Orthodontic-surgical treatment of unerupted permanent teeth using the fully repositioned flap technique. Part 1. Results, treatment time and post-treatment stability in 90 cases

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SUMMARY

Aim
The aim of this study was to investigate the surgical and orthodontic findings of combined orthodontic-surgical management of unerupted permanent teeth performed by the same team in one clinic and using the same fully repositioned flap as the surgical technique for tooth exposure. Methods This was a retrospective study using patients’ records, orthopantomographs and lateral cephalographs. From these records, the age, position of the impacted tooth, type of orthodontic anomaly, surgical and orthodontic treatment performed, duration and the orthodontic status after four years were recorded for each patient. The sample included 68 individuals aged 9-25 years, who received treatment in 68 maxillary and mandibular canines, 17 maxillary and mandibular incisors, four mandibular premolars and one mandibular molar. From the 90 teeth in total, 60 were positioned buccally and 30 palatally (all maxillary canines), while 79 were in the maxilla and 11 in the mandible. The surgical procedure used was the one-step fully repositioned flap including attachment of a bracket with a ligature wire using acid-etch technique, followed by orthodontic traction introduced always from the same jaw upon necessary space creation. The four-year follow-up re-examination of 48 patients, treated for unilateral exposure, included occlusal evaluation in the operated and the control teeth in the opposite side.

Results
In 86 teeth (95.5% of the total cases) the treatment was successful. In seven cases (7.7%) a second operation was needed because of wire or bracket failure during orthodontic traction. In further 12 cases (13.3%) a second step crown uncovering was performed after the tooth’s eruption, as a result of local gingival overgrowth. Mean eruption time in successful cases was 8.6 months (range 4-20 months). Statistical analysis of the data revealed that buccally positioned canines erupted quicker (x=7.9 months) than the palatal ones (x=11.4 months), whereas there was no statistically significant difference in eruption time among the buccally positioned canines and incisors. Eruption time was statistical significantly related in the cases of buccal canines with both the height and the angle of the impacted teeth, while in cases of palatal canines only with angle. In the cases of the buccally positioned incisors height was more relevant to the eruption time than angulation. Concerning their orthodontic status, 38 (79.1%) of the patients presented acceptable alignment on the impaction side as compared with 46 (95.8%) in the control side. This difference was statistically significant. Conclusions The results of this study indicate that the orthodontic-surgical treatment of unerupted teeth using the fully repositioned flap is a successful procedure and should be considered as a treatment of first choice in such cases. Possible future orthodontic problems may exist, but they can be resolved with proper clinical handling.

KEY WORDS. Impacted teeth, Orthodontic, Surgical, Treatment.

Introduction
The ectopic eruption and impaction of permanent teeth is a frequently presented clinical problem.
The aetiology of impaction has been previously reviewed [Bishara, 1992] and is connected to one of the following reasons:
- toothsize-arch length discrepancies;
- prolonged retention or early loss of primary teeth;
- abnormal position of the tooth bud;
- presence of clefts;
- ankylosis;
- local pathology;
- dilaceration;
- trauma to the primary teeth;
- idiopathic.

Recently it has been proposed that genetic factors may be largely involved with the aetiology of the anomaly [Peck et al., 1995].

The prevalence of non-erupting canines has been shown to be 0.9-2%, and females are more frequently affected than males [Fournier et al., 1982; Ericson and Kurol, 1998]. 85% of the impacted canines are found in the palate [Ericson and Kurol, 1998], whereas in 8% of cases bilateral impaction is found [Bishara, 1992].

Surgical exposure of the impacted teeth and orthodontic traction into the line of occlusion is the most desirable approach to the problem although other alternatives have also been proposed [Ferguson, 1990]. Surgical procedures involve either exposure and packing of the area prior to placing an orthodontic attachment in a later visit or a one step exposure and orthodontic attachment placement using a fully repositioned mucoperiosteal flap [Bishara, 1992]. Both methods have advantages and disadvantages and their use highly depends on the operator’s experience.

