



Periodontal response to early uncovering, autonomous eruption, and orthodontic alignment of palatally impacted maxillary canines

Andrew D. Schmidt^a and Vincent G. Kokich^b

Rhineland, Wis, and Seattle, Wash

Introduction: The purpose of this study was to evaluate differences in periodontal status, root length, and visual assessment in patients with palatally impacted maxillary canines that were surgically exposed, allowed to erupt freely into the palate, and orthodontically aligned. **Methods:** Clinical examinations of the maxillary lateral incisors, canines, and adjacent premolars were performed on 16 patients with unilaterally impacted canines and 6 with bilaterally impacted canines treated in this manner. The average age was 23 years 7 months, and the average posttreatment observation period was 2 years 11 months. Data from the bilaterally impacted canines were not used in the central analysis. **Results:** Differences in probing attachment level were found at the distolingual region of the lateral incisor and at the distobuccal region of the premolar adjacent to the treated canine. Crestal bone height was lower at the mesial and distal regions of the lateral incisor adjacent to the previously impacted canine, and the roots of the treated canine and adjacent lateral incisor were shorter than those of the contralateral control teeth. Twenty-three orthodontists and 9 second- and third-year orthodontic residents could identify the previously impacted canine in the unilateral patients an average of 78.9% of the time, but to a statistically significant degree in 66% of all patients. **Conclusions:** The overall consequences to the impacted canine of surgical exposure and free eruption are good compared with closed exposure and early traction, whereas consequences to the adjacent teeth, particularly the lateral incisor, are similar. Future research directly comparing the 2 methods with a larger sample and randomization could yield further insight. (*Am J Orthod Dentofacial Orthop* 2007; 131:449-55)

The palatally impacted maxillary canine is a difficult orthodontic problem, often requiring surgical and orthodontic cooperation. Two methods of surgical exposure are commonly used: open exposure, where traction is placed after the canine erupts freely into the palate, and closed exposure with placement of an auxiliary attachment, followed by traction of the canine with orthodontic forces.¹

The effects of placing traction on an impacted canine after exposure were studied by Woloshyn et al² and others.^{3,4} Visual differences, and posttreatment differences in pulpal status, attachment level, crestal bone height, and probing pocket depth, were reported between previously impacted canines and control ca-

nines not previously impacted.² In addition, posttreatment differences in root length, attachment level, and crestal bone height were found on lateral incisors and premolars adjacent to the impacted canines when compared with contralateral control lateral incisors and premolars.²

The studies involving open exposure with autonomous eruption focused mainly on the success of the surgical procedures. Pearson et al⁵ compared simple exposure and eruption with closed exposure, bracketing, and early traction in 104 consecutively treated patients with palatally impacted canines; they found that a second surgical intervention was needed in 15.3% of the open exposure patients and 30.7% of all patients exposed and bracketed. Ferguson and Parvizi⁶ studied the open exposure of 85 palatally impacted canines in 72 consecutive patients. They found that 84.6% of the exposures were successful, 10.4% were partially successful, and 5.1% of the canines required a second exposure.

Open exposure of a palatally impacted canine with natural eruption has several potential advantages, in-

^aPrivate practice, Bellingham, Wash.

^bProfessor, Department of Orthodontics, School of Dentistry, University of Washington, Seattle.

Reprint requests to: Vincent G. Kokich, 1950 S Cedar St, Tacoma, WA 98405; e-mail, vgtkoch@u.washington.edu.

