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Parkin, N.A., Freeman, J.V., Deery, C. et al. (2015) Esthetic judgments of palatally displaced canines 3 months postdebond after surgical exposure with either a closed or an open technique. American Journal of Orthodontics and Dentofacial Orthopedics, 147 (2). 173 - 181. ISSN: 0889-5406

https://doi.org/10.1016/j.ajodo.2014.10.026

Esthetic judgments of palatally displaced canines 3 months post-debond, following surgical exposure with either a Closed or Open technique

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Acknowledgements

The trial was funded by a grant from the British Orthodontic Society Foundation. The authors would like to thank the following people: Professor Donald Burden of Queen's University Hospital Belfast for sharing his original protocol, Alison Murray, Ann Marie Smith, David Tinsley, Richard Skeggs Jonathan Sandler and Richard Milner for helping with the protocol at the outset and with collecting records and Pam Del'Nero secretary to the Orthodontic Department at the Charles Clifford Dental Hospital for co-ordinating the randomization.

Introduction

Wisth and colleagues[1] suggested that a Closed surgical exposure of palatally displaced canines (PDC) leads to superior periodontal outcomes than an Open surgical exposure; however this was an inherently weak, retrospective study. A systematic review found no evidence of the superiority in terms of clinical attachment levels following treatment of one technique over the other.[2] A recent randomized controlled trial has confirmed this.[3]

One outcome that has received limited investigation is the esthetic appearance of the PDC, following surgical exposure and alignment. D'Amico and colleagues[4] obtained the esthetic judgments of orthodontists and patients concerning displaced canines that had been exposed using a closed surgical technique and orthodontically aligned. Their sample included the clinical photographs of 61 patients with either unilateral or bilateral, buccally or palatally displaced canines, a mean of 3.5 years after debond. They found that orthodontists rated the esthetic results as 'Good' in 57% of patients, 'Acceptable' in 26% and 'Not good' in 17%. Interestingly the orthodontists were only able to correctly identify 48% of the canines that were unilaterally buccal displacements compared with the normal contralateral and 61% of those that were unilaterally palatal displacements.

Ling et al[5] investigated the post-treatment appearance of unilaterally displaced palatal canines in 28 patients; half of whom had had surgical exposure and assisted eruption (SE) and half had 'unassisted eruption'. The canines that had surgical exposure were identified by two orthodontists in 12 out of 14 cases and both assessors used differences in inclination and the appearance of labial and gingival contours. All 14 subjects in the surgical exposure group were either 'satisfied' or 'very satisfied' with the overall final appearance.

There is no work in the literature investigating the judgments of lay people concerning appearance of treated palatally displaced canines. It has been shown that dentists and orthodontists differ in their judgments about the appearance and gingival health of the canine crown compared to lay people.[6] The aim of this study was therefore to explore any differences in the esthetic outcomes of canines exposed using a Closed versus an Open surgical technique using the views of two groups of judges, one consisting of orthodontists and one of lay people.

The following research questions were investigated:

1. Can the operated canine be identified by the orthodontists or lay people?
2. Were the judges able to identify the operated canine more frequently when it was treated using a Closed or an Open surgical procedure?

3. Is there a difference in the appearance of the teeth and gingiva between the two surgical procedures? This was judged in terms of:
    a. Which canine looks better? 'Is the gum health better if it is exposed with a Closed or an Open procedure'?
    b. Does the length of the canine have a tendency to be too long in the Closed group and too short in the Open group?
4. Are orthodontists better than lay people at identifying the operated canine?

The study was undertaken to test equivalence between the two techniques. Traditional comparative studies test the hypothesis that there is a difference between two techniques and if there is insufficient evidence that a difference exists (a non-significant p-value), then the researchers conclude that equality cannot be ruled out. Equivalence studies aim to test the opposite i.e. the evidence supporting equivalence. If there is not strong evidence supporting equivalence, then researchers conclude that nonequivalence cannot be ruled out.[7]

An assumption was made that equivalence would be established if the proportions of assessors correctly identifying the operated/unoperated tooth or teeth surgically exposed with a closed or open procedure was 50% and within an equivalence margin of 10 percent.

