sciendo

DOI: 10.2478/aoj-2007-0002

Comparison of surgical and non-surgical methods of treating palatally impacted canines. II - Aesthetic outcomes

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Background: Palatally impacted maxillary canines may appear unsightly after treatment because of changes in position and colour.

Aim: To determine if palatally impacted canines treated either by surgical exposure and orthodontic repositioning or by creation of space in the arch and unassisted eruption have different aesthetic outcomes.

Methods: Twenty eight subjects with unilateral palatally impacted canines who had completed orthodontic treatment at least 6 months previously were recruited from three specialist practices. In 14 subjects the canines had been treated by surgical exposure, orthodontic extrusion and repositioning in the arch (SE group) and in the remainder the deciduous canines were extracted and excess space created in the arch for the canines to erupt naturally (OT group). The contralateral canines were used as controls. The mean pretreatment ages of the subjects in the SE and OT groups were 13.5 (SD: 1.6) years and 13.5 (SD: 1.3) years respectively. The position and colour of the canines were assessed on post-treatment study models and 35 mm slides using the American Board of Orthodontics Objective Grading System (ABO OGS) and subjective appraisal by two orthodontists. Each subject used a semantic scale to rate the aesthetic outcome of treatment.

Results: Sixty four per cent of the treated canines in the SE group were significantly more 'intruded' than the treated canines in the OT group ($p = 0.004$) and the control canines ($p = 0.004$). The ABO OGS grades of the canines in the SE and OT groups were similar ($p = 0.173$). While the assessors detected a lack of labial root torque and gingival margin changes in the canines in the SE group, the subjects in both groups were satisfied with the appearance of the canines post-treatment.

Conclusions: Palatally impacted canines treated by surgical exposure, extrusion and orthodontic treatment were more likely to be displaced vertically ('intruded') after treatment than palatally impacted canines treated by extraction of the overlying deciduous canines and creation of excess space in the arch. Small occlusal and aesthetic changes detected by the orthodontists, but not the ABO OGS, did not appear to detract from the satisfaction of the subjects with the results of orthodontic treatment.

(Aust Orthod J 2007; 23: 8–15)

Received for publication: July 2006
Accepted: February 2007

Introduction

Despite extensive interest in the aetiology and management options for ectopic canines, only a few studies have focussed on the position and colour of the canines after treatment.[1–5] The maxillary canine is situated in a strategic position between the anterior and posterior segments and has important roles in an attractive smile and a functional occlusion.[6,7]

Early diagnosis and interceptive treatment with extraction of the overlying primary canines have been advocated for the management of impacted maxillary canines.[8,9] In less severe and uncrowded cases this simple procedure is relatively successful.[10] However, a recent prospective study of palatally impacted canines failed to find any difference between the success rates of impacted maxillary canines treated with extraction of the overlying primary canines and no treatment.[11]

In patients with crowding in the canine region, between 75 and 80 per cent of palatally impacted canines will emerge without direct orthodontic assistance if space is created in the upper arch.[11,12] If a palatally impacted canine fails to erupt following

Table I. Description of the sample.

	OT (N=14) Mean ± SD	SE (N=14) Mean ± SD	$p^{\dagger}$	p^{+}
Male : Female	5 : 9	2 : 12	0.190	
Right : Left proportion	8 : 6	4 : 10	0.127	
Sector of impaction II : III : IV	5 : 7 : 2	1 : 4 : 9	**0.019**	
Age at start of treatment (years)	13.5 ± 1.3	13.5 ± 1.6		0.979
Age at recall (years)	19.1 ± 2.2	18.8 ± 2.5		0.749
Active treatment duration (months)	27.9 ± 9.3	28.4 ± 7.5		0.877
Recall period (years)	3.4 ± 3	3.2 ± 2.4		0.847

† Chi-squared test, significant value in bold
+ Student's *t*-test

extraction of the overlying primary canine and creation of excess space in the arch, the most reliable treatment option is surgical exposure and orthodontic repositioning of the impacted tooth in the arch.