The purpose of this retrospective study was to investigate and analyse the results of the combined orthodontic-surgical management performed always in the same way, by the same team and in the same clinic, on 90 cases of unerupted permanent teeth, using the closed surgical procedure of fully repositioned mucoperiosteal flap.

Additionally, the aetiology of teeth impaction, the relation of treatment time and position of the impacted teeth as well as the post-treatment occlusal stability in unilateral impactions after four years were investigated.

The evaluation of the periodontal status of the successfully treated impacted teeth in long term will be reported later.

Material and methods

The procedure was performed, over a five-year period, in 68 patients that were presented with 90 impacted teeth and considered in the initial consultation appointment to have the proposed treatment. In 55 of the 68 individuals the impacted teeth were part of a major malocclusion (20 cases with Class I, 29 Class II, and 6 Class III) and these patients undertook full mouth orthodontic treatment. The remaining 13 did not have any major orthodontic anomaly and their presenting symptom was only the impacted tooth/teeth. All these patients were included in the study. The clinical selection criteria for impacted canines were determined, as previously described [Bishara, 1992], as follows:
- delayed eruption of the permanent canines or prolonged retention of the primary ones beyond the age of 14 for maxillary canines and of 13 for mandibular ones;
- absence of the normal labial palpable bulge, by the age of 11 in maxilla and 10 in the mandible;
- presence of a palatal bulge for the upper canines;
- delayed eruption, distal tipping and migration of the lateral incisor.

Relevant criteria were used for the incisors and the other impacted teeth. The clinical diagnosis was confirmed by orthopantomographs, while the location of the impacted teeth was evaluated using tube-shift technique or the Clark’s rule [Bishara, 1992]. The study group included 26 males and 42 females aged 9-25 years (mean age 13,9 years, SD +3,98). Of these, 48 had one tooth impacted, whereas a further 20 had two teeth impacted. From those patients with two teeth impacted, 16 had bilateral maxillary canine impaction, three had two maxillary central incisors, and the remaining single case had two canines in different jaws. The treated teeth included 68 canines, 17 incisors, four premolars, and one molar. In total 79 were in the maxilla, all of them canines and incisors, and 11 in the mandible. In the mandible the treated teeth were five canines, one incisor, four premolars and one molar. From the total 90 teeth, 60 were positioned buccally and 30 palatally, the latter being maxillary canines. The records of the patients were reviewed and data concerning their sex, age, aetiology of impaction, type of malocclusion, type and position of impacted tooth, surgical and orthodontic procedures and treatment duration were recorded. A s treatment time was considered as that starting from the time of traction initiation until the engagement of a straight square wire.
16x22 NiTi in the bracket of the exposed tooth. In order to determine the initial and the final position of the impacted teeth, the orthopantomographs (OPG) and lateral cephalograms in the beginning and end of the treatment period were reviewed by the two first authors (NAL, NTL) who were trained in data abstraction during a pre-test pilot study. All radiographs were taken in the same radiographic laboratory by the same technician using always the same radiographic parameters. The degree of angulation from the middle line in OPGs and the height from the occlusal tip of the impacted tooth to the occlusal plane in the lateral cephalographs were recorded. In the four cases of dilacerated teeth, height was measured from the most prominent tip of the cervical area of the tooth. To facilitate standardisation of the results only maxillary impacted teeth were studied for the purpose of evaluating the relationship of tooth location and treatment time. The described method was used as a simple and easily reproducible one, as there is no single standardised method for classifying impacted teeth in either OPGs or lateral cephalograms [Iramaneerat et al., 1998].

Inter-examiner reproducibility of the measurements on radiographs was standardised before and during the study and was found to be 97% and 96% for the variables of impacted teeth angulation and height from the occlusion plane.