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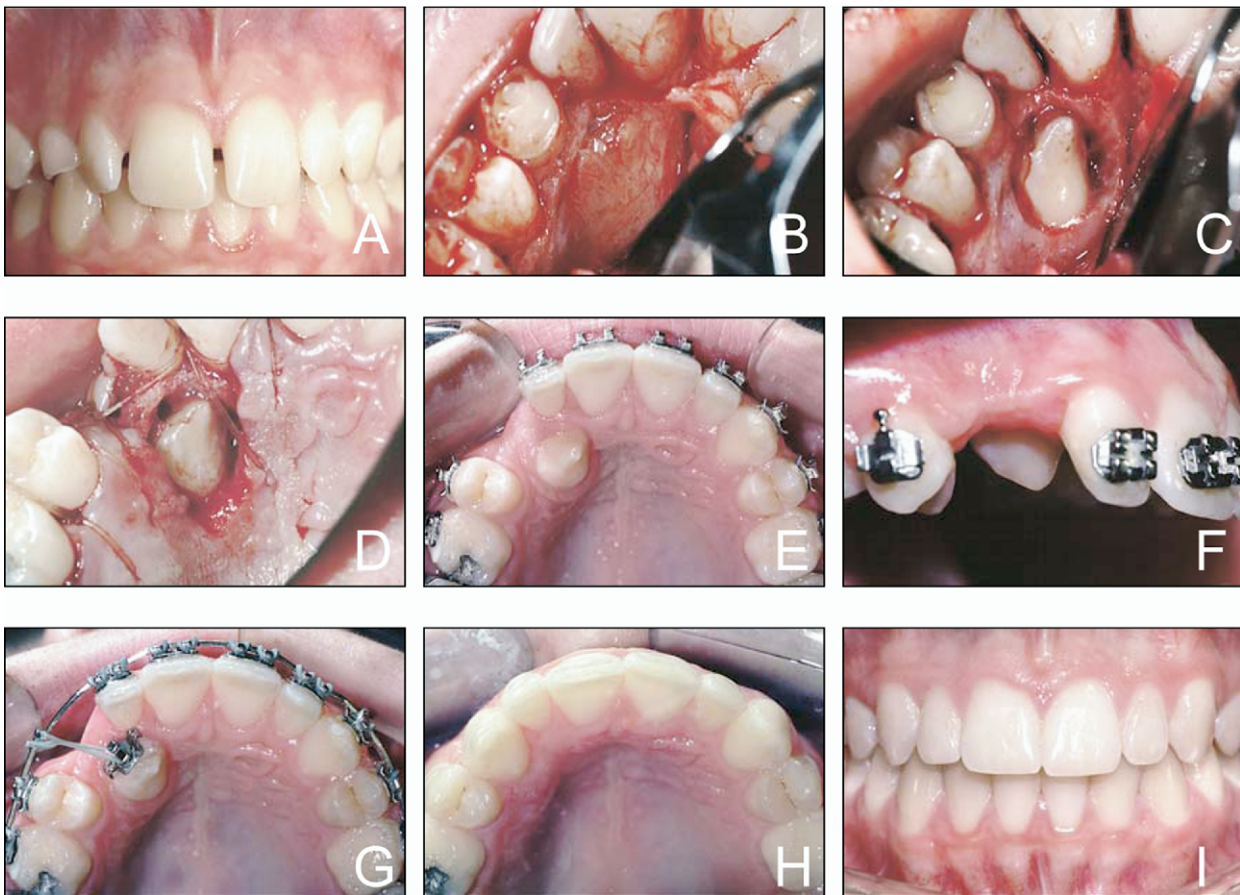


Fig 1. **A**, Patient had palatally impacted maxillary right canine. To permit impacted canine to erupt autonomously and reduce time in orthodontic appliances, impacted tooth was uncovered before orthodontic treatment. **B**, Mucoperiosteal flap was elevated, and it was determined that crown was still covered in bone. **C**, All palatal bone down to CEJ was removed so that the tooth could erupt unimpeded. **D**, Hole was made in flap, and it was repositioned and sutured over crown of impacted canine. **E** and **F**, Canine erupted without orthodontic forces. **G**, When cusp tip was at level of occlusal plane, bracket was placed on crown, and root was moved labially. **H** and **I**, Final alignment after appliance removal.

cluding fewer subsequent re-exposures,^{5,6} shorter treatment time,⁷ and improved hygiene during treatment. To date, no studies have examined the posttreatment effects of palatally impacted canines that were surgically exposed and allowed to erupt freely into the palate before placing traction. The purpose of this study was to evaluate periodontal, root length, and visual assessment differences between impacted canines treated in this manner and nonimpacted control teeth.

