Heliyon 8 (2022) e10854

Contents lists available at ScienceDirect

Heliyon

journal homepage: www.cell.com/heliyon

Research article

Evaluation of maxillary arch width and palatal volume and depth in patients with maxillary impacted canine by CBCT

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ARTICLE INFO

Keywords:
Impacted canine
Cone-beam computed tomography
Palatal volume
Maxillary arch width
Palatal depth

ABSTRACT

Introduction: Canines are the second most common tooth in terms of impaction. Impacted teeth can be associated with some different indices of dental arch and dentoalveolar structures. The aim of this study was to evaluate maxillary arch width as well as volume and depth of palate in patients with maxillary impacted canine by cone beam computed tomography (CBCT).
Methods: In this cross-sectional study, 45 CBCT images of patients with unilateral maxillary impacted canines were examined. All patients had palatally impacted canines. Three parameters of maxillary arch width, palatal volume and palatal depth were assessed using axial and sagittal incisions on the CBCT images. Then all the measurements on the impacted side were compared with the non-impacted side. Data were entered into SPSS software and paired sample t-test and Student's t-test were used to comparison. The significance level of 0.05 was considered.
Results: The maxillary arch width on the impacted side was significantly less than the normal side ($P < 0.001$). The mean depth of the palate was 14.86 ± 3.53 mm. There was a significant correlation between canine impaction and Palatal volume ($R = 0.728$ and P-value< 0.001), but no significant correlation between canine impaction and Maxillary arch width was shown ($R = 0.15$ and p-value $= 0.326$).
Conclusion: The impacted canine was significantly associated with a reduction in the width of the maxillary arch on the affected side, and it made no difference if the impacted side was left or right. Also, impacted canine teeth were significantly associated with volume reduction on the affected side.

1. Introduction

Permanent teeth do not always erupt properly, occasionally leading to an anomaly called dental impaction. According to a study by Fardi et al., Any permanent tooth can remain impacted [1]. Canines are the second most common tooth in terms of impaction [2, 3]. Under these conditions, if the tooth deviates from the natural path of growth, it can be created in two forms: buccal or palatal impaction [4, 5]. The reported incidence rate for palatal impaction is 0.8%–3% [6]. Impacted teeth can be associated with some different indices of dental arch and dentoalveolar structures [7]. For example, an impacted tooth can change the space in the dental arch. Buccal impaction is more common in cases of lack of space in the dental arch and palatal impaction is more of a genetic origin [8]. There is a hypothesis that tooth impaction can reduce the stimulation of bone growth caused by the chewing process [7]. MCconnell et al Linked palatal impaction to crosswise maxillary deficiency [9].

In the process of orthodontic diagnosis and treatment, it is very important to determine the exact position of the impacted tooth and its effect on adjacent structures such as the width and circumference of the maxillary arch, as well as the thickness and height of the alveolar bone. This data can be obtained from the evaluation of radiographic images. However, it is difficult to evaluate these indicators using conventional radiographic methods due to the superimposition of the surrounding structures [10]. Cone-beam computed tomography (CBCT) provides more accurate and reliable information compared to conventional imaging techniques [3, 11, 12]. CBCT was first used in dentistry in 1998 and is highly valued due to its higher resolution and lower radiation dose than CT scan imaging [13, 14].

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https://doi.org/10.1016/j.heliyon.2022.e10854
Received 24 March 2022; Received in revised form 27 July 2022; Accepted 26 September 2022

Palatal volume can be useful for realistically evaluating palate conditions and assisting in treatment decision-making and treatment evaluation processes. Measurement of palatal volume has always been a challenge. In the past, dental casts were used to measure the volume of the palate [15] and later 3D digital models were used for this purpose [16]. Measurements with these three-dimensional images had drawbacks, including image noise and indistinct margins, which the CBCT could provide useful volumetric information by overcoming these limitations [17]. Few studies have investigated the effect of unilateral canine impaction on dentoalveolar indices and palatal dimensions [7, 18, 19]. Therefore, the aim of the present study was to evaluate maxillary width and palatal dimensions in patients with impacted maxillary canine by CBCT.

