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Association between maxillary canine impaction and arch dimensions

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Objective: To compare palatal height index, arch width, and arch length characteristics in Iranian patients presenting with palatal and buccal canine impaction with a matched control group.

Materials and methods: The case-control study examined 53 patients with canine impaction. The subjects were divided into two groups determined by buccal or palatal impaction which were compared with 53 control subjects presenting without impaction. Subjects in the experimental groups were matched with individuals in the control group according to age, gender, crowding and type of malocclusion. Palatal height and arch length were measured with a Korkhaus three-dimensional divider. Arch width was determined in the anterior and posterior portions of the maxillary arch with a digital caliper. Data were compared with paired *t*-tests.

Results: The buccal canine impaction group exhibited mean differences in arch length between the case and control groups of 0.8 mm (SD 1.63, $p = 0.041$). The differences between the case and control groups in intermolar width, interpremolar width, intercanine width, palatal depth, and palatal height index were not statistically significant. The palatal impaction group showed no statistically significant differences between the case and control group in any of the dependent variables ($p \leq 0.05$). In a re-test examination of arch dimensions, Bland-Altman plots showed no differences between the first and second measurements.

Conclusions: Arch length in the buccal canine group was the only statistically significant variable. The difference was small and was considered not clinically significant.

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Introduction

The incidence of maxillary canine impaction varies according to population characteristics particularly related to gender.[1,2] In European populations, maxillary canine displacement is reportedly more frequent on the palatal than on the buccal side of the arch.[3-5] The aetiology of canine impaction is not well understood, and many influencing factors have been proposed.[6-10] Richardson and Russell[11] noted that the frequency of maxillary canine impaction increased with other genetically associated dental anomalies. It was shown that inadequate arch space was associated more with buccal canine impaction rather than palatal impaction. Jacoby [12] found that 85% of palatally impacted canines had sufficient space for eruption. However, the buccal failure of eruption of the maxillary canine was considered a result of crowding.

The extraction of deciduous canines has been proposed as an initial form of treatment for impacted maxillary canines.[13] Cervical-pull headgear, increasing maxillary arch perimeter, and maxillary expansion to treat palatally displaced canines have also been recommended.[13-16] McConnell et al.[17] reported a transverse maxillary deficiency in the anterior portion of the dental arch in subjects with canine impaction. However, it was found that arch length, arch perimeter, and intermolar width were similar to a control group. An additional report[18] indicated

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that maxillary interpremolar and intermolar widths were significantly wider in patients with palatal canine impaction compared with a control group. Intercanine width was not assessed and the landmarks used for intermolar width evaluation were at variance with those measured by McConnell et al. However, it was concluded that space conditions in the maxillary arch did not play a significant role in the aetiology of palatally displaced canines (PDC).

Langberg and Peck[19] reported that anterior and posterior maxillary dental arch width was adequate in patients with palatally displaced canines. It was also reported[20] that patients with a transverse discrepancy were more likely to have a unilateral impacted canine compared with patients without this discrepancy. However, increasing severity of the transverse discrepancy did not increase the likelihood of bilateral impaction but this conclusion needed to be treated with caution due to the small sample size of subjects presenting with bilateral canine impaction.

Recently, Baccetti et al.[21] supported the use of maxillary expansion,[18,20] to decrease the incidence of PDC. The use of a banded rapid maxillary expander in the early mixed dentition was considered to facilitate the successful eruption of canines. A palatal height index (PHI) was used to evaluate palatal shape and was calculated as palatal height multiplied by 100 divided by palatal width at the level of the upper first molar.[22] Since it has been considered that the morphology of the palate might affect the impaction of maxillary canines, the aims of this study were to evaluate PHI in an Iranian population presenting with palatal and buccal canine impaction and to compare with a matched control group. Anterior and posterior arch length and arch width were also compared between the groups.

