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Original Article

Orthodontic treatment of palatally impacted maxillary canines

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The aim of this study was to determine the feasibility of treating children with impacted maxillary canines by orthodontic treatment alone. The subjects were 28 children (mean age: 13.5 years, range 11.4-16.1 years) with between them 32 palatally impacted canines.
The overlying primary canines were extracted between 0 and 42 months before the start of appliance treatment to open space in the arches for the impacted teeth. No other surgical procedures were carried out prior to the start of appliance treatment. Appliance treatment was deferred for at least six months if an impacted canine was the main reason for treatment, otherwise treatment was commenced according to the needs of the patient.
In 94 % of the cases, the severity of impaction lessened following extraction of the overlying primary canines and orthodontic treatment. The deepest impactions tended to occur in the oldest children. The majority (75 %) of the canines emerged following orthodontic treatment to create space for them in the arch; the remainder were surgically exposed. Appliance treatment tended to take longer in children with the deepest impactions. It is concluded that fixed appliance treatment to create space for a palatally impacted canine is an effective management option for children with impacted maxillary canines.
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Introduction

Maxillary canines follow a long, and tortuous, path from the site of their initial formation high in the maxilla to emergence in the dental arch. Up to 3 per cent of all maxillary canines may impact palatally.[1] Radiographic examination of unerupted maxillary canines has been recommended when there is a pronounced difference in the emergence of right and left canines; when a palpable asymmetry in the form of the alveolar process exists; when occlusal development is advanced and an unerupted canine cannot be palpated; when the emergence of a lateral incisor is delayed, and when a lateral incisor is buccally displaced or proclined.[2]

Various methods of management of ectopic maxillary canines are available. In the majority of 10 to 13 year olds, extraction of an overlying primary canine may be the only form of treatment necessary to prevent impaction of an ectopic canine. Ectopic canines that are going to respond favourably to this simple procedure do so within twelve months of the extraction.[3,4] In older children, surgical exposure of an unerupted canine followed by orthodontic appliance treatment is generally required.[5,6,7] However, extended treatment times,[8] relapse, and periodontal and pulpal complications[7,9] have been reported to occur following surgical exposure and orthodontic treatment.

The purpose of this study was to determine the feasibility of treating children with impacted maxillary canines by orthodontic treatment alone. The underlying objective was to avoid the complications associated with prior surgical exposure of impacted maxillary canines followed by orthodontic treatment.

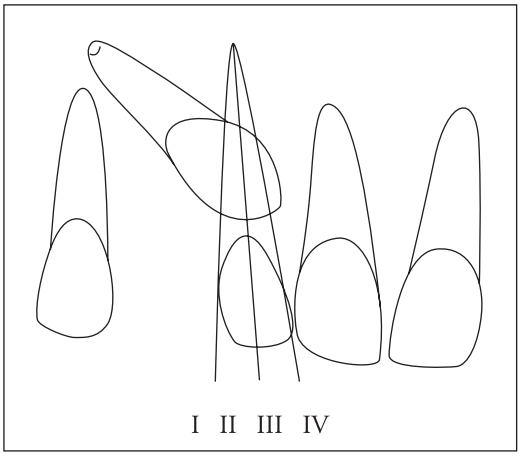


Figure 1. Classification used in this study (after Ericson S, Kurol J: 1988).
Sector I: area distal to the lateral incisor root;
Sector II: area mesial to Sector I but distal to the midline of the root of the lateral incisor;
Sector III: area mesial to Sector II but distal to the mesial outline of the lateral incisor root;
Sector IV: area mesial to Sector III.



Figure 2a. Panoramic radiograph (at the start of treatment) of a patient aged 10.2 years with an impacted maxillary canine treated without surgical exposure. The tip of the impacted canine (tooth 23) is in Sector IV. The primary canine was extracted at this stage.

Materials and methods

The subjects comprised 28 children with a mean age of 13.5 years (range: 11.4–16.1 years) who between them had 32 palatally impacted canines. Of these children, 15 shared 17 impacted maxillary canines. The overlying primary canines of these 15 children had been extracted, on average, 15 months (range: 6–42 months) prior to the commencement of orthodontic treatment. For the remaining 13 children with 15 impacted canines, the overlying primary canines were extracted within four months of the commencement of orthodontic treatment. No other surgical procedures were carried out prior to the start of appliance treatment. Four patients each had both maxillary canines impacted.