Three research hypotheses were tested:

- There is no difference in the assessor judgments of the appearance of operated and unoperated canines;
- There is no difference in the assessor judgments of the appearance of PDC treated with either a Closed or an Open surgical exposure;
- There was a difference in the esthetic judgments of lay people and orthodontists.

The first two hypotheses were examined by looking at the confidence intervals of the differences to see whether there was equivalence or clinically meaningful differences. The third research hypothesis was tested by the more traditional method of examining the probability that there was no difference, as it was assumed that orthodontists would be more expert than lay people.

The null hypotheses tested were:

- The assessor judgments of the appearance of operated and unoperated canines were not equivalent;

- The assessor judgments of the PDC treated with either a Closed or an Open surgical exposure were not equivalent
- The esthetic judgments of lay people and orthodontists were equivalent.

Participants and methods

The clinical material used in this study was collected as part of a multicenter, randomized controlled clinical trial, involving two parallel groups of patients with a unilateral PDC. Details of the study methodology, including the inclusion/exclusion criteria, have been described elsewhere.[8] Briefly, participants who agreed to take part and provided informed consent were randomized to either receive a Closed or an Open surgical procedure for their unilateral PDC. Following surgery, orthodontic treatment was undertaken by a specialist orthodontic practitioner to align the PDC. On completion of treatment the appliances were removed and the patient was supplied with a removable retainer to wear at night. Three months following debond records were obtained, including clinical photographs, which were used in the assessment process.

Esthetic judgments

Two groups of judges were convened; a dental panel comprising 11 specialist orthodontists (six males, five females) and a lay panel comprising 11 professional people (five males, six females) in non-dental occupations. The orthodontists were mainly senior specialists (NHS consultants) and participated in the assessment process during a regional audit meeting. The lay panel was a convenience sample of non-dentists. No incentive or reward was given to participants for taking part, except that refreshments were provided.

The panels were shown a PowerPoint™ (Microsoft Corp, USA) presentation of the 3-month debond photographs. Before the start of each presentation, a brief overview of the study was given to both groups, using images to explain the salient points. Participants were informed that there were no ‘right’ or ‘wrong’ answers and were asked to provide their own assessment, without conferring.

Each slide consisted of the buccal intra-oral images of both the operated and unoperated sides of one participant (Figure 1). Each member of the two panels was asked to rate the appearance of the two canines using a standard assessment sheet, which was developed and piloted amongst the research team before use (Appendix 1). Following initial piloting and modification it was piloted and

modified again amongst three orthodontists and three lay people who were not involved in the final process.

For the final assessment process, the principles of scoring were explained thoroughly, especially amongst the laypeople. Scoring included a rating of gingival health and appearance of each maxillary canine of the operated and unoperated canine. Assessment of appearance included a rating of crown length using a visual analogue scale (VAS) consisting of a 100mm line labelled 'very poor' on the left and 'very good' on the right. The respondents were also asked their subjective judgment about whether they considered the tooth crown to be too long or too short, which tooth looked better and which tooth they thought had been operated on. After the first slide, only one minute was allowed for the assessment.

Statistical methods

For the assessment of whether the operated canine could be identified, the outcome was a binary: Yes/No response. Whilst there was a category for those who could not guess, this has been interpreted as a 'No', because the question asked was: 'Can the operated canine be identified?' If the observer was unable to decide, then this was interpreted as meaning 'No they could not identify it correctly'.

For each set of patient images the percentage of times the operated tooth was correctly identified was calculated. To examine whether the correct tooth could be identified, a one-sample *t* test was conducted, to determine if the proportion of correctly identified treated teeth was significantly different to chance i.e. greater than 50%. The confidence intervals were examined for clinical significant differences. Lay judges and orthodontists were analyzed separately and any potential difference between the panels examined in the same manner.

