Original Article

Initial Vertical and Horizontal Position of Palatally Impacted Maxillary Canine and Effect on Periodontal Status Following Surgical-Orthodontic Treatment

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ABSTRACT

Objective: To evaluate the impact of surgical-orthodontic treatment and the initial vertical and mesiodistal position of palatally impacted maxillary canines on the periodontal health of impacted canines and adjacent teeth.

Materials and Methods: The study group consisted of 32 patients with unilateral palatally impacted maxillary canines. The initial position of the impacted canines was assessed on panoramic images. The treatment protocol of the impacted canines included surgical exposure with the closed-eruption technique and fixed orthodontic appliances.

Results: A significant increase in pocket depth was found at the canine mesiopalatal point after surgical-orthodontic treatment. Also, a correlation was found between the initial mesiodistal and vertical position of the impacted canine and the posttreatment periodontal status of the impacted canine, the adjacent lateral incisor, and the first premolar.

Conclusions: A combined surgical-orthodontic approach in the treatment of impacted maxillary canines produces clinically acceptable periodontal conditions. The average increase in pocket depth was less than 4 mm and clinically unimportant for most patients.

KEY WORDS: Canine impaction; Maxillary canine impaction; Panoramic image; Pocket depth; Surgical exposure

INTRODUCTION

Canines are important in establishing and maintaining the dentition's form, function, and aesthetics. The maxillary canine is one of the most frequently impacted teeth with an incidence of about 2%.[1,2] Previous studies have found palatal impaction in 85% of ectopically positioned maxillary canines.[3–5] In a more recent study, 50% of impacted maxillary canines were palatally impacted.[6]

Impacted teeth may cause neighboring teeth to migrate or become excessively mobile due to root resorption, loss of arch length, dentigerous cyst formation, local infections and referred pain, ankylosis, or resorption of the impacted tooth.[7–10] On the other hand, surgical-orthodontic treatment may damage impacted canines, adjacent teeth, and supporting structures and eventually cause detrimental changes in the periodontal status.[11–15] The anatomical structure of the soft tissue that covers impacted maxillary canines and the treatment technique are considered major factors that influence posttreatment periodontal health of the canines and their adjacent teeth.[16,17]

The initial vertical and horizontal position of the maxillary impacted canine may also affect posttreatment periodontal status, but data on this issue are scarce. The mesiodistal and vertical position of the cusp of the impacted canine was mainly used to predict canine eruption and impaction probability.[18,19] Orthodontic cor-

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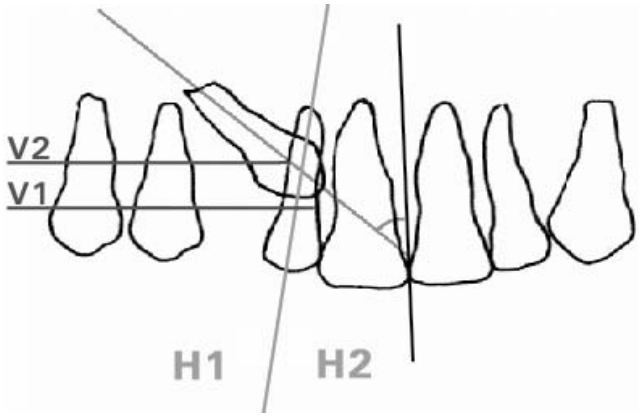

Figure 1. Schematic drawing illustrating the criteria used to define the position of the impacted maxillary canine. The criteria were modified from those proposed by Ericson and Kurol[18] (Horizontal: H1—the canine cusp is in the space between the premolar and the line drawn through the long axis of the lateral incisor; H2—the canine cusp is in the space between the long axis of the lateral incisor and the line between the central incisors. Vertical: V1—the canine cusp is in the coronal half of the lateral incisor root; V2—the canine cusp is in the apical half of the lateral incisor root).

rection of impacted canines requires movement in all three directions—vertical, palatal, and buccal—which rarely occurs in orthodontic treatment of other types of malocclusion and may affect the final periodontal status of the impacted tooth.[12] The distance and direction of movement of palatally impacted canines during treatment is determined by the canines' initial vertical and horizontal position. The effect the initial vertical and horizontal position of an impacted canine has on the canine's periodontal status after surgery with the closed-eruption eruption technique is unknown.