Surgical-orthodontic procedure. A standardised treatment procedure was used in all the patients. Initially clinical and radiographic evaluation of the patients recorded the degree of malocclusion and the position of the tooth including the degree of angulation and the distance from the occlusal plane. Treatment schedule included straight wire orthodontic fixed appliances in order to align the teeth and create adequate space for the impacted tooth, followed by arch stabilisation with square wire. The created space was considered adequate, when it was 10% more than the required, as it was calculated by the space occupied from the opposite erupted canine, or in cases of bilateral impaction by calculating the expected size using dimensional standards [Moyers et al., 1976] and a prediction method [Tanaka and Johnston, 1974]. At that time the position of the impacted tooth was again evaluated with clinical and radiographic examination including the tube-shift technique. The one-step surgical technique was always used in order to uncover the impacted tooth and attach an orthodontic appliance. The surgical procedure included local anaesthesia, incision at the gingival crest, reflection of a full thickness mucoperiosteal flap, slight bone removal when needed for uncovering of the occlusal portion of the crown and bleeding control. Then the procedure was followed by direct bonding (Quick bond chemically activated adhesive, Forestadent®, Bernhard Foster GmbH) of an orthodontic attachment (lingual button with short neck and round base, Forestadent®) ligated with twisted ligature wire 0,3 mm (Forestadent®), and control of its retention by applying force 5-10 min later. Finally the flap was replaced in the initial position, sutured, and the loose end of ligature wire was attached in a bracket of an adjacent tooth (Fig. 1-3). Sutures were removed one week later and light orthodontic

**Fig. 1** - Clinical view of a 15 year old female with bilateral impaction of maxillary canines, after five months of orthodontic treatment for alignment and space creation. The patient refused any treatment for the mandibular teeth.

**Fig. 2** - Clinical view of the design of the orthodontic attachment used in most of the cases.
traction (20 to 30 g) was applied after three weeks, always from the affected arch, using elastic chains (Fig. 4). During the traction period a 16x22 NiTi square wire was engaged in the arch and the

**Fig. 3** - Photograph showing an orthodontic attachment in place, one week after the operation and before any force had been applied.

**Fig. 4** - A clinical view of the same case showing arch near the end of the orthodontic traction period.

**Fig. 5** - A clinical view of the arch by the end of the treatment. Note the good health of the periodontal tissues at the operation site of the canines.

**Fig. 6** - Orthopantomograph at the beginning of the treatment, revealing the two impacted canines and their predecessor primary teeth in place.

**Fig. 7** - Orthopantomograph taken during the treatment, revealing the good course of the procedure. The impacted canines have been moved initially distally and then are directed towards the occlusal line.

**Fig. 8** - Orthopantomograph showing the completed case.
obtained space in the canine region was retained with open coil spring. Upon the treatment completion, orthodontic retention with heavy stainless steel wire 17x25 was applied for 4 months (Fig. 5-8) and subsequently a removable retainer was worn for a further year.

Post-treatment orthodontic evaluation. Four years after completion of the treatment all patients were re-examined and the orthodontic status of the successfully treated cases recorded always by the same author (NAL). Of the 68 patients that had unilaterally impacted teeth treated, 48 were used for orthodontic evaluation, as it was possible to use the opposite side of the mouth in the same jaw as control.

Regarding the orthodontic status of the treated teeth and the controls in the opposite side, the following parameters were clinically recorded (Becker et al., 1983): acceptable alignment, existence of space, existence of rotation, existence of spacing and rotation together.

Statistical analysis. Statistical analysis of the data was performed using the t-test for evaluating and comparing the total time needed for the treatment of the impacted teeth. The one-way ANOVA and Tukey tests were used for comparing the influence of two location variables, upon the eruption time. Finally a Chi² test with Yates correction was used for evaluating the stability of the orthodontic result.

Results

The main reasons for initial eruption failure in the patients of the present study was idiopathic tooth malposition (70/90; 77.8%), presence of local pathology (9/90; 10%), consequences of trauma on primary teeth (7/90; 7.77%), and dilaceration (4/90; 4.4%). In 86 teeth (95.5% of the total) the treatment was successful. The remaining four teeth (4.5%) that failed to erupt included one dilacerated maxillary incisor, one mandibular buccal canine, one mandibular buccal incisor, and one maxillary palatal canine where the clinical and radiographic evaluation of the authors was that they were ankylosed. In seven successfully treated cases (7.7%) a second operation was needed because of wire or bracket failure during orthodontic traction. In one more case, that needed two operations, the tooth eventually failed to erupt. In a further 12 cases (13.3%) a second step gingivoplasty was performed after the tooth's eruption, as a result of local gingival overgrowth.

