

Original Article

Correlation between maxillary cuspid impaction with available space and anomalies of maxillary lateral incisors

Kimia Rohani¹, Ladan Eslamian², Golnaz Nahvi³

¹MSc Student, Division of Oral Health and Society, Faculty of Dentistry, McGill University, Montreal, Canada ²Professor of Orthodontics, Dentofacial Deformities Research Center, Research Institute of Dental Sciences, School of Dentistry, Shahid Beheshti University of Medical Sciences, ³Department of Orthodontics, School of Dentistry, Shahid Beheshti University of Medical Sciences, Tehran, Iran

ABSTRACT

Background: Association of cuspid impaction with adjacent lateral incisor anomalies is under controversy. The aim of this study was to investigate the correlation between maxillary cuspid impaction with dental anomalies.

Material and Methods: In this *in vitro* experimental study, the material consisted of pretreatment dental records of 102 patients with at least one palatally or buccally displaced impacted permanent cuspid (palatal and buccal impaction groups). They were matched with a comparison control group of 102 patients having normally erupted maxillary cuspids. Available space, mesiodistal dimensions of teeth, and morphologic parameters of lateral incisors were measured using the digital caliper. Comparison of mean values of lateral incisors anomalies and severity of crowding between different groups were performed using the one-way ANOVA test, and the analysis of associations between position of the impaction and anomaly of the lateral incisors and severity of crowding was performed using the Chi-square test. $P < 0.05$ was considered statistically significant.

Results: There was no statistically significant difference in the arch length–tooth size discrepancy between the cuspid impaction groups and control group. The impaction group (buccal or palatal) presented statistically significant differences in terms of anomalies of maxillary lateral incisor compared to the control group. Peg-shaped lateral incisor was related to buccal cuspid impaction and microdontia had relationship with palatal cuspid impaction.

Conclusion: There is the relationship between cuspid impaction and adjacent lateral incisor abnormality, but no difference was observed between buccal and palatal cuspid impactions. Crowding revealed no relationship with cuspid impaction (buccal or palatal) in this study.

Key Words: Cupid, impacted, tooth

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Address for correspondence:

Dr. Golnaz Nahvi,
Department of
Orthodontics, School of
Dentistry, Shahid Beheshti
University of Medical
Sciences, Tehran, Iran.
E-mail: golnaznahvi@gmail.
com

INTRODUCTION

Cuspid tooth impaction is attributed to the infraosseous position of the tooth after the expected time of eruption^[1] or to the cuspid that is not expected

to erupt completely and promptly based on clinical and radiographic assessment.^[2]

The maxillary cuspid is the second-most common tooth affected by impaction after the third molar,

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with a prevalence range from a minimum of 0.8% to a maximum of 5.2% and different gender incidence depending on the population examined.^[1,3-6] Palatal impactions include 85% of the impacted maxillary permanent cuspids and 15% are labial impactions.^[7] Palatally impacted maxillary cuspids occur twice as often in females than males, with a high family association, and the prevalence is five times more common in Caucasians than Asians.^[8]

The etiology of maxillary cuspid impaction is not still well known. Although numerous probable factors are under assessment, it is reported that the buccally displaced cuspid and the palatally displaced cuspid are characterized by different etiopathogenesis.^[8,9]

Insufficient arch space and a vertical developmental direction of eruption are proposed to be associated with buccal cuspid impactions.^[7]

No exact etiology is attributed to the palatally impacted maxillary cuspids; however, two common theories are proposed: The guidance theory and the genetic theory. The “guidance theory of palatal cuspid displacement” expresses that local predisposing factors, including congenitally missing lateral incisors, supernumerary teeth, odontomas, transposition of teeth, and other mechanical interferences, may contribute to maxillary cuspid tooth impaction.^[10,11] Maxillary cuspids are among the last teeth to develop and have a long path before they erupt into the dental arch. These factors increase the potential for mechanical disturbances culminating in displacement and impaction.^[10]

The second theory focuses on a genetic cause for impacted cuspids.^[12,13] Palatally impacted maxillary cuspids often accompany with other genetic dental abnormalities, including tooth size, shape, number, and structure such as enamel hypoplasia of incisors and permanent first molars, aplasia of second bicuspid, and infraocclusion of primary molars.^[11]

Research demonstrates a higher prevalence of maxillary lateral incisor anomalies with impacted/displaced cuspids.^[14-18] However, none of the proposed theories could completely justify the causes of maxillary cuspid impaction, and hence, it still remains unclear that dental anomalies are associated with local or genetic factors.