2. Methods

This research was approved by the ethics and research project committee of the Shahid Sadoughi University of Medical Sciences with REC number: IR. SSU.REC1399.246. CBCT of the patients, having the informed consent of their parents or themselves, was used. In this cross-sectional study, CBCT stereotypes were used to evaluate dentoalveolar indices and palate dimensions. For this purpose, by referring to a database of the Oral and Maxillofacial Radiology Center, the CBCT stereotype of patients with unilateral palatally impacted canine without current orthodontic treatment was included in the study. By examining patients' records, stereotypes related to people with the following characteristics were excluded from the study: 1) patients with a history of orthodontic treatment; 2) history of syndromic diseases such as Wegener's granulomatosis, thalassemia, Paget's disease, fibrous dysplasia and systemic problems affecting bone; 3) history of extra teeth, cysts, or oral pathological problems; 4) patients with combined incisor and canine impactions. All graphs were prepared by Scanora 3D CBCT radiograph (Soredex, Tuusula, Finland) with 90 kVp, 8 mA current, FOV (field of view) 10 * 7.5 cm and 200 μ voxel size. The sample consisted of forty five patients (18 boys and 27 girls) with average age of 15.2 ± 1.3 years. The obtained graphics were uploaded in Medical Mimics software INK.21.0. The uploaded images were analyzed by a trained researcher under the supervision of a dental radiologist. The side involved was identified based on records and stereotypes. Then, three parameters of maxillary arch width, palatal volume and palatal depth were examined. To determine the width of the dental arch, the distance between the middle palate and 1/2 of buco-palatal thickness of the alveolar crest was measured from the mesial side of the first premolar (Figure 1). This was accomplished by making an incision on surface of the crystal bone in axial view and then the measurements were compared with both the impacted and non-impacted sides.

The palate volume was measured in mid-sagittal view. The area of interest included the upper, lower, anterior and posterior vectors, which are referred to as follows: (1) Upper vector: in the mid-sagittal view, the highest point of the palatal vault (point e); (2) Lower vector: a line drawn at the cemento-enamel junction (CEJ) of the central incisor parallel to the horizon; (3) Anterior vector: connecting line of CEJ central incisor to point e; (4) Posterior vector: The line from the posterior nasal spine (PNS) perpendicular to the lower vector (Figure 2a). The 3D palate model was created in Mimics software, version 21, using the dynamic region growing tool. In this way, the volume of the palate was provided by this software (Figure 2b). A line from the upper vector (point e) was perpendicular to the lower vector, which was calculated as the depth or height of the palate (Figure 3).

The extracted data were entered into Excel software and then into SPSS (version 17) statistical software. Descriptive statistics were provided by mean and standard deviation for each parameter. The normality of all quantitative data was evaluated by the Kolmogorov-Smirnov test in terms of the latent side. The results showed that all variables follow the normal distribution (p-value $>$ 0.05), therefore, parametric tests were used. Homogeneity of data variance was confirmed by leven's test for equality of variance with p-value $>$0.05. Therefore, equal variances assumption is established in both groups. The mean of maxillary arch width and palatal volume between two groups of the non-impacted and impacted canine side were compared using the paired t-test. The significance level of 0.05 was considered for all data analyses.

3. Results

Among the 45 CBCT images reviewed, impacted canine teeth were located on the right side in 21 cases (46.7%) and on the left side in 24 cases (53.3%). The mean width of the maxillary arch on the impacted and non-impacted sides was 13.97 ± 1.57 mm and 15.61 ± 1.47 mm, respectively. Statistical analysis showed that the maxillary arch width on the impacted canine side was significantly lower than the non-impacted side ($p < 0.001$) (Table 1). The average palatal volume was 4602.32 ± 2006.59 mm^3 and 5204.12 ± 2211.22 mm^3 for impacted and non-impacted sides, respectively. According to the results of paired t-test, the mean palatal volume in the impacted canine side was significantly lower than the healthy side ($p < 0.001$) (Table 1). The mean depth of the palate was 14.86 ± 3.53 mm (Table 2). There was a significant correlation between canine impaction and Palatal volume ($R = 0.728$ and P-value< 0.001), but no significant correlation between canine impaction and Maxillary arch width was shown ($R = 0.15$ and p-value $= 0.326$).

4. Discussion

The prevalence of palatally impacted canine among orthodontic patients is 0.8%–3%. Due to the important and undeniable role of canine in terms of beauty and function, lack of timely treatment for eruption can cause facial asymmetry. In some adult patients with impacted canine, due to the risk of ankylosis, we have to remove the canine tooth surgically, which will lead to a permanent facial asymmetry in the patient.

