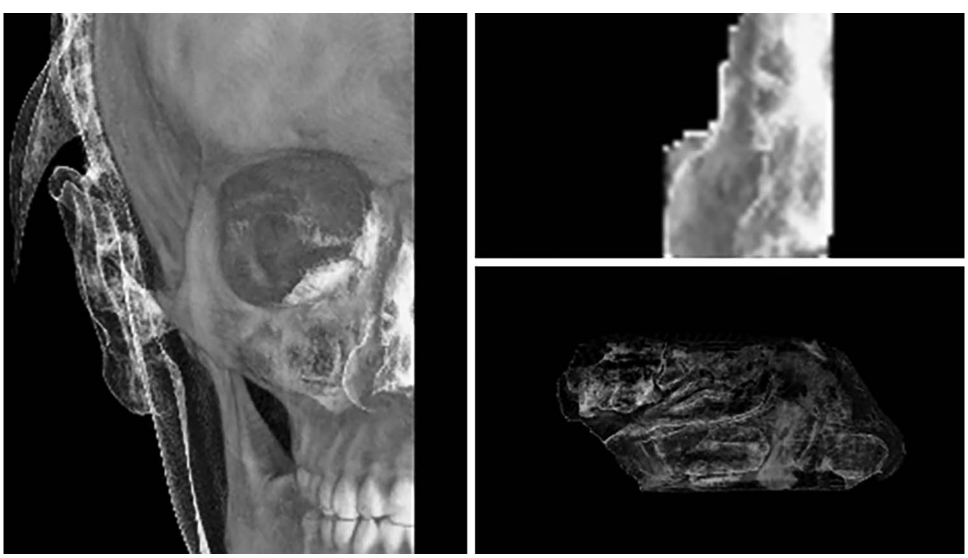

**Figure 6.** Nasal airway volume.

**Figure 7.** Hard palate length.

nondisplaced sides/subjects would be expected to differ. In the present study, the width of the nasal cavity between the two sides/groups was comparable. This was in agreement with Shahin et al.[27] who investigated the morphology of the maxilla in unilateral PDCs among the Saudi population.

On the displaced side of the PDC subjects, lower nasal airway volume was reduced compared with the controls. The higher prevalence of NSD observed in PDC subjects is thought to enhance the pneumatization of the middle turbinate[28] and induces nasal airflow turbulence that leads to turbinate thickening.[29] Therefore, the airway difference found in this study was more likely due to the NSD rather than from the canine impaction.

**Figure 8.** Nasal septum thickness.

**Table 2.** Distribution of Subjects Based on the Type and Direction of the Nasal Septal Deviation (NSD) and Maxillary Sinus (MS) Extension in the Two Groups and Differences Between Groups[a]

| | Group 1 PDCs (n = 44), n (%) | Group 2 NDCs (n = 48), n (%) | Chi-square *R* (*df*) | Cramerss V | *P* Value |
|---|---|---|---|---|---|
| Side of palatal displacement | | | | | |
| Right | 25 (56.8) | 0 | | | |
| Left | 19 (43.2) | 0 | | | |
| Presence of NSD | | | | | |
| No | 10 (22.7) | 24 (50.0) | 7.33 (1) | .282 | .006** |
| Yes | 34 (77.3) | 24 (50.0) | | | |
| Type of NSD | | | | | |
| Type 1 | 11 (32.4) | 5 (20.8) | 2.66 (3) | .214 | .446 |
| Type 2 | 4 (11.8) | 1 (4.2) | | | |
| Type 3 | 8 (23.5) | 9 (37.5) | | | |
| Type 7 | 11 (32.4) | 9 (37.5) | | | |
| Direction of NSD | | | | | |
| Right | 18 (40.9) | 13 (27.1) | 11.13 (3) | .348 | .011* |
| Left | 15 (34.1) | 7 (14.6) | | | |
| Right and left | 1 (2.3) | 4 (8.3) | | | |
| Direction of NSD and side of PDC | | | | | |
| Canine displacement in the side of NSD | 22 (50.0) | | | | |
| Canine displacement in the other side of NSD | 11 (25.0) | | | | |
| Canine displacement in two-sided NSD | 1 (2.3) | | | | |

[a] NDCs indicates nondisplaced canines; NSD, nasal septal deviation; PDCs, palatally displaced canines.
* $P < .05$; ** $P < .01$.

