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Long-term periodontal response to orthodontic treatment of palatally impacted maxillary canines

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SUMMARY One of the most important aspects to take into consideration when evaluating the outcome of treatment of impacted maxillary canines is the final periodontal status. The aim of the present study was to evaluate the long-term periodontal response of palatally impacted maxillary canines aligned using a codified procedure and the 'Easy Cuspid' compared with contralateral spontaneously erupted teeth. The periodontal conditions of the adjacent teeth were also considered. From an initial sample of 124 patients, 33 patients (24 females and 9 males) were selected. All patients who had undergone surgical orthodontic treatment conducted in accordance with a standardized protocol were recalled for follow-up at an average of 4.6 years after the end of treatment. The average treatment time was 29 months and the mean eruption time of the previously impacted tooth was 3.1 months. The average probing depth values showed no significant clinical differences. Probing depths recorded at the vestibular surface of the lateral incisor ($P < 0.05$) and at the midpalatal/midlingual aspect of the first premolar were statistically significant in comparison with the control elements. Student's *t*-test was used to compare the test and control group values. Coefficient of reliability was set at $P < 0.05$. The use of a closed-flap surgical technique in association with a codified orthodontic traction system (Easy Cuspid) allowed alignment of palatally impacted canines without damage to the periodontium.

Introduction

Palatal impaction of maxillary canines is a condition that has been reported in the literature for many years (Colyer, 1922; Twiesselmann and Brabant, 1967; Iseri and Uzel, 1993). Maxillary canine impaction has a prevalence ranging from 1 to 3 per cent (Peck *et al.*, 1994).

The relative prevalence of permanent maxillary canine impaction is due to its long development and to the course it takes from the point of its formation, in order to reach its final position in occlusion (Dewell, 1949). Palatal displacement of the canine is a condition in which the tooth is abnormally positioned despite the presence of sufficient space in the dental arch and this usually leads to impaction of the tooth (Peck *et al.*, 1994).

The aetiology of palatal impaction of maxillary canines is still not clear (Al-Nimri and Gharaibeh, 2005). Literature cited (Bishara *et al.*, 1976) both primary factors, such as the degree of the resorption of the root of the deciduous tooth, traumas to the permanent tooth bud, modifications in the eruption sequence, the presence of excessive space in the dental arch, rotation of the tooth bud, premature closure of the root apices, and eruption of the canine in the cleft area in subjects with cleft palate, and secondary factors, such as abnormal muscle pressure, febrile states, endocrine disorders, and vitamin D deficiency.

McSherry and Richardson (1999) demonstrated that palatally impacted canines do not exhibit the normal buccal movement during eruption, but they move palatally from the beginning to the end of their development.

According to Crescini *et al.* (2007), one of the fundamental indicator of the success of treatment of impacted maxillary canines is the final periodontal outcome. Literature shows that the most severe periodontal damage occurring in the treatment of palatally impacted canines is loss of supporting bone and it is associated with more radical surgical procedures involving exposure of the tooth underneath the cementoenamel junction (Kohavi *et al.*, 1984).

The surgical orthodontic treatment of palatally impacted canines can be carried out by means of open-flap or closed-flap surgery followed by orthodontic traction of the impacted canine (Crescini *et al.*, 1994; McSherry, 1998; Burden *et al.*, 1999; Kokich, 2004).

The available scientific evidence does not suggest which of these approaches offers appreciable clinical advantages over the other in terms of long-term periodontal outcome (Wisth *et al.*, 1976a; Becker *et al.*, 1996; Hansson and Rindler, 1998; Quirynen *et al.*, 2000).

Experimental studies showed that there is no loss of periodontal attachment during orthodontic tooth movement providing the periodontium is kept healthy (Ericsson and Thilander, 1978).

Loss of periodontal support is associated more with the formation of pockets than with gingival margin recession. The infrequency of gingival recession could be an effect of careful control of the orthodontic technique to ensure minimal palatal tilting of the root during the vestibular movement of the crown.