To determine if a Closed or Open surgical exposure resulted in a better appearance, several outcome variables were used. Observers were asked to rate whether they thought that one canine looked better than the other or both the same. In addition, gum health was measured directly on a continuous 0 to 100 point visual analogue scale. It was expected that in the majority of cases the untreated canine would be rated as looking better than the operated canine; therefore the percentage of times the untreated canine was thought to look best was initially compared between the Closed and Open groups, using a two sample *t* test. For these analyses interest was focused on the differences between the two procedures and so no comparisons were made between orthodontists and lay people. When analyzing the continuous measure of gum health, an analysis of variance using a random effects model was carried out with assessors as a random effect.

Differences between assessors were not inherently of interest, but by fitting them as a random effect it allowed us to account for the between assessor variation in the analysis and report the difference between the two operations, following adjustment for assessor. In addition, the health of the untreated canine was fitted as a covariate, in order to control for what the tooth should look like. The data were analyzed using SPSS version 20.

The final analysis was concerned with crown length. Was there a difference between the two procedures in terms of the length of the operated canine when compared to the unoperated canine? An analysis of variance using a random effects model was fitted with the length of the treated tooth as the outcome variable and assessor fitted as a random effect. In addition, the length of the untreated canine was fitted as a covariate, in order to control for what the tooth should look like. As with the analysis of gum health, interest was focused on the difference between the two procedures and so no comparisons were made between orthodontists and lay people.

No repeatability study was performed since we were interested in what the judges first thought about appearance of the canines. On examining the data it was clear that there were discrepancies in the recording of the judgments by one of the orthodontists and their data were subsequently excluded from the analysis.

Results

Recruitment of participants to the clinical trial commenced at the beginning of August 2002 and finished at the end of January 2007. Figure 2 shows the flow of patients through the trial and the numbers included and excluded from the esthetic analysis. Eighty one participants were recruited; however ten were excluded from all analyses, as outlined in a previous report.[8] Four participants were excluded from the esthetic analysis: one patient had an absent lateral incisor (Closed); one patient had the canine extracted after two attempts at surgical exposure (Open); and in two participants, no post debond photographs were available (Closed). Five participants received the incorrect procedure (Closed 1, Open 4); however the intention-to-treat principle was adhered to and they were all analyzed in their original allocated groups.

Question 1: Can the operated canine be identified by the orthodontists and lay people? (Table I)

On average 60.7% (95% CI: 53.7% to 67.8%) of the time the orthodontists correctly identified the tooth that was operated on and this percentage was significantly different from the null percentage of 50% (P=0.003). The results for the lay people indicated that they could not tell the operated canine from the unoperated canine, as on average they identified the operated canine correctly

49.7% of the time (95% CI: 45.3% to 54.0%) and this did not differ significantly from the null value (P=0.880). Interestingly one of the lay judges was particularly good at identifying the treated canine with 71.6% of their responses being correct. This was the second highest success rate out of all the judges; an orthodontist having the highest score of 73.1% correct identifications.

Question 2. Were the judges able to identify the operated canine more frequently when it was managed using a Closed or an Open surgical procedure? (**Table I)**

For the Closed procedure the orthodontists were able to identify the operated canine 59.4% of the time (95% CI: 48.5% to 70.3%) whereas for the Open group they were able to identify the operated canine 62.1% of the time (95% CI: 52.6% to 71.5%). The difference between the two procedures was 2.7% (95% CI: -11.4% to 16.8%) and this was not statistically significant (P=0.407).

For the lay people, 49.6% of the time they were able to identify the operated canine with the Closed procedure and 49.7% of the time for the Open procedure and this difference of 0.15% was not statistically significant (P=0.620).

Questions 3a & b. Is there a difference in the appearance of the teeth and gingivae between the two surgical procedures in terms of 'Which canine looks better?' and 'Is the gum health better if it is exposed with a Closed or an Open Closed procedure?' (**Table II)**

The majority of the assessments suggested that the unoperated canine was judged the better looking by both orthodontists (mean 60.7%; 95% CI: 53.4% to 68.1%) and lay people (mean 57.8%; 50.8% to 64.8%); however there were occasions when the operated side was judged better looking. When examining the data for differences between participants who had a Closed or an Open procedure, there were no significant differences in the judgments of whether the operated or unoperated tooth was the best looking for either the orthodontic assessors (P=0.270) or the lay assessors (P=0.430). This was the case for both the simple analysis with the percentage who classified the unoperated canine as best, and the random effects model of the VAS score.