**Table 3.** Means, Standard Deviations (SDs), Medians, and Interquartile Ratios (IQRs) for Variables in the Groups and Within-Group Differences

| | Group 1: Palatally displaced canines (PDCs) (n = 44) | | | | | |
|---|---|---|---|---|---|---|
| | Displaced Side | | Nondisplaced Side | | Wilcoxon Signed Ranks Test Statistics | |
| | Mean (SD) | Median (IQR) | Mean (SD) | Median (IQR) | Z Value | *P* Value |
| Nasal width (upper limit), mm | 11.17 (2.66) | 11.45 (9.50–13.25) | 11.49 (3.23) | 10.99 (9.55–13.43) | −0.90 | .369 |
| Nasal width (lower limit), mm | 15.57 (3.20) | 15.96 (13.84–17.69) | 15.26 (3.54) | 15.74 (13.38–17.39) | −0.41 | .683 |
| Thickness of inferior conchae (canine region), mm | 7.13 (1.67) | 7.06 (5.82–8.53) | 7.00 (1.48) | 7.01 (5.82–8.16) | −0.67 | .503 |
| Thickness of inferior conchae (molar region), mm | 9.67 (1.93) | 9.40 (8.22–10.74) | 9.46 (2.60) | 9.40 (7.32–10.88) | −0.77 | .443 |
| Palate thickness 5 mm lateral to midline suture (canine region), mm | 11.92 (3.34) | 12.28 (9.56–14.62) | 11.00 (3.49) | 11.32 (7.99–14.05) | −2.88 | .004** |
| Palate thickness 5 mm lateral to midline suture (molar region), mm | 2.46 (0.74) | 2.37 (1.99–2.93) | 2.66 (0.92) | 2.51 (2.07–3.17) | −2.13 | .034* |
| Maxillary bone volume, $mm^3$ | 12.35 (4.36) | 11.91 (9.02–14.82) | 11.50 (2.70) | 11.25 (9.12–13.59) | −1.15 | .250 |
| Lower nasal airway volume, $mm^3$ | 25.44 (9.86) | 24.61 (18.32–28.53) | 23.32 (7.86) | 23.55 (18.33–28.23) | −1.12 | .265 |
| | Group 2: Nondisplaced canines (NDCs) (n = 48) | | | | | |
| | Right Side | | Left Side | | Wilcoxon Signed Ranks Test Statistics | |
| Nasal width (upper limit), mm | 10.56 (2.17) | 10.58 (9.00–11.73) | 10.98 (2.27) | 10.55 (9.33–12.57) | −0.70 | .486 |
| Nasal width (lower limit), mm | 16.05 (2.51) | 15.97 (13.99–17.29) | 16.71 (2.54) | 16.56 (14.75–18.23) | −1.61 | .108 |
| Thickness of inferior conchae (canine region), mm | 6.68 (1.74) | 6.74 (5.69–8.01) | 6.20 (1.87) | 5.93 (4.63–7.46) | −1.94 | .053 |
| Thickness of inferior conchae (molar region), mm | 10.23 (1.88) | 10.39 (8.98–11.50) | 8.86 (1.82) | 8.50 (7.14–9.88) | −4.11 | .000*** |
| Palate thickness 5 mm lateral to midline suture (canine region), mm | 13.52 (3.63) | 14.14 (10.69–15.58) | 13.52 (3.38) | 13.12 (10.92–15.96) | −0.36 | .719 |
| Palate thickness 5 mm lateral to midline suture (molar region), mm | 2.51 (0.95) | 2.36 (1.77–3.18) | 2.80 (1.02) | 2.68 (2.10–3.47) | −2.95 | .003** |
| Maxillary bone volume, $mm^3$ | 11.49 (3.09) | 11.24 (9.46–12.52) | 10.96 (2.07) | 10.62 (9.42–12.91) | −0.82 | .412 |
| Lower nasal airway volume, $mm^3$ | 30.93 (10.34) | 27.55 (23.34–37.55) | 28.01 (10.78) | 24.65 (21.56–32.36) | −2.29 | .022* |

* $P < .05$; ** $P < .01$; *** $P < .001$.

