# Relationship between palatally impacted canines and dimensions and morphology of sella turcica: A cone-beam computed tomography study

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**Introduction:** This study aimed to analyze the association of unilateral and bilateral palatal canine impaction with the dimensions and morphology of sella turcica from 3-dimensional cone-beam computed tomography (CBCT) images. **Methods:** CBCT images of patients with bilateral (BPI) (n = 12; 9 female 3 male; 20.75 ± 5.88 years) and unilateral (UPI) (n = 35; 22 female 13 male; 19.28 ± 5.57 years) palatally impacted canines were compared with a control group (n = 56; 34 female 22 male; 20.82 ± 4.88 years). Linear measurements regarding sella turcica were made, and its morphologic variations were categorized. Two group comparisons were made with the Student *t* test or Mann-Whitney U-test, whereas one-way analysis of variance or Kruskal-Wallis tests were used for multiple group comparisons. Categorical variables were compared using the chi-square or Fisher exact test as appropriate. The binary logistic regression analyses and correlations using Spearman or Pearson correlation analyses were used to determine associations between variables ($P < 0.05$). **Results:** Sella diameter was significantly smaller in the BPI group compared to UPI and control groups. There was a significant association between sella diameter and BPI when compared with the control group ($\chi^2[1] = 9.150$; $P = 0.008$). There were no significant differences between groups in the distribution of sella turcica morphology. **Conclusions:** Despite the similar genetic origin of the sella turcica region and teeth, the association of palatal canine impaction with dimensions and morphology of sella turcica was weak. Both local and genetic factors might contribute to the ectopic position of the canine. (Am J Orthod Dentofacial Orthop 2022;162:626-35)

Maxillary canine impaction is a relatively common anomaly, and its treatment requires an interdisciplinary approach. Almost two thirds of impacted canines are located palatally, whereas approximately 8% of impactions are reported to be bilateral.[1] Although the exact etiology of palatal impaction remains unclear, 2 theories are generally offered to explain the cause: the guidance theory and the genetic theory. According to the guidance theory, the roots of lateral incisors guide the eruption path; the absence or malformation of this guidance leads to the impaction of the canines. On the other hand, the genetic theory points to the contribution of genetic factors causing the eruption disturbance and subsequent palatal impaction of maxillary canines. The genetic theory particularly emphasizes tooth size, shape, number and/or structure abnormalities, indicating the influences of a genetic pattern.[1,2] However, factors related to palatal canine impaction are still unclear, and the links to possible etiologic factors require further exploration.

Orthodontists routinely trace the sella turcica region during the cephalometric evaluations that enable the determination of its morphologic variations on lateral cephalograms. Embryologic findings reveal a common origin of sella turcica, dental epithelial progenitor cells, and maxillary, palatal, and frontonasal spheres through the development of neural crest cells.[3] Moreover, the role of genetic mutations on the development of the midface, teeth, and sella turcica has been expressed.[4] Because

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All authors have completed and submitted the ICMJE Form for Disclosure of Potential Conflicts of Interest, and none were reported.
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Submitted, July 2020; revised and accepted, May 2021.
0889-5406/$36.00
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https://doi.org/10.1016/j.ajodo.2021.05.017

of similar genetic origin, variations in the sella turcica region might assist clinicians early diagnosis and management of dental anomalies such as congenital absence, hyperdontia, impaction, and transposition.[5-8] In particular, previous studies performed on lateral cephalometric radiographs reported significant associations between sella turcica bridging (calcification of the interclinoid ligament of the sella turcica) and palatally impacted canines (PIC).[5,9-13] However, lateral cephalometric radiographs are usually limited in correctly examining anatomic structures because of their 2-dimensional (2D) nature. Superimpositions of images of different anatomic structures may obstruct 3-dimensional (3D) structures, which may lead diagnostic and treatment planning difficulties.[14] In this respect, 3D imaging techniques such as cone-beam computed tomography (CBCT) provide a more detailed and accurate assessment of craniofacial hard tissues by reconstructing scanned structures in multiple planes.[14,15] Recently, CBCT images have been preferred to determine the location and prognosis of impacted maxillary canines.[16-18] Despite this, a limited number of CBCT research has been done on the dimensions and morphology of sella turcica in the presence of PIC.[19-21] However, it has been reported that there were no associations between the presence of palatally displaced canines and linear dimensions or bridging of sella turcica.[19-21] Apart from bridging, none of these studies assessed the other morphologic variations and dimensions of sella turcica in patients with PIC.