Therefore, the aim of this study was to evaluate the association of cuspid displacement with other co-current dental anomalies. This may help to

diagnose patients with a high risk of cuspid impaction to facilitate earlier interception.

MATERIAL AND METHODS

The material for this *in vitro* experimental retrospective study consisted of the pretreatment orthodontic records (dental casts, panoramic and lateral cephalograms, and cone-beam computed tomography [CBCT]) of 102 nonsyndromic orthodontic patients. In this study, 102 participants with at least one cuspid impaction were randomly selected from patients seeking for orthodontic treatment at the Department of Orthodontics at Shahid Beheshti and Tehran University of Medical Sciences during February 2012–July 2015. This group comprised the Iranian participants (32 males and 70 females) diagnosed with cuspid impaction with the ages ranged from 14 to 39 years old and a mean age of 17.57 years (± 5.42). None of the selected samples have both buccal and palatal impactions. These participants were matched to 102 orthodontic unaffected patients based on the age and gender (control group). More detailed information is demonstrated in Table 1.

Participants were selected based on the following criteria:

1. Unilateral or bilateral maxillary cuspid impaction. The position of the impacted cuspid relative to the dental arch was determined by the parallax technique.^[19]
2. The impacted cuspids should have a fully formed root apex without any sign of eruption into the oral cavity
3. Both genders with maxillary cuspid impaction without any systemic disease, trauma or fracture of the jaw that might have affected normal growth of the dentition.

Patients with craniofacial syndromes associated with tooth aplasia or displacement, trauma, cleft lip/palate, and multiple agent chemotherapy were excluded.

Table 1: Demographic information of the study and control groups

Groups	Gender		Mean age (years) impaction		Impaction (n)	
	Male (n)	Female (n)	Buccal	Palatal	Buccal	Palatal
Samples	32	70	17.42	17.63	31	71
			17.57			
Control	32	70	17.60		–	–

The impaction diagnosis was determined on the basis of clinical examinations and standardized radiographs (panoramic radiographs, computed tomography, and intraoral radiographs) and confirmed visually during the surgery.

Clinical examination was conducted by conventional methods, including whole arch inspection, palpation to identify any retained deciduous cuspid, visualization of the cuspid bulge, splaying out of the lateral incisors, lost space, crowding, fibrous tissue overlying the cuspid region, and mobility of the primary cuspids. A review on patient's chronological age and history of dental eruption/exfoliation pattern was undertaken carefully.

Clinical examination was supplemented with the radiographic evaluation to reach the accurate diagnosis. Panoramic and anterior occlusal radiographs or CBCT views were used to determine the position of the impacted cuspid. All radiographs were viewed on view screen with the area surrounding of the radiographs shielded with dark paper to block interfering lateral light and to improve viewing contrast. The anatomical position of the impacted cuspid was classified as: Buccal, palatal, and bucco-palatal positions. The U1-SN angle was measured from pretreatment lateral cephalograms.

From the dental cast, the following parameters were obtained:

Measurements related to upper lateral incisor anomalies

- Peg-shaped/small maxillary lateral incisors – a small maxillary lateral incisor was diagnosed when the mesiodistal width of the crown was reduced compared to the contralateral tooth; a peg-shaped maxillary lateral incisor was diagnosed when the crown was reduced in size and had a conical shape^[20]
- Hypoplasia (mesiodistal distance smaller than the corresponding tooth in the lower jaw, the difference being at least 1 mm)
- Congenital aplasia

These data were recorded by direct observation from the dental cast and confirmed by radiographic examination.

Measurements related to space conditions

The mesiodistal width of each tooth

The mesiodistal width of a tooth was obtained by measuring the greatest distance between

contact points on proximal surfaces parallel to the occlusal and labial surfaces. An electronic digital caliper (Digimatic calipers, Mitutoyo Corporation 500-301 CD-15 Corporation, Tokyo, Japan) was used to read to the nearest 0.01 mm. Measurements were made as described by Moorrees *et al.*^[21]

The mesiodistal width of the unilateral impacted cuspid was judged to be equal to that of the contralateral permanent cuspid. Mesiodistal width of upper central and lateral incisors and the four lower anterior mandibular incisors were measured to predict mesiodistal width of cuspid, first and second bicuspid according to the method discussed by Meibodi *et al.*^[22]

Space available

Arch perimeter was calculated by dividing each arch into six sections. In the presence of cuspid, each quadrant was measured in three sections as follows:

1. Central papilla to lateral-cuspid papilla
2. Mesial cuspid papilla to distal cuspid papilla
3. Mesial of the first premolar papilla to mesial first molar papilla.