A reliable and objective method is required to evaluate tooth position following treatment. Previous studies have relied on assessments by orthodontists, by other dental professional groups, by the public, and measuring instruments, such as the American Board of Orthodontics Objective Grading System (ABO OGS).[5,13–16] The ABO OGS scores eight criteria, which are considered to provide a reliable and objective appraisal of tooth position.[16] There have been no previous reports of the use of the ABO OGS to determine the stability, or otherwise, of specific traits of malocclusion. A trained and observant eye may detect minor deviations in tooth position(s) that patients may be either unaware of or are satisfied with.[17,18] Patient perception and satisfaction may be assessed with instruments such as a semantic scale or a questionnaire.

The principal aim of this retrospective study was to determine if palatally impacted canines treated either by surgical exposure and orthodontic repositioning or by creation of space in the arch and unassisted eruption have different aesthetic outcomes. Additional aims were to determine if the ABO OGS could be used to assess the positions of the canines after treatment and to determine if the method of treatment influenced patient satisfaction.

Material and methods

Ethical clearance for this study was granted by the Medical Research Ethics Committee of the University of Queensland. Twenty eight subjects with unilateral palatally impacted canines who had completed orthodontic treatment at least 6 months previously were recruited from three specialist practices. In 14 subjects the canines had been treated by surgical exposure, orthodontic extrusion and repositioning in the arch (SE group) and in the remainder, the deciduous canines were extracted and excess space created in the arch for the canines to erupt naturally (OT group). Subjects were selected if they met the following criteria:

1. A unilateral palatally impacted canine was present.

2. A pretreatment panoramic radiograph was available.

3. There was no significant medical history.

4. Treatment had been completed at least six months previously.

5. In the surgical group, the subjects had undergone conservative surgical exposure and the wound had been dressed for 7–10 days before any orthodontic attachments were bonded.

The 14 subjects (5 males, 9 females) in the OT group had a mean age of 19.1 (SD: 2.2) years and the mean post-treatment period was 3.4 (SD: 3.0) years. The same orthodontist treated all subjects in the OT group. The 14 subjects (2 males, 12 females) in the SE group had a mean age of 18.8 (SD: 2.5) years and the mean post-treatment period was 3.2 (SD: 2.4) years (Table I). Three orthodontists treated the subjects in the SE group. The pretreatment panoramic radiographs were used to classify the sector of impaction using Lindauer et al. modification[19] of Ericson and Kurol's classification.[9] No sector I impacted canines were included in the study.

American Board of Orthodontics Objective Grading System

All subjects had a wax occlusal record and alginate impressions of both arches taken at the post-treatment assessment. The resulting study models were scored by a single examiner (KKL) with no prior knowledge of the side of impaction or the method of treatment. The alignment, marginal ridges, buccolingual inclinations, interproximal contacts, overjet, occlusal contacts and occlusal relationships of the teeth were assessed with the ABO OGS and the standardised measuring gauge. Root angulations were not assessed because post-treatment panoramic radiographs were not available. For each criterion, points were assigned based on the degree to which a relationship deviated from ideal. The individual components were scored and summed to yield an overall score. To assess intra-examiner reliability the ABO OGS scoring was repeated one week later.

Canine position and dental midline

The positions of both maxillary canines in each subject in relation to the adjacent teeth and the upper and lower dental midlines were analysed on the dental casts by one examiner. Intrusions, rotations and palatal translations were recorded as present or absent. Canines were classified as 'intruded' when there was no inter-arch contact or the height difference between the canines and adjacent teeth was greater than one millimetre. A rotation was recorded if a tooth was rotated more than five degrees. A canine was in palatal translation if the buccal overjet was reduced by more than one millimetre, if the tooth was in edge-to-edge relationship or in lingual cross-bite. The upper and lower dental midlines were measured with digital callipers.