This study aimed to (1) evaluate the dimensions and morphology of sella turcica in patients with bilateral and unilateral palatally impacted maxillary canines and compare it with that of a control group with erupted canines with the aid of CBCT images, and (2) to analyze the association between the changes in sella turcica region and the severity of impaction evaluated by the 3D position of canines and unilateral or bilateral occurrence.

We hypothesized that (1) unilateral or bilateral palatal canine impaction is associated with significant variations in the sella turcica region, and (2) changes in sella turcica dimensions and morphology are more evident as the severity of palatal impaction increases.

## MATERIAL AND METHODS

Ethical approval was obtained from the Gazi University Ethical Committee (77082166-302.08.01). Because no similar studies could be found in the literature, a priori sample size calculation was made to determine the magnitude of association between linear dimensions of sella turcica, in particular sella length, and angulation of maxillary canines with respect to the midsagittal plane. To measure the minimum effect size with 80% power and a significance level of 0.05, a minimum total sample size of 84 subjects is needed to achieve the correlation coefficient of at least 0.3.[22] The calculations were performed with G*Power software (version 3.1.3; Franz Faul, Universität Kiel, Germany). The CBCT images taken between January 2015 and December 2019 in the Department of Oral and Maxillofacial Radiology were reviewed retrospectively. A detailed computer-based search was performed according to the indication for CBCT examination, and the records of those patients with the following inclusion criteria were further analyzed: (1) Good quality CBCT images, including the sella turcica region without metal or motion artifacts; (2) aged $\geq$12 years; (3) presence of unilateral or bilateral palatal maxillary canine impaction; (4) no other supernumerary, missing, or impacted teeth except maxillary canines; (5) no history of previous or ongoing orthodontic treatment; (6) no history of trauma or surgery; (7) no history of systemic diseases, hormonal disorders, deformities or craniofacial syndromes such as cleft lip and palate that are associated with variations in sella turcica.

Based on these criteria, CBCT images of 47 patients with palatal canine impaction were included in this study. Palatal impaction was described as the presence of the canine crown on the palatal side of the adjacent teeth with completed root development. Those patients were then regrouped according to the number and site of palatal impaction as follows: (1) bilateral impaction (BPI), (2) left side unilateral impaction (UPI-L), and (3) right side unilateral impaction (UPI-R) groups.

A control group was constituted from the good quality CBCT images of patients referred to CBCT imaging for various clinical indications (temporomandibular disorder, implant surgery, third molars surgery, bone lesions, etc). The control group was matched with the study groups according to chronological age. The inclusion criteria for the control group were (1) no supernumerary, missing, or impacted teeth except third molars; (2) no history of previous or ongoing orthodontic treatment; (3) no history of trauma or surgery; (4) no history of systemic diseases, hormonal disorders, syndromes or deformities related to problems with the sella turcica region; and (5) no metal or motion artifacts in the images.

Data regarding the patient distribution can be seen in Table I.

The CBCT scans were acquired using the same machine (Promax 3D Mid; Planmeca Oy, Helsinki, Finland), with the same exposure parameters (90 kVp; 12 mA; 0.4-mm voxel size; scan time, 13.2 seconds; and field of view of 20 $\times$ 17 cm and 20 $\times$ 10 cm). The scans were taken according to the radiation protection rules. Three-dimensional images were evaluated using inbuilt software (version 2.7.0; Romexis; Planmeca Oy, Helsinki,

**Table I.** Patient distribution among the groups

| Groups | Age | | Gender | |
|---|---|---|---|---|
| | Mean ± SD | Median (Min-Max) | Female | Male |
| BPI (n = 12) | 20.75 ± 5.88 | 21.5 (12-29) | 9 | 3 |
| UPI-left (n = 22) | 20.82 ± 6.09 | 20 (12-30) | 14 | 8 |
| UPI-right (n = 13) | 16.69 ± 3.35 | 16 (13-23) | 8 | 5 |
| Control (n = 56) | 20.82 ± 4.88 | 20.5 (14-30) | 34 | 22 |
| Total (n = 103) | 20.29 ± 5.24 | 20 (12-30) | 65 | 38 |

*SD*, standard deviation; *Min*, minimum; *Max*, maximum.

