
Article:
Parkin, N.A., Almutairi, S. and Benson, P.E. orcid.org/0000-0003-0865-962X (2019) Surgical exposure and orthodontic alignment of palatally displaced canines: can we shorten treatment time? Journal of Orthodontics, 46 (1_suppl.). pp. 54-59. ISSN 1465-3125

https://doi.org/10.1177/1465312519841384

Surgical exposure and orthodontic alignment of palatally displaced canines: Can we shorten treatment time?

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Abstract

This review will discuss the influence of various factors on the time taken to orthodontically align a palatally displaced maxillary permanent canine following surgical exposure. Previously unpublished data from a clinical trial, involving participants with unilateral PDC randomly allocated to either a closed or open surgical exposure, will be included to strengthen the debate.

Keywords: Canine; Orthodontics; Surgical exposure.

Introduction

Patients with palatally displaced maxillary canines (PDCs) are a common source of referrals for orthodontic advice and treatment. The evidence base in relation to this treatment has improved over recent years, but has this led to reduced treatment times?

Various interventions have been suggested for young people aged 10 to 14 years that might correct the path of a PDC and avoid surgical exposure, but they are not guaranteed to succeed (Parkin et al., 2012a); therefore, there will inevitably be a proportion of patients with PDC who will require surgical exposure and orthodontic alignment.

The two broad options for surgical exposure are:

- 'Open' exposure, when palatal tissue is removed, the canine allowed to erupt and then aligned above the mucosa. The exposure is carried out before orthodontic appliances are fitted and the canine is left to erupt for 6-9 months prior to orthodontic intervention.
- 'Closed' exposure, when a chain is bonded to the tooth, which is then aligned under the mucosa. This type of exposure is commonly carried out after orthodontic space creation with fixed appliances.

We undertook a clinical trial, involving participants with a unilateral PDC, who were randomly allocated for either a closed or an open exposure followed by orthodontic alignment. The method and results for most outcomes have been published (Parkin et al., 2013; Parkin et al., 2012b; Parkin et al., 2015). In summary, these showed no differences in surgical, periodontal or aesthetic outcomes between the two surgical techniques; however, one secondary outcome of the trial has yet to be reported; orthodontic treatment duration.

In our trial, the longest time that a participant had their fixed appliances was 55 months. This patient had all four first molars extracted, which might have prolonged treatment duration; however, the period of active traction was still 39 months. The patient attended 37 visits and wore braces between the ages of 13 and 17.5 years (Figure 1).

Figure 1 – Participant Nos 7 who spent the longest time in fixed appliances

Was this appropriate use of NHS resources or was the cost too high to the young person and their family, in terms of missed time at school, travel to and from the orthodontist, let alone the impacts of wearing a fixed appliance, including potential damage to the dentition. Did the taxpayer get good value for money? The answer to the question is obviously subjective, but since patients with PDC often do not begin treatment until age 13 years, then, perhaps active treatment for no more than 3 years is reasonable. Can we reduce treatment time by type of exposure and treatment mechanics? Following the results of our trial, we believe the answer is 'yes'.

This article will review the literature on what we believe to be the most important factors influencing orthodontic treatment duration in patients with PDC and report previously unpublished data from the trial. We will also discuss some of our experiences of treating patients during the trial, how this has changed our clinical practice and provide some recommendations.

Orthodontic Treatment Duration

Several recent studies have shown significant variation in the treatment duration of patients with PDC (Bazargani et al., 2013; Smailiene et al., 2013; Naoumova et al., 2018).Various reasons have been suggested for this variation including factors related to the patient and their malocclusion (e.g. severity of canine displacement and age of patient) and factors related to the way they were treated (e.g. surgical technique and orthodontic treatment mechanics).

One limitation of research in this area is differences in the definition of treatment duration within the published literature. Some investigators are referring to the time to actively bring the canine into the line of the arch and others the total time in fixed appliances. The latter clearly being longer than the former, depending on other treatment goals that need to be achieved.

