European Journal of Orthodontics 27 (2005) 461–465
doi:10.1093/ejo/cji022
Advance Access publication 16 June 2005

Space conditions and dental and occlusal features in patients with palatally impacted maxillary canines: an aetiological study

Kazem Al-Nimri and Tareq Gharaibeh
School of Dentistry, Jordan University of Science and Technology, Irbid, Jordan

SUMMARY The aetiology of palatal canine impaction is unclear. The aim of this research was to investigate the occlusal features that could contribute to the aetiology of palatal maxillary canine impaction. The material consisted of the pre-treatment dental casts of 34 patients (27 female and seven male) with unilateral palatal canine impaction (impaction group). The average age of this group was 17.7 years (± 4.6). These were matched according to age, gender and type of malocclusion with a comparison group of pre-treatment dental casts from unaffected orthodontic patients. From the dental casts the following parameters were obtained: (1) dentoalveolar arch relationship, (2) missing or anomalous teeth, (3) the mesiodistal width of each maxillary tooth, (4) the upper arch perimeter, (5) the maxillary inter-premolar and inter-molar widths. The arch length–tooth size discrepancy was only calculated for subjects with no missing teeth.

Palatal canine impaction occurred most frequently in subjects with a Class II division 2 malocclusion. There was an association between palatal canine impaction and anomalous lateral incisors ($P = 0.01$). The transverse arch dimension was significantly wider in the impaction group than in the comparison group ($P < 0.01$). There was no statistically significant difference in the mesiodistal width of maxillary teeth or in the arch length–tooth size discrepancy between the palatal canine impaction group and their matched comparisons ($P > 0.05$). These results suggest that the presence of an 'excess palatal width' and anomalous lateral incisor may contribute to the aetiology of palatal canine impaction.

Introduction

The maxillary canine is the second most frequently impacted tooth in the dental arch after the third molars (Shah *et al.*, 1978). The incidence of upper canine impaction has been reported to vary between 1 and 2.2 per cent (Dachi and Howell, 1961; Thilander and Myrberg, 1973). In 70–85 per cent of these impactions the canine is located palatal to the dental arch, while in the remaining 15–30 per cent the canine is buccally impacted or is in the line of the arch (Nordenram and Stromberg, 1966; Jacoby, 1983).

Palatal and buccal canine impactions are considered to be completely different entities. Buccal canine impaction is thought to be a form of crowding. Insufficient space in the upper arch for the eruption of the maxillary canine culminates in its impaction (Jacoby, 1983). Nevertheless, given time and space this tooth will usually erupt in the oral cavity (Thilander and Jakobsson, 1968).

The aetiology of palatal canine impaction is not very clear. Some authors believe, contrary to buccal impaction, that the presence of excess space in the upper arch could lead to palatal canine impaction by allowing the canine to cross back from the buccal to the palatal side. Jacoby (1983) reported that 85 per cent of palatally impacted canines have sufficient space for eruption. Stellzig *et al.* (1994) also found arch length sufficiency in 82 per cent of subjects with palatally impacted canines. However, McSherry and Richardson (1999) found that palatally impacted canines actually failed to initially cross from the palatal to the buccal side but continued to descend on a palatal pathway throughout their development. Others incriminated the congenital absence or presence of small lateral incisors to palatal canine impaction (Becker *et al.*, 1981). Those authors suggested that the presence of a lateral incisor root with the correct length, formed at the right time, is an important variable needed to guide the erupting canine into a favourable direction. The mesiodistal crown width of the maxillary and mandibular incisors has been reported to be significantly smaller in patients with palatal canine impaction (Langberg and Peck, 2000a). Mossey *et al.* (1994) found an association between palatal canine displacement and lateral incisors of smaller than average crown width, while Brenchley and Oliver (1997) reported that there was no statistically significant evidence to support the view that palatally displaced canines are associated with diminutive maxillary lateral incisors. A different aetiology was discussed by McConnell *et al.* (1996), who implicated a deficiency in the maxillary width as a local mechanical cause for palatal canine displacement. They studied a sample of orthodontic patients diagnosed with maxillary canine impaction and found that these patients had transverse maxillary deficiency. On the other hand, Langberg and Peck (2000b) observed no statistically significant difference in the anterior and posterior maxillary arch widths between subjects with palatally displaced canines and a comparison sample.