Canine colour and side of impaction

Two independent orthodontists (Assessor A and Assessor B) subjectively assessed the colour of the maxillary canines on projected 35 mm Kodachrome slides of the frontal smile, the anterior occlusal view and the upper occlusal view. The slides were taken at standardised settings with the same camera at the post-treatment assessments. The assessors were unaware of the side of impaction and method of treatment. They were asked to assess the colour of both canines and to identify the side of impaction from the dental casts and colour slides.

Questionnaire

Subject satisfaction with the overall appearance of the canines, colour of the canines, colour of the lateral incisors and position of the canines were evaluated by questionnaire. The subjects were asked to rate their satisfaction with each of the four characteristics on a 5 point scale. The scale was anchored with the descriptors, 'very satisfied' and 'very dissatisfied'.

Statistical analysis

Statistical analysis was carried out with Minitab for Windows (Release 14, Minitab Inc., USA) and the level of significance for all statistical procedures was set at 5 per cent. Additionally, SPSS for Windows (Version 12.0, SPSS Inc., Chicago, USA) was used to perform the McNemar test. The Bonferroni correction was applied when appropriate. The age of the subjects at commencement of active treatment, ages at recall, the durations of treatment and the post-treatment follow-up periods in the groups were compared with Student's *t*-tests. Chi-squared tests were used to determine if there were different proportions of subjects in the impaction sectors in the SE and OT groups. The durations of treatment carried out by the three orthodontists were examined with the one-way analysis of variance. Post-hoc Tukey tests were used to test the differences between pairs of orthodontists.

Intra-observer duplication error for the ABO OGS overall score was tested with the paired *t*-test. Overall ABO OGS scores were analysed for the two treatment groups. A one-way ANOVA was used to check for a difference in ABO OGS scores between orthodontists. Attribute agreement analysis (Cohen's Kappa) was used to examine the intra-examiner reliability in determination of deviation from an ideal canine position. As the results indicated a high degree of reliability (Kappa: 0.65-1), either the initial or the second set of measurements was chosen randomly to be tested with Fisher's Exact test for differences in the proportions of canine intrusion, rotation and palatal displacement in the groups. Comparison within each group (palatally impacted canine versus the contralateral canine) was tested with McNemar tests. Differences in midline deviations between OT and SE groups were tested with the Mann-Whitney U test.

Inter-examiner agreement for canine colour and identification of a previously palatally impacted maxillary

Table II. Duration of active treatment.

	Treatment duration (Months) Mean ± SD	Range	*p*
Orthodontist A (N=3)	37.67 (4.16)[a]	33–41	
Orthodontist B N=8)	28.13 (5.08)[b]	21–36	
Orthodontist C (N=3)	20.00 (5.00)[b]	15–25	
			0.004

Different letters in the Mean (SD) column indicate a significant difference
One-way ANOVA, significant value in bold

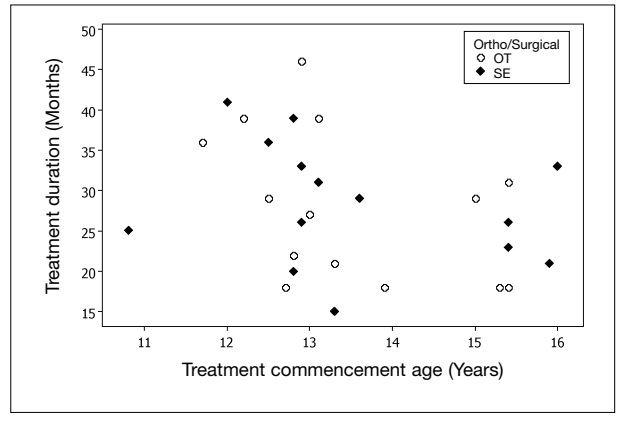


Figure 1. Treatment duration versus age at the commencement of active treatment.

Table III. Frequency of intrusion, rotation and palatal translation of previously impacted canines (PIMC).

