Periodontal health of palatally displaced canines treated with either an Open or Closed surgical technique: A randomized controlled trial.

Nicola A Parkin PhD, FDS (Orth)
Consultant Orthodontist, Charles Clifford Dental Hospital, Sheffield and Barnsley Hospital NHS Foundation Trust, Barnsley, UK.

Richard S Milner BDS, MRCP
Consultant in Restorative Dentistry, Barnsley District General Hospital & Charles Clifford Dental Hospital, Specialist Practitioner, Derby, Uk.

Chris Deery PhD, FDS (Paed Dent)
Professor/Honorary Consultant in Paediatric Dentistry, Academic Unit of Oral Health and Development, School of Clinical Dentistry, University of Sheffield, Sheffield, UK.

David Tinsley BDS, MClinDent, MOrth
Specialist Orthodontist, Orthodontic Centre, 498 Ecclesall Road, Sheffield, UK

Anne-Marie Smith BDS, FDS (Orth)
Consultant Orthodontist, Royal Derby Hospitals NHS Foundation Trust, Derby UK.

Peter Germain BDS (Hons), MFDS, MClinDent, MOrth
Post CCST Development Registrar Newcastle Dental Hospital and Cumberland Infirmary, Carlisle

Jennifer V. Freeman BSc, MSc, PhD
Senior Lecturer in Medical Statistics, School of Health and Related Research, University of Sheffield, Sheffield, S1 4DA

Sarah J Bell BDS, MFDS
Clinical Lecturer in Orthodontics, Academic Unit of Oral Health and Development, School of Clinical Dentistry, Claremont Crescent, Sheffield UK.

Philip E. Benson PhD, FDS (Orth)
Reader/Honorary Consultant in Orthodontics, Academic Unit of Oral Health and Development, School of Clinical Dentistry, Claremont Crescent, Sheffield Uk.

Address for correspondence:
Philip Benson
Academic Unit of Oral Health & Development,
School of Clinical Dentistry,
Sheffield
Tel +44 (0114) 2717889
p.benson@sheffield.ac.uk

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Introduction

Ectopia of the maxillary canine is a common clinical scenario and amongst orthodontic clinics, prevalence has been reported to be as high as 13%.[1] The majority of ectopic canines are palatally displaced [2] and treatment can be complex, time consuming and expensive for both the patient and health care system. Whereas orthodontic treatment has been found to be mildly detrimental to the periodontium,[3] case reports have described severe periodontal destruction in some cases of aligned palatally displaced canines (PDC).[4]

Burden and colleagues[5] highlighted controversy in the literature regarding the periodontal outcome of an Open or Closed surgical exposure and subsequent orthodontic alignment of the PDC. Reported periodontal problems included loss of alveolar bone height, increase in pocket probing depths and loss of attached gingivae. Many authors have criticized the Open technique as they feel that periodontal health is compromised when palatal mucosa is excised. [6-8] This criticism appears to arise from a paper published in 1976,[9] which was an inherently weak retrospective study of 56 patients with unilateral PDCs, but was, until now the only published study to directly compare the periodontal consequences of Open versus Closed surgical exposure. The literature contains less criticism of the Closed technique in terms of periodontal impact, although some authors have still reported periodontal concerns when canines aligned with a Closed technique are compared to unoperated canines.[10, 11] A recent Cochrane systematic review found no robust evidence to support one surgical technique over the other.[12]

The principal purpose of this trial was to explore any differences in the periodontal health between canines exposed using an Open versus a Closed surgical technique. Differences in periodontal health between canines that have had an operation (those that were palatally displaced and had been surgically exposed) versus the contralateral canines that have not undergone an operation (and can act as a control) were also examined.

Two null hypotheses were tested

- There is no difference in periodontal health of PDC treated with either an Open or a Closed surgical exposure.
- There is no difference in the periodontal health between the operated and unoperated canines.

Participants and methods

The study was a multicenter, randomized controlled clinical trial involving two parallel groups of patients with a unilateral PDC, randomized to one of two surgical exposure techniques and treated in a hospital setting. Ethical approval was obtained from South Sheffield Ethics Committee (SS02/072) and North and South Derbyshire Local Ethics committees (NDLREC REF: 857). Details of the study methodology, including the inclusion/exclusion criteria, have been described elsewhere.[13] Once informed consent was obtained from participants they were randomly allocated to one of two interventions. The randomization was undertaken using computer generated random numbers to ensure that equal numbers were allocated to each intervention and allocation concealment was with consecutively-numbered, sealed, opaque envelopes as outlined previously.[13]

The two surgical techniques are summarized briefly below:

Open surgical exposure: Following exposure of the PDC and excision of the palatal mucosa, a surgical pack was sutured in place. After 10 days, the patient was reviewed and the pack removed.

Closed surgical exposure: Following uncovering of the PDC, an eyelet attachment with a gold chain was bonded to the palatal or buccal surface of the ectopic canine (whichever was the most accessible).

Only participants with unilaterally displaced canines were included, so that the contra-lateral canine could be used as a control.