Regardless of the aetiology, maxillary canine impactions occur with a frequency that warrants extensive study of possible preventive treatment measures. Currently, the most common preventive treatment is to extract the primary canine with the expectation that the permanent canine resolves its unfavourable position. Two studies have reported good success with this treatment, finding favourable eruption in 78 per cent (Ericson and Kurol, 1988) and 62 per cent (Power and Short, 1993) of subjects.

The aims of this study were to determine the types of malocclusion frequently associated with unilateral palatal canine impactions and to assess the occlusal features associated with this pattern of maxillary canine impaction. This may help to identify subjects with a high risk of palatal canine impaction facilitating earlier interception.

Material and methods

The material for this study consisted of the pre-treatment dental casts of 34 (27 female and seven male) non-syndromic orthodontic patients with unilateral palatally impacted maxillary canines (impaction group). This group comprised all the subjects diagnosed with unilateral palatal canine impaction at the Dental Hospital, Jordan University of Science and Technology in the period between 2000 and 2003. Their ages varied from 13 to 27 years, with a mean of 17.7 years (± 4.6). Each of these subjects was matched according to age (rounded to the whole year), gender and type of malocclusion, based on incisor classification, by a case randomly selected from a list of orthodontic patients at the same dental hospital (comparison group).

The subjects were selected based on the following criteria: (1) Unilateral palatal canine impaction. The position of the impacted canine relative to the dental arch was determined by the parallax technique. (2) The impacted canines should have a fully formed root apex without any sign of eruption into the oral cavity. (3) The primary canine should be present in the dental arch when the impressions were taken.

From the dental cast the following parameters were obtained:

1. The dentoalveolar arch relationship. This was determined directly from the dental cast based on incisor classification according to the following: Class I, the lower incisor edges occlude with or lie immediately below the cingulum plateau of the upper central incisors; Class II division 1, the lower incisor edges lie posterior to the cingulum plateau of the upper central incisors with the upper central incisors proclined; Class II division 2, the lower incisor edges lie posterior to the cingulum plateau of the upper central incisors with the upper central incisors retroclined; Class III, the lower incisor edges lie anterior to the cingulum plateau of the upper central incisors.
2. Missing or anomalous teeth. This was recorded by direct observation from the dental cast and confirmed by radiographic examination.
3. The mesiodistal width of each tooth. This was measured from the mesial anatomical contact point to the distal anatomical contact point.
4. Space condition. This was calculated by subtracting the total tooth size from the arch perimeter. The mesiodistal width of the impacted canine was judged to be equal to that of the contralateral permanent canine. The arch perimeter was measured by dividing the dental arch into four straight-line segments as described by Proffit and Fields (1992); each segment was measured individually. The arch length–tooth size discrepancy was not calculated for subjects with congenitally missing maxillary teeth (n = 5).
5. Inter-premolar and inter-molar widths of the upper arch. The inter-premolar width was measured by placing the calliper tips into the deepest portion of the central fossae of the upper first premolars at their junctions with the most lingual aspect of the buccal cusp. The inter-molar width was recorded with the calliper tips placed into the deepest portion of the central fossae at its junction with the most lingual aspect of the mesiobuccal cusp.

All dental cast measurements were made at least twice by the same examiner (KA) using a sharpened Boley gauge. 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 Dahlberg's (1940) double determination method. The results of the measurement error were 0.55 mm for arch perimeter, 0.24 mm for mesiodistal tooth width and 0.30 and 0.34 mm for inter-premolar and inter-molar arch widths, respectively.

Statistical analysis

Means and standard deviations for the two groups were calculated for all variables using SPSS (Chicago, Illinois, USA). The differences between the impaction and comparison groups were determined using a chi-square test for space condition and anomalous lateral incisors and a Student's t-test for the reminder of the variables. P values less than 0.05 were considered significant.