Methods

The records of 106 individuals (53 subjects and 53 matched controls) were evaluated in a retrospective case-control study. The sample size was calculated based on a mean (± standard deviation) difference in overall arch dimensions between the canine impaction and normal groups of 1.0 ± 1.83 mm, and an α value of 0.05, for 80% power. It was determined that 53 subjects were required for each group and all provided written informed consent for their records to be reviewed. Subjects with maxillary canine impaction were referred to, and were treated by one operator (HF). The composition of each matched group comprised 42 (79.2%) skeletal Class I cases (ANB 1-5°, Wits' measurement -3 - 0 mm, and normal profile) and 11 (20.7%) skeletal Class II cases (ANB > 5°, Wits' measurement ≥ 1 mm, and convex profile). Orthodontic diagnosis and treatment planning of participants required forced eruption of the impacted canines, involving surgical exposure and orthodontic elevation. Pretreatment canine position was determined radiographically and confirmed during surgical exposure. Each subject in the treatment group was matched according to age, gender, type of malocclusion and level of crowding. There were no buccal crossbites in the control group; however, this characteristic was not considered as an exclusion criteria in the experimental group.

Palatal depth and arch length were measured with a three-dimensional bow divider (Korkhaus, model 028-353 Dentaurum, Germany) at the level of the occlusal plane of the upper first molars (Figure 1). The three-dimensional divider had a horizontal and a scaled vertical axis. The horizontal axis indicated arch length measured from the labial surfaces of the upper central incisors to the first molars, when the divider tips were placed in the molar fossae (Figure 1). Palatal depth was measured on the vertical axis. Intermolar width was measured from the point of intersection of the transverse fissure with the buccal fissure of the first permanent molars (Figure 2). The PHI was subsequently calculated by dividing palatal height by the intermolar width using the following formula:

$$\frac{\textit{Palatal height} \times 100}{\textit{Intermolar width}} = \textit{PHI}$$

Interpremolar width was recorded with a digital caliper to 0.01mm accuracy (model CD-6GS, Mitutoyo, Japan). Measurements were taken from the lower-most point of the transverse fissure of the first premolars (Figure 2). Intercanine distance was measured by placing the caliper tips on the cingulum of the deciduous canines or on the midpoint of the alveolar crests in the impaction group. This measurement was recorded in the control group from the cingulum of the canines. All recordings were measured by a dental student who was blinded to group allocation. Measurement error was determined by remeasurement of the distances in 50 subjects randomly sampled two weeks later by the same

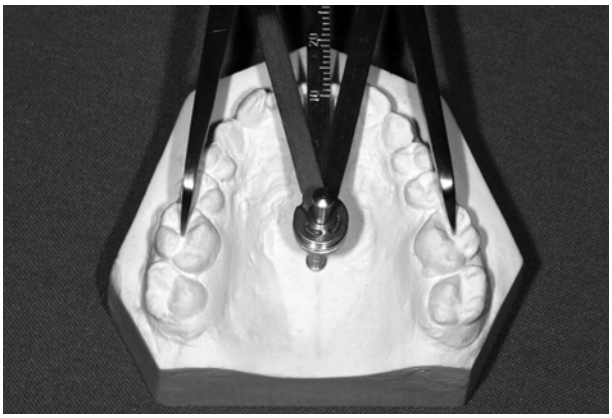


Figure 1. Palatal height, arch width and length measured using Korkhaus three-dimensional divider.

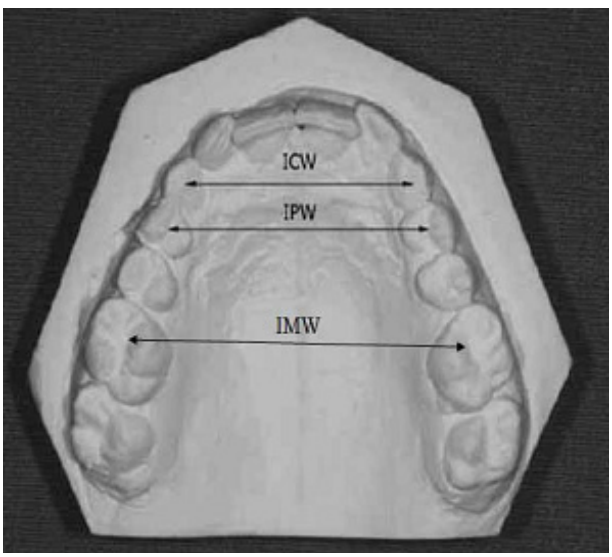


Figure 2. Intercanine and interpremolar distance measured in the study cast.
ICW: Intercanine width
IPW: Interpremolar width
IMW: Intermolar width

examiner. Agreement was evaluated with a Bland-Altman plot of the two measurements which revealed no error (Table I).