The angulation from the midline and the height from the occlusal plane of the impacted canine and incisor teeth are shown in Tables 1 and 2. Mean eruption time of all the successful cases into the line of occlusion was 8.7 months (SD +3.6, range 3m-20m).

Statistical analysis of the data (Table 3) revealed that buccally positioned canines erupted more quickly than the lingual ones, whereas there was no statistically significant difference in eruption time among the buccally positioned canines and incisors. A statistical significant relationship, however, was found when the initial degree of angulation and the height from the occlusal plane was associated with the time needed to align all the upper teeth (Table 4). The impacted teeth positioned at small angles in relation to the vertical axis and closer to the occlusal line needed less time to erupt when compared with those with an increased angle and height. However, further statistical analysis revealed that in the cases of palatally positioned canines only angulation was significantly related to eruption time, whereas in the buccally positioned canines eruption time was significantly related with both height and angulation of the impacted tooth (Table 4). Finally, in the buccally positioned incisors only height was significantly related to eruption time (Table 4).

Concerning the orthodontic status of these 48 unilaterally impacted teeth, 24 were palatal, 14 buccal, and 8 buccal incisors. The height from the occlusal plane and angulation of the impacted teeth are shown in Table 1.

### Table 1

<table>
<thead>
<tr>
<th>Tooth position</th>
<th>0-10</th>
<th>10-20</th>
<th>20-30</th>
<th>30-40</th>
<th>40-50</th>
<th>50-60</th>
<th>60-70</th>
<th>70-80</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td>Number of palatal canines</td>
<td>2</td>
<td>4</td>
<td>3</td>
<td>8</td>
<td>8</td>
<td>1</td>
<td>1</td>
<td>3</td>
<td>30</td>
</tr>
<tr>
<td>Number of buccal canines</td>
<td>14</td>
<td>13</td>
<td>11</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>38</td>
</tr>
<tr>
<td>Number of buccal incisors</td>
<td>8</td>
<td>9</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>-</td>
<td>17</td>
</tr>
</tbody>
</table>

**Table 1** - Angulation (in degrees) measured in orthopantomographs in all 85 impacted incisors and canines, in both jaws.
patients (Table 5) with unilateral impaction, 46 (95.8%) of them presented acceptable alignment in the control side as compared with 38 (79.1%) on the affected side.

This difference was statistically significant (p<0.05). The affected sides that did not present acceptable alignment included three cases of spacing, five cases of rotations and two cases of spacing and rotation simultaneously.

On the contrary the control sides without acceptable alignment, presented only 2 cases with spacing.

**Discussion**

<table>
<thead>
<tr>
<th>Tooth position</th>
<th>Number of teeth at distance from occlusal line (mm)</th>
<th>Total</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>0-10</td>
<td>10-20</td>
</tr>
<tr>
<td>Palatal canines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buccal canines</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buccal incisors</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Palatal canines</td>
<td>23</td>
<td>4</td>
</tr>
<tr>
<td>Buccal canines</td>
<td>14</td>
<td>13</td>
</tr>
<tr>
<td>Buccal incisors</td>
<td>8</td>
<td>9</td>
</tr>
</tbody>
</table>

**Table 2** - Distance in mm from the occlusion line measured in lateral cephalographs of all 85 impacted incisors and canines, in both jaws.

<table>
<thead>
<tr>
<th>Teeth</th>
<th>Number</th>
<th>Mean eruption time in months ± SD</th>
<th>t-test probability</th>
<th>p-Test probability</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palatal canines</td>
<td>29</td>
<td>11.4±3.7</td>
<td>a vs b = -4.41 4.016*</td>
<td></td>
</tr>
<tr>
<td>Buccal canines</td>
<td>37</td>
<td>7.9±2.6</td>
<td>b vs c = 2.13 0.038</td>
<td></td>
</tr>
<tr>
<td>Buccal incisors</td>
<td>15</td>
<td>6.2±2.4</td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 3** - Eruption time in months of the 81 successfully treated canines and incisors, in both jaws.