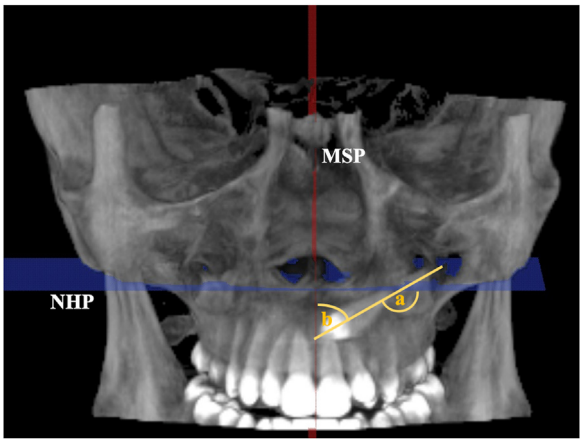



**Fig 1.** Angular position of canine assessed by CBCT images. *a*, nasal horizontal plane-longitudinal axis of canine (°); *b*, midsagittal plane-longitudinal axis of canine (°).

Finland). The observer was allowed to manipulate the contrast and brightness features and to use the zoom tool of the software for optimum visualization. The images were reconstructed in 3 orthogonal planes (sagittal, axial, and coronal sections, with 0.4 mm isotropic voxel resolution). To standardize the measurements, Frankfurt horizontal plane was accommodated parallel to the floor, and midsagittal plane was placed perpendicular to Frankfurt horizontal plane.

Three-dimensional positions of maxillary canines were evaluated on axial views according to midsagittal and nasal horizontal reference planes, respectively. The nasal horizontal plane was drawn parallel to the floor of the nasal cavity, whereas the midsagittal plane was adjusted to be perpendicular to the floor and pass through the anterior nasal spine. The angulation between the longitudinal axis of each canine (right and left) with these planes was measured to determine their 3D angular positions (Fig 1).

Linear sella turcica measurements were made on the midsagittal plane. The length, depth, and diameter of sella turcica were measured. Sella length is the

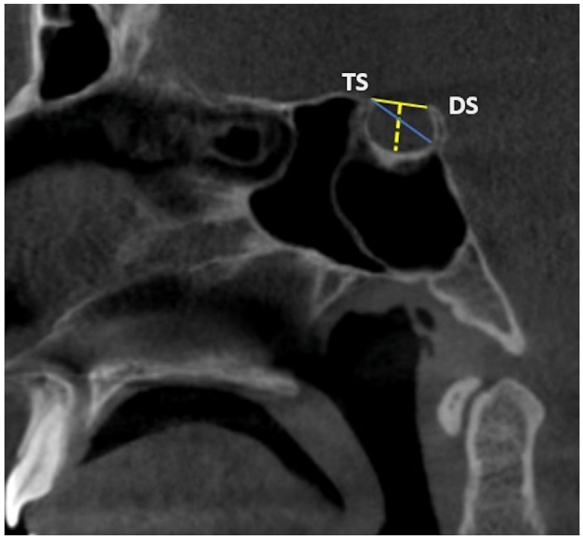



**Fig 2.** Linear dimensions of sella turcica. *Dashed yellow-line*, depth; *yellow line*, length; *blue line*, diameter.

anteroposterior distance between the crest of tuberculum sella and dorsum sella. Depth of the sella is defined as the perpendicular distance from the deepest point of the floor of sella turcica to the line drawn between dorsum sella and tuberculum sella. The sella diameter is defined as the anteroposterior distance between the deepest point in the posterior wall of sella turcica and the crest of tuberculum sella (Fig 2). All measurements were recorded in millimeters. The shape of the sella turcica was categorized and evaluated according to the classification of Axelsson et al[23]: normal, oblique anterior wall, double contour of the floor, sella turcica bridging, irregularity (notching) in the posterior part of the dorsum sellae, and pyramidal shape of dorsum sellae. Apart from other classifications, the decision regarding sella turcica bridging was given after a thorough evaluation of the right and left anterior and posterior clinoid processes separately on the axial and sagittal views. If there were any fusions in one of the slices, this was classified as bridging. All measurements and classifications were made by the observer, who is an experienced dentomaxillofacial radiologist (G.A.). To assess the intraobserver agreement, CBCT images of 20 patients were randomly selected and reanalyzed 1 month after the first measurements.

### Statistical analysis

The data were analyzed using the SPSS (version 11.5; SPSS Inc, Chicago, Ill). Data were summarized as the mean ± standard deviation and median (minimum-maximum) for continuous variables and frequencies (percentiles) for the categorical variables.