Records from a sample patient demonstrate the surgical and orthodontic treatment of a palatally impacted maxillary canine with surgical exposure and autonomous eruption (Fig 1). This patient had a Class I uncrowded malocclusion with a palatally impacted maxillary right canine. The impacted canine was sur-

gically exposed 4 months before appliance placement, the canine was bonded, and traction was placed 11 months after the surgical exposure. The total time in orthodontic appliances was 23 months. How does this method of treating palatally impacted canines compare with the traditional method of closed exposure and immediate traction?

MATERIAL AND METHODS

We attempted to follow the study design used by Woloshyn et al,² except that the canines in our study were treated with open exposure and autonomous eruption.

From the offices of 5 orthodontic practices, 49 consecutive patients were identified who had at least 1

Table I. Description of patient sample (n = 22)

	Mean	Range
Age at start of treatment	17 y 7.2 mo	12 y 8 mo-59 y 6 mo
Treatment period	2 y 9 mo	1 y 4 mo-5 y 2 mo
Recall period	2 y 11.5 mo	1 day-9 y 6 mo
Age at recall	23 y 6.8 mo	16 y 1 mo-67 y

previous palatally impacted canine. Each previously impacted canine was exposed and allowed to erupt into the palate before traction and orthodontic alignment. Of the 22 patients agreeing to participate in clinical follow-up examinations, 6 had bilaterally impacted canines, and 16 had unilaterally impacted canines. Their average age was 23 years 6.8 months, with an average posttreatment period of 2 years 11.5 months (Table I). One patient had been out of treatment for several years but had just finished a brief retreat and was thus labeled as 1 day posttreatment.

Oral hygiene and gingival inflammation were evaluated by using the visible plaque index (VPI)⁸ and gingival bleeding index (GBI).⁹ The sulcular depth of the maxillary lateral incisors, canines, and adjacent premolars (study teeth) were measured to the nearest 0.2 mm with a standardized force probe (0.25 N, Florida Probe, Gainesville, Fla) at the mesiobuccal, midbuccal, distobuccal, distolingual, midlingual, and mesiolingual aspects. The distance from the cementoenamel junction (CEJ) to the gingival margin was measured to the nearest 0.5 mm with a Michigan "0" probe with Williams markings. A negative recording indicated that the gingival margin was located apical to the CEJ. Two measurements were taken for each site, several minutes apart, and the 2 values were averaged. Probing attachment level was calculated by subtracting the CEJ-gingival margin distance from the sulcular depth.

Current periapical radiographs of the study teeth were used for all measurements of crestal bone height and root length. The radiographs and a transparent millimeter ruler for calibration were digitally scanned at 800 DPI. The digital image was then imported, calibrated, and analyzed with ImageJ (public domain Java image-processing program available on the Internet at <http://rsb.info.nih.gov/ij/>). The positions of the CEJ, the levels of the alveolar crest, and the root apices of the study teeth were evaluated by the second author (V.G.K.) without knowledge of the impacted side. Bone level was measured as the vertical distance from the CEJ to the alveolar crest. Bone level was not measured at the premolars because the radiographs were not diagnostic in that area. Root length was

measured as the distance from the midpoint of a line connecting the mesial and distal CEJ to the root apex. Measurements were made to the nearest 0.01 mm. Nonmeasurable sites were omitted. Two measurements were made, several days apart, and the values were averaged.

Intraoral frontal photographs of 15 of the 16 patients with unilaterally impacted canines were taken at the follow-up examinations, coded for identification, and randomly placed to a PowerPoint presentation. Twenty-three orthodontists and 9 second- and third-year orthodontic residents were asked to identify the impacted canine in each patient. The raters were also asked to give a short rationale for each choice made.

Data analysis

This study was designed as a split-mouth study. Six of the 22 patients, however, had bilaterally impacted canines. After data analysis and consultation with a statistician, it was determined that statistically stronger results could be obtained by not combining the bilaterally impacted canines with the unilateral canines, because this allowed the statistically stronger *t* test for paired data to be used on the data from the unilaterally impacted canines.

For all data, differences were calculated between the previously impacted canines and adjacent teeth, and the contralateral control teeth. Probing pocket depth, attachment levels, crestal bone height, and root lengths were compared by using a paired *t* test for the unilateral patients. The data from the bilaterally impacted canines were averaged for each patient so that each patient with bilaterally treated canines had only 1 data set. These data were compared with the data from the control teeth from the patients with unilaterally impacted canines by using the *t* test for independent samples.