The results for gum health and crown height were similar; however the mean ratings by the lay panel for gum health in particular were much lower than those of the orthodontic panel.

Question 4: Are orthodontists better than lay people at identifying the operated canine? (**I**)

There is a tendency for the orthodontists to be better in their identification of the operated canine than the lay people and this was confirmed by the analysis. The mean difference between orthodontists and lay people was 11.1% (95% CI: 4.3% to 17.9%) and this difference was statistically

significant (P=0.002); however the lower limit of the confidence interval suggests that the 'true' difference might be as low as 4.3%, which is unlikely to be clinically significant.

Discussion

This study was the first to ask lay people to judge the appearance of unilateral palatally displaced maxillary canines that had been surgically exposed and orthodontically aligned, using either an Closed or an Open surgical technique. We found that lay people were not able to reliably distinguish operated from unoperated canines, even though they more frequently rated the appearance of the unoperated canines to be better than the operated canine.

The analysis was undertaken on the basis of testing for equivalence, rather than the more traditional approach of testing for a difference. An assumption was made that if the proportions of assessors correctly identifying the operated/unoperated tooth or teeth surgically exposed with a closed or open procedure was 50% and within an equivalence margin of 10 percent then equivalence would be established. The equivalence margin was chosen after consultation with colleagues about what limits might be considered acceptable. Figure 3 shows the data from Table I in the form of forest plots, which illustrate the principle of equivalence graphically. The two plotlines at the top of the figure show that on average the orthodontists were more successful than the lay people at distinguishing the operated and unoperated canines. Although the confidence intervals of the proportion of orthodontists and lay people correctly identifying the operated teeth did overlap by a small amount, the confidence interval of the differences did not overlap, therefore equivalence could not be assumed. The remaining plots show little difference in the judgments for correctly identified canine teeth operated with either a closed or open technique, therefore equivalence is assumed.

Orthodontists were more successful at identifying the operated canines; however they were only able to do this with certainty, on average 60.7% of the time. This figure is very similar to the results of the study by D'Amico and colleagues,[4] who asked a panel of five orthodontists to judge the clinical images of patients with unilateral displaced permanent maxillary canines that had received a closed surgical exposure. The judges in their study were able to identify with certainty 61% of the operated canines.

Woloshyn and colleagues[9] found clinicians could correctly identify approximately three quarters (74.2%) of unilateral maxillary canines that had been exposed using a closed technique and

orthodontically aligned; however the two judges used in the study appear to have been intimately involved in many aspects of the study, including the treatment of participants. This close involvement with the treatment of participants might have affected their judgments. The orthodontists who acted as judges in our study were not involved in the treatment of participants.

Schmidt and Kokich[10] convened a relatively large panel of clinicians (23 orthodontists and nine residents) to judge the esthetic results from the post-treatment clinical images of 15 patients, with displaced canines that had been exposed using an Open technique. They found that the operated canines were identified on average 78.8% of time, which is a higher success rate than the most successful clinician in our study. The methodology of the investigation was poorly described and it is unclear if the judges were allowed a 'Don't know' category. The main reasons given for identifying the previously impacted canine were torque, gingival health and alignment, with the difference in torque being the most common reason. This reflects the difficulty in moving the root of the canine buccally. Torque control may be more difficult with an Open procedure than Closed owing to the way the canine is dragged above the mucosa, however torque was not specifically measured in this study.

No study was found where lay people were used as assessors in rating the esthetics of operated canines. In the study by Bowman and Johnston[6], where a panel of lay people and dentists were asked to evaluate profiles of patients that had been orthodontically treated with and without extracting premolars, dentists VAS scores were higher than laypersons for both groups. This finding is similar to our study in that laypersons are more critical and give harsher scores than orthodontists.

