

Factors influencing the non-surgical eruption of palatally impacted canines

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Background: Many palatally impacted canines in children do not require surgical exposure prior to the start of orthodontic treatment. They erupt in mid-alveolar positions providing excess space is made for them in the arch. The time required for an impacted tooth to emerge under these conditions is highly variable.

Aim: To determine the factors influencing the time required for a palatally impacted canine to spontaneously disimpact following orthodontic treatment to create excess space in the arch.

Method: Thirty palatally impacted canines, which emerged following orthodontic treatment to open excess space in the arch, were used. The impacted teeth were present in 28 children. No canines were surgically exposed. The positions of the impacted canines before treatment, the mesiodistal widths and rotations of the adjacent and contralateral lateral incisors, age and gender of the subjects, subjects' dental ages, presence of either incisor or premolar hypodontia, number of subjects with bilaterally impacted canines, and number of siblings with impacted canines were recorded. Canines that erupted in less than nine months of treatment were compared with canines that required more than nine months of treatment. The canines were grouped by severity of impaction (sectors II - IV) and compared.

Results: There were significantly more severe (sector IV) impactions in the long duration group compared with the short duration group. Significantly more cases of incisor - premolar hypodontia were found in the short duration group. Canines impacted in sector IV emerged after 21 months of treatment and canines in sectors II and III emerged after eight months of treatment. Lateral incisors adjacent to the impacted teeth were rotated mesiolabially to a greater extent in the sector IV group compared with lateral incisors in the sector II group. Differences in rotation of the adjacent and contralateral lateral incisors were significantly less in the sector II group compared with the lateral incisors in the sector III and IV groups.

Conclusions: The sector of impaction was the best guide to the duration of treatment prior to emergence.

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Introduction

Surgical exposure is only occasionally necessary to disimpact palatally impacted canines in children. Many impacted canines in children, between 10 and 13 years of age, will emerge spontaneously following extraction of the overlying primary canine.¹⁻⁴ Impacted canines that do not respond to this procedure will frequently emerge if excess space is created in the arch for them.⁵ The duration of this orthodontic treatment has been reported to be shorter than the orthodontic treatment required to move a surgically exposed tooth into the arch.^{6,7} The time required to align an impacted canine after surgical exposure is thought to be a main reason for prolonged treatment. For example, Iramaneerat *et al.*⁸ reported that

alignment of an impacted tooth following surgical exposure could take between 17.7 and 19.3 months, depending on the surgical technique employed.

It is generally agreed that genetic factors are the main cause of canine impaction. Palatally impacted canines occasionally present bilaterally and are associated with smaller, including peg-shaped, and missing lateral incisors. There are gender and racial differences in the prevalence of impacted canines. Impacted canines can occur in families.⁹⁻¹⁵ It has been postulated that the aetiology of impacted canines may depend on whether dental development is delayed or on-time.^{16,17} There is also some evidence that nongenetic factors, such as failure of the overlying primary canine to resorb and lack of guidance from the root of the adjacent lateral

incisor, may be involved in the aetiology of impacted canines.^{2,12,18,19}

The aim of this study is to determine the factors considered to influence the time required for a palatally impacted canine to spontaneously disimpact and erupt in a mid-alveolar position following orthodontic treatment to create space in the arch.

Materials and methods

The subjects in this investigation were 28 children (8 male, 20 female) with 30 palatally impacted canines that spontaneously disimpacted following extraction of the overlying primary canines and fixed appliance treatment to open space in the arch for the impacted teeth. All canines were in a mid-alveolar position at the conclusion of the study. Three subjects had bilaterally impacted canines, and in one of these subjects one canine was treated by creating space in the arch for the impacted tooth and the contralateral canine was surgically exposed. Only the tooth treated orthodontically was included in the study. Prior to treatment all canines were located in sectors II (N = 12), III (N = 12), or IV (N = 6) (Figure 1).⁵ Canines were excluded if they did not erupt into a mid-alveolar position, if they were surgically exposed or if they were impacted in sector I. Details of 19 subjects were reported in a previous study.⁵

The following information was collected for all subjects:

1. Classification of impaction using Lindauer *et al.*'s modification of Kuroi's classification (Figure 1).⁵
2. Age at the start of orthodontic treatment, in years.
3. Duration of orthodontic treatment, in months. The time taken by a canine to erupt in a mid-alveolar position after the start of orthodontic treatment.
4. Stage of dental development on the pretreatment panoramic film (OPG) using Becker's normal data.¹⁶ The development of each erupted tooth was assessed to the nearest half year. It was recorded as a positive value if advanced relative to Becker's data or a negative value if delayed. This method uses the age at emergence and stage of root development, particularly closure of the apices, of the following teeth: maxillary central incisors (Mean: 10 years), maxillary lateral incisors (Mean: 11 years), first premolars (Mean: 14 years), and second molars (Mean: 15 years). The mean developmental age of these teeth with incomplete apices was used.

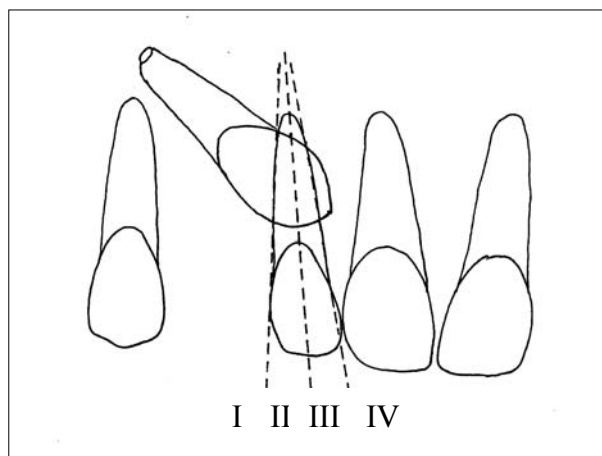


Figure 1. Classification of palatal canine impaction.⁵

Sector I – distal to the outline of the root of the lateral incisor root.
Sector II – mesial to sector I, but distal to the midline of the root of the lateral incisor.
Sector III – mesial to sector II, but distal to the mesial outline of the root of the lateral incisor.
Sector IV – mesial to sector III.

5. Exfoliation of the primary dentition was assessed to the nearest half year, and recorded as a positive score if advanced relative to Becker's data and a negative score if delayed.¹⁶
6. Mesiodistal widths of the upper lateral incisors, measured on the photocopies of the pretreatment study models to the nearest 0.5 millimetre. The contralateral lateral incisor was missing in one subject.
7. Degree of rotation of the lateral incisors to the nearest degree, measured on tracings taken from photocopies of the pretreatment maxillary study models. Mesiolabial rotations were recorded as positive values and distolabial rotations were recorded as negative values.
8. Distance between the cemento-enamel junction (CEJ) on the most distal aspect of the impacted canine and the CEJ on the most mesial aspect of the adjacent premolar, measured on the pretreatment OPG to the nearest millimetre.
9. Gender.
10. Number of subjects in which the root of the first premolar appeared to contact the root of the impacted canine on the pretreatment OPG.
11. Number of subjects with bilaterally impacted canines. A subject was included if the contralateral canine was: palatally impacted in sector I, if it erupted following extraction of the overlying primary canine, or if it was surgically exposed.

Table I. Comparison of the short and long duration groups.

Variables	Short duration group (N = 14)		Long duration group (N = 14)		<i>p</i>
	Mean	SD	Mean	SD	
Age	13.62	1.08	13.28	1.68	0.517
Dental development	-0.52	0.41	-0.52	0.58	1.000
Primary exfoliation	-0.95	0.98	-1.08	1.33	0.756
Width (I)	6.12	0.97	6.33	0.70	0.488
Width (C)	6.23	0.76	6.35	0.67	0.661
Width difference	-0.04	0.41	0.10	0.39	0.371
Rotation (I)	7.50	11.35	11.60	15.86	0.423
Rotation (C)	8.21	12.01	7.70	8.48	0.896
Rotation difference	1.00	10.82	3.90	15.80	0.326
CEJ distance	7.73	1.51	8.40	2.06	0.321

Unpaired *t*-test, degrees of freedom calculated using the Welch method
 I, impacted/ipsilateral side
 C, contralateral side

12. Number of siblings with a palatally impacted canine.

13. Number of subjects with incisor – premolar hypodontia. A subject was included if either an upper lateral incisor, or an upper or lower premolar was missing on the pretreatment OPG, and there was no history that the missing tooth had been extracted.