This retrospective study evaluates the impact of surgical treatment with the closed-flap eruption technique combined with orthodontics and the initial vertical and mesiodistal position of palatally impacted maxillary canines on the periodontal health of the impacted canines and adjacent teeth.

MATERIALS AND METHODS

This retrospective study included 32 patients (22 female and 10 male) previously treated for unilateral palatally impacted maxillary canines. Mean treatment time was 17.1 ± 6.7 months (range: 6–30 months). Average patient age at the periodontal examination 3 months after removal of the fixed appliances was 18.2 ± 5.1 years (range: 12–42 years).

The initial position of the impacted canine was assessed on a panoramic image using a modified version of the criteria proposed by Ericson and Kurol[18] (Figure 1). The vertical and horizontal position of the impacted canine was evaluated in relation to the adjacent lateral incisor. A horizontal line was drawn through the midpoint of the lateral incisor root to determine the vertical position of the impacted canine. The impacted permanent canine could have one of two vertical positions: the canine's cusp could be above (V1) or below (V2) the horizontal reference line.

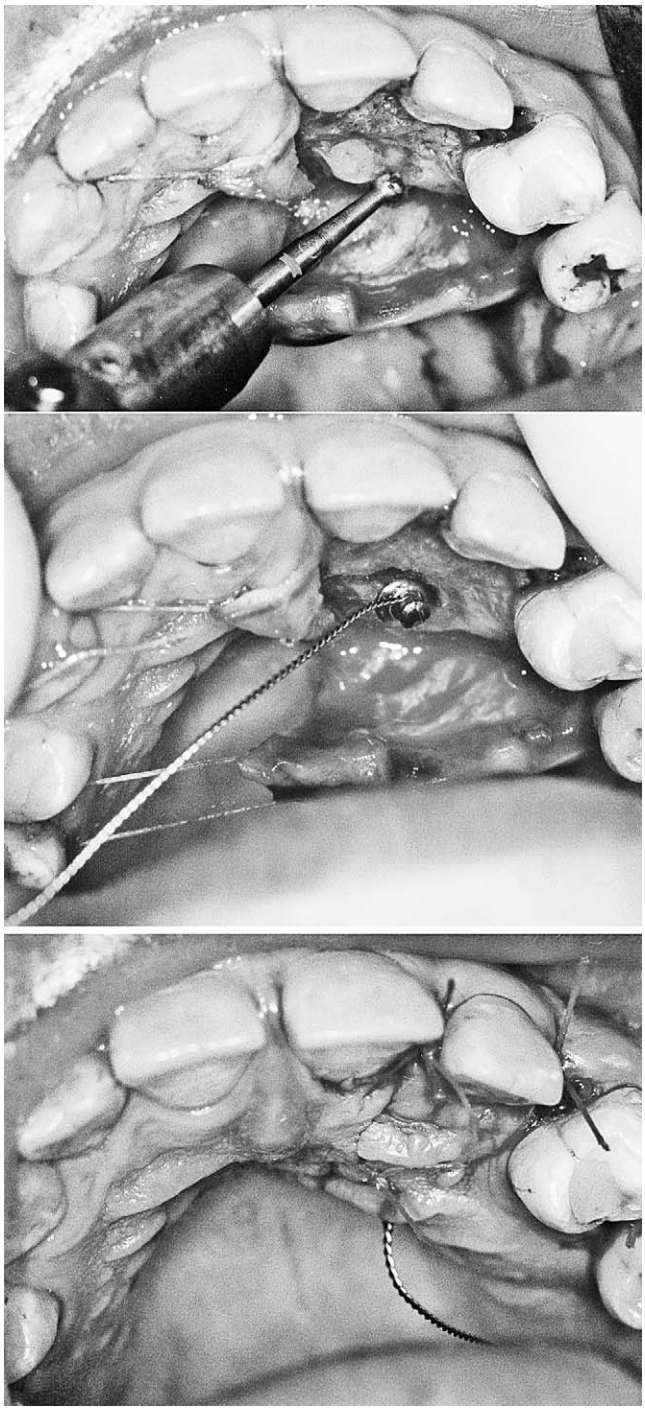

Figure 2. Different steps in the closed-eruption technique: (a) the cusp of the impacted canine exposed; (b) orthodontic eyelet bonded to the cusp of the canine and connected to a ligation chain; (c) the repositioned flap with the ligation chain extending through the flap.

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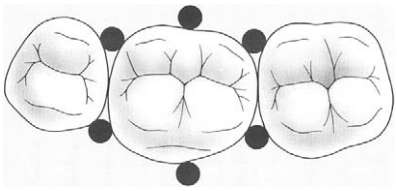

Figure 3. Schematic drawing of the six sites where pocket depth was probed (MPP indicates mesiopalatal point; PP, palatal point; DPP, distopalatal point; MLP, mesiolabial point; LP, labial point; DLP, distal labial point).

The horizontal position of the impacted canines was determined according to the long axis of the adjacent lateral incisor. The impacted permanent canine could have one of two horizontal positions: the canine's cusp could be distal (H1) or mesial (H2) to the vertical axis of the lateral incisor (Figure 1).