**Table 4.** Means, Standard Deviations (SDs), Medians, and Interquartile Ratios (IQRs) and Differences Between Groups

| | Group 1/PDC Subjects Displaced Side | | Group 2/NDC Subjects Average (Right and Left Sides) | | Mann-Whitney *U* Test Statistics | |
|---|---|---|---|---|---|---|
| | Mean (SD) | Median (IQR) | Mean (SD) | Median (IQR) | Z Value | *P* Value |
| HP length | 50.98 (5.04) | 50.46 (47.86–53.49) | 51.94 (4.15) | 52.64 (49.40–54.67) | −1.77 | .077 |
| Nasal septum thickness (canine region) | 6.57 (2.01) | 6.52 (4.77–7.98) | 6.73 (1.52) | 6.56 (5.90–7.58) | −0.46 | .647 |
| Nasal septum thickness (molar region) | 4.09 (1.07) | 4.02 (3.18–5.03) | 4.46 (0.95) | 4.32 (3.92–4.97) | −1.56 | .119 |
| Nasal width (upper limit), mm | 11.17 (2.66) | 11.45 (9.50–13.25) | 10.78 (1.75) | 10.58 (9.63–12.01) | −1.08 | .282 |
| Nasal width (lower limit), mm | 15.57 (3.20) | 15.96 (13.84–17.69) | 16.38 (2.09) | 16.31 (15.19–17.69) | −0.75 | .453 |
| Thickness of inferior conchae (canine region), mm | 7.13 (1.67) | 7.06 (5.82–8.53) | 6.44 (1.48) | 6.41 (5.09–7.63) | −1.81 | .071 |
| Thickness of inferior conchae (molar region), mm | 9.67 (1.93) | 9.40 (8.22–10.74) | 9.44 (1.49) | 9.48 (8.28–10.34) | −0.30 | 0.763 |
| Palate thickness 5 mm lateral to midline suture (canine region), mm | 11.92 (3.34) | 12.28 (9.56–14.62) | 13.52 (3.45) | 13.53 (11.32–15.75) | −1.98 | .048* |
| Palate thickness 5 mm lateral to midline suture (molar region), mm | 2.46 (0.74) | 2.37 (1.99–2.93) | 2.65 (0.93) | 2.40 (1.93 –3.23) | −0.60 | .547 |
| Maxillary bone volume, mm$^3$ | 12.35 (4.36) | 11.91 (9.02–14.82) | 11.23 (2.12) | 11.02 (9.75–12.47) | −0.94 | .346 |
| Lower nasal airway volume, mm$^3$ | 25.44 (9.86) | 24.61 (18.32–28.53) | 29.47 (9.87) | 26.47 (23.47–33.22) | −1.97 | .049* |

[a] HP indicates hard palate; MS, maxillary sinus; NDCs, nondisplaced canines; PDCs, palatally displaced canines.
* $P < .05$.

In the current study, the presence of NSD and the maxillary bone volume were predictors of PDCs. The relationship between PDCs and maxillary bone dimensions and volume is controversial.[12,30–32] It has been reported that the reduced nasal airflow associated with NSD may affect the palatal arch morphology.[33] Kim et al.[3] found that the palatal vault of the PDC group was narrower and deeper compared with the buccal impacted canine group. On the other hand, Ballanti et al.[5] reported no association between transverse maxillary deficiency and NSD.

The present study was in agreement with Al-Nimri and Gharabieh,[32] who reported a wider maxillary arch on the affected side of PDC subjects, while it was in contradiction to the results reported by Yassaei et al.[12]

The findings of this study shed light on the possible association between NSD and PDCs. The presence of NSD may be used as an indicator for the early detection and diagnosis of PDCs. Dentists are better able to identify nasal septum anatomy and abnormalities due to the widespread use of CBCT. However, this developmental relationship between NSD and PDCs could not be deduced based on the current findings, as all subjects included in this study were adults.

Limitations of this study included an increased female-to-male ratio, subjects presenting with different malocclusions, and canine displacements of variable severity. In addition, an intermediate FOV CBCT was used, which limited the measurement of the nasal airway to the intraorbital rim line.

## CONCLUSIONS

- NSD was detected in 77% and 50% of PDC and NDC subjects, respectively.
- In the PDC group, palate thicknesses in the canine and molar regions were different between the displaced and nondisplaced sides.
- In the PDC group, the palate thickness and the lower nasal airway volume were reduced compared with the control group.
- In the presence of NSD, the odds of developing PDC increased by 3.35 times.
- For each one-unit increase in maxillary bone volume, the odds of developing PDC decreased by 20%.

**Table 5.** Binary Regression Output, Odd Ratios (ORs), and 95% Confidence Intervals (CIs) for Predicting the Odds of PDCs (Coded as 0) and NDCs (Coded as 1) With Respect to the Studied Variables

| Variable | B | SE | Wald | *P* Value | *df* | Exp (B) | 95% CI |
|---|---|---|---|---|---|---|---|
| NSD (yes) | 1.21 | 0.54 | 4.96 | .026* | 1 | 3.35 | 1.16–9.73 |
| ANB, ° | −0.17 | 0.10 | 2.64 | .104 | 1 | 0.85 | 0.69–1.04 |
| Max/Mand, ° | −0.01 | 0.05 | 0.01 | .920 | 1 | 0.99 | 0.91–1.09 |
| HP length | 0.06 | 0.05 | 1.25 | .263 | 1 | 1.06 | 0.96–1.18 |
| Palate thickness 5 mm lateral to midline suture (canine region) | 0.14 | 0.08 | 3.01 | .083 | 1 | 1.15 | 0.98–1.35 |
| Palate thickness 5 mm lateral to midline suture (molar region) | 0.28 | 0.31 | 0.81 | .369 | 1 | 1.32 | 0.72–2.44 |
| Maxillary bone volume | −0.23 | 0.11 | 4.12 | .042* | 1 | 0.80 | 0.64–0.99 |
| Lower nasal airway volume | 0.03 | 0.03 | 1.21 | .272 | 1 | 1.03 | 0.98–1.09 |

[a] ANB indicates A point–Nasion–B point; HP, hard palate; Max/Mand, maxillary/mandibular plane angle; NSD, nasal septal deviation.
* $P < .05$.

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