Closer examination of the data reveals that some of the canine teeth displayed more obvious visual clues, regarding a history of treatment, compared with other teeth. Figure 4 shows the images of one patient, treated using an open surgical exposure, in which the appearance of the gingival contour above the upper left canine, at three months post debond, is highly suggestive of orthodontic alignment. This was correctly identified by the orthodontists 100% of the time and by the lay judges 90% of the time. Some canines that were more readily identified by the orthodontists were not so easily identified by lay people. Figure 5 shows the images of a canine , exposed using a closed surgical technique, which was identified by orthodontists on average 90% of the time, but by lay people, on average, only 55% of the time (i.e. not much better than chance). The operated canine was easy to identify, from an orthodontic point of view, owing to its reduced crown length and inadequate torque, compared with the contra-lateral canine. Figure 6 shows the images of a canine tooth that was difficult to identify by both panels (orthodontists: 30%; lay people 55%). It is likely that the orthodontists considered Slide 2 to be the treated canine, owing to the increased

crown height and evidence of recession at the mid buccal aspect of the canine. The lay people were unsure and overall scored marginally better than chance (55%) in identifying the correct tooth.

When comparing whether the judges were more successful at identifying the canines that had been exposed using the Closed surgical technique compared with the Open surgical technique, there was a minimal difference in the success rates amongst the orthodontists, with 3.7% more successful judgments correctly identify the operated canine in the Open group compared with the Closed group, which was statistically non-significant. There was even lower difference amongst lay people (0.5%). Interestingly, there were marked differences between individual examiners of both panels as reflected by the wide confidence intervals in Table I.

As expected, the results for Question 1 (can the operated canine be identified?) and Question 4 (which canine looks better?) were similar amongst the orthodontic assessors. Interestingly, amongst lay people, there was much more of a discrepancy. The lay people rated the unoperated canine as best 58.7% of the time in the Closed group and 57.7% of the time in the Open group; however, when they were asked to identify which canine had been treated, they did so with certainty 50.1% of the time in the Open group and 49.6% of the time in the Closed group. This suggests that lay people may have been confused when asked to identify the operated tooth and may have used different criteria when judging 'best appearance' to those used for judging which canine had been treated.

The results of the response to Question 4, especially those of the lay people, suggests that exposure and alignment of PDC does have an esthetic impact. Therefore, if there is a non-surgical alternative, for example interceptive extraction of the primary canine, then this should be considered, although currently, no robust studies exist to provide evidence of the effectiveness of such interceptive treatment.[11]

The numerous claims in the literature that an Open surgical exposure leads to poorer esthetics and gingival health originate from the retrospective comparison study of Wisth and colleagues published in 1976.[1] No study has actually compared the esthetics following Open versus the Closed surgical procedures. Ling and colleagues[12] compared canines treated with an Open surgical exposure with canines treated non-surgically using space creation and spontaneous eruption. They found the non-surgical treatment to be superior in terms of esthetics, as their two orthodontic judges found it more difficult to identify the treated canines in this group. Unfortunately, the two groups were not equivalent in terms of severity of impaction at the start and the numbers of treated teeth assessed (14) and judges (2) were quite small.

It appears, from the literature that the main way clinicians identify a previously operated canine is by looking at the torque and the gingival health of the tooth;[12] however when the assessors in our study were asked to rate gingival health, no significant differences were found between the Open and Closed groups. The question concerning crown height was included in our study, as we thought there might be a difference owing to the way in which the canine was orthodontically aligned (with the Closed technique the canine moves beneath the mucosa and with the Open technique, the canine moves above the mucosa). We found that neither the orthodontists, nor the lay people rated the crown height differently between the Closed and Open groups; although both panels rated the operated side to have a shorter crown length than the unoperated side, there was considerable variation in the responses.