Orthodontic management

A fixed appliance was placed in the upper arch either prior to surgery or shortly after surgery. For both groups, orthodontic traction was applied using a twin-wire technique or elastic chain once a 0.018-inch stainless steel arch wire was in place and there was sufficient space to align the canine. The fundamental difference in orthodontic management was that the canine exposed with an Open exposure was moved into alignment above the mucosa (Figure 1) and the canine exposed with a Closed procedure was moved beneath the mucosa (Figure 2).

Periodontal measurements were recorded at baseline in order to eliminate the possibility of previous pathology and three months following removal of fixed appliances. The periodontal outcomes were as follows:

Primary outcome

The primary outcome of the trial was the difference in the clinical periodontal attachment level (CAL) between the PDC treated using the Open surgical technique and PDC treated using the Closed technique at 3 months following removal of the orthodontic appliance.

The CAL was determined from the six-point probing depths on the mesial, midline and distal aspects of the buccal and palatal tooth surfaces and gingival recession measured clinically from the visible cemento-enamel junction to the gingival margin. The clinical attachment level was calculated as follows:

Clinical Attachment Level = Periodontal Probing Depth + Gingival Recession

All measurements were undertaken using a Williams Sensor Periodontal Probe® (Hu-Friedy Sensor Probe Type US) to the nearest millimeter. This probe is pressure sensitive and the force is limited to 20g. The examining clinician was instructed to insert the probe parallel to the long axis of the canine and gently 'walk' it around each surface of the tooth.

Secondary outcomes

The secondary outcomes were palatal gingival recession, crown height and radiographic alveolar bone levels.

Palatal gingival recession: This was recorded using the following index:

- Cemento-enamel junction not visible;
- Cemento-enamel junction and less than 2 mm of root surface visible;
- Cemento-enamel junction and 2 mm or more of root surface visible.

The reason for this categorization was because of the difficulty of clinically measuring recession on the mid-palatal aspect of the canine with precision.

Crown height: Measurements were recorded with calipers to the nearest 0.5mm from the 3 month post-debond study models.

Alveolar bone levels: This was measured from periapical radiographs taken between three and 12 months post-treatment using computerized image analysis (Figure 3). Although there was some variation as to exactly when the radiographs were taken, images of the operated and the unoperated sides were obtained at the same time and compared. Rinn® film holders (Rinn XCP Dentsply, Surrey, UK) and the long cone technique were used for standardization.

The radiographs were analyzed by quantifying bone levels at the interproximal area between the canine and lateral incisor. This area was chosen as it was the clearest and most consistently imaged site. If not already in digital format the images were captured using a digital camera (Kodak DCS 760) suspended above a light box at a standardized distance with standardized shutter speed and aperture settings. Once in digital format the images were analyzed with Image-Pro Plus computer software (version 7.0) using a technique described previously.[14]

A single operator carried out all the measurements on the masked images, which were repeated after two weeks. The repeatability of the methods was assessed using a paired *t* test to detect systematic error and an intra-class correlation coefficient to determine random error. The random error was low (ICC 0.896). A potential systematic difference between the first and second readings was detected (P=0.034); however the mean difference between the readings was very small (0.09mm) and considered not to be clinically significant.

Clinical examinations

Three clinicians undertook the direct clinical measurements for the trial. Prior to recruitment, training and calibration was undertaken with a specialist restorative dentist (RSM). Percentage agreements ranged from 81 to 88% with kappa scores of 0.66 to 0.83, which were considered acceptable.

The examiners were masked as to the patient's group allocation when undertaking the clinical examinations. The patient details were removed from all study models and radiographs, which were only labeled with the participant randomization number.

Sample Size

An *a priori* sample size calculation using data from a previous study[10] suggested that for the primary outcome measure of clinical attachment level a sample size of 60 was required to detect a significant difference between the Open and Closed exposure groups of 0.5mm (SD 0.61mm, 90% power; 5% significance level, two-tailed). The sample size was increased to 80 (40 Open and 40 Closed) to allow for a 25% drop-out rate.

Statistical methods

Data analysis has been divided into two sections: The first section compares the two surgical techniques; the second section investigates the impact of exposing and aligning a PDC (compares operated with unoperated canines).

Comparing Open versus Closed surgical exposure

The difference between the CAL of the operated and unoperated canines within each participant was calculated. Since there was little evidence of any serious deviation from the assumption of Normality, independent *t* tests were used to compare the within individual mean six-point CAL differences (Operated CAL - Unoperated CAL) between the Open and Closed groups. To avoid the dilution effect of taking the mean of six recordings and also to investigate which areas are most severely affected, the CAL at individual sites was also recorded. The independent samples t-test was also used to analyze the data for the individual sites.

For mid-palatal and mid-buccal recession, a chi-squared test for trend was used.

Crown lengths were analyzed by comparing the difference in height between the operated and unoperated canines in the Open and Closed groups. This relative value assumes that the height of the unoperated canine is the 'true' measurement and relates the height of the operated canine to it, which means that variation in actual tooth size will not influence results. The height of the operated canine was subtracted from the unoperated canine for each participant included in this analysis. The difference was compared using independent samples *t* tests.

Differences in alveolar bone levels were analyzed by again subtracting the unoperated values from the operated values and comparing the difference between Open and Closed groups. Independent samples *t* tests were used to compare the differences.