Results

Table 1 shows that palatal canine impaction occurred most frequently in subjects with a Class II division 2 incisor classification (44 per cent). The number of subjects with anomalous or missing lateral incisors was significantly greater in the impaction group (P = 0.01). The impaction group had four subjects with bilateral congenital absence of the maxillary lateral incisors, one with bilateral peg-shaped laterals and one with unilateral peg-shaped laterals on the affected side. None of these anomalies was found in the comparison group.

Table 2 shows the space condition in both groups. Forty-two per cent of the impaction group presented without crowding compared with 31 per cent in the comparison group. However, this was not statistically significant ($P = 0.303$).

The maxillary transverse dimensions were greater in the impaction group, showing a statistically significant difference ($P = 0.000$ and $P = 0.005$ for inter-premolar and inter-molar widths, respectively). There was no statistically significant difference between the two groups with regard to the degree of crowding ($P = 0.208$), maxillary arch perimeter ($P = 0.143$), and total mesiodistal width ($P = 0.361$, Table 3).

Female subjects in the impaction group tended to have a smaller lateral incisor–mesiodistal width than their comparison counterparts. However, this difference was not statistically significant ($P = 0.345$). In male subjects, the width was virtually the same in both groups ($P = 0.814$, Table 4).

Table 1 Incisor classification in the impaction group ($n = 34$).

Incisor classification	Palatal canine impaction (%)	Representative population (%)
Class I	35	57
Class II division 1	9	18
Class II division 2	44	15
Class III	12	10

Table 2 Number of subjects (%) presenting with or without crowding in the upper arch in the impaction and comparison groups (sample restricted to those without missing permanent teeth).

Arch length discrepancy	Impaction group ($n = 29$)	Comparison group ($n = 34$)
Spacing	8 (28)	2 (7)
Well aligned	4 (14)	7 (24)
Mild crowding (<4 mm)	8 (28)	8 (28)
Moderate crowding (4–8 mm)	6 (21)	8 (28)
Severe crowding (>8 mm)	3 (10)	4 (14)
Pearson chi-square	0.303	

Discussion

The purpose of this study was to identify the occlusal features associated with palatal impaction of the maxillary canines. This anomaly occurs most frequently in Class II division 2 malocclusions (Basdra *et al.*, 2000), a malocclusion that has been reported to be associated with an increased transverse dimension of the upper arch, less crowding and smaller tooth sizes than other forms of malocclusion (Buschang *et al.*, 1994; Peck *et al.*, 1998). For this reason, the impaction and comparison groups were matched by the type of malocclusion.

In subjects with an impacted maxillary canine, as loss of the primary canine could affect the arch perimeter and thereby the space condition, only subjects with retained primary canines were included in this study. The inter-premolar width was used to determine the anterior arch width instead of the inter-canine width because as first premolar eruption precedes that of the permanent canine its position in the arch is less affected by crowding.

The reason for the gender bias in the case sample could be explained by the gender differences in the occurrence of palatal canine impaction (Peck *et al.*, 1994) and the greater demand for orthodontic treatment among females in north Jordan (Abu Alhaija *et al.*, 2004).

The fact that 18 per cent of the impaction group had missing or peg-shaped lateral incisors demonstrates a clear association between palatal impaction of the maxillary canine and anomalous lateral incisors. This supports the previous findings of Becker *et al.* (1981) and Peck *et al.* (1994).

Several authors have commented on the existence of palatally impacted canines in association with a spaced dentition (Jacoby, 1983; Becker, 1984). In this study, when subjects with congenital absence of permanent maxillary teeth were not included in the space analysis, there was no statistically significant difference in the degree of crowding or in the number of subjects with crowding between the palatal canine impaction group and their matched comparisons.

Table 3 Measurements (mm) of different occlusal features in the impaction and comparison groups.

Occlusal feature	Impaction group ($n = 34$)	Comparison group ($n = 34$)	Difference	Significance
Inter-premolar arch width	35.30	33.00	2.30*	0.000
Inter-molar arch width	45.29	43.65	1.64*	0.005
Arch length–tooth size discrepancy	0.66	2.36	–1.70	0.208
Arch perimeter	73.27	71.70	1.57	0.143
Total mesiodistal width of upper teeth	72.93	74.06	–0.13	0.361

*Statistically significant $P < 0.01$.

Table 4 Mean difference in the ipsilateral mesiodistal width (mm) of the affected side between impaction and comparison groups in female and male subjects.