**Table II.** Results of Bland-Altman analysis for intraexaminer reliability of numeric variables in this study

| | | | | 95% limits of agreement | |
|---|---|---|---|---|---|
| *Measurements* | *n* | *Mean difference* | *SD* | *Lower* | *Upper* |
| Midsagittal plane-right canine | 20 | 0.495 | 2.201 | −3.820 | 4.810 |
| Midsagittal plane-left canine | 20 | 0.272 | 2.136 | −3.194 | 4.457 |
| Nasal horizontal plane-right canine | 20 | 0.516 | 2.223 | −3.841 | 4.872 |
| Nasal horizontal plane-left canine | 20 | -0.449 | 2.467 | −5.284 | 4.386 |
| Sella length | 20 | 0.373 | 0.988 | −1.564 | 2.310 |
| Sella depth | 20 | 0.279 | 0.929 | −1.541 | 2.099 |
| Sella diameter | 20 | 0.338 | 0.767 | −1.167 | 1.842 |

*SD*, standard deviation.

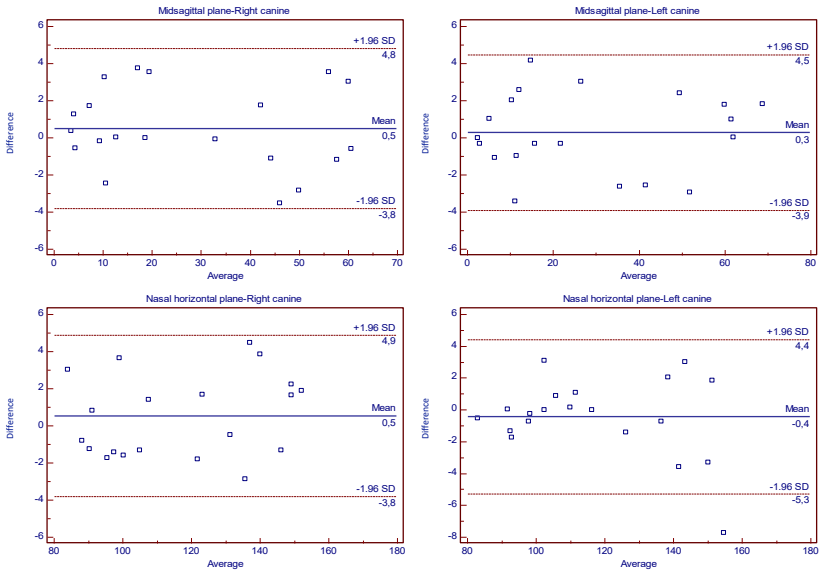



**Fig 3.** The Bland-Altman plots of canine positions regarding nasal horizontal and midsagittal planes.

The intraclass correlation for all numeric variables was evaluated by the Bland-Altman method, and the agreement between 2 measures was illustrated by plots for each variable using MedCalc software.[24] Cohen's Kappa was used to determine if there was an agreement between classifications of sella turcica morphology.

The normality of the data was measured using the Shapiro Wilk test. Depending on the distributional properties of the data, the Student *t* test or Mann-Whitney U-test was used for 2 group comparisons, whereas the differences between ≥2 groups were evaluated by one-way analysis of variance test or Kruskal-Wallis test, as appropriate. Categorical variables were compared using the chi-square or Fisher exact test as appropriate. Wilcoxon or paired *t* tests were used to compare 2 dependent groups of continuous variables. The binary logistic regression analysis was used to determine associations between bilateral palatal impaction and control groups and unilateral palatal impaction and control groups separately. Statistical significance was set at a value of $P < 0.05$. Separate correlation analyses were performed with linear dimensions of sella turcica and the angular positions of impacted (average mean values of canines in bilateral impaction group and values of impacted canines in unilateral groups) and erupted (average mean values of canines in the control group only) canines, respectively. All correlations were assessed using Pearson or Spearman correlation tests, depending on the distributional properties of the data, and tested against a Bonferroni adjusted significance level of $P < 0.016$ (0.05/3).