<table>
<thead>
<tr>
<th>Teeth</th>
<th>N°</th>
<th>Angle° (±SD)</th>
<th>Height mm (±SD)</th>
<th>Eruption time mths (±SD)</th>
<th>ANOVA p</th>
<th>Tukey’s Test p</th>
</tr>
</thead>
<tbody>
<tr>
<td>Palatally positioned canines</td>
<td>29</td>
<td>x=36.82 (+19.14)</td>
<td>x=13.06 (+4.15)</td>
<td>x=11.41 (+3.7)</td>
<td>44.21</td>
<td>6.22E-014*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>range: 0-73</td>
<td>range: 5-23</td>
<td>range: 4-20</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>angle vs. time 25.41 height vs time 1.65</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buccally positioned canines</td>
<td>33</td>
<td>x=11.96 (+9.48)</td>
<td>x=13.30 (+2.59)</td>
<td>x=7.93 (+2.52)</td>
<td>7.49</td>
<td>0.0009*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>range: 0-28</td>
<td>range: 10-21</td>
<td>range: 5-15</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>angle vs. time 4.03 height vs time 5.36</td>
<td>*</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Buccally positioned incisors</td>
<td>15</td>
<td>x=8.60 (+6.81)</td>
<td>x=11.66 (+2.35)</td>
<td>x=6.26 (+2.37)</td>
<td>5.73</td>
<td>5.73*</td>
</tr>
<tr>
<td></td>
<td></td>
<td>range: 0-18</td>
<td>range: 9-18</td>
<td>range: 3-13</td>
<td></td>
<td></td>
</tr>
<tr>
<td></td>
<td></td>
<td>angle vs. time 2.33 height vs time 5.40</td>
<td>N.S</td>
<td></td>
<td></td>
<td></td>
</tr>
</tbody>
</table>

**Table 4** - Statistical analysis of the results concerning eruption time and tooth position of the 77 successfully treated canines and incisors in the maxilla.
In cases of impacted permanent teeth the clinician should consider the various treatment options available for the patient [Ferguson, 1990; Bishara, 1992]. These include:

- no treatment if the patient does not desire it. In such cases the patient is informed that the long term prognosis for the retained primary tooth is poor, regardless of its present root length and the aesthetic acceptability of its crown;
- autotransplantation of the impacted tooth, a technique with uncertain outcomes and limitations;
- extraction of the impacted tooth and, if orthodontically possible, closure of the space;
- extraction of the impacted tooth and prosthetic replacement;
- surgical exposure of the impacted tooth and orthodontic treatment to bring the tooth into occlusion.

In our study all patients had been informed of these alternatives and they accepted the surgical-orthodontic treatment. Seven more adolescent patients with impacted canines refused any treatment and preferred to either remain with the primary canine (four patients) or had the impacted tooth extracted and replaced with a prosthetic appliance. At the end of the study the patients that had accepted the surgical-orthodontic treatment revealed satisfactory results, as in 95.5% of them the treatment was successful. This result indicates that this procedure for the treatment of unerupted teeth should be considered as the treatment of first choice in such cases.

Surgical exposure is not without problems, however, and one of the points that has attracted major attention is the health of the periodontium after the tooth alignment [Fournier et al., 1982; Theofanatos et al., 1999]. For this reason the fully repositioned mucoperiosteal flap technique has been proposed [Hunt, 1977; Hunder, 1983] as a suitable procedure to preserve as far as possible the keratinized gingiva that is essential for the future periodontal health of the aligned tooth. However, during the surgical procedure in this technique, care should be taken in essential bone removal, in order to make space for the orthodontic attachment to be placed. Bone removal should never intentionally approach the cemento-enamel junction (CEJ), since it has been shown that radical exposure beyond the CEJ is responsible for future periodontal problems including destructive bone loss [Becker et al, 1983; Kohavi et al., 1984] The use of acid-etch retained small appliances instead of cemented bands in the impacted teeth reduces greatly the need for excessive bone removal, since the appliance may be positioned as coronally as possible. The risk of gingival attachment loss appears to be greatly reduced with the one step method as described here. This surgical procedure allows the tooth to erupt almost normally through the surrounding tissues and the use of small orthodontic attachments as coronally as possible reduces the risk for soft tissue damage and inflammation during tooth eruption. In some cases, where tooth eruption is followed by the surrounding tissues, periodontal surgery is indicated at the end of the eruption in order to uncover the crown fully as it was the case in 13.3% of our patients.