If the cuspid was absent in the arch, the space between lateral and first bicuspid was considered in measurements [Figure 1]. If there was no space between lateral and bicuspid, the quadrant was divided into two parts and the measurements were performed.

Space available was calculated by subtracting the total tooth size from the arch perimeter. This value was added to the required space for U1-SN angle correction (102 ± 2 degrees is considered as normal

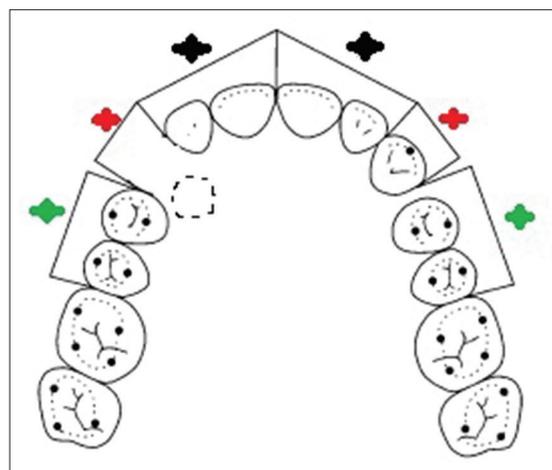


Figure 1: Space available measurements in cases of the presence of cuspid (left side) and the canine impaction (right side).

and the amount of 0.8 mm is added or subtracted for each degree correction) and levelling curve of spee to measure the amount of crowding according to the method proposed by Merrifield.^[23,24]

The following categorization was performed to quantify the amount of crowding:

- <0 spacing
- 0–5 mild crowding
- 5–10 moderate crowding
- >10 severe crowding.

All dental cast measurements were made at least twice by the same examiner using a digital caliper. If the difference between the two measurements was apparent, a third reading was made and the aberrant one discarded. The mean of the two closest measurements was used in the calculations. The measurement error was calculated according to the Dahlberg's double determination method.^[25] The results of the measurement error were 0.50 mm for arch perimeter.

Statistical analysis

Statistical descriptive analysis was performed, and the data were analyzed using the version 22 of SPSS software (Statistical Package for the Social Sciences, IBM Corporation, New York, NY, USA). Comparison mean values of quantitative variables between three groups of buccal impaction, palatal impaction, and control group were performed using the one-way ANOVA test, and the analysis for significant associations between impaction position and lateral incisors anomaly and severity of crowding was performed using the Chi-square test; $P < 0.05$ were considered statistically significant.

Variables of lateral incisor size and shape were compared to the counterpart to investigate the correlation between cuspid impactions and adjacent lateral incisor anomalies, and then, the data were compared in the control and study (buccal and palatal) group.

RESULTS

- Dental crowding had normal distribution in three groups of control, buccal, and palatal impaction using the Shapiro–Wilk test. The mean dental crowding in three groups was compared using the one-way ANNOVA test. The result showed no statistically significant difference between the groups ($P = 0.052$) [Figure 2]

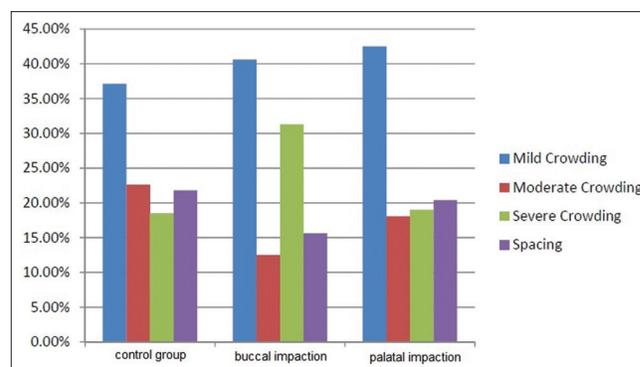


Figure 2: Percentage of the amount of crowding in different groups (control, buccal and palatal impactions).