Comparing operated versus unoperated canines

Clinical attachment level has been reported as a mean of six-point probing attachment loss. As the data were Normally distributed paired *t* tests were used to compare the differences between the two sides. Related Wilcoxon Signed Rank tests were used to calculate differences between operated and unoperated canines at individual sites since the data were skewed.

Data for palatal recession were categorical and a McNemar's test was used; however, for the mid-buccal site, recession was measured to the nearest millimeter although the maximum value obtained for any individual was only 2mm. As a consequence a Related Wilcoxon Signed Ranks test was used.

Crown height and mesial alveolar bone levels were both analyzed using a paired samples t-test.

Results

Recruitment commenced at the beginning of August 2002 and finished at the end of January 2007. Figure 4 shows the flow of patients through the trial. Eighty one participants were recruited; however ten were excluded from all analyses as outlined in a previous report.[13] Nine participants were excluded from the periodontal analysis, as seven failed to attend follow-up visits (Open 2; Closed 5) and two, both in the Closed group, abandoned treatment midway. Five participants received the incorrect procedure (Open 4, Closed 1); however the intention-to-treat principle was adhered to and they were all analyzed in their original allocated groups.

The final sample consisted of 62 participants (Open 33, Closed 29). Details of equivalence between the two groups in terms of demographics and severity of initial impaction have been published previously.[13]

Comparing Open versus Closed surgical exposure

Clinical attachment level

The primary outcome of the trial was the mean six-point CAL measurements. When the CAL values for the unoperated teeth were subtracted from the CAL values for the operated teeth, the mean difference between Open and Closed groups was just 0.1mm [Open 0.5mm, SD 0.8; Closed 0.6mm, SD 0.6), which was not statistically significant (independent *t* test, P=0.782).

The mean attachment loss for three out of four of the sites was found to be marginally greater in the Closed compared with the Open group; however the difference was not statistically significant (Table I).

Recession

Mid-palatal: Eight subjects (28%) showed root visibility between zero and 2mm in the Closed group and 12 subjects (36%) in the Open group. This difference was not statistically significant (chi-squared test, P= 0.464.

Mid-buccal: In the Closed group, nine subjects (31%) showed recession of at least 1mm on the mid-buccal aspect of the operated canine (seven subjects showed recession of 1mm, two showed recession of 2mm). In the Open group, eight participants (24%) showed recession of at least 1mm (five = 1mm and three = 2mm). No significant difference was found between the two groups (chi-squared test, P = 0.774).

Crown height

The available sample of 66 participants was slightly higher for this outcome measure (Closed = 33, Open = 33). The four additional patients included in this outcome did not attend for their 3 month post debond records, but because their immediate debond study models were available it was decided to include these subjects to increase sample size. These subjects had good oral hygiene and there were no obvious signs of gingival inflammation or gingival hypertrophy, which, if present, may have affected crown height..

There was considerable variation in the crown lengths between participants (ranges: operated 6-12mm; unoperated 7-12mm). This necessitated the use of 'difference in crown height' between the operated and unoperated canines to compare the Open and Closed groups (height of operated canine crown – height of unoperated canine crown). The results are shown in Figure 5. A positive value indicates that the operated canines have a slightly shorter clinical crown than the unoperated canines and vice versa. No statistical significance was found between the two groups (mean difference 0.2mm, 95% CI: -0.29mm to 0.67mm; independent samples *t* test, P=0.43).

Alveolar bone levels

When the bone levels taken from the unoperated side were subtracted from the bone levels from the operated side no significant difference was found between Open and Closed groups (independent *t* test, P=0.936); however the number of available radiographs was low (n=34; Closed 15, Open 19), as films from some participants were not available. Also it was not always possible to see bone levels clearly enough for assessment purposes.

Comparing operated versus unoperated canines

Clinical attachment level

Table II shows the differences in the mean six point CAL between operated and unoperated canines. It can be seen that there was a mean of 0.5mm more attachment loss with the operated versus the unoperated side and this difference was statistically significant (paired *t* test, P = 0.001).

The results for the individual sites are shown in Table III. Mid-buccal and mid-palatal sites have not been presented, as the probing depths for these sites were mainly scored at zero or 1mm. The difference was statistically significant in all four sites. The greatest mean difference was found at the mesio-buccal and disto-buccal sites of the operated canine (0.55mm and 0.50 respectively).

Recession

Generally the scores for recession were low, only the scores at the mid-buccal and mid-palatal aspects have been described in detail:

Mid-palatal (Table IV)*:* No subject scored higher than '1' meaning that the amount of recession was always less than 2mm. On the operated side, 20 out of 62 subjects showed some degree of recession. On the unoperated side, only four subjects out of 62 had some visible root surface on the palatal aspect. This difference in prevalence of recession between operated and unoperated canines was statistically significant (McNemar's test, P=0.001).

Mid-buccal: Recession was evident in the operated canines, but the figures were again low, the highest recorded measurement was 2mm. Mean recession for the operated canines was 0.4mm (SD 0.6) and for the unoperated canines 0.2mm (SD 0.5), this difference was statistically significant (Related Wilcoxon Signed Ranks test, P=0.031); however, the difference is unlikely to be clinically relevant.