Differences in the VPI and GBI scores were tested by using the sign test. Rater agreement in the photographic evaluation was assessed with the kappa statistic, and the results were analyzed with the binomial distribution test.¹⁰

RESULTS

No differences in GBI, VPI, pocket probing depth, probing attachment level, crestal bone height, or root length were found in the 6 patients with bilaterally impacted canines when compared with the control teeth from the 16 patients with unilaterally impacted canines. The following reported differences are all from the unilateral sample when compared with the contralateral control teeth of the same patients.

No differences were found in the GBI or the VPI between the previously impacted canines and the adja-

Table II. Gingival and plaque measurements of unilateral sample (n = 16)

	Impacted side (experimental)			Nonimpacted side (control)		
	Score 0	Score 1	Score 2	Score 0	Score 1	Score 2
GBI measurements						
Lateral incisor	56%	44%	0%	50%	50%	0%
Canine	56%	44%	6%	63%	37%	0%
Premolar	56%	44%	0%	56%	44%	0%
VPI measurements						
Lateral incisor	94%	6%	0%	100%	0%	0%
Canine	88%	12%	0%	94%	6%	0%
Premolar	94%	6%	0%	94%	6%	0%

Table III. Mean differences in probing attachment level between previously impacted canines and adjacent lateral incisors and premolars (impacted side) and contralateral control teeth (nonimpacted side) (n = 16)

		Impacted side		Nonimpacted side		Mean difference	P value
		Mean (mm)	SD	Mean (mm)	SD		
Lateral incisor	MB	0.53	0.50	0.58	0.61	0.05	NS
	B	0.60	0.47	0.49	0.40	0.11	NS
	DB	0.51	0.60	0.51	0.41	0	NS
	DL	0.73	0.59	0.28	0.55	0.45	.012
	L	0.45	0.61	0.59	0.60	0.14	NS
	ML	0.35	0.49	0.43	0.48	0.08	NS
Canine	MB	0.64	0.64	0.63	0.28	0.01	NS
	B	0.40	0.45	0.40	0.46	0	NS
	DB	0.53	0.82	0.28	0.37	0.25	NS
	DL	0.65	0.71	0.63	0.48	0.02	NS
	L	0.67	0.92	0.65	0.53	0.02	NS
	ML	0.41	1.17	0.56	0.43	0.15	NS
Premolar	MB	0.60	0.47	0.60	0.53	0	NS
	B	0.50	0.42	0.37	0.47	0.13	NS
	DB	0.63	0.66	0.35	0.64	0.28	.045
	DL	0.04	0.55	0.38	0.52	0.34	NS
	L	0.22	0.46	0.48	0.54	0.26	NS

MB, Mesiobuccal; B, buccal; DB, distobuccal; DL, distolingual; L, lingual; ML, mesiolingual; NS, Not significant.

cent teeth and the contralateral control teeth (Table II). The probing attachment level, the distance between the base of the pocket and the CEJ, was found to be significantly greater at the distolingual aspect of the lateral incisors on the impacted side ($P = .012$) and the distobuccal aspect of the premolars on the impacted side ($P = .045$) when compared with the contralateral control teeth (Table III). No other significant differences in probing attachment level were found.

Crestal bone height was lower at the distal and mesial sites of the lateral incisor adjacent to the impacted canine when compared with the contralateral lateral incisor. The distal aspect of the lateral incisor on the affected side was an average of 0.76 mm lower than the control side ($P = .006$); the mesial aspect of the affected lateral was an average of 0.29 mm lower ($P = .034$) than the control side (Fig 2).

The roots of the previously impacted canine and adjacent lateral incisor were significantly shorter than those of the control canine and lateral incisor. The previously impacted canine was an average of 1.08 mm shorter ($P = .025$) than the control canine; the adjacent lateral incisor was an average of 1.87 mm shorter ($P = .01$) than the contralateral control lateral incisor (Fig 3).