The aim of the present study was to evaluate the long-term periodontal response (probing depth) of palatal impacted maxillary canines aligned using a codified procedure with the use of 'Easy Cuspid' (Caprioglio, 2004) compared with contralateral spontaneously erupted teeth. The periodontal conditions of the teeth adjacent to the test and control teeth (lateral incisor and first premolar) were also considered.

Materials and methods

Sample

The study was carried out as a retrospective project. From an initial sample of 124 patients, 66 were selected according to these primary exclusion criteria: eruption time longer than 12 months, bilateral palatally canine inclusion, treatment with extractions of upper first premolars, angle $\alpha > 55$ degrees, distance $d > 30$ mm, and vertical axial eruptive path (VAEP) > 50 degrees. From this group, we selected 33 patients (24 females and 9 males) who showed availability to undergo the research and who had all the records and showed for follow-up. Patients ages ranged from 12.4 to 24.1 years (mean: 16.3 years).

All the patients were submitted to surgical orthodontic treatment conducted in accordance with a standardized protocol and were recalled for follow-up at an average of 4.6 years after the end of their treatment (Table 1).

Radiographic parameters

The position of the impacted canines was established using different techniques: dentalpantomography (DPT) and latero-lateral teleradiography.

The DPT evaluation was carried out using the criteria suggested by Ericson and Kurol (1988) (Figure 1):

- angle α = the angle formed between the long axis of the impacted canine and the inter-incisor median line (normal value = 20–53 degrees)
- distance *d* = the distance between the peak of the impacted cuspid and the occlusal plane (normal value = 7–26 mm)
- sectors = the area in which the impacted cuspid is located.

Divided in three sub-sectors 1–3:

Sector 1: between the inter-incisor median line and the long axis of the central incisor.
Sector 2: between the long axes of the lateral and central incisors.
Sector 3: between the long axes of the lateral incisor and the first premolar.

Table 1 Description of the sample. SD, standard deviation.

	Average	SD	Minimum–maximum
Age at the beginning of treatment (years)	16.3	3.9	12.4–24.1
Treatment time (months)	29	9.8	17–39
Time to canine eruption (months)	3.1	2.1	1–10
Recall (years after the end of treatment)	4.6	2.5	2.1–9.3

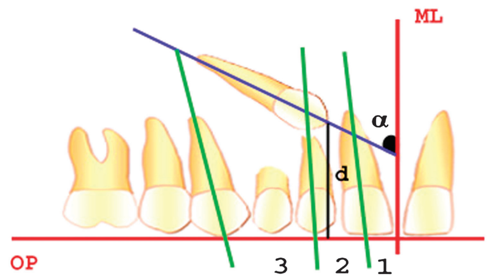

Figure 1 Measurements for canine diagnosis on dentalpantomography.

Latero-lateral teleradiography provides three data items on the impacted maxillary canine (Szarmach *et al.*, 2006):

- VAEP (normal value = 20°–44°; Figure 2)
- the height of the impaction
- the sagittal position of the cuspid in relation to the incisor apices.

For each patient, the following parameters were calculated as most significant: angle α, distance *d*, and VAEP.

Surgical procedure

The surgical procedure was performed in all cases by the same surgeon using a closed exposure technique. A full-thickness flap was prepared and the clinical crown was exposed in order to allow the positioning of an attachment with a metallic chain (Figure 3a). A metallic ligature connecting the attachment and the fixed appliance emerged at the incision margin. If the deciduous canine was present, its extraction was performed.

Seven days after surgery, stitches were removed and the orthodontic traction for the impacted canine was placed.

Orthodontic device for traction of the impacted canines

In this study, a device called the Easy Cuspid (Caprioglio, 2004) was used to apply traction to the palatally impacted canines. Exposure of the crown of the impacted tooth was followed by the placement of an orthodontic button attached to a chain (with eyelets). Traction of the canine was started after the removal of the sutures.