## RESULTS

The Bland-Altman method showed excellent intraobserver consistency for most variables (Table II; Figs 3 and 4).[24,25] Almost perfect intraexaminer consistency

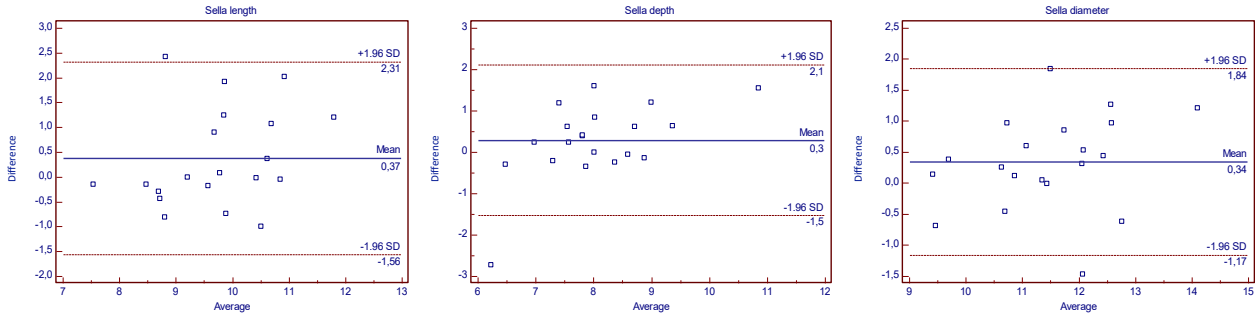



**Fig 4.** The Bland-Altman plots of linear dimensions of sella turcica.

was found for the classification of sella turcica as well ($\kappa = 0.910$; $P < 0.001$).

The distribution of participants regarding their chronological age was similar between the groups ($P = 0.059$).

The angle between the midsagittal and nasal horizontal planes with the long axis of impacted canines was significantly larger than the erupted canines. Significant differences were recorded between BPI and control groups, BPI and UPI groups, respectively (Table III).

When the dimensions and morphology of sella turcica were evaluated, there were no significant differences between males and females regarding length ($P = 0.574$), depth ($P = 0.521$), and diameter ($P = 0.068$) of sella turcica when the data was pooled.

Unilateral impaction groups were combined (UPI), and evaluations of the size and morphology of sella turcica were performed with 3 groups. Sella diameter was significantly smaller in the BPI group than UPI and control groups (Table IV).

The results of the binary logistic regression analysis indicated a significant association between sella diameter and BPI when compared with the control group ($\chi^2[1] = 9.150$; $P = 0.008$).

Correlations were evaluated for the impaction status of the maxillary canines. Among linear measurements of sella turcica, there were no statistically significant correlations with angular positions of erupted or impacted canines (Table V).

There were no significant differences between groups in the distribution of sella turcica morphology (Table VI). Regardless of the impaction of maxillary canine, normal sella turcica morphology was detected approximately in half of the patients in each group. Although it was not statistically significant, the most commonly seen morphologic variation was the irregularity (notching) in the posterior part of dorsum sellae in all groups. Only 2 patients in the control group (3.6%) had bridging diagnosed with the evaluation of axial slice images in detail. One had partial bridging on the right side, whereas the other had complete bridging on the right and left sides (Fig 5).

## DISCUSSION

In this study, CBCT images were assessed in subjects with bilateral and unilateral PIC and compared with a control group regarding the dimensions and morphology of sella turcica. According to our results, there seems to be a relation between sella diameter and palatal canine impaction, particularly with bilateral impaction. Sella diameter was significantly smaller in BPI, and this relationship was also confirmed with binary logistic regression analysis. In addition, it was found that the angle between the long axis of maxillary canines with both sagittal and horizontal reference planes was larger if the tooth was impacted, but we could not detect significant associations between linear dimensions of sella and the angular positions of impacted canines. There was also no significant difference in the morphology of sella turcica and distribution of morphologic variations within or between the groups. According to our results, our first hypothesis was partially accepted and second hypothesis was rejected.

Only a few studies have assessed the association between PIC and the sella turcica region with the aid of CBCT images.[19-21] In El Wak et al,[21] the consistency between lateral cephalometric radiographs and CBCT images about the diagnosis of sella turcica bridge was evaluated. The authors could not find any association between bridging and PIC, but they did not group the patients according to the number (unilateral or bilateral) or site (left or right) of impaction and did not analyze the dimensions and other morphologic variations of sella turcica. In contrast, Ortiz et al[20] and Ugurlu et al[19] grouped the patients similar to our study design. While Ortiz et al[20] only focused on the interclinoid distance and sella turcica bridging, Ugurlu et al[19] performed linear measurements of sella turcica and clinoid