The material consisted of all patients who were treated by one of the authors (DS) during a period of 4 years and underwent surgery with the closed-eruption technique according to Kokich and Mathews[20] (Figure 2). An orthodontic eyelet connected to a ligation chain was bonded to the surface of the impacted canine after surgical exposure, and the flap was repositioned with the ligation chain extending through the flap. The canine was brought into position with a light force. The palatal arch was used for anchorage at the start of treatment and a fixed appliance was used later for the final positioning of the canine into the dental arch. The patients' oral hygiene was assessed monthly after instruction at the start of treatment.

The posttreatment periodontal examination was carried out by one periodontologist 3 months after the fixed appliances were taken off and a removable retainer was fitted. The periodontal status of the first premolar, canine, and lateral incisor was evaluated by assessing periodontal pocket depth and gingival recession. Pocket depth was measured from the base of the pocket to the gingival margin with an accuracy of 1 mm.[21] A Williams probe was inserted parallel to the vertical axis of the tooth and "walked" circumferentially around each surface of the tooth to detect the areas of deepest penetration. Six tooth surfaces were probed (Figure 3): mesiolabial (ML), labial (L), distolabial (DL), distopalatal (DP), palatal (P), and mesiopalatal (MP). The technique used to evaluate pocket depth was also used to evaluate gingival recession, but the distance from the cementoenamel junction to the gingival margin was measured.[21] Four tooth surfaces were used for measurement of gingival recession: mesial (M), palatal (P), distal (D), and labial (L). A split-mouth method was used to compare the affected side with the unaffected side in the same pa-

Table 1. Periodontal Pocket Depth of Impacted Canines and Adjacent Teeth After Surgical-Orthodontic Treatment[a]