Crown Height

The differences in canine crown height between operated and unoperated sides are shown in Figure 6. Although there was no significant difference in crown height between the operated and unoperated canines (paired t test, P=0.10) the variation was much greater on the operated side. There were 28 patients in whom the crown height of the unoperated canine was greater than the crown height of the operated canine and only 18 patients where the crown height of the operated canine was greater than that of the unoperated canine. This suggests that the clinical crowns of the operated canines are slightly shorter than those of the unoperated canines. Figure 6 supports this suggestion in that 50% of the values in the operated sample lie between eight and 10mm whereas 50% of the values in the unoperated sample lie between nine and 10mm.

Alveolar bone levels

The mean difference between operated and unoperated canines was 0.40mm (operated 0.60mm, SD 0.57; unoperated 0.20mm, SD 0.19), this was statistically significant (Related Wilcoxon Signed Ranks test P<0.001). The boxplots (Figure 7) show the variation in bone levels in operated canines to be far greater than in the unoperated canines.

Discussion

The findings of this clinical trial indicate that there is a small periodontal cost to a palatally displaced maxillary canine when it is surgical exposed and aligned; however the periodontal health scores are

similar at 3 months following removal of the fixed orthodontic appliance, whether an Open or a Closed surgical technique is used.

The main question the study attempted to address was 'Does moving the canine above or below the mucosa influence clinical attachment levels?' and the findings suggest that, with regard to this outcome, it makes no difference which technique is used. No evidence of a difference is an interesting finding as previous authors have tended to imply that the Closed technique is superior in terms of clinical attachment levels.[8, 15, 16] Schmidt and Kokich[17] felt that allowing the exposed canine to erupt autonomously prior to placement of an orthodontic attachment could cause less overall trauma to the periodontium and improve 'cleansibility'. In our study, normal eruption of the PDC was allowed to some extent in the Open group since an orthodontic bracket was not bonded until adequate enamel was available; however, there was no significant improvement in periodontal health following autonomous eruption, as compared with immediate traction following Closed exposure.

The only published work that directly compares the periodontal health of Open versus Closed surgical exposure is by Wisth and colleagues.[9] They found the periodontal impact of aligning canines following an Open exposure to be more detrimental, in terms of probing depths (Open mean 2.46mm, Closed mean 2.06; $P<0.05$); however in regard to CAL this only reached significance on the palatal surface, (Open mean 1.85mm, SD 1.58; Closed mean 1.09mm, SD 0.87). Unfortunately this study, which has been quoted on numerous occasions[5, 7, 10, 17] has many shortcomings. It was retrospective, therefore is at high risk of selection, allocation and treatment bias. In addition it is not clear when the periodontal assessments were untaken, or by whom and whether they were suitably masked, therefore it is at a high risk of assessment bias.

There is more evidence in the literature in regard to the impact on the periodontal health of surgical exposure and alignment. Becker and colleagues[7] assessed the periodontal health of a cohort of 23 young people, who had had surgical exposure of a unilateral maxillary canine and orthodontic alignment, an average of 2.3 years after treatment. They found the mean six-point pocket depths were significantly greater for the operated canines (2.5mm SD 0.7) compared with the unoperated canines (2.2mm SD 0.5). The surgical technique, as described, appears to be more radical than the ones used in this study, although their findings were very similar. Becker and colleagues did not assess CAL therefore it is more difficult to compare results; however another retrospective cohort study[18] carried out with children who had one or two maxillary ectopic canines and who were an average of 3.5 years after treatment also found significant differences in the pocket depths between operated and unoperated sides, but again the differences were in the order of 0.5mm, which is

similar to the results of our study. A systematic review by Bollen and colleagues[3] found that orthodontic treatment had a minimal impact on periodontal health with 0.23 mm of increased pocket depth (95 percent CI, 0.15-0.30), but the evidence was weak. Some individuals in our study were assessed to have more extensive attachment loss following treatment (max 3.2mm for the operated canines and 2.3mm for the unoperated canines), but the long term implications for the health of the teeth are unknown.

Some studies have found that the periodontal effects of aligning an ectopic tooth are more pronounced in certain sites around the tooth. Woloshyn et al[10], using a closed exposure and Hansson and Rindler[19], using mainly an open exposure found probing depths to be deeper on the mesial aspect of the tooth. We found that the largest mean difference in CAL was 0.5mm, which was on both the mesio-buccal and disto-buccal aspects of the operated canine.

Another consequence of surgical exposure and orthodontic alignment was a mild degree of recession on the palatal and buccal aspect of the canine. Of the few other studies that have recorded recession very little difference between the operated and unoperated canines has been reported.[15, 16] In a retrospective analysis by Zasciurinskiene and colleagues[20] consisting of 32 patients who underwent surgical exposure using the Closed technique, six patients (18.8%) were found to have gingival recession, although the mean values were small and it was not clear at which site the recession was present, nor was the range of the recession quantified. The largest mean value was at the palatal aspect of the canine (0.16mm, SD 0.22), which was not significantly different to the unoperated contra-lateral canines. Our clinical trial is the only study to compare recession between Open and Closed exposures and no significant difference was found. Aesthetic analysis of exposed canines will be reported in a future publication.