The photographic evaluation surveys were assessed in 2 ways. Each rater was scored individually as a percentage of the correctly identified impacted canines, and the scores were averaged. Orthodontists and residents could identify the previous unilaterally impacted canine an average of 78.8% of the time. The mean average of the orthodontists alone was 81%; the mean average of the residents alone was 74%. The overall kappa statistic, a measurement of rater agreement, was 0.58.

The surveys were also scored as a percentage score

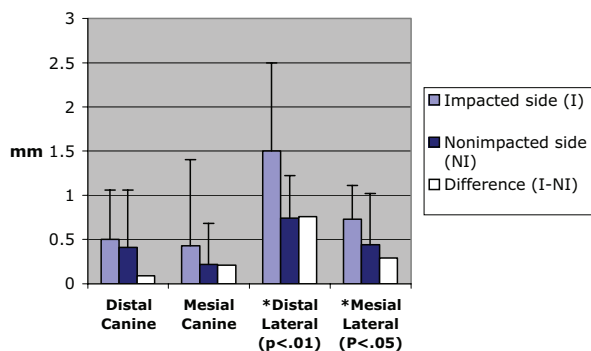


Fig 2. Mean differences in crestal bone height of experimental teeth (impacted side) compared with control side (nonimpacted side).

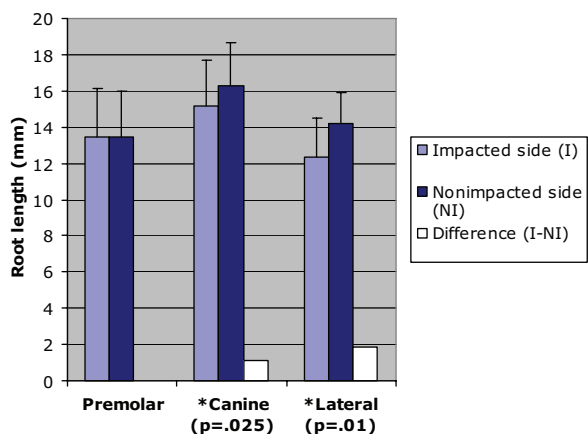


Fig 3. Mean differences in root length of experimental teeth (impacted side) compared with the control side (nonimpacted side).

of raters correctly identifying the previously impacted canine for a particular patient. Agreement of 22 of the 32 raters was significant to the 0.05 level.¹⁰ Ten of the 15 canines, or 66%, were correctly identified to a significant level. In 5 of the 15 patients, the raters could not identify the previously impacted canine to a significant level.

The reasons for identifying the impacted canine were tabulated into 7 categories: torque, gingiva (gingival attachment/gingival margin), alignment, crown length/wear, recession, color, and other. The reasons given in identification of the previous palatally impacted maxillary canine are summarized in Table IV.

DISCUSSION

This study was designed to be compared with the 1994 study of Woloshyn et al.² Those authors examined the posttreatment results of previously impacted canines that had been conservatively exposed, had

attachments placed at the time of surgical exposure, and were consequently aligned with light, continuous forces and closed eruption. The previously impacted canines in our study were surgically exposed, packed with surgical dressing, and had no attachments placed until the teeth had erupted into the palate. The study designs were similar so that the results could be directly compared, and posttreatment differences between the 2 techniques could be detected. A direct comparison of the radiographic data was attempted so that the raw data from the 2 studies could be directly compared without differences in measurer or measuring technique, but the radiographs from the study of Woloshyn et al.² were unavailable.

No differences were found between the bilaterally impacted canines and the control teeth from the patients with unilaterally impacted canines. The reasons for this are most likely twofold. The sample of the bilaterally impacted canines was too small to pick up a difference if one existed, and a weaker statistical *t* test had to be used in analysis because of the increased variability between independent samples. The remainder of the discussion focuses on the differences in the paired sample: the unilaterally impacted canines and adjacent teeth and the contralateral controls.