The Easy Cuspid is a modified auxiliary (Figure 3b) originally conceived for the distalization of upper molars. The feature of this ballista system is to have two terminals for the insertion at the molar level: the main terminal of greater dimensions is destined to the tube for the extraoral traction, while the other of smaller dimensions is destined to be inserted in the seat for the auxiliary wire (Figure 3c). By using molar bands with three tubes, we have the possibility to use the main tube with the main arch wire to stabilize the arch form and the extraoral traction and the accessory tube for the ballista device therefore gaining rotation control (Figure 3d). This provides three dimensional and solid anchorage of the ballista.

A palatal bar is inserted passive or fairly bilaterally active to obtain crown-vestibular torque. The debridement of the canine is performed.

After 7 days, the ballista, described above, is inserted in the molar tubes.

The design of the ballista features two helices: the first helix at the level of cross over (Figure 3d) and the second helix for attachment of the steel ligature linked to the steel chain (Figure 3e).

A safety ligature is set from the hook of the molar tube to the hook of the ballista. The strength of traction is modified to correspond to 3–4 oz. The ballista is checked every 2–3 weeks and in case activated back to that force level.

Once the canine is erupted, the ballista system is removed and conventional orthodontic therapy is carried out.

Long-term periodontal response

The periodontal follow-up was carried out at an average of 4.6 years after the end of the active treatment phase.

The evaluation was based on probing depth measurements recorded using a Williams DE Offset periodontal probe. Probing depth was measured for the impacted elements and the adjacent teeth (test group) and for the contralateral spontaneously erupted upper canines and adjacent teeth (control group). All elements were examined at six sites: mesiovestibular (MV), midvestibular (V), distovestibular (DV), mesiopalatal (MP), midpalatal (P), and distopalatal (DP).

Statistical analysis

Student's *t*-test was used to compare the test and control group values. Measurements were taken three times for each side in order to avoid method error. Coefficient of reliability was set at $P < 0.05$.

Results

The clinical characteristics of the sample are summarized in Table 1. In particular, the patients recruited had a mean age of 16.3 years (range 12.4–24.1).

The average treatment time was 29 months (range 17–39) and the mean eruption time of the previously impacted tooth was 3.1 months (range 1–10). With eruption meaning when the first tip of the crown of the impacted element was visible. Table 2 gives the pre-treatment radiographic parameters recorded in the sample.

The average probing depth values calculated to the second decimal (Table 3) show no significant clinical differences between the test and control groups. Probing depths recorded at the vestibular surface of the lateral incisor ($P < 0.05$) and at the midpalatal aspect of the first premolar were statistically significant in comparison with the control elements ($P = 0.06$).

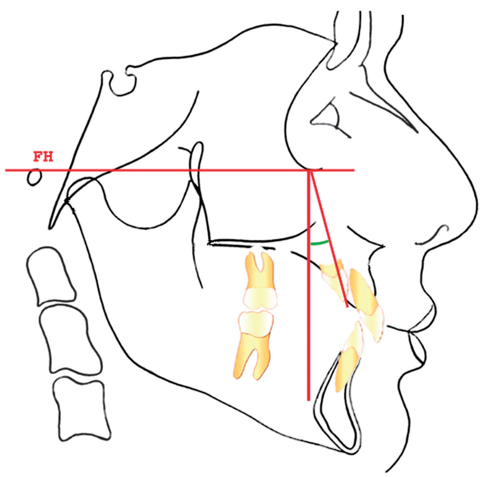

Figure 2 Measurements for canine diagnosis on latero-lateral teleradiography.