One of the strengths of our study is that the images of unoperated and operated canines were collected using appropriate research methods to reduce bias. Unfortunately there were a number of withdrawals and drop outs; however 83% of the initial sample was included in the final analysis. With regard to the assessment process the study is strengthened by including a panel of lay people, as it is these judgments, rather than necessarily those of dentists, that are important to our patients. The lay panel was a convenience sample of mainly profession non-dentists and it would have been preferable to have included a random mix of professionals and non-professionals to ensure the opinions were representative of different socio-economic groups. Another potential weakness was that the primary outcome of the overall study was based on periodontal, rather than the esthetic outcomes and evaluated using the traditional approach of testing the null hypothesis of no difference.[3] An analysis that tests for equivalence usually requires a larger sample size; therefore the study might not have sufficient power to determine equivalence.

No visual or written material was provided to the lay panel concerning what constitutes ‘health’ or ‘poor health’ of a tooth, as it was decided not to provide any criteria that might influence their opinion about what an ideal canine (from the viewpoint of a dental profession) should look like. We wanted to know the judges’ own impression of the appearance of ‘health’ and what ‘looks good’ rather than how good they were at following preset criteria. It would be interesting to investigate what features the judges were using, particularly the lay panel, during their assessments, as they were gave much lower scores and therefore were apparently more critical of gingival health compared with the orthodontic panel. This should be a subject of future studies.

Conclusions

- There is an esthetic impact involved in aligning a PDC, both orthodontists and lay people rated the unoperated canine as looking the 'best' in the majority of cases;
- Clinicians were, on average, able to distinguish between operated and unoperated canines, but only on 60.7% of occasions. Lay people were successful in 49.7% of the assessments, which is no better than chance;
- There were no differences between Closed and Open groups, in terms of any of the esthetic judgments.