Attachment or wire failure may also be a problem, but this has greatly improved in recent years with the use of the acid-etch technique. Great attention, however, should be paid to bleeding control during the operation and to the wire type that will be used with the orthodontic attachment. Bleeding control may be helped by the use of any vasoconstrictive agent in the operating area or temporal placement of surgical cement around the uncovered crown during the
appliances placement. An application of force in the attached orthodontic appliance should always be attempted before the flap repositioning, in order to check its retention. In cases of attachment or wire failure a second operation is needed, as happened in 7.7% of our cases, a percentage much lower than the 30.7% reported in a previous study [Pearson et al., 1996]. In our failures, only three cases revealed attachment loss, while the remaining four were wire failure, probably a result of mistaken force application. This problem, although small in proportion, remains the only drawback to the fully repositioned mucoperiosteal flap technique.

Another consideration is the method of applying orthodontic traction [Bishara, 1992]. In all our cases traction was always applied only from within the affected arch and not from the opposite as some authors have suggested. Using the opposite arch as an anchorage it becomes difficult to control the magnitude and direction of the applied force from the mobile mandibular arch. Additionally, in our study, the following considerations were strictly followed:
- availability or creation of sufficient space in the arch;
- maintenance of the space using a coil spring on the arch wire;
- sufficient stiffness of the arch wire during the traction (e.g. 0.016x0.022 NiTi) in 0.018 bracket slot in order to resist the deformation by the applied forces;
- direction of the initial force in an appropriate way to move the impacted tooth away from the roots of the adjacent teeth;
- use of light forces, no more than 2 oz (60 g);
- sufficient retention of the achieved result using 17x25 stainless steel stiff wire, as it has been reported that the affected side may reveal rotations and spacing twice as often as the opposite side after the ideal alignment and the removal of the appliances [Becker et al., 1981; Becker et al., 1983]. This finding was also observed, to a lesser extent, in our study. The solution for this problem may be the extended time for retention.

Finally, the time needed for the alignment of impacted teeth seems to be closely linked with their position. Therefore the position of the impacted tooth should be clinically and radiographically evaluated in the beginning of the procedure when treatment time is scheduled and presented to the patients. Buccally positioned teeth, regardless their type, appear to align quicker than the palatal ones and eruption time is related mainly to the height of the tooth and to a less extent to the angulation. On the contrary in palatal canines, eruption time is strongly related mainly to the degree of angulation of the impacted tooth in the bone. The time needed to align the teeth in the present study was much less than that presented in a previous study [Iramaneerat et al., 1998] where using the same surgical technique, teeth were aligned in a mean time of 19.3 months (range 7.5-46.8). This difference may be attributed to the many different clinicians involved in that study in contrast with our single team, whereas additionally the clinical orthodontic procedures were not described in detail.

Conclusions
The results of this study indicate the following.
1 The orthodontic-surgical treatment of unerupted teeth using the one-step fully repositioned flap is a successful procedure in 95.5% of the cases.
2 Complications such as wire or bracket failure may be as low as 7%.
3 Palatally impacted teeth erupt more slowly than buccally.
4 Treatment time appears to be closely related to the initial angle of the palatally impacted canines and with both the initial height and angulation in cases of buccally impacted canines. Eruption time of impacted incisors is related only to initial height.
5 Retention of the orthodontic result on the affected side appears to be less stable when compared with the contra-lateral teeth.

References