Points of Measurement	Periodontal Pocket Depth (mm)								
	Quadrant with Impacted Canines (n = 32)				Control Quadrant (n = 32)				
	Mean	SD	Max	Min	Mean	SD	Max	Min	*P*
Lateral incisor									
MPP	2.31	0.69	3	1	2.17	0.60	3	1	NS
PP	1.89	0.70	3	1	1.90	0.75	4	1	NS
DPP	2.59	1.07	6	1	2.50	0.77	5	1	NS
MLP	2.00	0.80	5	1	2.15	0.62	4	1	NS
LP	2.00	0.92	5	1	1.90	0.72	3	1	NS
DLP	2.41	1.10	6	1	2.19	0.67	4	1	NS
Canine									
MPP	3.06	1.01	5	1	2.40	0.61	4	1	**
PP	1.94	0.76	3	1	1.85	0.74	4	1	NS
DPP	2.72	1.11	7	1	2.54	0.80	5	1	NS
MLP	2.69	1.12	6	1	2.27	0.64	3	1	NS
LP	2.28	1.28	6	1	2.15	0.74	3	1	NS
DLP	2.53	0.98	5	1	2.35	0.67	3	1	NS
First premolar									
MPP	2.91	1.15	6	1	2.58	0.94	5	1	NS
PP	2.03	0.70	4	1	1.92	0.77	4	1	NS
DPP	2.56	0.76	5	2	2.56	0.82	5	1	NS
MLP	2.53	0.98	5	1	2.38	0.64	3	1	NS
LP	2.19	0.69	4	1	2.02	0.73	3	1	NS
DLP	2.36	0.86	5	1	2.44	0.77	4	1	NS

[a] Max indicates maximum; Min, minimum; MPP, mesiopalatal point; PP, palatal point; DPP, distopalatal point; MLP, mesiolabial point; LP, labial point; DLP, distal labial point.

** $P < .01$; NS indicates nonsignificant.

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Table 2. Influence of the Initial Vertical Position of the Impacted Canine on Periodontal Pocket Depth (mm) After Surgical-Orthodontic Treatment [a]

Point of Pocket Depth Measurement	Vertical Sector V1 (n = 18)		Vertical Sector V2 (n = 14)		Level of Significance *P*
	Mean	SD	Mean	SD	
Lateral incisor					
MPP	2.28	0.67	2.36	0.75	NS
PP	1.89	0.68	1.86	0.77	NS
DPP	2.33	1.14	2.93	0.92	*
MLP	2.06	0.87	1.93	0.73	NS
LP	1.89	0.68	2.14	1.17	NS
DLP	2.22	0.73	2.64	1.45	NS
Canine					
MPP	3.17	0.99	2.93	1.07	NS
PP	2.00	0.77	1.86	0.77	NS
DPP	2.89	1.37	2.50	0.65	NS
MLP	2.72	1.07	2.64	1.22	NS
LP	2.28	1.23	2.29	1.38	NS
DLP	2.50	1.10	2.57	0.85	NS
First premolar					
MPP	3.00	1.18	2.83	1.15	NS
PP	1.86	0.66	2.17	0.71	NS
DPP	2.29	0.47	2.78	0.88	NS
MLP	2.43	1.09	2.61	0.92	NS
LP	2.07	0.73	2.28	0.67	NS
DLP	2.29	0.83	2.33	0.91	NS

[a] MPP indicates mesiopalatal point; PP, palatal point; DPP, distopalatal point; MLP, mesiolabial point; LP, labial point; DLP, distal labial point.

* $P < .05$; NS indicates nonsignificant.

Table 3. Influence of the Initial Mesiodistal Localization of the Impacted Canine on Periodontal Pocket Depth (mm) After Surgical-Orthodontic Treatment [a]

Point of Pocket Depth Measurement	Horizontal Sector H1 (n = 7)		Horizontal Sector H2 (n = 25)		Level of Significance *P*
	Mean	SD	Mean	SD	
Lateral incisor					
MPP	2.24	0.67	2.57	0.79	NS
PP	1.76	0.66	2.29	0.76	NS
DPP	2.52	1.16	2.86	0.70	NS
MLP	1.88	0.83	2.43	0.54	*
LP	1.92	0.99	2.29	0.49	NS
DLP	2.20	0.96	3.14	1.35	NS
Canine					
MPP	3.24	1.01	2.43	0.79	**
PP	1.92	0.76	2.00	0.82	NS
DPP	2.68	1.15	2.86	1.07	NS
MLP	2.52	1.07	3.29	1.26	NS
LP	2.00	1.12	3.29	1.39	**
DLP	2.40	0.91	3.00	1.16	NS
First premolar					
MPP	2.76	0.97	3.43	1.62	NS
PP	1.92	0.57	2.43	0.98	NS
DPP	2.48	0.71	2.86	0.90	NS
MLP	2.36	0.95	3.14	0.90	*
LP	2.04	0.68	2.71	0.49	**
DLP	2.20	0.91	2.71	0.49	*