**Table III.** Descriptive statistics related to canine positions and comparison between groups

| Measurements | BPI (n = 12) | | UPI-left (n = 22) | | UPI-right (n = 13) | | Control (n = 56) | | P value |
|---|---|---|---|---|---|---|---|---|---|
| | Mean ± SD | Median (Min-Max) | Mean ± SD | Median (Min-Max) | Mean ± SD | Median (Min-Max) | Mean ± SD | Median (Min-Max) | |
| Midsagittal plane-right canine (°) | 52.77 ± 15.75[a] | 52.43 (17.95-81.54) | 12.11 ± 6.52[b] | 11.23 (3.64-23.13) | 47.87 ± 12.61[a] | 48.47 (21.12-61.55) | 11.24 ± 10.901[b] | 9.7 (2.11-75.62) | <0.001 |
| Midsagittal plane-left canine (°) | 55.61 ± 12.29[a] | 57.70 (25.03-72.46) | 48.16 ± 13.60[a] | 48.65 (21.48-73.38) | 10.06 ± 4.92[b] | 10.95 (2.31-16.90) | 10.20 ± 5.66[b] | 10.23 (2.49-35.12) | <0.001 |
| Nasal horizontal plane-right canine (°) | 139.63 ± 18.15[a] | 139.83 (106.43-177.00) | 97.61 ± 8.27[b] | 98.54 (76.69-111.66) | 139.67 ± 11.07[a] | 141.86 (120.96-153.00) | 97.29 ± 9.12[b] | 97.30 (72.66-119.90) | <0.001 |
| Nasal horizontal plane-left canine (°) | 142.87 ± 15.62[a] | 147.73[a] (110.19-161.46) | 136.31 ± 13.25[a] | 137.82 (111.98-163.59) | 98.07 ± 7.20[b] | 98.10 (82.67-109.91) | 98.65 ± 7.23[b] | 99.60 (80.86-122.96) | <0.001 |

Note. Groups with the same superscripted letters are not significantly different.
*SD*, standard deviation; *Min*, minimum; *Max*, maximum.

processes. Although bridging is not the only morphologic variation of sella turcica, none of these studies examined the other morphologic patterns with the classification by Axelsson et al.[23] Based on the literature search, this is also the very first study that aims to find a possible relationship between the severity of impaction expressed by the angulation of the maxillary canines and uni- or bilateral occurrence with the changes in sella turcica region.

The morphology and dimensions of sella turcica of patients with PIC were previously assessed via lateral cephalometric radiographs.[5,9-12] However, 2D images have limitations such as the superimposition and distortion of anatomic structures, which may alter the evaluation of these structures and the accuracy of the measurements.[26] On the other hand, CBCT images present the actual anatomy of the craniofacial region, allowing clinicians to make more precise measurements and classifications.[14] For these reasons, CBCT images were used in this study.

In the literature, the influence of age and gender on linear dimensions of sella turcica has been evaluated.[12,23,27-30] For the effect of age, some studies have indicated that dimensions of sella turcica increase with age to accommodate the development of the pituitary gland.[23,28-30] To overcome the possible effect of age on our measurements, we set an age limit (≥12 years old) for this retrospective study in line with previous studies and constituted a control group in a similar age range to the study groups.[20,26] The lower age limit was set in accordance with the literature reporting that dimensions and morphology of sella turcica do not change significantly after 10-12 years of age.[31,32] On the other hand, we could not find any effect of gender on our measurements, which was consistent with the results of previous studies with both lateral cephalograms[12,29,31] and CBCT images.[27,30]

This study evaluated whether there were differences in linear dimensions of sella turcica between the patients with palatally impacted and normally erupted canines. These measurements were assessed previously by studies performed on lateral cephalometric radiographs, and different results were reported. Baidas et al[9] noted significant differences in the length, diameter, and depth of sella turcica between patients with PIC and the controls. In some studies, the only affected linear measurement of sella turcica from palatal impaction of canines was reported to be the length, which was shorter in these circumstances.[10,12] In contrast, Scribante et al[7] could not find a difference in sella turcica measurements between the patients with dental anomalies and controls. Related to this subject, the only study on CBCT images was done by Ugurlu et al,[19] and they reported a