- Lateral incisor abnormalities (microdontia, missing, or peg-shaped) to adjacent cuspid tooth (control, buccal, or palatal impaction) were compared using the Chi-square test. A significant difference was observed between three groups ($P = 0.015$); in the control group, lateral anomaly was less than the groups with buccal or palatal impaction (control = 5.9%, buccal impaction = 19.4%, and palatal impaction = 19.7%)
- Two by two comparison of groups in terms of existence of lateral incisor abnormalities using the Chi-square test showed significant difference in buccal impaction and control groups ($P = 0.003$) and palatal impaction and control groups ($P = 0.007$). However, no significant difference was observed between buccal and palatal impaction groups in terms of lateral incisor anomaly ($P = 0.966$)
- Percentage of each anomaly (missing, peg-shape, or microdontia) in three groups of normal, buccal, and palatal impaction is demonstrated in Table 2
 - There is no significant difference between three groups (control, buccal or palatal impaction) in terms of lateral incisor missing using the Fisher's exact test ($P = 0.369$)
 - There is a significant difference between three groups (control, buccal or palatal impaction) in terms of peg-shaped lateral incisor using the Pearson Chi-square test ($P = 0.042$)
 - There is significant difference between three groups (control, buccal or palatal impaction) in terms of lateral incisor microdontia using the Fisher's exact test ($P = 0.026$).
- Comparison of buccal and palatal groups in terms of the existence of each lateral incisor anomalies (missing, peg-shaped, and microdontia)

is demonstrated in Table 3 using Fisher’s exact test. None of the anomalies demonstrated significant difference between buccal and palatal groups

- No statistical difference was observed between male and female in terms of buccal or palatal cuspid impaction using Fisher’s exact test ($P = 0.325$).

DISCUSSION

Since cuspid teeth have considerable significance in determining facial proportion and esthetic and also harmony of the occlusal relationship, impaction or displacement of these teeth could lead to various complications such as temporomandibular disorders, cyst formation, and root resorption of the adjacent teeth or local infection. Therefore, early diagnosis and adoption of an appropriate approach to guide this tooth to its proper location could reduce or eliminate the mentioned consequences and culminate into a better maintenance of the oral apparatus and adjacent structures, desirable occlusion, and facial esthetic and function.^[26] This study could give a better understanding of the relationship between cuspid impaction, dental anomalies, and available space in the dental arch.

In the current study, the prevalence of maxillary cuspid impaction in female was more than two times greater than male which was in contrast with another study, which reported a higher prevalence of cuspid impaction in males.^[3] Higher frequency of maxillary cuspid impaction in women reported in this study is the same as the epidemiological descriptions in most

other studies,^[5,17,27-30] which is contributed to more orthodontic treatment demands by women.^[31] Despite more prevalence of cuspid impaction in women, no statistical relationship was found between cuspid impaction and gender in this study as well as other studies conducted by Brin *et al.* and Mossey *et al.*^[32,33] This result is in contrast with other study conducted by Peck *et al.* which reported correlation between gender and tooth impaction.^[34] We should take this fact into consideration that small sample size used in this study and more orthodontic treatment demands in women could influence the interpretation and generalization of the results. In another study conducted in Iranian population, the frequency of dental anomalies including impactions was not different between males and females, which is in accordance with the results of our study.^[35]

In the current study, palatal cuspid impaction occurred two times as much as buccal impaction, which is in accordance with some studies^[12,36] and in contrast with another study which reported a higher prevalence of buccal unilateral cuspid impaction.^[37]

In this study, no significant difference was observed in terms of dental crowding or spacing between buccal and palatal impaction and control group, which is in accordance with some studies.^[16,27,38,39] This result may give a more power to genetic theory than the guidance theory, whereas other studies showed affinity for spaced dentition in palatal impactions in the clinical point of view.^[12]

In this study, the prevalence of the lateral incisor with microdontia was more in palatal impaction group, and the peg-shaped lateral incisor was more prevalent in buccal impaction group. Furthermore, the lateral incisor missing was the same in normally erupted and buccal or palatal impaction groups. Considering all three lateral incisor anomalies (missing, peg-shaped, or microdontia) investigated in this study, buccal and palatal impaction groups had no statistical difference which supports the results reported by some studies which showed no difference in lateral incisors abnormality in buccal and palatal impaction groups.^[16,28,40] Chaushu *et al.* reported greater mesiodistal size of the teeth and therefore more crowding in buccal impaction group.^[41] However, we did not find significant difference in terms of crowding between buccal and palatal impaction groups, although the lateral incisor was mesiodistally smaller in the palatal group. According to these results,