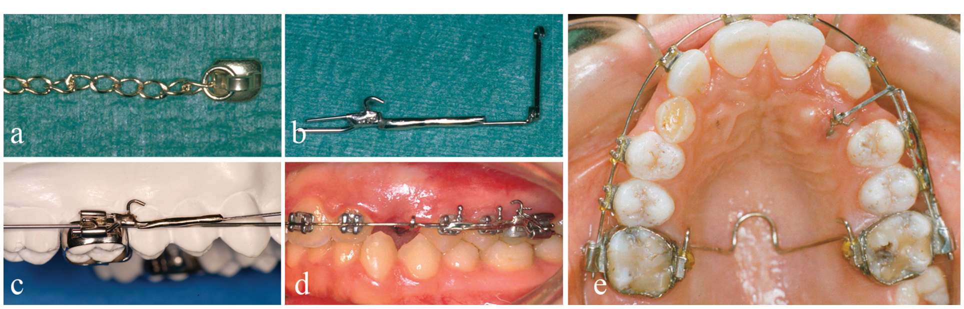

Figure 3 (a) Attachment with traction chain; (b and c) easy cuspid; (d) helix of the disposal; and (e) fitting of the disposal to the perimeter of the arch.

Discussion

The treatment of impacted, ectopic, or displaced canines demands a multidisciplinary approach and it can be considered completed when the tooth is correctly aligned in the dental arch with adequate attached gingiva and no periodontal damage (e.g. abnormal probing depths and presence of gingival recession).

Therefore, the aim of surgical orthodontic treatment of an impacted tooth has to be the simulation of the natural tooth eruption process.

Experimental studies showed that there is no loss of periodontal attachment during orthodontic tooth movement providing the periodontium is kept healthy (Ericsson and Thilander, 1978). Consequently, the variable loss of periodontal attachment observed in some clinical studies (Zachrisson and Zachrisson, 1972; Zachrisson and Alnaes, 1973; Alstad and Zachrisson, 1979) could be a reflection of variable levels of oral hygiene associated with fixed orthodontic appliances.

Table 2 Pre-treatment radiographic parameters. SD, standard deviation; VAEP, vertical axial eruptive path.

	Average	SD	Minimum–maximum
Angle α (°)	29.8	12.1	20–53
Distance *d* (mm)	15.2	4.4	7–26
VAEP (°)	29.6	10.3	20–44

Furthermore, the tooth root may tilt palatally during the initial application of the orthodontic traction forces and this, causing temporary thinning of the palatal tissue, increases the likelihood of gingival recession (Baker and Seymour, 1976; Steiner *et al.*, 1981; Årtun and Krogstad, 1987).

The most significant alteration is the loss of bone around the treated canine, a constant finding, reported in particular by Becker *et al.* (1983) in subjects evaluated 2 years after the end of their orthodontic treatment.

The results of a study conducted by Woloshyn *et al.* (1994) confirmed the hypothesis that surgical orthodontic treatment to align palatally impacted canines is associated with a loss of periodontal supporting tissue. In accordance with different studies (Hansson and Linder-Aronson, 1972; Boyd, 1982; Becker *et al.*, 1983), the differences in periodontal attachment status between previously impacted canines and contralateral control teeth were found to be minor and, from a clinical point of view, less significant. However, the active treatment phase is associated with the appearance of more serious changes. The severe periodontal changes reported by Wisth *et al.* (1976b) seem to reflect more radical surgical exposures or inadequate oral hygiene practices.

This study evaluated the periodontal outcome after surgical orthodontic treatment of palatally impacted canines, considering the adjacent and contralateral teeth, too.

In some studies, palatally impacted canines showed increased probing depths compared to spontaneously

Table 3 Depth of probing. DP, distopalatal; DV, distovestibular; MP, mesiopalatal; MV, mesiovestibular; P, midpalatal; SD, standard deviation; V, midvestibular.

Surface of the tooth	Test group		Control group		Difference	Significancy
	Average	SD	Average	SD		
Lateral Incisor						
MV	1.58	0.56	1.78	0.44	−0.20	n.s.
V	1.36	0.49	1.78	0.44	−0.42	*
DV	1.58	0.56	1.56	0.53	0.02	n.s.
DP	1.45	0.51	1.56	0.53	−0.11	n.s.
P	1.30	0.47	1.44	0.53	−0.14	n.s.
MP	1.58	0.56	1.89	0.60	−0.31	n.s.
Canine						
MV	1.55	0.56	1.67	0.50	−0.12	n.s.
V	1.55	0.56	1.56	0.53	0.01	n.s.
DV	1.48	0.51	1.67	0.50	−0.19	n.s.
DP	1.33	0.48	1.67	0.50	−0.34	n.s.
P	1.33	0.48	1.56	0.53	−0.23	n.s.
MP	1.39	0.56	1.56	0.53	−0.17	n.s.
First premolar						
MV	1.81	0.65	1.78	0.44	0.03	n.s.
V	1.84	0.64	1.56	0.53	0.28	n.s.
DV	1.97	0.55	1.89	0.33	0.08	n.s.
DP	1.68	0.60	1.67	0.50	0.01	n.s.
P	1.71	0.59	1.78	0.44	−0.07	n.s.
MP	1.55	0.51	1.89	0.33	−0.34	*