Clinical crown height is an outcome that has not been assessed in previous studies. Clinical experience suggests that an Open exposure may lead to 'bunching' of the mucosa during traction and a reduced crown height. In contrast, Closed exposure theoretically could lead to an increased clinical crown length due to difficulty in immediately placing the bracket in the correct position. If the eyelet had been placed on the palatal aspect of the canine during surgery, the canine may erupt in a rotated position. The process of de-rotating the canine could result in reduced attached gingivae on the buccal aspect and an increase in length of the crown.

The height of the clinical crown was found not to be significantly different between canines treated with either the Open or Closed surgical technique or between operated and unoperated teeth, although there was more variation in height of operated canines. Considering the finding that more

recession was found in operated canines, the implication is that for those canines where crown height is reduced, there must have been considerable reduction to compensate for those canines where recession was present. This makes clinical sense as we know that PDC are often under-torqued at the end of treatment, which may be a subject for future research.

Our study found statistically significant lower alveolar bone levels on the mesial aspect of the operated canine compared with the unoperated canine. These findings are in agreement with the retrospective study of canines exposed using a Closed technique by Woloshyn and colleagues,[10]. The results contrast with canines exposed with an Open technique by Schmidt & Kokich,[17] who only found a significant difference in bone levels around the lateral incisor adjacent to the operated canine, particularly the distal aspect. Again the differences were small (mean 0.76mm more bone loss) and it may be questioned if this is clinically significant in the long term.[5] There was no difference in alveolar bone levels for Open versus Closed exposure; however the difference in our study between operated versus unoperated canines was so small (0.4mm) and the variability such that it is unlikely that even a study with a much larger sample size would detect a clinically significant difference.

One potential problem with this study was that participants were lost at several points during the trial. Fifteen patients who were recruited and consented did not receive their allocated surgery for various reasons explained in another publication;[13] though five of these were included in the analysis under the intention-to-treat guidance. In addition nine participants were lost to follow-up (Open 2, Closed 7). Only one patient had an infection requiring systemic antibiotics following surgery. The final proportions of patients included in the analysis were 83% in the Open group and 71% in the Closed group and this level of dropouts was accounted for in the sample size calculation.

Another possible limitation of the study was that several operators and assessors were involved. Participants were recruited from more than one center to ensure that adequate numbers were achieved. The use of multiple centers also allows for more generalizability, as the results are less likely to be due to the skill and experience of an individual operator. The impact of using several assessors to measure the outcomes should be minimal. Advice was sought from an experienced periodontist and a calibration exercise was undertaken prior to recruiting participants. In addition only patients with a unilateral displaced canine were included in the trial. Potential inconsistencies between assessors with regard to the absolute measurements were reduced by examining the differences between the operated and the contralateral, unoperated canine measured by the same assessor, in the same patient. Wherever possible the assessor was different to the operator to reduce the possibility of assessment bias if they had knowledge of the group allocation.

This trial was undertaken, using appropriate research methods to reduce the possibility of bias. ; however, a null finding prompts the question as to whether there were sufficient participants to find a significant difference between the two techniques, if one exists. We used a clinical difference (0.5mm) which, although measurable, might be considered too harsh by some.[5] The sample size calculation was based on weak retrospective data, but the variation in our study was of a similar magnitude, which is probably due to the age of the participants, in whom periodontal disease is rare. We did find a statistically significant difference between the operated and unoperated sides, but no difference between the two surgical techniques. Close examination of the data suggests that the differences and variability are such that even a trial with a considerably larger sample size would be unlikely to find a statistically significant difference. We are therefore reasonably confident that these null findings are generalizable to patients from other centers and populations with similar inclusion and exclusion criteria; however this will need confirmation with further clinical trials.

Conclusion

This randomized clinical trial found that exposure and alignment of PDCs has a small impact on periodontal health. The magnitude of this impact is not influenced by surgical technique (in terms of Open versus Closed exposure) and is so small as to be unlikely to influence the prognosis of the tooth in the long term in the majority of patient.

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Figure and Table Legends

Figures

Figure 1: Example of a participant who received an Open surgical exposure where the canine was brought into alignment above the mucosa.

Figure 2: Example of a participant who received a Closed surgical exposure where the canine was brought into alignment beneath the mucosa.

Figure 3: Example of the intra-oral periapical radiographs taken of both the operated and contralateral unoperated sides in one participant at 3 months following removal of the fixed appliance (randomisation number 4).

Figure 4: Consort diagram showing the flow of participants through the trial.

Figure 5: Boxplots showing the median values, interquartiles and ranges for the differences in the canine crown height (mm) between the operated and unoperated sides in the Open and Closed surgical exposure groups.

Figure 6: Boxplots showing the median values, interquartiles and ranges for the canine crown height (mm) on the operated and unoperated sides.

Figure 7: Boxplots showing the median values, interquartiles and ranges for alveolar bone levels (mm) between the canine and the lateral incisor on the operated and unoperated sides.

Tables

Table I: Baseline data for all participants included in the periodontal analysis (N = 62)

Table II: Descriptive data for the differences in CAL (mm) between the operated and contra-lateral unoperated canine teeth at individual sites for the Open and Closed groups. Differences were examined with an independent t test.

Table III: Mean six point CAL (mm) from the Operated and Unoperated canines. Differences examined with paired t test.

Table IV: Descriptive data for the CAL (mm) from the between operated and unoperated canines at individual sites. Differences were examined with Wilcoxon Signed Rank tests.