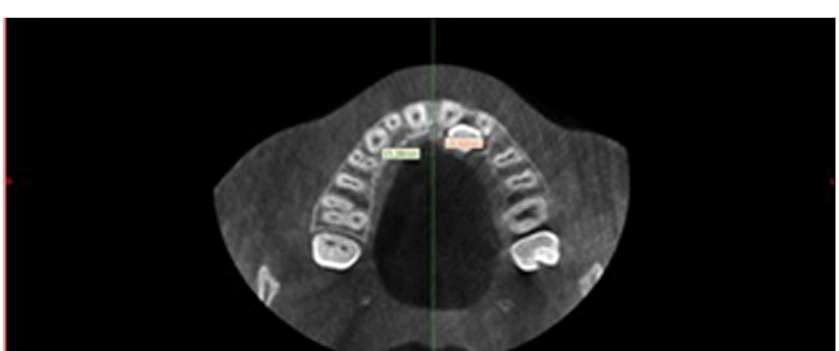

Figure 1. Determination of the maxillary arch width, the distance between the middle palate and 1/2 of bucopalatal thickness of the alveolar crest was measured from the mesial side of the first premolar.

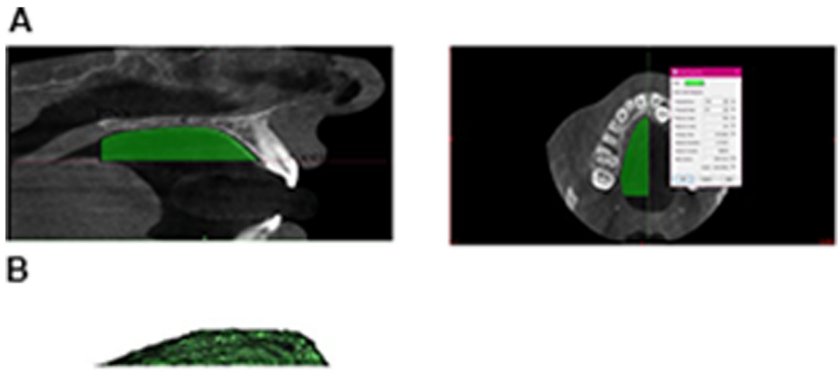

Figure 2. (A) Determination of the palatal volume The palate volume was measured in mid-sagittal view. The area of interest included the upper, lower, anterior and posterior vectors. (B) The 3D palate model was created in mimics software, version 21, using the dynamic region growing tool.

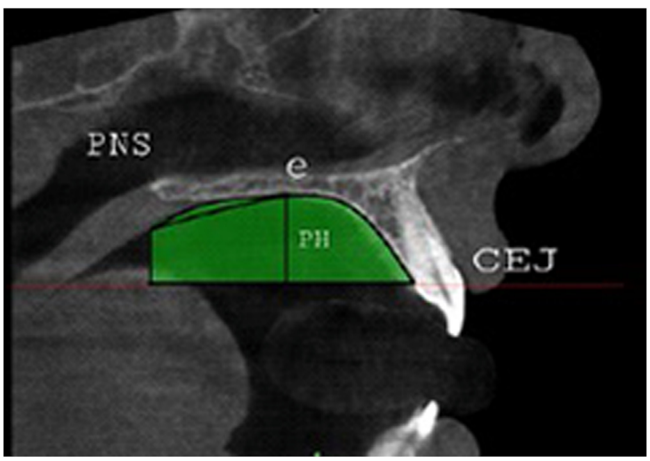

Figure 3. Determination of the patal depth A line from the upper vector (point e) was perpendicular to the lower vector, which was calculated as the depth or height of the palate.

Table 1. Mean maxillary arch width and palatal volume according to impacted canine position.

Parameter	Side	No.	Mean	S.D	P-value*
Maxillary arch width	non-impacted	45	15.61	1.47	<0.001
	Impacted	45	13.97	1.57	
	Difference	45	1.64	2.07	
Palatal volume	non-impacted	45	5204.12	2211.22	<0.001
	Impacted	45	4602.32	2006.59	
	Difference	45	601.79	871.27	

*paired t-test.

Table 2. Mean palatal depth with impacted canine.

Impacted canine patients	No.	Mean (mm)	SD (mm)	min	max
Total	45	14.86	3.53	8.08	28.30

On the other hand, maxillary stenosis is common in people with mouth breathing, which is more common in areas with cold [20] and dry [21] climates. In the study of Lion et al., mouth breathers with different palatal morphologies had 27.1% smaller palatal volume than those that breathe normally [22]. Primozic et al. Also found that prolonged mouth breathing in developing individuals causes the palate to develop narrower and deeper than in normal individuals [23]. The relationship between this narrowing of the palate and low palatal volume with impacted canine has been investigated in some studies [7, 9, 24, 25, 26] and in the present study, this case has also been addressed.

In the present study, CBCT images (n = 45) with unilateral maxillary impacted canines were examined. All images were measured independently in terms of maxillary arch width, palatal volume and palatal depth on both impacted and non-impacted sides. One of the challenges of this study was to find a sufficient sample size. Therefore, the number of samples has been tried to be more than similar studies. Accordingly, in the present study, 45 samples of CBCT images were examined, which was more than the study of Tadinada et al. (39 samples) and Arriola-Guillén et al. (28 samples) [7, 18].