No differences in crestal bone height or probing attachment level were found around the previously impacted canines when compared with the control canines. Woloshyn et al.² and others found greater radiographic bone loss mesial¹¹ and distal^{3,11} to the previously impacted canines. Woloshyn et al.² also found differences in probing attachment level when comparing impacted and control canines, a result not supported by our study. It is possible that this study also had such differences, but the relatively small sample size of 16 prevented the differences from being shown. It is also possible that differences in technique of canine exposure and alignment accounted for decreased differences in bone height and probing attachment level in this study. The studies previously mentioned had attachments bonded on all^{2,3} or some¹¹ impacted canines at the time of exposure. Allowing the normal eruptive mechanism to take place before traction is placed on the tooth could cause less overall trauma to the impacted canine. Moreover, exposure of the canines without immediate attachments could improve cleansability and contribute to the decreased bone and attachment loss seen in this study.

Loss of probing attachment level was, however, found at the distolingual aspect of the lateral incisor on the impacted side. This is consistent with the results of Woloshyn et al.,² who found a similar difference in probing attachment level distal to the affected lateral

Table IV. Reasons given in identifying previously impacted maxillary canine

	<i>Torque</i>	<i>Gingiva</i>	<i>Alignment</i>	<i>Crown length/wear</i>	<i>Recession</i>	<i>Color</i>	<i>Other</i>
% of reasons given	28%	27%	17%	13%	6%	5%	3%

incisor. Similarly, in agreement with other studies,³ both studies reflect attachment loss distal to the affected lateral incisor in the crestal bone height measurements; both studies showed approximately 0.8 mm of mean bone height loss when compared with the contralateral side. Our study also showed a small amount of crestal bone loss on the mesial aspect of the affected lateral incisor, a unique finding compared with Woloshyn et al² and other studies.^{3,11}

This study agrees with findings by Woloshyn et al² and others,¹² showing root resorption of the lateral incisor on the impacted side. Woloshyn et al found a mean root loss of 1.33 mm, and we found a mean root loss of 1.87 mm. Woloshyn et al also showed that root resorption was associated with the impacted-side premolars, but our study shows mean root loss on the previously impacted canine but not the adjacent premolars. Perhaps more force is transmitted to the premolar mechanically through traction than when the canine is allowed to freely erupt, resulting in more root resorption in the premolar area with early canine traction. The increased root resorption in the canine allowed to freely erupt could be a result of the long distance the root must travel when the tooth erupts into the palate.¹³ It is also possible that the affected canines lack the developmental root length of normally erupting canines, and that the differences are a result of developmental differences rather than resorptive differences.

We found that orthodontists and second- and third-year orthodontic residents could correctly identify the previously impacted canine an average of 78.8% of the time, a similar rate to that found by the 2 senior authors in the study of Woloshyn et al (74.2%).² When analyzed by individual patient, however, orthodontists and residents could definitively identify the correct canine in only 67% of the patients to a 0.05 level of significance. The kappa statistic, a value estimating the proportion of agreement between raters after accounting for chance, was 0.58. The kappa statistic approaches 1 when there is perfect intrarater reliability and moves toward 0 when there is no agreement other than what would be expected by chance alone. A kappa of 0.58 indicates moderate intrarater agreement in canine identification.

The 3 most common reasons given for identifying the previously impacted canines were torque, gingiva, and alignment. Differences in torque, noted in 28% of

the reasons, reflect the difficulty in moving the root of the treated canine buccally enough with orthodontic appliances to mimic the contralateral canine eminence. Gingiva, comprising 27% of the reasons, indicates a perceived difference in amount of attached gingiva when compared with the contralateral tooth, or a difference in the relative heights of the gingival margins. Alignment, a reason given 17% of the time, reflects either a tendency toward relapse of the treated canine or a lack of complete alignment of the impacted canine after orthodontic treatment.

CONCLUSIONS

Treating palatally impacted maxillary canines with open surgical exposure, natural eruption of the canine, and orthodontic alignment has minimal effects on the periodontium. In this study, the roots of the impacted canine and the adjacent lateral incisor were slightly shorter than those of the contralateral control teeth, and no significant pulpal changes were identified. Visual differences were present in the previously impacted tooth when compared with the contralateral control canine. The overall consequences to the impacted canine with this technique seem better than with closed exposure and early traction of impacted canines. Consequences to the adjacent teeth, particularly the lateral incisor, seem quite similar with both techniques. Future research directly comparing the 2 methods with a larger sample and randomization could yield further insight.

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