In our clinical trial, we recorded both active traction and total time in fixed appliances. Active traction was defined as from when a force, in the form of a twin (or 'piggy back') wire or elastomeric chain was first applied to the PDC to when the first rectangular archwire (usually a 0.018 x 0.025-inch NiTi) could be placed. Total treatment time was when orthodontic bracket were placed to when the fixed appliance was removed. We believe the period of active traction to be the most relevant as this focuses on canine alignment rather than correcting other factors associated with the malocclusion.

We will now look at some of the important factors we believe influence the duration of traction, as well as overall orthodontic treatment time.

Patient factors affecting treatment duration

Severity of displacement of unerupted canine

The severity of displacement of the unerupted PDC is assessed using various characteristics, including the amount of displacement towards the midline, vertical height from the occlusal plane, angulation of the tooth and position of the root apex. The literature suggests that the most important of these is the degree of palatal displacement i.e. the more displaced towards the midline the unerupted canine, then the longer are both the traction and the overall treatment time (Stewart et al., 2001; Pitt et al., 2006; Zuccati et al., 2006; Fleming et al., 2009; Nieri et al., 2010; Bazargani et al., 2013).

Table 1 shows the duration of orthodontic traction of participants in the trial, according to the mesio-distal sector position, as described by Ericson and Kurol (Ericson and Kurol, 1988). The majority of participants (35) had unerupted canines in sectors 4 and 5, which shows significant displacement towards the midline. Eighteen participants had an unerupted canine in sectors 2 or 3, which is relatively mild displacement. Four participants had an unerupted canine in sector 1, which we would not consider to be displaced towards the midline. In two of these patients, the unerupted canines were considered to have cystic change, but in the other two the reason for failure to erupt naturally was unclear. The data show a clear relationship between palatal displacement and duration of traction.

Table 1: Duration of orthodontic traction in months according to medial displacement of the PDC (N = 61)

Sector	N	Duration of Traction (mths)		
		Median	Min	Max
1	4	5.5	4	12
2	8	7	4	12
3	10	8	5	24
4	27	12	3	29
5	8	11	4	39

Patient age

Our clinical trial found a very low correlation between patient age and traction time (r = -0.11, Pearson correlation coefficient) suggesting no association between age and duration of treatment; however the age range of participants was deliberately limited, using the study inclusion criteria (<20 yrs; actual range 10.1 to 17.6 yrs). Fleming and colleagues also found no relationship between age and treatment duration in their sample aged 12.4 to 18 yrs (Fleming et al., 2009).

Becker and Chaushu (Becker and Chaushu, 2003) compared the treatment duration of 19 consecutively treated adults (23 PDC, mean age: 28.8 yrs) with a matched group of 19 young people (mean age 13.7 yrs). Both groups had 23 PDC. There was a significant increase in the mean time taken to 'resolve the impacted canine' in the adult group (mean 11.4 mths aged 20 to 29 yrs; 12.8 mths >30 yrs) compared to the young person group (6.2 mths matched to 20-29 yrs; 4.7 mths matched to >30 yrs), although the variability was large. The differences in overall treatment duration were smaller (22.3 mths aged 20 to 29 yrs; 24.4 mths aged >30 yrs compared with 19.6 mths & 19.4 mths in the matched groups). They also concluded the success rate of alignment in the adult group was lower, as they failed to extrude five out of the 23 teeth and two were only partially extruded. They were all treated using a closed surgical procedure.

Zuccati and colleagues (Zuccati et al., 2006) concluded that patients over 25 years with a PDC required an average of 30 more visits (total treatment) than patients less than 25 years; however they do not state what type of surgical procedure was undertaken.

We believe that it is important not to treat patients with suspected PDC too early, as the unerupted tooth might still be erupting vertically and the deeper the exposure, the more complex is surgical management. Also, if the patient is in the mixed dentition there might be some delay in waiting for permanent teeth to erupt. We find management of PDC in adult patients is unpredictable and canines often move slowly. For this reason, alignment of moderate to severely displaced PDC in adults is probably best avoided.

Treatment factors affecting treatment duration

Surgical technique

Our clinical trial did find a small difference in the mean total treatment time between the Closed group (25.1, sd 9.7 mths) and the Open group (28.5, sd 8.1), which was not statistically significant (p = 0.113, independent *t* test). There was also a difference in the 'active traction' time of 3 months in favour of the Open group (Closed, 13.2 mths; Open, 10.2 mths), but again this was not statistically significant (p= 0.301, Mann Whitney U test). This was probably because treatment duration was a secondary outcome and the study sample size was not based on detecting a difference of 3 months. It is also a matter of judgement whether 3 months could be considered a clinically significant difference.