Table V: Prevalence of recession on the mid-palatal aspect of the canine in the Operated and Unoperated canines.

Figures

Figure 1: Example of a participant who received an Open surgical exposure where the canine was brought into alignment above the mucosa.

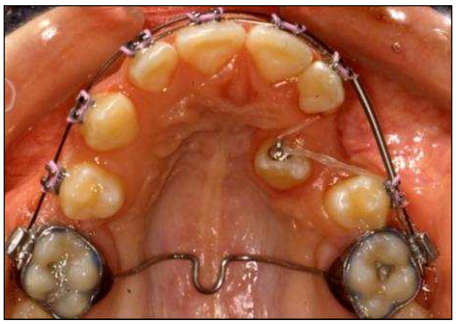


Figure 2: Example of a participant who received a Closed surgical exposure where the canine was brought into alignment beneath the mucosa

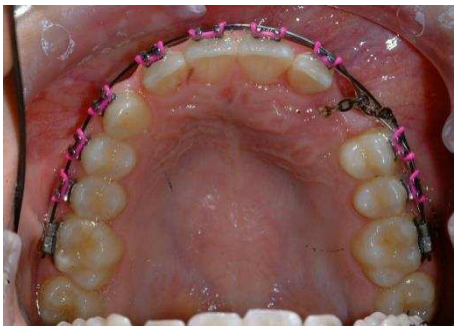


Figure 3: Example of the intra-oral periapical radiographs taken of both the operated and contralateral unoperated sides in one participant at 3 months following removal of the fixed appliance.

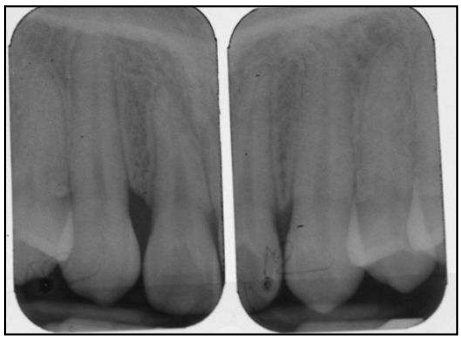


Figure 4: Consort diagram showing the flow of participants through the trial.