	Intrusion			Rotation			Palatal translation		
	PIMC	Control	*p*+	PIMC	Control	*p*+	PIMC	Control	*p*+
OT (N=14)	1	0	1.000	4	0	0.125	1	1	1.000
SE (N=14)	9	0	**0.004**	8	1	**0.039**	4	0	0.125
p†	**0.004**	1.000		0.252	1.000		0.326	1.000	

Significant values in bold
† Fisher's Exact test
+ McNemar test

Table IV. Discolouration of impacted canines reported by two orthodontists.

	OT (N=14)	SE (N=14)	*p*†
Assessor A	2	5	0.190
Assessor B	1	1	1.000

†Chi-squared test

canine from dental casts and colour slides were analysed using attribute agreement analysis and Cohen's Kappa. The inter-examiner agreement was low. Thus, results from each orthodontist assessor were analysed separately with Fisher's Exact test. Ordinal data from the questionnaires assessing patient satisfaction were analysed with the Mann-Whitney U test.

Results

The results are given in Tables I–VI and Figures 1–3.

There were significantly more sector IV canines in the SE group and the durations of active treatment of the three orthodontists were significantly different (Tables I and II). The post-hoc Tukey test disclosed that Orthodontist A took significantly longer than Orthodontists B and C to complete treatment, but there was no difference in the time taken by Orthodontists B and C to complete treatment (Table II). The scatter plot of the treatment duration versus age at the commencement of treatment did not indicate any relationship between the two variables (Figure 1). Approximately 41 per cent of the variability in treatment time of the subjects in the SE group was accounted for by age at the commencement of treatment and the orthodontist providing the treatment (SE group: r-square, 40.68 per cent).

There was no statistically significant difference between the two sets of ABO OGS overall scores (p = 0.224). The first set of scores were used for further analysis. When the distribution of the ABO OGS overall scores was examined, nine subjects in the OT group (64 per cent) and six subjects in the SE group (43 per cent) had overall scores greater than 30 and failed to meet the treatment standards of the

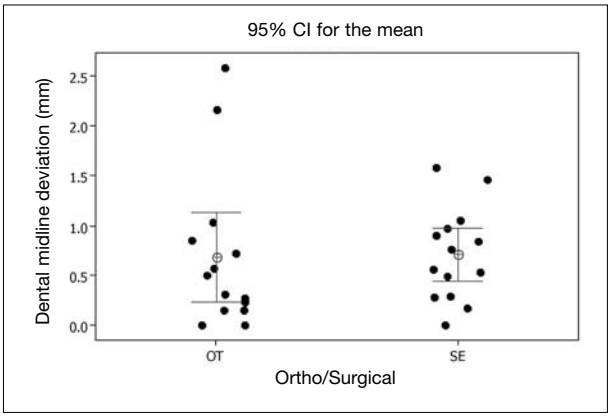


Figure 2. Individual post-treatment dental midline deviation.

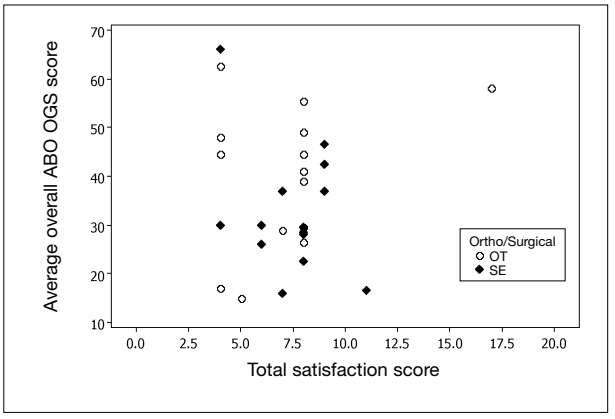


Figure 3. Overall ABO OGS score versus total satisfaction score. A high score indicates a poor occlusal outcome and a low score greater satisfaction.