[a] MPP indicates mesiopalatal point; PP, palatal point; DPP, distopalatal point; MLP, mesiolabial point; LP, labial point; DLP, distal labial point.

* $P < .05$; ** $P < .01$; NS indicates nonsignificant.

tient. Significance was determined with the Mann-Whitney *U*-test.

The Simplified Oral Health Index (OHI-S) by Greene and Vermillion[22] was used to assess oral hygiene at the posttreatment examination and avoid bias of the latter factor on pocket depth. Measurement errors were analyzed using a method suggested by Bland and Altman.[23] Pocket depth and gingival recession were measured twice for 10 patients. The estimated error between measurements was calculated with this formula:

$$SDd = \sqrt{\sum (d_1 - d_2)^2/(2N)}$$

where ±2 SD are the limits within which 95% of the differences between repeated measurements are expected to lie, d_1 = first measurement, d_2 = second measurement, and N = number of patients. Error in pocket depth is reported as ±2 SD of the differences between repeated measurements and does not exceed ±0.4 mm. The limits of mean gingival recession were ±0.1. The effects of these errors on the reliability of the pocket depth and gingival recession measurements were deemed nonsignificant.

Statistical Analyses

Statistical analyses were carried out using the Statistical Package for the Social Sciences for Windows (SPSS V8.0). The mean, standard deviation, minimum, and maximum were calculated for each variable. Pocket depth and gingival recession around the impacted canine were compared with those of the control (normally erupted canine on the contralateral side) using the nonparametric Kruskal-Wallis test.

RESULTS

Mean pocket depth at the mesiopalatal point (MPP) on the canine that had undergone surgery combined with orthodontics was 3.1 mm (±1.0 mm). This was greater than mean pocket depth at the same point on the contralateral canines (2.4 ± 0.6 mm; $P < .01$) (Table 1).

Pocket depth varied in some sectors: at the distopalatal point (DPP) on the lateral incisor, pocket depth

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Table 4. Effect on Gingival Recession (mm) in Patients Treated for Impacted Maxillary Canines[a]

Point of Measurement of Gingival Recession	Quadrant With Impacted Canines Treated by Surgical-Orthodontic Treatment n = 32		Control: Quadrant With Normally Erupted Canines n = 32		Level of Significance *P*
	Mean	SD	Mean	SD	
Lateral incisor					
MP	0.031	0.061	0.000	0.000	NS
PP	0.000	0.000	0.000	0.000	NS
DP	0.031	0.061	0.000	0.000	NS
LP	0.063	0.122	0.000	0.000	NS
Canine					
MP	0.031	0.061	0.000	0.000	NS
PP	0.156	0.218	0.000	0.000	NS
DP	0.031	0.061	0.000	0.000	NS
LP	0.063	0.122	0.000	0.000	NS

[a] MP indicates mesial point; PP, palatal point; DP, distal point; LP, labial point. NS indicates nonsignificant.

was greater in the group of impacted canines with initial vertical position V2 (2.93 ± 0.92 mm) than in the group with a vertical position V1 (2.33 ± 1.14 mm; $P < .05$). At other points on the teeth, differences in pocket depth in groups V1 and V2 were nonsignificant (Table 2).