	Female (n = 27)				Male (n = 7)			
	Impaction group	Comparison group	Mean difference	P value	Impaction group	Comparison group	Mean difference	P value
Central incisor	8.637	8.821	0.184	0.202	8.720	8.825	0.105	0.798
Lateral incisor	5.831	6.375	0.544	0.345	6.820	6.687	0.133	0.814
First premolar	7.070	7.007	0.063	0.658	7.180	7.025	0.155	0.681
Second premolar	6.285	6.739	0.454	0.223	6.740	6.625	0.115	0.729

However, this finding should be interpreted with caution, as arch form may be constricted in the area of the impacted canine (Becker, 1984), resulting in a reduction in the arch perimeter.

Only 42 per cent of the impaction group without missing teeth had sufficient space for canine eruption. Even when the five subjects with congenitally missing teeth were included, still only 56 per cent of the palatal impaction group had sufficient space for canine eruption. These percentages are smaller than those reported by Jacoby (1983) and Stellzig *et al.* (1994). In the present study, the fact that 44 per cent of the subjects with palatal impaction had crowding in the upper arch does not necessarily contradict the earlier suggestion that the canines become palatally impacted by crossing back to the palatal side if extra space is available in the maxilla (Jacoby, 1983), because crowding is a diagnosis related to inadequate space to accommodate the aggregated mesiodistal diameters of the crowns of the teeth. By contrast, the distance between the roots of the same teeth may become progressively larger, providing more space mesiodistally in the root area, which is where the impacted canine is located.

There was no significant difference in the mesiodistal width of the maxillary teeth between the impaction and comparison groups. The comparable tooth size in the palatal impaction and comparison groups contradicts the findings of Langberg and Peck (2000a), who reported that, on average, the mesiodistal crown diameter of the maxillary incisors was smaller in their palatally displaced canine sample than in the comparison group. This contradiction could be attributed to the method of selection of the comparison group. Palatal canine impaction occurs most frequently in subjects with a Class II division 2 malocclusion. Subjects with this type of malocclusion have been reported to have a smaller tooth size than other types of malocclusion (Peck *et al.*, 1998). Therefore, comparing the crown mesiodistal width between a palatal impaction group and a comparison group that is not matched by the type of malocclusion could be misleading.

The anterior and posterior maxillary transverse dimensions were found to be significantly greater in the palatal impaction group than in their comparison counterparts. There have been two studies concerned with maxillary width in patients with impacted canines; the first reported transverse maxillary arch deficiency (McConnell *et al.*, 1996), while the second reported similar transverse arch widths in subjects with palatally ‘displaced’ canines and a comparison group matched by gender and age but not type of malocclusion (Langberg and Peck, 2000b). In the first study the authors did not identify the precise position of the impacted canine and labial impaction subjects were not differentiated from palatal impaction subjects. Thus, the transverse arch deficiency reported could be attributed to the inclusion of patients with buccal canine impaction.

Because the maxillary transverse dimensions were found to be greater in subjects with palatal canine impaction, it could be suggested that the presence of ‘excess palatal width’ may contribute to the aetiology of palatal canine impaction. This would explain the frequent occurrence of palatal canine impaction in Class II division 2 subjects and the five-fold increase in the incidence of palatal canine impaction in those of European origin compared with those of Asian origin who characteristically exhibit a greater frequency of maxillary underdevelopment (Peck *et al.*, 1994). This excess palatal width would also explain why the typical orthodontic treatment of palatally impacted canines involves neither palatal ex-pansion nor permanent tooth extraction (Langberg and Peck, 2000b).

Conclusions

1. Palatal canine impaction occurred most frequently in subjects with a Class II division 2 incisor malocclusion.
2. There was an association between palatal canine impaction and missing or anomalous lateral incisors.
3. Space conditions in the upper arch did not seem to play a significant role in the aetiology of palatal canine impaction.
4. The mesiodistal widths of the maxillary teeth were not significantly different in the impaction and comparison groups.
5. Subjects with palatally impacted canines had greater maxillary transverse dimensions than their comparison

counterparts. This excess palatal width could be a strong contributory factor towards the aetiology of palatal canine impaction.