In the present study, the mean maxillary arch width on the impacted canine side (13.97 mm) was significantly lower than the normal side (15.61 mm), but no significant correlation between canine impaction and Maxillary arch width was shown (R = 0.15 and p-value = 0.326).

Dental casts, two-dimensional radiographs and CBCT have been used in various studies to evaluate the dental arch width. Al-Khateeb et al. in a study examining 240 panoramic radiographs and 100 dental casts and the equivalent number as a control group, reported that the maxillary arch width in the study group was significantly less than the control group [27]. McConnell et al. studied 57 patients with impacted canine, the results of which showed that transverse maxillary deficiency was significantly more common in the study group than in the controls [9]. Al-nimri and Gharabieh reported a wider maxillary arc on the impacted side than on the opposite side [19]. Cacciatore also studied digital casts and reported that patients with impacted canines had significantly less palatal depth and narrower maxillary width than controls [24].

In a study of 79 occlusogram of patients with impacted canine, Saiar et al. calculated maxillary inter alveolar width at three levels of canine, premolar, and first molar, and reported decreased inter alveolar width at the canine level in the study group.

Arriola-Guillén et al. and Farokhi examined 28 and 46 CBCT images of individuals with unilateral impacted canine, respectively, in both studies the maxillary arch width on the affected side was less than the healthy side [18, 26]. The CBCT images are now the gold standard because they provide high-resolution 3D images and can provide linear and angular measurements for research purposes with minimal error.

In the present study, CBCT was used to assess canine position and dentoalveolar indices. The studies of Al-Khateeb, McConnell, Saiar, Arasena, and Farrokhi were consistent with the present study, and a significant decrease in maxillary width was observed in individuals with impacted canines in all the studies mentioned. The narrow width on the side of the impacted tooth is probably due to the lack of proper growth and lateral expansion of the palate on the side of the impacted canine relative to the opposite side. However, Mohammed and Mahmoud's study did not report a significant difference in palatal width between the maxillary impacted canine group and the non-impacted group [28]. Fattahi et al. [29] and Stanaitytė et al. [30] reported maxillary canine impaction not related to palatal width, and these findings are not consistent with the results of the present study. Therefore, this study was conducted to address these inconsistencies and its results are important in this regard.

The results of the present study showed that the mean palatal volume on the impacted canine side was 4602.32 mm3 and on the normal side was 5204.12 mm3, which was significantly lower. This means that the volume of the palate on the affected side is significantly less than on the normal side. There was a significant correlation between canine impaction and Palatal volume ($R = 0.728$ and P-value< 0.001).

In the present study, In the present study, the mean depth of the palate was 14.86 ± 3.53 mm. Since palatal depth is a single parameter for each CBCT image, a comparison was not made between subjects with right and left impacted canines. Zarringhalam et al. examined the depth of the palate in individuals with different occlusions on dental casts and reported an average palatal depth of 16.75 mm in healthy individuals with normal occlusion [31]. Moshajari et al. Also examined the mean palatal depth in individuals with different occlusions using CBCT images in mid-sagittal view and reported an average palatal depth of 22.20 ± 4.20 mm [32]. While in the present study, the average depth of the palate was 14.86 mm, this difference may indicate that people with impacted canine have less palatal depth than others, and impacted canine can reduce the depth of the palate.

According to searches in databases such as PubMed and google scholar, no study was found that examined the relationship between the volume and depth of the palate with the impacted canine, which was performed in the present study. Therefore, the need for further studies on these two variables is obvious.

5. Conclusion

The impacted canine was significantly associated with a reduction in the width of the maxillary arch on the affected side, and it made no difference if the impacted side was left or right. Also, impacted canine teeth were significantly associated with volume reduction on the affected side. There was a significant correlation between canine impaction and Palatal volume, but no significant correlation between canine impaction and Maxillary arch width was shown.

Declarations

Author contribution statement

Soghra Yassaei: Conceived and designed the experiments; Analyzed and interpreted the data.

Yaser Safi and Faeze Valian: Performed the experiments; Contributed reagents, materials, analysis tools or data.

Asma Mohammadi: Analyzed and interpreted the data; Wrote the paper.

Funding statement

Asma Mohammadi was supported by Yazd Reproductive Sciences Institute, Shahid Sadoughi University of Medical Sciences.

Data availability statement

Data will be made available on request.

Declaration of interest's statement

The authors declare no conflict of interest.

Additional information

No additional information is available for this paper.

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