Statistical analysis

Normal distribution of the measurements was evaluated with the Kolmogrov-Smirnov test at $p \leq 0.05$. Paired *t*-tests were used to compare the parameters in canine impaction case-control pairs (total and separately for buccal and palatal groups). A p value of 0.05 or lower was considered statistically significant. All data were analysed with SPSS (version 16) software.

Results

There were more females (83%) in the case and control groups and the 15 to 20-year-old subjects predominated (34%). The age range of participants was between 13 and 31 years (Mean = 20.57; SD = 4.85) in the case group and 13 and 34 years (Mean = 20.58; SD = 4.97) in the control group, respectively. The difference was not statistically significant (p = 0.984). Palatal canine impaction was present in 33 patients (62.3%), of whom 18 had unilateral and 15 had bilateral impactions. Twenty patients (37.7%) had buccal impaction of which 19 were unilateral and one was a bilateral impaction. In combining the groups, 37 subjects (69.7%) had unilateral impaction and 16 (30.2%) had bilateral impaction. The distribution of unilateral and bilateral canine impaction was dissimilar.

Table I summarises the results of intermolar width, interpremolar width, intercanine width, palatal depth, arch length and palatal height index measurements in the buccal and palatal canine groups compared with their matched controls. Arch length was greater in the buccal impaction group compared with the control group. The mean difference, 0.8 mm (SD = 1.63) and 0.67 (SD = 2.13) respectively, was statistically significant (p = 0.041; p = 0.026). No other statistically significant differences were evident in other parameters in the buccal and palatal impaction groups or in the control group ($p > 0.05$).

Discussion

No clinically significant differences were found in PHI and arch dimensions between subjects with and without canine impaction. In subjects with canine impaction (buccal and palatal), PHI was approximately 36%, a figure not significantly different from the PHI in the matched control group without impaction. This percentage was lower than the 42% reported earlier as the average ratio in normal individuals.[22]

McConnell et al.,[17] in a retrospective study, reported that subjects with impacted maxillary canines had transverse deficiencies in the anterior portion of the arch. It was stated that mean intercanine width for the experimental group was two standard deviations below that of a control group. McConnell et al. defined an impacted canine as a non-functional tooth which failed to erupt into normal position. The impaction was also confirmed based on pretreatment

Table I. Mean (SD) of evaluated parameters in canine impaction case-control pairs.

Parameters		Case (N = 53)	Control (N = 53)	*p* value[1]
Intermolar width	Buccal (N = 20)	44.38 (1.80)	44.45 (2.50)	0.918
	Palatal (N = 33)	44.79 (2.00)	44.59 (2.56)	0.732
Interpremolar width	Buccal (N = 20)	34.43 (1.73)	34.75 (2.45)	0.612
	Palatal (N = 33)	35.02 (2.04)	34.45 (2.60)	0.401
Intercanine width	Buccal (N = 20)	27.95 (1.74)	28.80 (2.05)	0.087
	Palatal (N = 33)	28.26 (2.35)	28.50 (2.62)	0.735
Palatal depth	Buccal (N = 20)	16.28 (1.77)	15.98 (1.67)	0.540
	Palatal (N = 33)	15.42 (1.43)	15.82 (1.89)	0.335
Arch length	Buccal (N = 20)	31.05 (2.39)	30.25 (1.92)	**0.041**
	Palatal (N = 33)	30.71 (2.07)	30.12 (2.10)	0.166
Palatal height index	Buccal (N = 20)	36.66 (3.42)	36.07 (4.94)	0.656
	Palatal (N = 33)	34.45 (3.64)	35.47 (4.97)	0.352