Table V. Identification of previously impacted canines by two orthodontists.

	OT (N=14)			SE (N=14)		
	Incorrect	Correct	Uncertain	Incorrect	Correct	Uncertain
Assessor A	3	11	0	2	12	0
Assessor B	1	5	8	0	12	2

ABO. The ABO OGS scores for the OT (Mean: 39.9; SD:14.7) and SE (Mean: 32.6; SD:13.0) groups were not significantly different (p = 0.173). There were no significant differences between the overall scores for the patients in the SE group treated by each of the three orthodontists. The mean overall ABO OGS scores for orthodontists A, B and C were 22.83, 36.88 and 30.83 respectively.

The number of previously impacted and control (contralateral) canines that were intruded, rotated and/or palatally placed in the OT and SE groups are given in Table III. Nine out of 14 treated canines (64 per cent) in the SE group were intruded. Of the treated canines more teeth were intruded in the SE group compared with the OT group (p = 0.004) and the control canines (p = 0.004). The latter finding was statistically significant after the Bonferroni correction had been applied. In the SE group more treated canines were rotated at recall than control canines (p = 0.039). There was no significant difference in midline deviations in the OT (Mean: 0.40 mm) and SE (Mean: 0.66 mm) groups. The maximum midline deviations in the OT and SE groups were 2.58 mm and 1.58 mm respectively (Figure 2).

There were no significant inter-group differences in the colour of the previously impacted teeth (Table IV). Assessor A correctly identified 11 previously impacted canines in the OT group and 12 teeth the SE group (Table V). Assessor B was uncertain in eight (57 per cent) cases in the OT group and two cases in the SE group (14 per cent). Assessor B correctly identified five cases in the OT group and 12 cases in the SE group. Both assessors used differences in inclination and the appearance of the labial and palatal gingival contours to identify previously impacted canines.

The subjects were generally 'satisfied' or 'very satisfied' with the colour and positions of the treated canines. Only one subject in the OT group chose 'very dissatisfied' as the response to the question about overall appearance. Similarly, the majority of subjects were 'satisfied' or 'very satisfied' with the colour of the lateral incisors and only one subject from each group was 'dissatisfied'. There were no significant differences between the OT and SE groups to the questions relating to overall satisfaction, colour of the lateral incisors, colour and position of previously impacted maxillary canines (Table VI). There was also no significant difference between the OT and SE

Table VI. Subject satisfaction post-treatment.

		Very satisfied	Satisfied	Don't know	Not satisfied	Very dissatisfied	*p*†
Overall appearance	OT	6	7	0	0	1	
(Impacted canines)	SE	6	8	0	0	0	
							0.872
Colour (PIMC)	OT	5	8	0	1	0	
(Impacted canines)	SE	2	12	0	0	0	
							0.505
Colour - lateral	OT	5	8	0	1	0	
incisors	SE	2	7	4	1	0	
							0.108
Position	OT	5	7	1	1	0	
(Impacted canines)	SE	5	8	1	0	0	
							0.836

† Mann-Whitney U test

groups when the scores of the four questions were combined (p = 0.448). Finally, there was no significant correlation between the combined satisfaction scores and the ABO OGS scores (Figure 3).

Discussion

We set out to determine if palatally impacted canines surgically exposed and repositioned in the arch had better crown colour and position than canines permitted to erupt naturally after excess space had been created in the maxillary arch. Although the clinicians were able to identify small variations in the positions of the canines that the ABO OGS could not pick up, the subjects were generally very satisfied with the outcome.