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Legends

Figures

Figure 1: An example of one of the slides shown to the judges

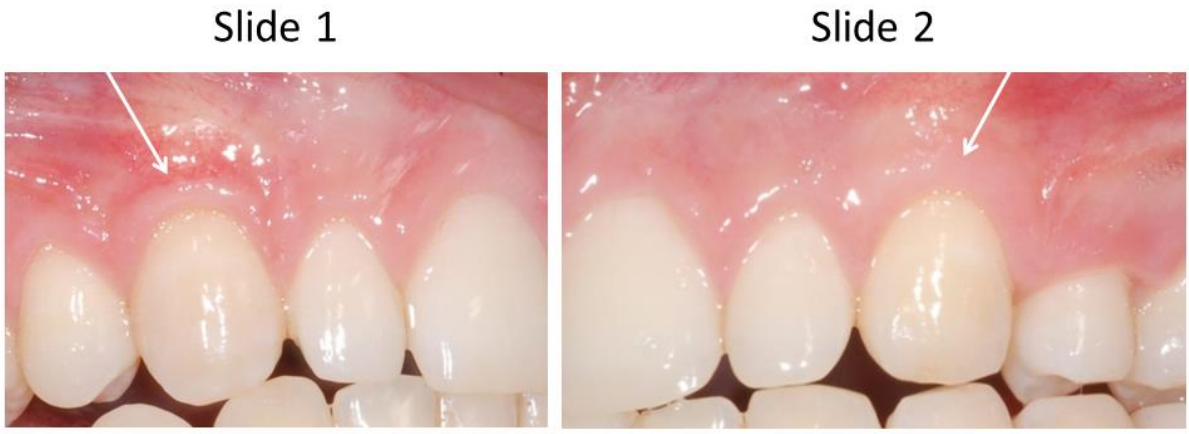

Figure 2: Participant flow through the trial

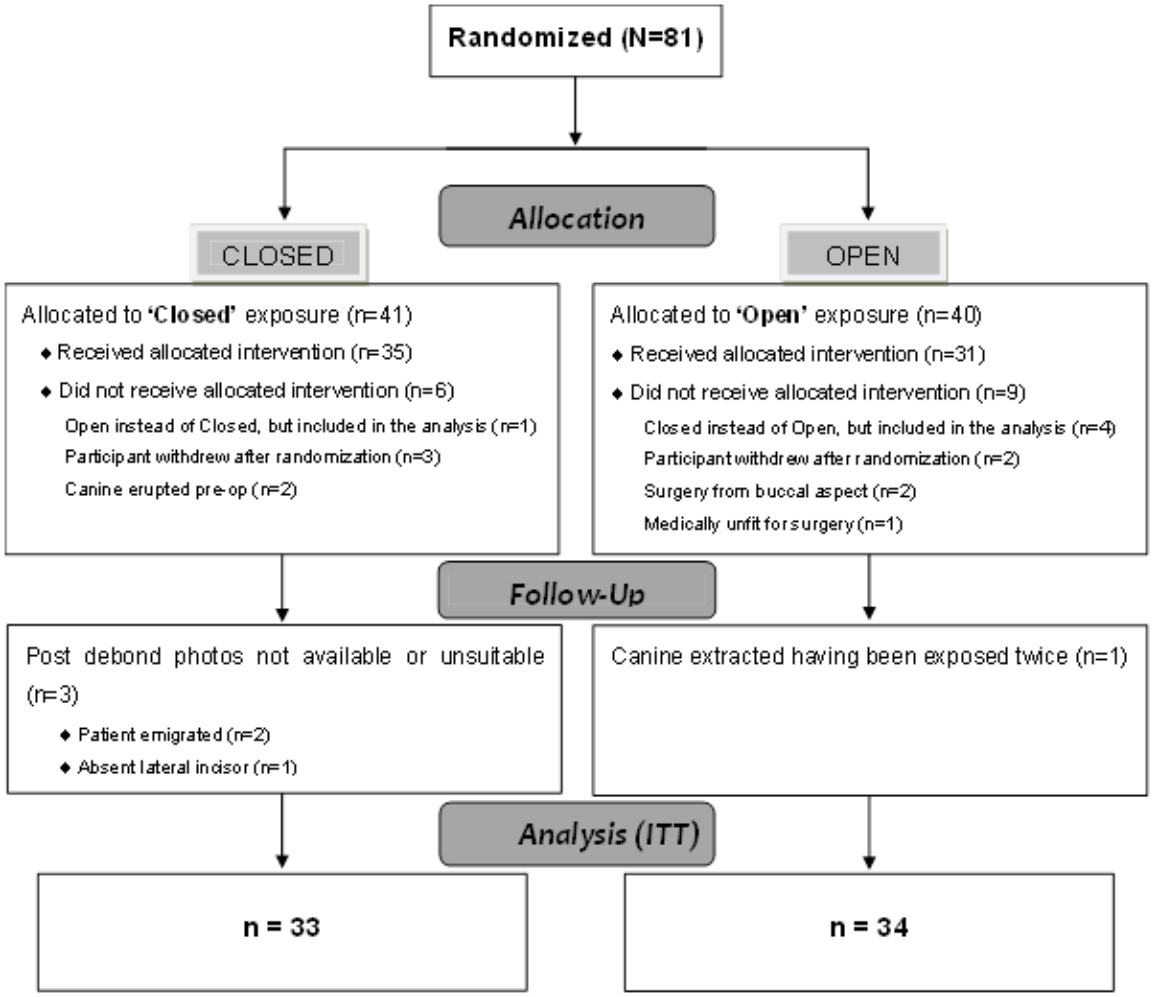

Figure 3: Graphical representation (forest plots) of data from Table 1 (means and confidence intervals) demonstrating equivalence/non-inferiority.