The canines were arbitrarily divided into those that emerged in a mid-alveolar position in less than nine months of orthodontic treatment (short duration group), and canines that took at least nine months of orthodontic treatment (long duration group) to emerge in a mid-alveolar position. A few canines that were in a mid-alveolar position, but had not emerged, were included in the latter group. There were 15 canines in each group.

Student's *t*-tests for unpaired data were used to test for inter-group differences in the continuous variables. An analysis of variance (ANOVA) was used to determine whether significant differences existed between the sectors, and *t*-tests for unpaired data were then used to identify sectors significantly different. Chi-squared tests were used to test for significant differences in: gender, apparent contact between the canine root and the adjacent premolar root, sector,

Table II. Comparison of the short and long duration groups.

		Short duration group	Long duration group	Total	<i>p</i> *
Gender	Male	5	3	8	0.409
	Female	10	12	22	
Root contact	Yes	4	5	9	0.690
	No	11	10	21	
Sector of impaction	II	6	6	12	0.011
	III	9	3	12	
	IV	0	6	6	
Occurrence	Unilateral	12	10	22	0.409
	Bilateral	3	5	8	
Sibling affected	Yes	4	1	5	0.142
	No	11	14	25	
Hypodontia	Yes	4	0	4	0.032
	No	11	15	26	

*Chi squared, significant values are in bold

unilateral or bilateral presentation, number of siblings with impacted canines and hypodontia. The five per cent level of significance was used in all tests. All continuous variables (variables 3–8) were repeated at least one week later to assess the reproducibility of the measurements. The differences between the first and second measurements were tested with *t*-tests for paired data. The reproducibility of the radiographic imaging technique was not assessed.

Results

Statistically significant differences were found between the first and second measurements of the widths of the lateral incisors (Impacted side: $p = 0.010$; Contralateral side: $p = 0.002$). Determination of the delay in dental development was also significantly different ($p = 0.031$). To improve the reliability of the method the means of first and second measurements were used in all subsequent calculations.

There were no significant differences between the continuous variables in the short and the long duration groups (Table I). The distribution of canines by sector of impaction was significantly different (Table II). In the short duration group the majority (60 per

Table III. Comparison of the sector groups.

	Sector II		Sector III		Sector IV		<i>p</i> *
	Mean	SD	Mean	SD	Mean	SD	
Age	13.40	1.67	13.45	1.39	13.56	0.94	0.978
Duration	8.33	4.87	8.25	4.37	20.83	7.78	0.000
Dental development	-0.69	0.45	-0.46	0.52	-0.29	0.46	0.243
Primary exfoliation	-1.48	1.35	-0.88	0.99	-0.38	0.63	0.134
Width (I)	6.44	0.97	6.02	0.69	6.21	0.86	0.490
Width (C)	6.56	0.61	6.07	0.72	6.17	0.77	0.218
Width difference	0.04	0.50	0.05	0.35	0.00	0.32	0.974
Rotation (I)	5.12	14.30	8.88	11.88	19.8	12.51	0.097
Rotation (C)	10.75	10.08	6.45	12.28	5.08	4.27	0.458
Rotation difference	-5.62	12.79	4.73	10.03	14.67	10.36	0.004
CEJ distance	8.67	1.75	7.62	1.84	7.75	1.81	0.339

*ANOVA, significant values are in bold

The bars indicate groups different at the 5% level of significance.

Duration: sector II versus sector IV ($p = 0.009$), sector III versus sector IV ($p = 0.01$)

Rotation (I): sector II versus sector IV ($p = 0.048$)

Rotation difference: sector II versus sector III ($p = 0.042$), sector II versus sector IV ($p = 0.004$)

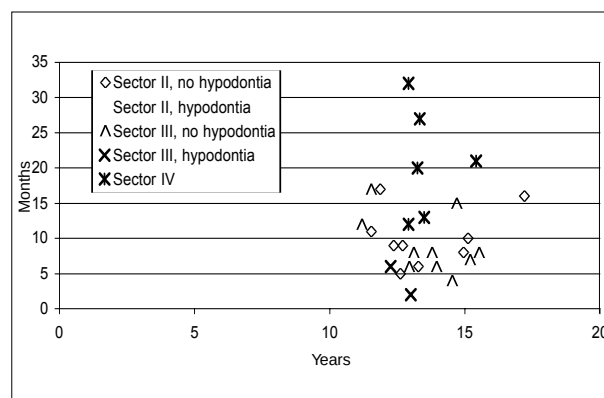
Table IV. Comparison of the sector groups.