Diagnosis that a canine was palatally impacted was made after clinical examination of the lateral incisor on the affected side, palpation of the alveolar process, and with the aid of conventional panoramic radiographs. The position of an impacted canine on the radiographs was then classified with Lindauer and co-workers'[10] modification of Ericson and Kurol's classification.[4] A canine was considered a Sector I impaction if the tip was distal to the root of the lateral incisor; a Sector II impaction, if the tip lay between the distal outline and the midline of the root of the lateral incisor; a Sector III impaction, if the tip was between the midline and the mesial outline of the root of the lateral incisor; and a Sector IV impaction, if the tip was mesial to the root of the lateral incisor (Figure 1).

All maxillary canines in the present study were in Sectors II to IV. The Sector II and III canines were from consecutive patients treated over a 7-year period. Fewer Sector IV impactions were available because these were surgically exposed without pre-surgical orthodontic treatment in the early years of this study. As a result, the Sector IV impactions were from consecutive patients treated in the past four years. Sector I impactions were excluded because accurate diagnosis of palatal impaction was not possible with the panoramic radiographs used.

Pre-surgical orthodontic treatment was usually carried out with pre-adjusted Edgewise appliances. Using stopped round archwires, excess space was opened in the arch for an impacted tooth. In many cases, the space created in the arch was about 1 cm more than the width of an impacted tooth and the maxillary incisors were proclined and displaced up to 3 mm across the midline. In many cases, the lateral incisor on the affected side was not bonded for several months. Five patients were treated with rapid maxillary expansion and then fixed appliances. A further two patients had rapid maxillary expansion only, and the impacted canines emerged without further treatment. Two patients had all second premolars extracted. During treatment with fixed appliances, the patients were observed at approximately monthly intervals.

The following information was obtained for all patients.

1. Classification of impaction (Figure 1).



Figure 2b. Panoramic radiograph of the same patient at 12.9 years of age, when fixed appliance treatment was commenced. The impaction appears to have worsened.

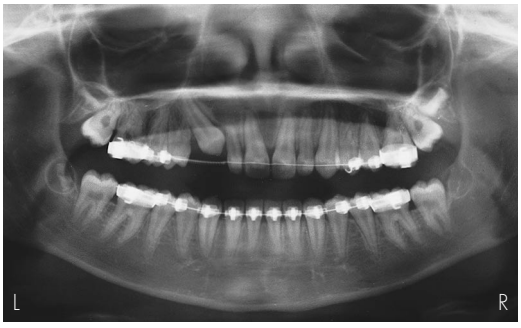


Figure 2c. Panoramic radiograph taken of the same patient at 13.8 years of age, showing the space opened in the arch for the impacted tooth. Tooth 23 emerged in the line of the arch two weeks after this radiograph was taken.

2. Observation period between the extraction of an overlying primary canine(s) and the start of fixed appliance treatment to open space for the impacted canine (months). If the period between extraction of the overlying primary tooth and initiation of appliance treatment was equal to or less than four months, the teeth were placed in Group A. In Group B, the period between extraction and the initiation of appliance treatment varied between six and 42 months. These groups were determined by the response of an impacted canine following extraction of the overlying primary canine. The response was considered to be favourable when an impaction lessened in severity, and unfavourable when an impaction worsened and/or an impacted tooth failed to emerge. Impacted canines that did not improve their position or emerge after at least six months were considered to be 'non-responders', and orthodontic treatment was commenced.

3. Age at the start of fixed appliance treatment.

4. Whether or not a tooth was surgically exposed.

5. Duration of appliance treatment. The period between the start of active appliance treatment that aimed to create space in the arch for the impacted tooth and the emergence of the impacted tooth (months). An impacted tooth may have emerged following orthodontic treatment alone (OT group); or following orthodontic treatment and surgical exposure (OTSE group). All patients were given the option of surgical exposure at any time, and many decisions to surgically expose impacted teeth were made as the result of requests by patients.

In each group, an analysis of variance was used to determine whether statistically significant differences existed between the sectors. Student's *t*-test for unpaired data was then used to identify groups significantly different.

Results

The radiographs of a 10.25 year-old female patient with a Sector IV impaction of tooth 23 are shown in Figure 2.

The *t*-test for unpaired data was used to determine whether statistically significant age ($p = 0.995$) and treatment ($p = 0.281$) differences existed between Groups A and B. Because no statistically significant differences were found, the data in both groups were combined. Details of the 32 palatally impacted maxillary canines are given in Tables I and II. Overall, 24 canines (75 %) were successfully managed by orthodontic treatment alone, and 23 canines in this group emerged in the line of the arch. The majority (87 %) of all Sector II and III impactions were treated without surgery.