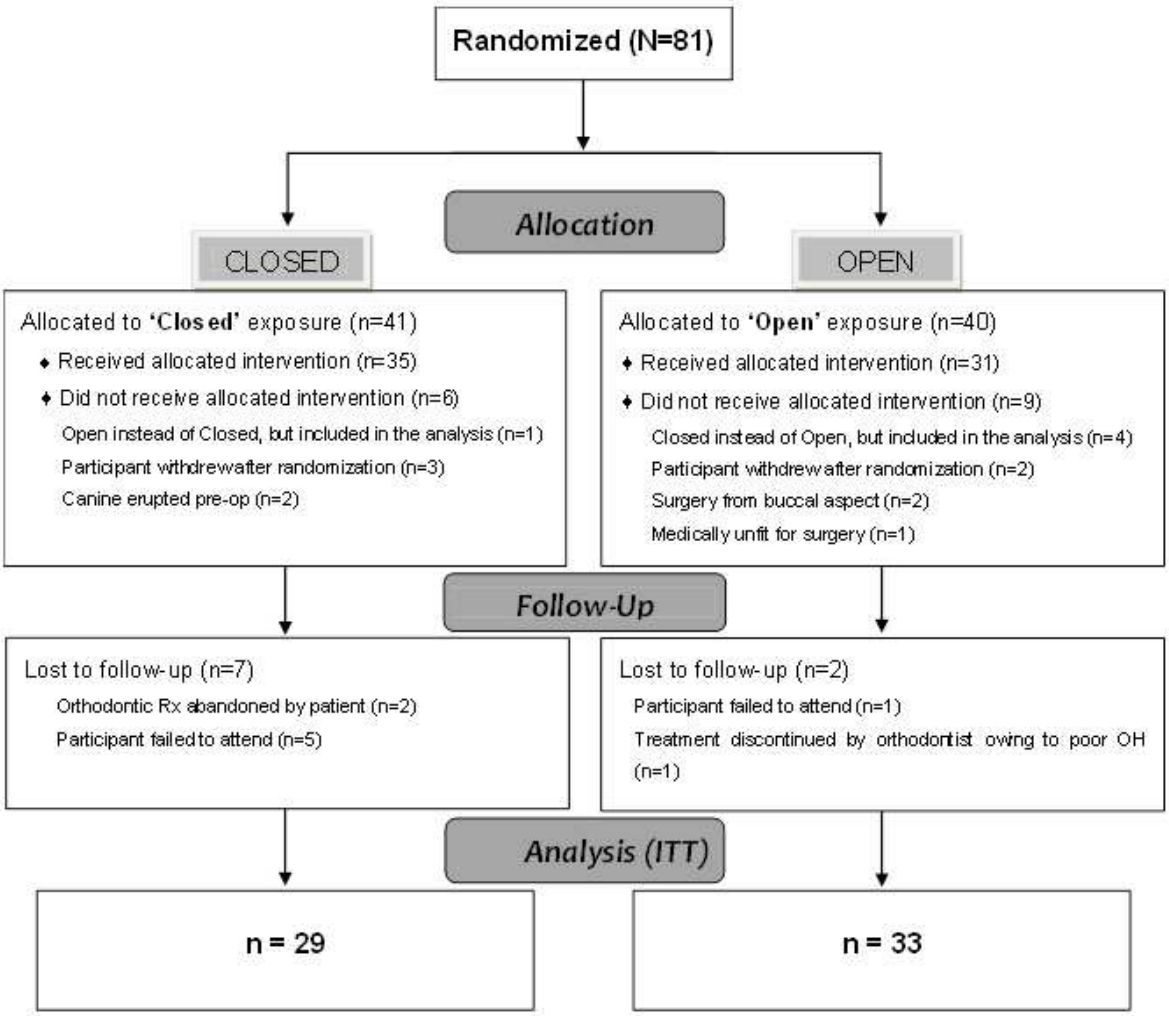


Figure 5: Boxplots showing the median values, interquartiles and ranges for the differences in the canine crown height (mm) between the operated and unoperated sides in the Open and Closed surgical exposure groups.

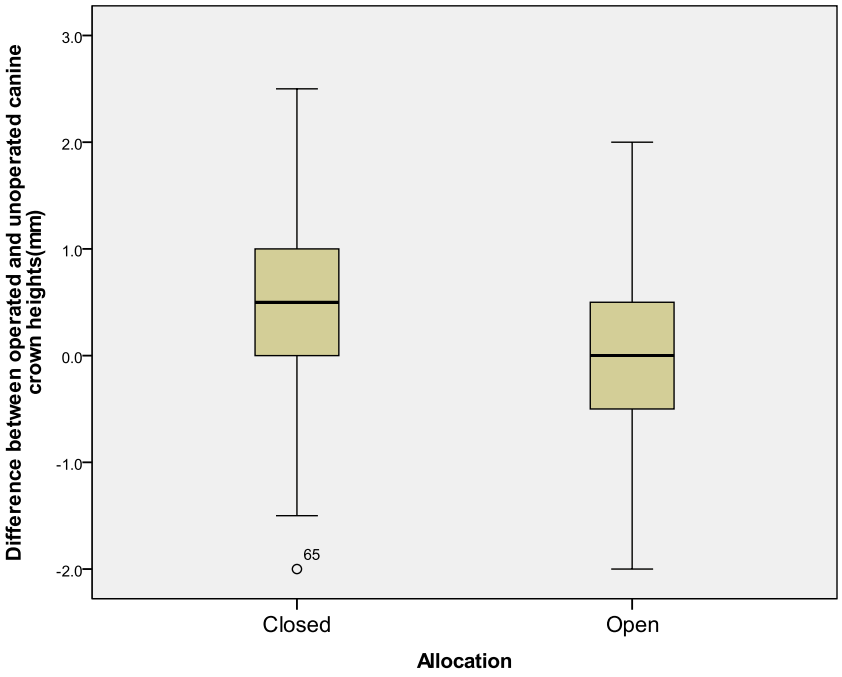


Figure 6: Boxplots showing the median values, interquartiles and ranges for the canine crown height (mm) on the operated and unoperated sides.

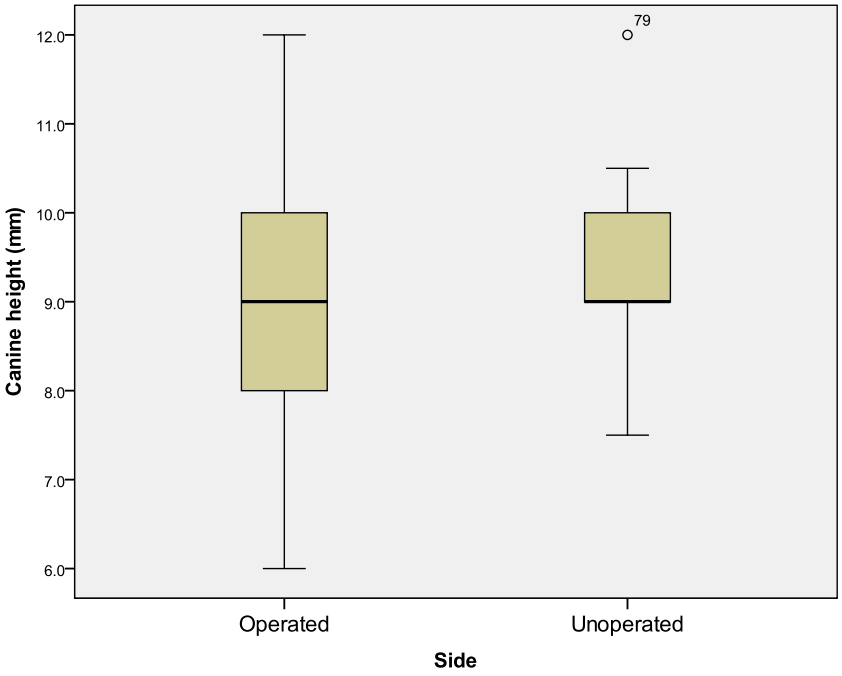
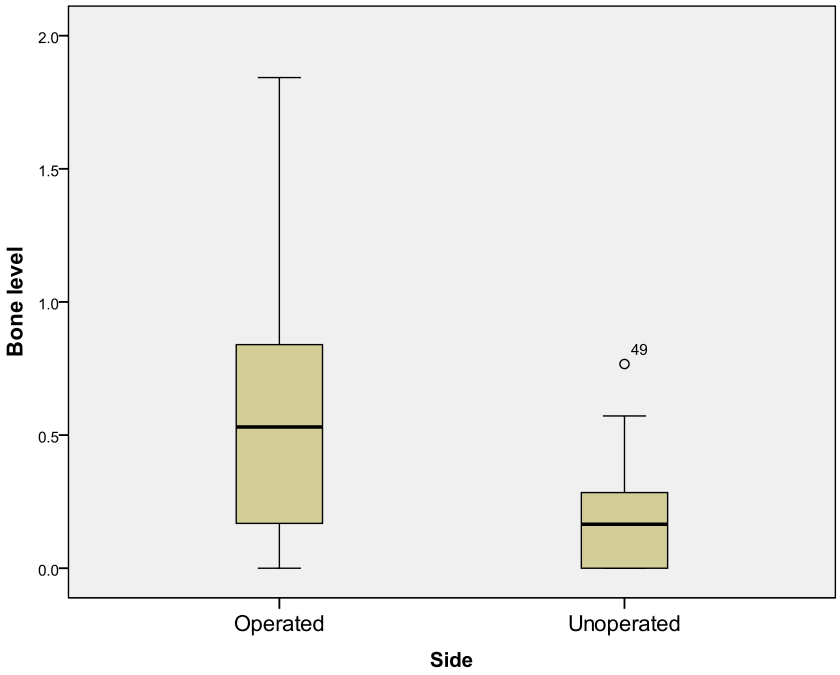