Table 2: Percentage of three groups of normal, buccal, and palatal impacted cuspid in terms of adjacent lateral incisor anomaly (missing, peg-shape or microdontia)

Groups	Normal	Missing	Peg-shape	Microdontia
Normally erupted cuspid	93.1	1.0	2.0	3.9
Buccal impacted cuspid	80.6	0.0	12.9	6.5
Palatal impacted cuspid	73.2	4.2	8.5	14.1
<i>P</i>		0.369	0.026*	0.042*

**P*- value less than 0.05 is considered as significant

Table 3: Comparison of buccal and palatal groups in terms of the existence of each lateral incisor anomalies (missing, peg-shaped, and microdontia)

Impaction groups	Missing (mean)	Peg-shape (mean)	Microdontia (mean)
Buccal	0.0	12.9	6.5
Palatal	4.2	8.5	14.1
<i>P</i>	0.551	0.721	0.331

buccal cuspid impaction is not related to crowding and palatal impaction could not be attributed to lateral incisor anomalies which give more importance to genetic theory rather than the guidance theory of the cuspid impaction.

In the current study, no significant association was found between cuspid impaction and congenital missing of lateral incisor in any group of the buccal, palatal, or control groups. This finding is the same as a study conducted by Mercuri *et al.* which reported no correlation between palatal cuspid impaction and having a congenitally missing lateral incisor or hypodontia,^[42] while others declare that lateral incisor missing is an etiologic factor for palatal cuspid impaction.^[16,27,28,31,39]

The current study showed significant relationship between impactions (buccal or palatal) and lateral anomaly which is in accordance with numerous studies reporting the relationship between lateral incisor anomaly and palatal cuspid impaction.^[16,27,28,31,39,40,43] No significant difference was observed between buccal and palatal groups in terms of anomalous lateral which is the same as Chaushu *et al.*'s study that reported no difference in the prevalence of anomalous lateral between buccal and palatal groups.^[44]

In the literature, few studies exist regarding comparing lateral anomalies of buccal and palatal impactions. In a study conducted by Nagpal *et al.*, buccal and palatal impactions showed the same amounts of lateral incisor anomalies,^[39] which is the same as the result of our study.

Regarding different ethnic traits, insufficient studies in buccal impactions, and a high prevalence of the associated anomalies with cuspid impactions in studies with considerable sample size,^[45,46] it can be proposed that buccal and palatal cuspid impactions are not two distinct phenomena with different etiologies. They could be associated with several dental anomalies and their position with regard to the dental arch is compromised by numerous factors.

Although considerable researches have been conducted to figure out the etiology and pathogenesis of cuspid impactions, yet exist continuing speculations with this regard. The result of the current research did not show significant difference between buccal and palatal cuspid impaction in terms of the adjacent lateral incisor anomaly in Iranian population but care must be taken in generalizing this result to other populations. Complicated and prolonged path

of eruption of the cuspids, ethnical varieties, and different accompanied anomalies propose numerous factors in full eruption and the presence of these teeth in the oral cavity.

One of the drawbacks of the current study is the limited sample size of the buccal cuspid impactions. We suggest another study to be conducted with more sample size in buccal and the same sample size in buccal and palatal areas.

It is also suggested to conduct other studies to investigate other teeth abnormalities (not only lateral incisors) in the selected samples. This study does not investigate the genetical history of the samples. It is one of the limitations of this study because it is of importance to discriminate genetical from the environmental factors.

CONCLUSION

The current study with all of its limitations revealed that:

- There is no relationship between buccal or palatal cuspid impaction and dental crowding
- There is the relationship between lateral incisor abnormality (microdontia, missing or peg-shaped) and buccal or palatal canine impaction
- There is no difference between buccal and palatal canine impaction in terms of adjacent lateral incisor abnormality
- Positive relationship exists between peg-shaped lateral incisor and buccal cuspid impaction and also between microdontia and palatal cuspid impaction
- No relationship existed between cuspid impaction (buccal or palatal) and gender.

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Conflicts of interest

The authors of this manuscript declare that they have no conflicts of interest, real or perceived, financial or non-financial in this article.

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