The overall mean age at the commencement of treatment was 13.4 years (SD: 1.4 years). The children in the OTSE group were 18 months older than the children in the OT group at the start of appliance treatment ($p = 0.003$). The five patients in the OTSE group with Sector IV impactions were over 14 years of age at the commencement of appliance treatment. Only one patient over 14 years of age with a Sector IV impaction was successfully managed with appliance treatment alone (Table I).

Table I. Raw data

Patient	Sector	Start age (Years)	Observation period (Months)	Appliance treatment (Months)	Total management time (Months)	Surgical exposure (Y/N)
1	II	11.9	0	2	2	N
2	II	11.4	0	10	10	N
3	II	11.8	0	8	8	N
4	II	11.8	42	17	59	N
5	II	12.7	7	3	10	N
6	II	13.3	0	6	6	N
7	II	13.3	6	5	11	N
8	II	13.3	11	6	17	N
9	II	13.9	9	8	17	N
10	II	12.2	12	10	22	N
11	II	13.9	17	12	29	Y
12	III	13.0	23	8	31	N
2	III	11.4	0	17	17	N
13	III	12.3	0	6	6	N
14	III	11.8	0	4	4	N
15	III	15.2	4	7	11	N
3	III	11.8	0	17	17	N
16	III	14.7	3	15	18	N
17	III	15.4	10	8	18	N
18	III	14.5	6	4	10	N
19	III	12.9	15	5	20	N
7	III	13.3	6	11	17	Y
20	III	13.6	7	5	12	Y
21	IV	12.1	8	4	12	N
22	IV	15.4	0	21	21	N
23	IV	13.3	0	27	27	N
24	IV	12.9	32	12	44	N
25	IV	16.1	0	6	6	Y
26	IV	16.0	2	8	10	Y
27	IV	14.6	13	9	22	Y
28	IV	14.8	0	10	10	Y
18	IV	14.5	6	20	26	Y

The total management time equals the observation period plus the appliance treatment time.

Table II. Palatally impacted canines treated with and without surgical exposure, classified by sector.[1]

Group	Sector II			Sector III			Sector IV			ANOVA
	N	Mean	SD	N	Mean	SD	N	Mean	SD	*p*
Start age (years)										
OT	10	12.5	0.8	10	13.3	1.5	4	13.4	1.4	0.334
OTSE	1	13.9	_	2	13.4	0.2	5	15.2	0.8	0.062
Observation (months)										
OT	10	8.7	12.6	10	6.5	7.5	4	10	15.1	0.842
OTSE	1	17.0	_	2	6.5	0.7	5	4.2	5.4	0.152
Appliance (months)										
OT	10	7.5	4.3	10	9.1	5.2	4	16	10.1	0.067
OTSE	1	12	_	2	8	4.2	5	10.6	5.5	0.789
Total (months)										
OT	10	16.2	16.1	10	15.6	7.3	4	26	13.5	0.362
OTSE	1	29	_	2	14.5	3.5	5	14.8	8.7	0.324

[1] After Ericson S, Kurol J; 1988. OT: orthodontic treatment only; OTSE: orthodontic treatment followed by surgical exposure.

Open exposure surgery was performed between six and 20 months (mean: 10 months) after the commencement of appliance treatment for the eight canines in the OTSE group (Table I). Only two OTSE Sector IV canines, both in patients over 16 years of age, failed to improve their positions during space opening. These teeth were surgically exposed after six and eight months of treatment. All canines in the OT group emerged between two and 27 months of appliance treatment. All Sector II and III canines in the OT group emerged within 17 months of the commencement of treatment. There was a trend for Sector IV canines in the OT group to take the longest time to emerge.

In the OTSE group, there was a tendency for children with Sector IV impactions to be older than those with Sector III impactions (Table II). The canines were more deeply impacted in the OTSE group compared with the canines in the OT group: five canines were in Sector IV, two canines were in Sector III, and one canine was in Sector II. The children in the OTSE group with Sector IV impactions were significantly older ($p = 0.048$) than the children in the OT group with Sector IV impactions.

Discussion

Impacted maxillary canines can present as a decision-making problem for both patient and clinician. Both may be concerned about the possibility of root resorption, the likelihood of prolonged treatment, discomfort associated with surgical exposure, additional cost, poor appearance, instability of the end-result, and the periodontal and endodontic complications that occasionally accompany teeth exposed surgically. This retrospective study has demonstrated that it is not necessary to surgically expose all impacted maxillary canines in children, thereby avoiding the complications reported to occur following surgical exposure.[7–9]

There was a trend for less severe Sector II impactions to be found in younger patients and more severe Sector IV impactions to be found in older patients. For example, more Sector IV impactions were found in patients over 13.25 years of age (N = 14) than in younger patients. Of these fourteen teeth, seven were Sector IV impactions, five were Sector III impactions, and only two were Sector II impactions. Seven of these canines were exposed surgically either after conservative treatment had failed or patients had requested surgical exposure.