Further examination of the data highlights an interesting difference between the two surgical techniques. The variability of active traction times for the Closed group (sd 8.5; Min 3, Max 39 mths) was much greater than that for the Open group (sd 4.2; Min 2, Max 18 mths). It was also noted that all seven participants who were in active traction for over 18 months were in the Closed group.

Looking at the literature other studies had similar findings. Unfortunately, like so much evidence in this, as well as other areas of orthodontics, much of the data are based on retrospective studies, with generally poor research designs and often lacking important detail of orthodontic and surgical techniques (Wisth et al., 1976; Pearson et al., 1997; Iramaneerat et al., 1998). Iramaneerat and colleagues report similar mean total treatment durations for their Closed and Open groups (28.8 mths), but the range was greater for the Closed group (16.0- 62.0 mths) compared with the Open group (16.5- 44.5mths), as it was for the Traction period (Closed 7.5-46.8; Open 8.3-34.3 mths).

Smailiene and colleagues(Smailiene et al., 2013) found a mean difference in the total orthodontic treatment time between their two surgical groups of nearly 4 months (Closed 32.2, Open 28.4 mths)

and again the variability in the total treatment time of the those treated with a closed exposure was higher (Closed sd 11.7, Open sd 5.0 mths). When they compared the mean traction time, which they defined as 'from surgical exposure to bonding a bracket on the middle of the labial surface' there were also similar findings to our study (Closed 6.9, sd 4.5; Open 3.1, sd 1.1 mths).

Naoumova and colleagues concluded that the overall treatment time (and variability) did not differ between the two centres, one routinely using a closed exposure and the other an open procedure (Closed 27.1 sd 8.4 mths; Open 28.0 sd 9.7 mths) (Naoumova et al., 2018). The patients who underwent the open surgery were allowed a period of time after surgery whilst the canine erupted (median approximately 400 days or 13 mths). It is not clear whether the patients were wearing appliances during this time, but the authors do state that for those patients who received the closed procedure orthodontic traction was started earlier, the 'active treatment time', from the start of canine traction until removal of the appliance, was longer and the number of appointments was significantly higher.

We believe that the main reason for the variability in duration of 'active traction' is the inability to visualise the crown of the canine. Subsequently, there is an element of 'blind pulling' with no knowledge of where the bond was placed, on the canine, at the time of surgery. If the orthodontic force is not placed in the correct direction, then the canine might be obstructed by the root of the lateral incisor or buccal plate, thus preventing progress. Another outcome of inappropriate force vector is rotation of the canine as it eventually erupts into the mouth. De-rotating canines takes time and might lead to some gingival recession.

The previously mentioned participant of our clinical trial with the longest treatment time received a closed exposure. After investigating why treatment took so long, it appears that there was a period when traction resulted in no movement. The PDC was high, near the apex of the central incisor and it is likely that force was applied using inappropriate force vectors. This may have led to the canine being obstructed by the root of the lateral incisor or cortical plate, resulting in no movement.

Comparison of two surgical techniques with recommendations for orthodontic treatment mechanics

Open surgical exposure

Advantages

- Option of starting in late mixed dentition, by the time all permanent teeth are through the canine will be fully erupted in the palate. Do not start too early, as it is more difficult for surgeons to expose when the canine is too high.
- Give the patient the option of keeping the primary canine *in situ* to avoid an unsightly gap. The primary canine can be extracted by the GDP, as the successor is brought in to alignment.
- If incisal root resorption is apparent, then force can be avoided on these teeth as the canine erupts autonomously.
- Easy visualisation by the orthodontist and so optimal force direction can be chosen.
- When the canine has erupted sufficiently to be brought into position, the use of a twin-wire 'piggy back technique', using a long steel ligature if the canine is very displaced, is an efficient technique (Figure 2)

Figure 2 – Twin-wire or 'piggyback' Archwire being used to align a PDC following an open exposure.