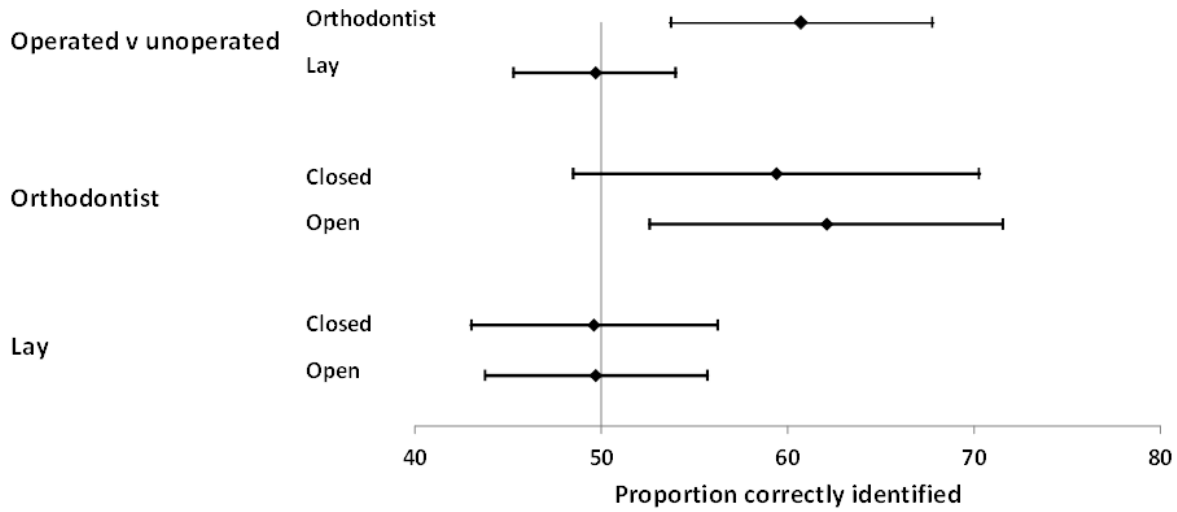

Figure 4 – Post-debond images of Participant Nos 71, who received an Open surgical exposure. The operated canine (Slide 2) was identified 100% of the time correctly by orthodontists and 90% of the time by lay people.

Figure 5: Post-debond images of Participant Nos 32, who received a Closed surgical exposure. The operated canine (Slide 2) was identified correctly 90% of the time by orthodontists and 55% of the time by lay people.

Figure 6: Post-debond images of Participant Nos 4, who received an Open surgical exposure. The operated canine (Slide 1) was identified correctly 30% of the time by orthodontists and 55% of the time by lay people

Tables

Table I: Proportions correctly identified by assessor group, operated and unoperated, Closed and Open (mean and 95% confidence interval) with differences tested using a one-sample *t* test

	% Correctly identified (Mean and 95% CI)	Difference	P-value
Operated v Unoperated			
Orthodontist	60.7 (53.7 to 67.8)		0.003
Lay	49.7 (45.3 to 54.0)		0.880
		11.1 (4.3 to 17.9)	0.002
Orthodontist:			
Closed	59.4 (48.5 to 70.3)		
Open	62.1 (52.6 to 71.5)		
		2.7 (-11.4 to 16.8)	0.470
Lay:			
Closed	49.6 (43.0 to 56.2)		
Open	49.7 (43.8 to 55.7)		
		0.2 (-8.6 to 8.9)	0.620

Table II: Results for 'which canine looks best', gum health and canine length. Difference were tested using a two-sample *t* test for the assessment of which canine looks best and an analysis of variance using a random effects model for assessments of gum health and crown length.

	Mean & 95% CI	Difference	P-value
Unoperated canine rated best (%)			
Orthodontist:			
Closed	60.9 (49.1 to 72.7)	0.32 (-14.5 to 15.1)	0.270
Open	60.6 (51.1 to 70.1)		
Lay:			
Closed	58.7 (47.7 to 69.7)	1.73 (-12.4 to 15.9)	0.430
Open	57.0 (47.5 to 66.4)		
Gum Health VAS (mm):			
Orthodontist:			
Closed	53.7 (51.1 to 56.2)	0.7 (-2.8 to 4.2)	0.700
Open	52.9 (50.5 to 55.4)		
Lay:			
Closed	36.7 (35.7 to 37.6)	0.2 (-1.2 to 1.5)	0.820
Open	36.5 (35.5 to 37.5)		
Crown length VAS (mm):			
Orthodontist:			
Closed	59.5 (56.8 to 62.2)	0.7 (-3.0 to 4.5)	0.70
Open	58.8 (56.2 to 61.4)		
Lay:			
Closed	43.1 (41.6 to 44.6)	-1.1 (-3.2 to 1.0)	0.30
Open	44.2 (42.7 to 45.6)		