In many patients an unerupted maxillary canine could be palpated as a "bulge" in the alveolar process between six and nine months before the tooth emerged. This apparent delay in emergence prompted six out of the eight patients in the OTSE group to request surgical exposure of the impacted tooth.

In the present study, 20 out of 23 Sector II and III impactions were managed with orthodontic treatment: the teeth emerged into the oral cavity between two and 17 months after commencement of appliance treatment. While it could be argued that surgical exposure of an impacted canine might hasten its emergence, orthodontic treatment alone avoided the complications mentioned above. A further advantage of an orthodontic approach was the finding that the majority of the teeth emerged unassisted in the line of the arch. In the OT group only one Sector IV canine emerged in the palate, whereas in the OTSE group four canines required orthodontic treatment to move them into position. In the present study surgical exposure was carried out after appliance treatment, whereas many clinicians prefer to expose an impacted tooth before commencing appliance treatment. The timing of surgical exposure could be the subject of a further investigation.

In Sector IV, four out of nine canines were successfully managed without surgical exposure, and three of these teeth were in patients younger than 14 years of age at commencement of orthodontic treatment. The fourth patient was 15.4 years of age at the start of appliance treatment. Sector IV canines in three patients between 14 and 15 years of age improved substantially during orthodontic treatment, whereas two canines in older patients failed to improve after six and eight months of orthodontic treatment. The decisions to intervene surgically may have been premature given the mean treatment time of 16 months for the Sector IV canines managed successfully with appliances. While Sector IV impactions in patients over 14 years of age might, as a rule, require surgery, some canines in older children can be expected to respond favourably to appliance treatment. This finding could be used in selected cases to reduce the severity of an impaction prior to carrying out surgery.

It could be argued that appliance treatment was unnecessary in some children, particularly when less than twelve months had elapsed following extraction of an overlying primary canine. However, for the 22 patients who were either over 14 years of age at commencement of treatment, or who had impacted canines that failed to improve after twelve months observation, or who had tired of waiting for an impacted tooth to emerge and requested surgical exposure, extraction of the overlying deciduous canine was unlikely to correct the impacted canine. In the present study, it is not possible to separate the effects of extraction of the overlying primary canine and orthodontic treatment on the position of an impacted tooth. Therefore, on the basis of the present study and Ericson and Kurol's[4] work the following protocol is recommended.

1. Before 10 years of age: screen for impacted maxillary canines by palpation.

2. After 10 years of age:

a) If a canine is not palpable labially, or

b) If the canines are not symmetrically palpable on the labial, or

c) If there is either delayed eruption or proclination or an upper lateral incisor, a panoramic radiograph should be taken. If palatal impaction is suspected, but not confirmed by the panoramic radiograph, an occlusal radiograph may be indicated. If impaction is confirmed, the overlying deciduous canine(s) should be extracted.

3. For canines impacted in Sectors I, II or III in children under 16 years of age, or for Sector IV impactions before 13 years of age:

a) If an impacted canine is the only trait requiring treatment, wait between nine and twelve months. If a tooth remains unerupted, confirm its position radiographically, and commence orthodontic treatment to open excess space.

b) If an impacted canine is not the only reason for orthodontic treatment, commence appliance treatment at the appropriate stage of dental development.

4. During orthodontic treatment check periodically for the development of a canine bulge.

5. If a canine bulge is not present by nine months into appliance treatment, consider referral for surgical exposure of the canine.

6. If the canine is a Sector IV impaction and the patient is more than 14 years of age, advise the parents/patient that surgical exposure will be required.

Conclusion

In the present study, 30 out of 32 of impacted maxillary canines (94 %) improved their position following extraction of the overlying primary canines and fixed appliance treatment to open space for the impacted teeth. Twenty-four canines (75 %) emerged after 2 to 27 months of fixed appliance therapy.

When the tip of a palatally impacted canine crosses the mesial outline of the root of a lateral incisor, as indicated on a panoramic radiograph, orthodontic treatment may improve its position. For patients over 14 years of age surgical exposure may be required.

Fixed appliance treatment to create space for palatally impacted maxillary canines is an effective management option for children between 11 and 15 years of age. This option is recommended when the tip of an impacted maxillary canine does not appear to cross the mesial outline of the root of the adjacent lateral incisor root, as indicated on a panoramic radiograph.

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