Disadvantages

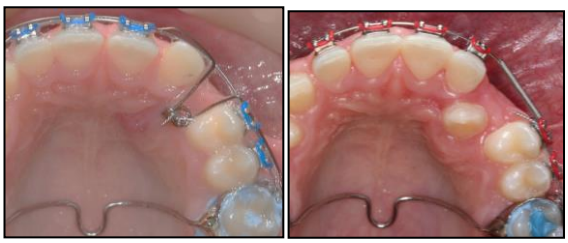
- If there is inadequate removal of bone around the canine crown then autonomous eruption may not occur and re-exposure may be necessary (Mathews and Kokich, 2013).
- An open wound following exposure might cause discomfort and impairment (Bjorksved et al., 2018). The surgeons in our unit use a periodontal dressing (COE-PAK™, GC Corporation, Tokyo, Japan) for 7 days (without sutures) and our study found no differences in patient-reported discomfort between the two techniques (Parkin et al., 2012b).
- For deep severely displaced canines, there is a risk of the mucosa re-covering. An adequate dressing will, hopefully, avoid this complication; however, in our study three out of 31 participants (9.6%) in the open group required re-exposure for this reason. In Scandinavia glass ionomer cement is bonded to the permanent canine during surgery (Naoumova et al., 2018). Mathews and Kokich (Mathews and Kokich, 2013) suggest using a light-cured periodontal dressing (Barricaid™, Dentsply Sirona, PA, USA), but it is not available in the UK.
- Bunching of the mucosa as the canine is pulled into position, with subsequent shortening of clinical crown height. This will cause delay in treatment as bucco-lingual movement is difficult and the canine either, has to be forcefully extruded or be allowed to erupt. We recommend allowing sufficient time for autonomous eruption prior to placing an appliance.

Closed surgical exposure

Advantages

- This might be the surgeon's preference for high unerupted canines, avoiding an open wound.
- Potentially improved patient comfort immediately post exposure. Discomfort when applying traction, however, has not been assessed.
- Canines can be brought underneath the mucosa thus avoiding mucosal bunching.
- For moderate/severe PDC, the canine should be moved distally, using a hook from a TPA, to avoid the roots of incisors or a Ballista spring used for vertical eruption (Becker, 2012). With the latter approach, the mechanics are the same as an open exposure, the crown is easily visible and correct force vectors can be applied (Figure 3). The lateral incisor bracket can be left off initially to limit root damage. This is especially recommended if there are already signs of root resorption.

Figure 3 – Ballista spring applied to erupt a canine following a closed exposure.



Disadvantages

- Duration of active traction is less predictable due to an inability to visualise the canine.
- The surgeons usually place any attachment on the palatal surface of the unerupted canine, as this is the most accessible tooth surface. If an attempt is made to align the canine outwards towards the line of the arch this results in the canine being rotated. De-rotating the canine will increase treatment duration, place more force on the roots of the incisors and may lead to gingival recession and increased height of the clinical crown.
- Ballista springs can result in over–eruption of canines and lack of bone support if excessive force is delivered.
- More likely to get pseudo-ankylosis as the canine impacts against the cortical plate or lateral incisor as inappropriate force vectors are placed. The only cases of true ankylosis we have seen are from closed exposures where prolonged forces have been applied

Final thoughts and conclusions

Having completed the clinical trial seven years ago we have been constantly modifying our practice with the primary goals of reducing treatment duration and avoiding risks to not only the PDC, but

also the adjacent incisors. We now almost routinely request an open exposure for moderate-to-severely displaced canines (medial sectors 3 and 4), sometimes consider keeping the primary canine *in situ* until we are certain of success. For those patients with significantly displaced canines (medial sector 5) we more frequently advise keeping the primary canine for as long as possible, avoiding the need for surgical exposure and lengthy orthodontic treatment altogether. If the PDC is severely displaced then the root of the primary canine tends to be good.

Despite the short term discomfort that might be experienced post-surgery following an Open exposure, we believe that duration of treatment is more predictable and the period of active traction shorter. This has a huge benefit to both our patients and the NHS. We feel it is a safe way of dealing with this difficult problem, forces can be kept away from the incisor roots for a significant period of treatment and there is a reduced risk of pseudo or true ankylosis against the buccal plate of bone.

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