The main limitation in this study is related to the method of sampling. In this study, consecutively treated patients fitting the inclusion criteria were retrospectively identified and invited to participate. The participation rate was only 58 per cent, which resulted in a relatively small sample. Bias due to satisfied patients being more likely to participate in the study cannot be eliminated. Another problem relating to the small sample size is the possibility of having a Type II error, so that the null hypothesis is wrongly accepted due the inability to detect a difference. The probability of a Type II error decreases as the sample size increases. While the best strategy is to obtain the largest possible sample, this was not possible because of the low participation rate.[20] A future prospective study would be able to address some of these concerns. There are also recognised objections to the validity of findings from questionnaires, since some respondents might have been inclined to select the perceived 'right' answer and selecting a suitable answer format inevitably inhibits free expression.[21] Hence, the findings from the patient satisfaction survey in this study may be optimistic.

Ideal alignment in the present study was 71 per cent in the OT group and 14 per cent in the surgical group. The result from the surgical group was much lower than reported in the literature, which ranges from 40–48 per cent.[2,3,5] The differences between the studies may be due to the differences in the criteria for determining rotation, intrusion and palatal translation. Generally, it is accepted that some degree of relapse is inevitable,[2–5] but the changes found in this study were surprising. In the SE group, the previously impacted canines were intruded in nine subjects (64 per cent) and rotated in eight subjects (57 per cent). These are much higher proportions than in the OT group or on the control sides in both groups. Palatal displacement was a marginally less frequent finding with four subjects (29 per cent) in the SE group affected. Even though four subjects (29 per cent) in the OT group presented with rotation of previously impacted canines, palatal displacement and intrusion rarely occurred in this group.

A concern with the technique of allowing an impacted canine to erupt naturally is that a residual

dental midline deviation may persist post-treatment. The technique involves the creation of excess space of up to 10 mm and may require proclination and displacement of the maxillary incisors across the midline. Investigation of midline deviations yielded no significant difference between the groups.

The ABO OGS found the scores for both groups were similar, implying a similar standard of finishing or amount of relapse. However, the scores did not agree with the clinical assessment. The main reason for the failure to detect a difference could be related to the method of scoring the models. The full ABO OGS sums the discrepancies in all criteria and it is not sensitive enough to detect a small departure from the ideal position, and it is not designed to assess the positional deviation(s) of an impacted canine.

One of the factors that may influence the occlusal outcome is the duration of active orthodontic treatment.[22,23] In the present study there was no significant difference between the groups in the duration of treatment. The mean duration of treatment in the SE group was 28 months and was comparable with other studies where active eruption was used following surgical exposure.[3,24]

There was no colour difference between the canines in the two groups. It was not possible to determine the incidence of discolouration because of the poor agreement between the assessors. Identification of previously impacted canines by the two assessors also showed poor agreement, although they were more likely to correctly identify a previously impacted canine in the SE group than in the OT group. The lesser amount of relapse in the OT group may have made identification of a previously impacted canine difficult.

There was a high level of patient satisfaction following both methods of treatment. Only one subject from the OT group expressed dissatisfaction with treatment, but this was not correlated with the occlusal outcome, as demonstrated by the ABO OGS score for this subject. Clustering of the satisfaction scores in this study into a narrow range, irrespective of the ABO OGS scores, indicates satisfaction was not dependent on or correlated with occlusal outcome (Figure 3). Overall, palatally impacted canines corrected by extraction of the overlying primary canine and orthodontic space opening showed better alignment and less relapse than canines managed with surgical exposure, extrusion and orthodontic alignment.

Conclusions

1. Palatally impacted canines treated by surgical exposure, extrusion and orthodontic treatment were more likely to relapse vertically than those treated by extraction of the overlying deciduous canines and creation of excess space in the arch.

2. The ABO OGS failed to detect small changes in the positions of the canines in both groups.

3. There were no colour differences between the previously impacted canines in the two groups. The assessors correctly identified high percentages of previously impacted canines in the surgical group, but not the non-surgical group.

4. The subjects in both groups were satisfied with the outcome of treatment.

Acknowledgments

This study was supported by a grant from the Australian Society of Orthodontists' Foundation for Research and Education. The authors would like to thank the orthodontists who were involved in this study for their assistance with assembling the sample and collecting the data.

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