n.s., not significant.

erupted canines at mesiopalatal and mesiovestibular sites (Hansson and Linder-Aronson, 1972; Hansson and Rindler, 1998). According to the authors, this could be attributable to failure of the correct uprighting movement for the impacted canines during the orthodontic treatment, with the result that, when they reach their final position in occlusion, the periodontal attachment is located more apically. Wisth *et al.* (1976b) instead found deeper pockets at the distal aspects of treated canines, probably a result of the application of excessive orthodontic forces.

Szarmach *et al.* (2006), assessing the periodontal status of previously impacted maxillary canines, reported increased pocket depths at the mesiovestibular, mesiopalatal, distovestibular, and distopalatal aspects of previously palatally impacted canines as well as greater loss of clinical attachment at the mesiovestibular and mesiopalatal surfaces. Their study confirmed that the process of alignment of an impacted canine alters the structure of the periodontal tissue, probably due to the long forced eruption process and the tortuous and difficult course the tooth must travel in order to reach the occlusal plane. Furthermore, poor oral hygiene during fixed appliance therapy can lead to a build up of plaque, rising inflammatory processes detrimental to the health of the periodontium itself (Zachrisson and Shultz-Haudt, 1968; Frank and Long, 2002).

In addition, in our test group, the mean probing depth at the mesiovestibular/mesiobuccal site of the treated tooth was increased compared to the values recorded at all the other sites of the same tooth. Woloshyn *et al.* (1994) confirmed these findings; in their study, the probing depths at the mesial and distal aspects of the treated teeth were lower than those of the controlateral and control group teeth.

Crescini *et al.* (1994) found increased probing depths at vestibular, distovestibular/distobuccal, and distopalatal/distolingual sites at the end of active orthodontic treatment of impacted maxillary canines, whereas at follow-up 3 years later, only the vestibular values were increased. This pattern of improvement over the 3 years, without attachment loss, was due to the apical migration of gingival margin and reduction of the free gingiva.

This is also shown by the finding of increased probing depths at the mesial and distal sites and reduced probing depths at the medial sites of the test group teeth, a pattern probably indicating a process of remodelling and regeneration of the interdental papilla that also allows the gum line to be preserved.

Becker *et al.* (1983) found increased probing depths at all the surfaces of treated compared to spontaneously erupted canines, while the values for the adjacent teeth were normal. This study also found that impacted canines had greater mean probing depths on the vestibular compared to the palatal side.

As regards the adjacent premolars, we found increased probing depths in the test group compared to the control group at the mesiovestibular, vestibular, distovestibular, and distopalatal sites. Similar results were reported by Szarmach *et al.* (2006), who found increased probing depths at mesiovestibular and mesiopalatal sites.

Schmidt and Kokich (2007) found greater loss of periodontal attachment in the distovestibular region of the first premolar adjacent to the impacted canine.

Conclusions

One of the most important aspects to take into consideration when evaluating the outcome of treatment of impacted maxillary canines is the final periodontal status. In order to achieve adequate periodontal status, it is necessary to use conservative surgical techniques and orthodontic systems that generate mild continuous forces, guiding the impacted tooth into its correct position in the dental arch and mimicking as far as possible the natural pattern of eruption.

The use of a closed-flap surgical technique in association with a codified orthodontic traction system allows alignment of a palatally impacted canine without damage to the periodontium.

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