Table 3 presents pocket depth dependence on the initial mesiodistal position of the impacted canine. Pocket depth at the adjacent premolar labial point (LP) was greater (2.7 ± 0.5 mm; $P < .01$) in the group of impacted canines with initial horizontal position H2 than in the group with horizontal position H1 (2.04 ± 0.68 mm). Increases in pocket depth at the premolar distal labial point (DLP, $P < .05$) and mesiolabial point (MLP, $P < .05$) were similar. Deeper pocket depths occurred at the lateral incisor MLP ($P < .05$) and the canine LP ($P < .01$) in group H2.

The opposite was observed at the canine MPP. Pocket depth was smaller (2.4 ± 0.8 mm) when the initial mesiodistal position of the canine cusp was in sector H2 than in sector H1 (3.2 ± 1.0 mm; $P < .01$).

Six of 32 (18.75%) canines had gingival recession. Differences in gingival recession between the test and control groups were nonsignificant (Table 4). No gingival recessions were found at the first premolars. The mean OHI-S score was 0.6 ± 0.7, and there was no difference in oral hygiene comparing test and control sides.

DISCUSSION

Most patients in our study were 20 years old or younger. Only two were older than 25 years. The periodontal status of the older subjects after surgical-orthodontic treatment showed no pathologic changes and did not influence our results. The patients were selected from all patients treated during the year 2000–2004 and were not randomly selected. The closed eruption technique is the most often used technique in our University because of advantages presented, for example, by Woloshyn and Artur[15] and Kokich and Mathews.[20]

We found that surgical-orthodontic treatment affected pocket depth at the MPP on the impacted canine, which was greater (3.1 ± 1.0 mm) than on the control canines (2.4 ± 0.6 mm; $P < .01$). These findings support those of other research studies. D'Amico et al[24] found that pocket depths were greater (by 5%) at the distobuccal surface of the impacted canines and at the mesiolingual, distolingual, and mesiolabial surfaces of the adjacent lateral incisors. Other authors found greater pocket depths on adjacent lateral incisors distolingually and on first premolars mesiolingually.[25] In contrast to our study, Quirynen et al[26] found no differences between test and control sides.

Analyzing the initial vertical and mesiodistal localization of the impacted canine and its influence on pocket depth, we found that pocket depth at the incisor DPP was greater (2.93 ± 0.91 mm) in the group of impacted canines with initial vertical position V2 than in the group with initial vertical position V1 (2.33 ± 1.13 mm; $P < .05$). This suggests that the periodontal tissue of the adjacent teeth undergoes increased stress during canine extrusion. The horizontal position of the impacted canine was also found to affect pocket depth when the groups of canines located in sectors H1 and H2 were compared. Pocket depths in group H2 were greater at the incisor MLP and premolar MLP, the LP, and the DLP than in group H1.

We found pocket depth differences between teeth adjacent to the impacted canine. Other authors have made similar observations.[24–25] This suggests that surgical-orthodontic treatment mainly influences adjacent teeth, which are exposed to larger intrusive forces and root torque during extrusion, distal movement, and alignment of the impacted canine. Differences in pock-

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et depth at the canine MPP may be explained by lack of root torque on the canine during correction of its position from the palatal position.

It could be said that the initial vertical and mesiodistal position of an impacted maxillary canine influences the periodontal condition of adjacent teeth following orthodontic-surgical treatment. However, pocket depth differences between control canines and adjacent teeth and between previously impacted canines and adjacent teeth were less than 4 mm and therefore clinically not significant.[27] Therefore, our results indicate that a combined surgical-orthodontic approach in the treatment of impacted maxillary canines produces clinically acceptable periodontal conditions in the majority of patients treated.

CONCLUSIONS

- A combined surgical-orthodontic approach in the treatment of impacted maxillary canines produces clinically acceptable periodontal conditions.
- No significant differences in gingival recession were found between the test and the controls.
- Periodontal conditions of the impacted canine and adjacent teeth after surgical-orthodontic treatment depend on the initial vertical and horizontal position of the impacted canine.

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