**Table IV.** Descriptive measurements of sella turcica morphology and comparison between groups

| | *BPI (n = 12)* | | *UPI (n = 35)* | | *Control (n = 56)* | | |
|---|---|---|---|---|---|---|---|
| *Measurements* | *Mean ± SD* | *Median (Min-Max)* | *Mean ± SD* | *Median (Min-Max)* | *Mean ± SD* | *Median (Min-Max)* | P *value* |
| Sella length (mm) | 8.54 ± 2.06 | 7.81 (5.73-11.90) | 9.81 ± 1.43 | 9.81 (6.81-13.21) | 9.42 ± 1.95 | 9.32 (4.00-13.60) | 0.200 |
| Sella depth (mm) | 7.61 ± 1.33 | 8.05 (4.82-9.40) | 7.79 ± 1.50 | 8.01 (4.87-11.63) | 8.00 ± 1.35 | 8.00 (5.22-11.61) | 0.598 |
| Sella diameter (mm) | 10.16 ± 1.52[a] | 10.05 (7.21-13.90) | 11.36 ± 1.51[b] | 11.33 (8.21-14.71) | 11.54 ± 1.42[b] | 11.60 (8.50-15.01) | 0.013 |

Note. Groups with the same superscripted letters are not significantly different.
*SD*, standard deviation; *Min*, minimum; *Max*, maximum.

**Table V.** Correlations of angular positions of impacted and erupted canines with linear dimensions of sella turcica

| | *Impacted canines (n = 47)* | | | | *Erupted canines (n = 56)* | | | |
|---|---|---|---|---|---|---|---|---|
| | *Midsagittal plane-canine (°)*[†] | | *Nasal horizontal plane-canine (°)*[†] | | *Midsagittal plane-canine (°)*[‡] | | *Nasal horizontal plane-canine (°)*[†] | |
| *Measurements* | *r* | P *value* | *r* | P *value* | *r* | P *value* | *r* | P *value* |
| Sella length | −0.221 | 0.136 | −0.234 | 0.114 | −0.071 | 0.604 | −0.071 | 0.604 |
| Sella depth | −0.130 | 0.385 | −0.056 | 0.708 | −0.141 | 0.299 | 0.010 | 0.944 |
| Sella diameter | −0.009 | 0.954 | 0.045 | 0.765 | −0.046 | 0.738 | 0.045 | 0.741 |

[†]Pearson correlation; [‡]Spearman correlation.

**Table VI.** Morphology of sella turcica and comparison between groups

| *Sella morphology* | *BPI (n = 12)* | *UPI (n = 35)* | *Control (n = 56)* | P *value* |
|---|---|---|---|---|
| Normal | 6 (50%) | 16 (45.7%) | 27 (48.2%) | 0.859 |
| Oblique anterior wall | 1 (8.3%) | 2 (5.7%) | 6 (10.7%) | |
| Double contour of the floor | – | – | 1 (1.8%) | |
| Sella turcica bridging | – | – | 2 (3.6%) | |
| Irregularity (notching) in the posterior part of dorsum sellae | 3 (25%) | 14 (40%) | 13 (23.2%) | |
| Pyramidal shape of dorsum sellae | 2 (16.7%) | 3 (8.6%) | 7 (12.5%) | |

significant difference in the right sella length measured between right external anterior and posterior clinoid processes, only where it was significantly shorter in unilateral impaction group than bilateral impaction and control groups. The present study found a significant reduction of sella diameter in the bilateral impaction group, confirming the association with regression analyses. But no significant correlations could be detected. The different study results might be attributed to the variabilities in sample size, age range, and measurement methods.

To detect an abnormal morphology or a pathology, it is necessary to use a classification that defines the normal morphology of sella turcica and its possible variations. Up to date, numerous attempts have been made to classify images of sella turcica on lateral cephalometric radiographs but they lack a detailed quantitative evaluation of anatomic components.[33,34] To overcome this problem, Axelsson et al[23] have introduced a classification system that evaluates the morphologic differences between tuberculum sella, dorsum sella, and sella floor. It has been reported that anatomic variations of sella turcica can also be seen in healthy patients and may not be an additional symptom of a pathologic condition.[23] Still, normal morphology of sella is the dominant morphology in healthy subjects in studies performed on lateral cephalometric radiographs.[23,31] The CBCT studies on healthy subjects using the same classification method also have reported normal morphology in 49.8%-85.4% of the subjects.[35-37] Similar to these studies, almost 50% of the subjects in this study showed normal morphology of sella turcica regardless of the presence of a PIC and with no statistical significance between groups (Table VI). In addition, morphologic variations were seen in all groups. The most frequently observed morphologic variation was irregularity (notching) in the posterior part of dorsum sellae both in bilateral (25%) and unilateral (40%) palatal impaction groups as well as the control group (23.2%), followed by pyramidal shape of dorsum sellae in all groups (BPI, 16.7%; UPI, 8.6%; control,