		Sector II	Sector III	Sector IV	Total	<i>p</i> *
Gender	Male	2	5	1	8	0.316
	Female	10	7	5	22	
Root contact	Yes	5	3	1	9	0.490
	No	7	9	5	21	
Occurrence	Unilateral	8	9	5	22	0.742
	Bilateral	4	3	1	8	
Sibling	Yes	3	2	0	5	0.407
	No	9	10	6	25	
Hypodontia	Yes	2	2	0	4	0.562
	No	10	10	6	26	

* Chi squared

cent) were sector III impactions, whereas in the long duration group there were equal numbers of sector II and IV impactions (40 per cent each). The distribution of hypodontia in the two groups was also significantly different: the four subjects with hypodontia were in the short duration group.

There were five significant sector differences (Tables III and IV). The duration of orthodontic treatment was significantly shorter in the sector II and III groups compared with the duration of treatment for the sector IV canines. There was no significant difference between the durations of treatment of the sector

**Figure 2.** Duration of treatment to emergence (months) vs age at commencement of treatment (years).

II canines (Mean: 8.33 months) and sector III canines (Mean: 8.25 months). There were no significant differences between the ages at the commencement of orthodontic treatment (Table III, Figure 2).

The lateral incisors on the impacted side in the sector IV group were rotated mesiolabially to a greater extent than the lateral incisors in the sector II group ($p = 0.048$). Although there were no significant differences between the rotations of the contralateral lateral incisors there were two significant side-to-side sector differences: the difference in rotation (I rotation minus C rotation) was significantly less in

sector II (Mean: -5.62 degrees) compared with the lateral incisor rotations in sectors III (Mean: 4.73 degrees, $p = 0.042$) and IV (Mean: 14.67 degrees, $p = 0.004$).

There were no significant differences in the distributions of gender, contact between the first premolar and canine, unilateral/bilateral occurrence, number of siblings with impacted canines or lateral incisor – premolar hypodontia (Table IV).

Discussion

The severity of impaction was the best indicator of the time required for a palatally impacted canine to spontaneously disimpact following orthodontic treatment to create excess space in the arch. On average, palatally impacted canines with their cusp tips mesial to the root of the lateral incisor took up to 18 months longer than less severely impacted canines with their cusp tips lying over the root of the lateral incisor. The mean duration of orthodontic treatment for the six most severely impacted canines is longer than that reported for alignment of palatally impacted canines following surgical exposure.⁸ The severity of impaction was not reported by Iramaneerat *et al.*⁸ An earlier suggestion that age at commencement of orthodontic treatment might be an important factor in determining whether a sector IV palatally impacted canine emerged in a mid-alveolar position is not supported by the present data.⁵

There are a number of limitations arising from the design of the present study. Unfortunately, the original study models had not been kept and only photocopies were available to measure tooth widths and rotations. The significant difference between the first and second measurements of the widths of the lateral incisors casts doubt on the reliability of this method for recording tooth sizes. Crown outlines were indistinct on some photocopies with the result that it was difficult to obtain consistent measurements of crown widths. The poor reproducibility of the determinations of the stage of dental development using Becker's method¹⁶ contrasts with the reproducible assessments of exfoliation of the primary dentition. Both determinations used the same panoramic radiographs. Difficulty in appraising the stage of root development of the permanent teeth appears to have been the major contributor to this finding.