Address for correspondence

Tareq Gharaibeh
Oral and Maxillofacial Surgery
School of Dentistry
Jordan University of Science and Technology
PO Box 3030
Irbid
Jordan
E-mail: tareqgh@just.edu.jo

References

Abu Alhaija E S J, Al-Nimri K, Al-Khateeb N S 2004 Orthodontic treatment need and demand in 12–14 year-old north Jordanian school children. European Journal of Orthodontics 26: 261–263

Basdra E K, Kiokpasoglou M, Stellzig A 2000 The Class II division 2 craniofacial type is associated with numerous congenital tooth anomalies. European Journal of Orthodontics 22: 529–535

Becker A 1984 Etiology of maxillary canine impaction. American Journal of Orthodontics 86: 437–438

Becker A, Smith P, Behar R 1981 The incidence of anomalous lateral incisors in relation to palatally displaced cuspid. Angle Orthodontist 51: 24–29

Brenchley Z, Oliver R G 1997 Morphology of anterior teeth associated with displaced canines. European Journal of Orthodontics 24: 41–45

Buschang P H, Stroud J, Alexander R G 1994 Differences in dental arch morphology among adult females with untreated Class I and Class II malocclusion. European Journal of Orthodontics 16: 47–52

Dachi S F, Howell F V 1961 A survey of 3874 routine full mouth radiographs. Oral Surgery, Oral Medicine, Oral Pathology 14: 1165–1169

Dahlberg G 1940 Statistical methods for medical and biological students. George Allen and Unwin, London

Ericson S, Kurol J 1988 Early treatment of palatally erupting maxillary canines by extraction of the primary canines. European Journal of Orthodontics 10: 283–295

Jacoby H 1983 The etiology of maxillary canine impactions. American Journal of Orthodontics 84: 125–132

Langberg B J, Peck S 2000a Tooth-size reduction associated with occurrence of palatal displacement of canines. Angle Orthodontist 70: 126–128

Langberg B J, Peck S 2000b Adequacy of maxillary dental arch width in patients with palatally displaced canines. American Journal of Orthodontics and Dentofacial Orthopedics 118: 220–223

McConnell T L, Hoffman D L, Forbes D P, Jensen E K, Wientraub N H 1996 Maxillary canine impaction in patients with transverse maxillary deficiency. Journal of Dentistry for Children 63: 190–195

McSherry P, Richardson A 1999 Ectopic eruption of the maxillary canine quantified in three dimensions on cephalometric radiographs between the ages of 5 and 15 years. European Journal of Orthodontics 21: 41–48

Mossey P A, Campbell H M, Luffingham J K 1994 The palatal canine and the adjacent lateral incisor: a study of a west of Scotland population. British Journal of Orthodontics 21: 169–174

Nordenram A, Stromberg C 1966 Positional variation of impacted upper canine. Oral Surgery, Oral Medicine, Oral Pathology 22: 711–714

Peck S, Peck L, Kataja M 1994 The palatally displaced canine as a dental anomaly of genetic origin. Angle Orthodontist 64: 249–256

Peck S, Peck L, Kataja M 1998 Class II division 2 malocclusion: a heritable pattern of small teeth in well-developed jaws. Angle Orthodontist 68: 9–20

Power S M, Short M B 1993 An investigation into the response of palatally displaced canines to the removal of deciduous canines and an assessment of factors contributing to a favourable eruption. British Journal of Orthodontics 20: 215–223

Proffit W R, Fields H W 1992 Contemporary orthodontics. Mosby, St Louis

Shah R M, Boyd M A, Vakil T F 1978 Studies of permanent tooth anomalies in 7886 Canadian individuals. Journal of the Canadian Dental Association 44: 262–264

Stellzig A, Basdra E K, Komposch G 1994 The etiology of canine impaction–space analysis. Fortschritte der Kieferorthopädie 55: 97–103

Thilander B, Jakobsson S O 1968 Local factors in the impaction of maxillary canine. Acta Odontologica Scandinavica 26: 145–168

Thilander B, Myrberg N 1973 The prevalence of malocclusion in Swedish school children. Scandinavian Journal of Dental Research 81: 12–20