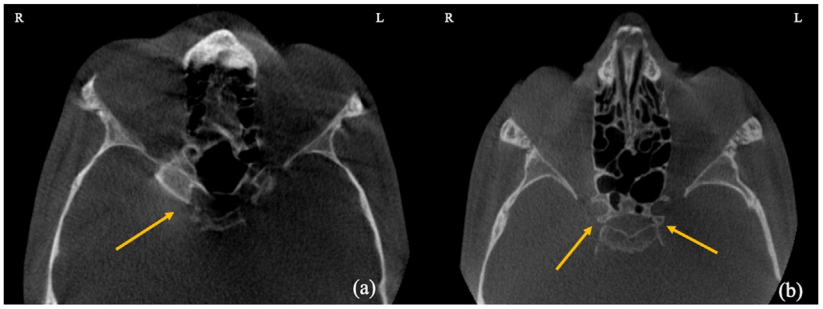



**Fig 5.** Axial slice views of 2 patients in the control group who had sella turcica bridging. **a**, first patient with partial bridging only on the right side; **b**, second patient with complete bridging on both right and left sides.

12.5%). Literature reveals that the presence of bridging is the most frequent abnormality of sella morphology in patients with PIC.[5,7,9] In our study, bridging was found only in 3.6% (2 patients out of 56) of control subjects, similar to a previous study on healthy subjects, with a range between 4.6%-11.1%.[23] Figure 5 shows the axial slices of these patients, one having a partial bridging on the right side, whereas the other one has complete bridging both at the left and right clinoid processes. No bridging could be observed in subjects with impacted canines, which might be explained by the elimination of superimposition of the clinoid region in CBCT images, as the sella morphology could be evaluated more accurately.[14,26] Although lateral cephalometric radiographs are frequently used, clinicians should accept that the image they analyze results from superimpositions of overlying structures. Thus, morphologic classifications of sella turcica constituted according to 2D lateral cephalometric images may not reflect the original 3D morphology of the region. Confirming this, El Wak et al[21] found a significant difference in the classification of sella turcica bridging between lateral cephalograms and CBCT images.

The limitations of the present study were the small sample size because of its retrospective nature and the determined inclusion criteria. Our study included images in which both maxilla and sella regions are clearly observed (middle field of view). Therefore, from almost 900 images in our archives, we could find only 47 impacted canine cases because most of them did not have sufficient field of view area and imaging up to the sella region. The small sample size may limit the generalization of the results to the whole population. But the etiology behind palatal impaction of maxillary canines has not been clearly identified, and with this study, we wanted to question this fact from a different perspective by considering the 3D position of the canines together with the sella turcica region. If the sella turcica region is accepted to have a connection with dental anomalies because of the similar embryologic origin, our results cannot present a possible link to the genetic origin of palatal impaction of maxillary canines. Further studies evaluating buccally displaced canines and the effect of local dentoalveolar factors that lead to impaction with larger sample sizes may add to the results. On the other hand, measurements and classifications were performed by the same examiner, and because of the 3D nature of the data, blinding the groups was unfortunately impossible. After evaluating the results of our study and together with other studies using CBCT images for sella turcica morphology, developing a new classification system for the 3D morphology of sella turcica is needed for standardized and comparable studies in this area.

## CONCLUSIONS

1. The diameter of sella turcica was significantly smaller in the bilateral impaction group compared with unilateral impaction and control groups. As supported by the regression analysis results, there was a significant association between sella diameter and bilateral palatal impaction of maxillary canines when compared with the control group.
2. The angular position of PIC in 3-dimensions was not associated with changes in the dimensions or morphology of sella turcica when compared with the control group.
3. The presence of unilateral or bilateral PIC was not significantly related to the occurrence of a specific type of morphologic variation of sella turcica. Normal morphology of sella turcica was the common type in all groups. Regardless of impaction, the most frequently observed morphologic variation was irregularity (notching) in the posterior part of dorsum sellae.

## AUTHOR CREDIT STATEMENT

Nehir Canigur Bavbek contributed to conceptualization, original draft preparation, manuscript review and editing, and visualization; Gülsün Akay contributed to methodology, resources and data curation; İrem Kar contributed to formal analysis and visualization; Cumhur Tuncer contributed to conceptualization and methodology; Kahraman Güngör contributed to resources; and Burcu Baloş Tuncer contributed to conceptualization, manuscript review and editing and supervision.

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