[1]paired *t*-test
Significant value in bold

radiographs and the treatment received by the subject. It was also reported that approximately 71% of the patients had PDC and 29% had labially displaced canines. However, no differentiation between palatal and labial impaction was noted in their results. In addition, the age of the participants was not revealed, nor was the control group adequately defined or matched. Saiar et al.[23] reported a reduced intercanine width in palatally displaced canines compared with a control group. However, it was speculated that this was the result of the eruptive status of the deciduous or permanent canines rather than the cause of impacted canines. Schindel and Duffy[20] concluded that there was an association between potentially impacted canines and a transverse discrepancy across the molar region. A sector classification proposed by Lindauer and Hang[24] was used to diagnose early impactions based on panoramic radiographs. The experimental group consisted of orthodontic patients in the mixed dentition who were selected by visual observation to possess a maxillary transverse discrepancy and a clinically noticeable crossbite. The transverse discrepancy was calculated as the difference between the maxillary and mandibular intermolar widths.

Langberg and Peck[19] found no interpremolar or intermolar width deficiency in patients with PDC. A shortcoming of the study by McConnell et al.[17] was the fact that the measurement points were based on a visual estimate of the putative 'normal' site of canine eruption. Accordingly, this technique was considered 'an unreliable estimate and contraindicated for a quantitative study'. In contrast, Al-Nimri and Gharaibeh[18] found a greater interpremolar and intermolar width in a group of subjects with unilateral palatal impaction compared to a control group. In this study, matching of the patients was not ideal, as most of the subjects in the impacted group (44%) presented with a Class II division 2 incisor classification while the subjects with a Class I malocclusion were dominant in the control group (57%). In addition, the position of the impacted canine relative to the dental arch was determined by a parallax technique, rather than by direct inspection.

Maxillary expansion has been proposed[17,20] as an interceptive technique to assist the rate of eruption of PDC in subjects with a transverse discrepancy. Baccetti et al.[21] detected no transverse deficiency of the maxilla at the skeletal level in early mixed dentition subjects with palatally-displaced canines. However, a reduced intermolar width (42.5 mm) in

PDC groups was evident in association with a Class II or Class III tendency compared with an intermolar width figure of 46 mm[25] in subjects with normal occlusal relationships. Nevertheless, 3.5 mm of inter-arch transverse discrepancy was shown at the dental level. The authors[21] concluded that the maxillary arch might be deficient and recommended rapid maxillary expansion as an interceptive treatment to encourage the eruption of a PDC. Intermolar width in the current impaction groups was 44.5 mm and therefore much greater than the value previously reported.[21] This difference was attributed to the different ages of the participants in the two studies. Based on the results of the present study, arch expansion cannot be supported as a corrective treatment option for impacted canines in older subjects without transverse discrepancy. Arch expansion might be recommended as an effective interceptive approach to facilitate the eruption of a PDC when accompanied by a transverse discrepancy.

The present study confirmed that the incidence of palatal canine impaction (62.3%) remains higher than buccal impaction (37.7%). Peck et al.[5] reported that published cases of palatal canine impaction or displacement were of European origin and concluded that the relative prevalence rate ratio for all types of impacted canines between Europeans and Asians was 2:1. This ratio was 5:1 for a PDC. The present study in an Iranian population indicated a higher incidence of palatal displacement similar to that reported in European groups.

A significant strength of the present study was the ability to distinguish between the two types of canine impaction as direct inspection of the canines occurred at the time of surgical exposure. Since many etiologic factors are proposed for buccal and palatal canine impactions,[12] and maxillary transverse deficiency may not influence the impaction of canines, based on the results of the present study, different management protocols require consideration. A more precise diagnostic tool, such as 3D imaging, would be of value in aiding clinicians in definitive diagnosis and treatment planning decisions.

Conclusions

The palatal height index was similar in subjects with an impacted canine and in matched controls without impaction.

There was no anterior or posterior arch width deficiency in patients with canine impaction compared with subjects without impaction.

Palatal depth was similar in matched subjects with and without impaction.

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