Figure 7: Boxplots showing the median values, interquartiles and ranges for alveolar bone loss (mm) between the canine and the lateral incisor on the operated and unoperated sides.



Tables

Table1: Baseline data for participants included in the periodontal assessment n= 62

		Open (N=33)	**Closed (N=29)**
Age (years)	Mean (sd)	14.2 (SD 1.3)	14.0 (SD 1.6)
Gender	Male	11(33%)	8 (28%)
	Female	22 (67%)	21 (72%)
Side of impaction	Left	10 (30%)	13 (45%)
	Right	23 (70%)	16 (55%)
Extractions	Permanent teeth extracted	13 (40%)	12 (41%)
Duration	Duration of active traction	10.2 months (SD 4.2)	13.2 months (SD 8.5)

Table II: Descriptive data for the differences in CAL (mm) between the operated and contra-lateral unoperated canine teeth at individual sites for the Open and Closed groups. Differences were examined with an independent *t* test.

Site	Open (n=33)		Closed (n=29)		Differences		
	Mean	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**p-valu**
Mesio-buccal (MB)	0.3	-0. 1 to 0.8	0.8	0.3 to 1.3	0.5	-0.2 to 1.1	0.176
Mesio-palatal (MP)	0.4	0.0 to 0.7	0.5	0.1 to 0.9	0.12	-0.4 to 0.6	0.377
Disto-buccal (DB)	0.6	0.2 to 1.0	0.4	0.0 to 0.8	-0.2	-0.8 to 0.3	0.420
Disto-palatal (DP)	0.2	-0.2 to 0.6	0.6	0.2 to 1.0	0.4	-0.1 to 0.9	0.071

Table III: Mean six point CAL (mm) comparing canine teeth treated with the Open versus the Closed surgical technique (unpaired *t* test) and the Operated versus the contra-lateral Unoperated canine teeth (paired *t* test).

Side	Mean (mm)	95% CI	Differences		
			Mean (mm)	95% CI	p-value
Open (n=33)	1.5	1.2 to 1.8	0.1	-0.2 to 0.5	0.523
Closed (n=29)	1.6	1.4 to 1.9			
Operated (n=62)	1.6	1.4 to 1.7	0.5	0.4 to 0.7	<0.001
Unoperated (n=62)	1.1	0.9 to 1.2			

Table IV: Descriptive data for the CAL (mm) from the between operated and unoperated canines at individual sites. Differences were examined with Wilcoxon Signed Rank tests.

Site	Operated canine (n=62)		Unoperated canine (n=62)		Differences		
	Mean	**95% CI**	**Mean**	**95% CI**	**Mean**	**95% CI**	**p-value**
Mesio-buccal (MB)	2.0	1.7 to 2.3	1.5	1.2 to 1.7	0.5	0.2 to 0.8	0.002
Mesio-palatal (MP)	1.8	1.6 to 2.0	1.4	1.2 to 1.6	0.4	0.2 to 0.7	0.002
Disto-buccal (DB)	1.9	1.6 to 2.1	1.4	1.2 to 1.6	0.5	0.2 to 0.8	0.001
Disto-palatal (DP)	1.6	1.3 to 1.9	1.2	1.0 to 1.4	0.4	0.1 to 0.6	0.005

Table V: Prevalence of recession on the mid-palatal aspect of the canine in the Operated and Unoperated canines.

	Operated (n=62)		Total
	No recession	**Recession**	
Unoperated (n=62)			
No recession	38	20	58
recession	4	0	4
Total			62