When the canines were compared by sector, that is by severity of impaction, the lateral incisors adjacent to

the most severely impacted teeth (sector IV) were more mesiolabially rotated than the lateral incisors in the less severely impacted sector II group. In the entire sample only two lateral incisors had distolabial rotations and a further eight lateral incisors were aligned normally. Mesiolabial rotation of an upper lateral incisor before the upper canine erupts may be the trait of 'proclined' incisors mentioned by Ericson and Kurol,²⁰ and indicate a developing canine impaction on the same side. Although the severity of mesiolabial rotation provides no indication of the duration of treatment to emergence, it may indicate a developing sector IV impaction. When the degrees of rotation of the impacted side lateral incisors were compared with the contralateral lateral incisors significant differences were found between sectors II and III, and sectors II and IV. In the sector II group the lateral incisors were more likely to be aligned normally or distolabially rotated whereas the lateral incisors in the sector IV group were generally mesiolabially rotated. Considering the shape of the roots of the upper lateral incisors, these findings are consistent with, and support a place for the guidance theory of canine tooth eruption.¹²

In the short-duration group there were significantly more subjects with incisor – premolar hypodontia than in the long duration group. Hypodontia in this study included subjects with at least one missing tooth: either an upper lateral incisor, or an upper or lower premolar. Previous investigators have reported that smaller teeth and missing upper lateral incisors are associated with palatally impacted canines.^{10,12,13} The four subjects with hypodontia were equally distributed in the sector II and III groups. One subject with multiple missing premolars and molars had a sibling with both upper canines impacted in sector IV. These canines erupted without surgical exposure: one following extraction of the primary canine and the other following 4 months of orthodontic treatment.⁵

Delayed exfoliation of the primary dentition and delayed development of the permanent dentition are not associated with prolonged orthodontic treatment for palatally impacted canines. In nine children (1 boy, 8 girls) exfoliation of the primary dentition was delayed for more than one year, and in 19 children (7 boys, 12 girls) it was on-time. Development of the permanent dentition was delayed in three girls and on-time in 25 children (8 males,

17 females). The latter finding contrasts with previous studies, which reported that exfoliation of the primary dentition and development of the permanent dentition were delayed in approximately 50 per cent of subjects with palatally impacted canines.^{16,17} Because of the poor reproducibility of dental age assessment this finding should be interpreted cautiously.

No relationship was found between the duration of treatment to emergence and occurrence of palatally impacted canines in siblings. There were only five affected siblings in the whole sample and three of these had sector II impacted canines. Two siblings had impacted canines that failed to emerge following orthodontic treatment and were surgically exposed. One subject with a sector II impaction had the contralateral sector IV canine surgically exposed prior to commencing orthodontic treatment. This subject's sibling had a sector III canine that took 15 months of orthodontic treatment before it emerged in a mid-alveolar position. Occurrence of palatally impacted canines in siblings may indicate underlying genetic factors, which require further investigation.

No significant relationship was demonstrated between the duration of treatment and presence of bilaterally impacted canines. There were no subjects with bilaterally impacted canines in the short duration group. Of the six subjects with bilaterally impacted canines three subjects had a canine each in sector IV. Two of these canines were surgically exposed and the third tooth erupted without exposure surgery after 32 months: the longest duration of treatment in the present study. In two subjects with bilaterally impacted teeth one impacted canine in each subject improved to sector I following removal of the primary canine, and erupted in a mid-alveolar position during orthodontic treatment. Further investigation is required to determine if bilateral impaction is a useful predictor of the duration of orthodontic treatment to emergence.

No significant relationship was found between the duration of treatment to emergence and the distance between the roots of the impacted canine and the adjacent premolar. This measurement gave an estimate of intra-alveolar crowding, which could impede eruption and alignment of an impacted canine. Variations in premolar root morphology can contribute to proximity of the roots of the canine and premolar.²¹ In all cases the root of the adjacent

premolar was moved distally to prevent it from impeding the movement of the impacted canine.

Most sector II and III canines erupted after about eight months of orthodontic space opening. This is the treatment of choice for impacted canines in sectors II and III that do not respond to extraction of the overlying primary canines. Sector IV canines in older patients, where the risks of protracted treatment and failure are high, should be surgically exposed prior to orthodontic treatment.⁵ This study reinforces the importance of assessing the sector of impaction of a palatally impacted canine on an OPG before considering the treatment options.

Conclusions

The severity of impaction was the best guide of the duration of treatment to emergence of palatally impacted canines. The most severely impacted teeth took the longest time to erupt into a mid-alveolar position after excess space had been made in the arch. Timely emergence may be anticipated in subjects with incisor – premolar hypodontia.

In subjects with sector II canines the lateral incisors were more likely to be aligned normally or distolabially rotated whereas lateral incisors in subjects with the most severely impacted canines were generally mesiolabially rotated. These findings are consistent with the guidance theory of canine tooth eruption.

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