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Abstract
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Keywords
Stepwise approach; Impaction; Transposition

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Cover Page Footnote
CONFLICT OF INTEREST The authors declare no conflicts of interest ETHICAL APPROVAL This study was approved by the Institutional Review Board of Cathay General Hospital (CGH-P110011) PATIENT CONSENT Provided
CASE REPORT

Strategies for Treatment of Bilateral Impacted High Canine—Lateral Incisor Transposition: A Stepwise Approach

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ABSTRACT

To achieve a satisfactory outcome for transposed impacted teeth, the esthetic assessment and functional rehabilitation should be considered from both the orthodontic and periodontic perspective. In this case, a stepwise approach was used for both surgical uncovering and orthodontic treatment to manage the soft and hard tissue of transposed high canine. The case involved a girl aged 11 years and 7 months with bilateral high impacted canine—lateral incisor transposition. The impacted canines were first uncovered with the closed eruption technique and then moved horizontally to a normal sequence in the arch. Apically repositioned flap surgery was then performed, and the canines were pulled into occlusion. The entire treatment took 48 months. Finally, the transposed canines were moved to their normal position in the arch with consideration for both esthetic preferences and functionality. Taiwanese Journal of Orthodontics 2021;33(1):33–43

Keywords: Stepwise approach; Impaction; Transposition

INTRODUCTION

The permanent canine is the most frequently transposed tooth in the maxilla.1 The incidence of bilateral transposition among high impacted canines is extremely low.1 Canine—incisor transposition occurs less frequently than canine—premolar transposition does.1 Transposition also occurs more frequently in women than in men.1

The characteristic features of maxillary canine and lateral incisor transposition are as follows: 1) retained deciduous canines; 2) labially blocked-out and often rotated canines and lateral incisors; 3) small lateral incisors and premolars; and 4) impacted canines or central incisors, most often at the site of transposition.2

The condition in which the crowns and roots are parallel in their transposed malpositions is known as complete transposition. The condition in which the crowns overlap each other but the root apices are in their respective normal positions is called incomplete transposition.1

For incomplete transposition, canine uprighting is the usual form of orthodontic treatment to align a transposed canine back to its normal order in the arch.1,3 However, repositioning the completely transposed anterior teeth to their normal position can be time intensive when considering both the esthetic and functional dimensions. The design of orthodontic mechanics and appliances has become more complex and should be carefully considered to prevent jeopardizing the roots or damaging supporting structures, especially in cases involving the labial—lingual direction. Finishing procedures, such as torqueing, uprighting, and paralleling of the canine and the lateral incisor, are time intensive.1,3

To the best of our knowledge, the literature has identified three techniques to uncover labially impacted teeth: gingivectomy, apically positioned flap (APF) and the closed eruption (CE) technique.4–8 Each of these techniques are indicated for various conditions. Selecting the appropriate surgical
technique is crucial for achieving an esthetically satisfying result with a healthy periodontal condition. The esthetic and functional results of these procedures, such as changes in gingival height, clinical crown length, width and attachment levels of the attached gingiva, as well as the potential for gingival scarring and relapse, require critical assessment to identify the optimal method for uncovering the labial impacted tooth. Although APF allows for a sufficient amount of attached gingiva, the process involves several drawbacks: 1) the extensive operation field leading to postoperative discomfort for the patient; 2) potential infection caused by wide bone exposure; and 3) negative esthetic effects, such as an increase in clinical crown length, an increase in the width of attached tissue, gingival scarring, and intrusive relapse. In contrast, the CE technique tends not to cause apical or uneven gingival positions or produce a longer clinical crown, nor does it lead to attachment loss, gingival scarring, or vertical relapse. However, CE incurred narrow attached gingiva, and the crestal bone was located apically. CE remains controversial because it won’t meet all the requirements of the broad varieties of tooth impaction.

In this report, we describe the logical treatment of a case of bilateral high canine–lateral incisor transposition with a stepwise approach that incorporated both the orthodontic and the periodontal perspectives. We also presented the final outcome of the case, in which both upper canines returned to a normal sequence in the arch and a healthy and esthetically satisfying periodontal condition was achieved.

CASE REPORT

The patient was a girl aged 11-years and 7 months who was referred to our hospital for anterior crowding with retained deciduous canines. She was in good general health and had no history of systemic disease. Her initial extraoral photos showed a symmetrical facial pattern and a straight profile. Her nasolabial angle was obtuse, and her upper and lower lips relative to the E-line were –2 mm and 0 mm, respectively (Figure 1, Figure 4, Table 1). An intraoral examination revealed that she was in the

Figure 1. Initial extraoral and intraoral photographs.
late mixed dentition stage with an Angle’s Class I molar relationship on both sides, anterior crowding, and insufficient space for both upper canines to erupt. We observed a 30° mesial-out rotation in upper left lateral incisor, a 15° mesial-in rotation in upper right lateral incisor, and retained primary canine and primary second molar on both sides of upper arch. The lower arch had almost transited to permanent dentition, except for the reserved left primary second molar (Figure 1). The initial

Table 1. Cephalometric analysis before and after treatment.

<table>
<thead>
<tr>
<th>Measurements</th>
<th>Initial</th>
<th>Final</th>
<th>Norm</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>Skeletal Analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>SNA</td>
<td>80°</td>
<td>82.5°</td>
<td>81.5° ± 3.5°</td>
</tr>
<tr>
<td>SNB</td>
<td>78°</td>
<td>79.5°</td>
<td>77.7° ± 3.2°</td>
</tr>
<tr>
<td>ANB</td>
<td>2°</td>
<td>3°</td>
<td>4.0° ± 1.8°</td>
</tr>
<tr>
<td>Wits (AO-BO)</td>
<td>−2.5 mm</td>
<td>−1.5 mm</td>
<td>−3.5 mm</td>
</tr>
<tr>
<td>A-Nv</td>
<td>1 mm</td>
<td>4 mm</td>
<td>0±2 mm</td>
</tr>
<tr>
<td>B-Nv</td>
<td>−2 mm</td>
<td>2 mm</td>
<td>−6±8 mm</td>
</tr>
<tr>
<td>Pog-Nv</td>
<td>−2 mm</td>
<td>1.5 mm</td>
<td>−5±8 mm</td>
</tr>
<tr>
<td><strong>Vertical analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>UFH/LFH</td>
<td>48/58%</td>
<td>49.7/50.3%</td>
<td>45/55%</td>
</tr>
<tr>
<td>SN-MP</td>
<td>30°</td>
<td>30°</td>
<td>33.0° ± 1.8°</td>
</tr>
<tr>
<td><strong>Dental Analysis</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>U1-SN</td>
<td>110.5°</td>
<td>109°</td>
<td>108.2° ± 5.4°</td>
</tr>
<tr>
<td>U1-NA</td>
<td>3 mm</td>
<td>3.5 mm</td>
<td>6.4 ± 2.7 mm</td>
</tr>
<tr>
<td>U1-L1</td>
<td>115°</td>
<td>112°</td>
<td>119.9° ± 8.5°</td>
</tr>
<tr>
<td>L1-MP</td>
<td>103.5°</td>
<td>109°</td>
<td>F:93.7° ± 6.3°</td>
</tr>
<tr>
<td><strong>Soft tissue</strong></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>E-line U</td>
<td>−2 mm</td>
<td>−2.5 mm</td>
<td>F:0.7–3.1 mm</td>
</tr>
<tr>
<td>E-line L</td>
<td>0 mm</td>
<td>−0.5 mm</td>
<td>F:0.2–3.4 mm</td>
</tr>
</tbody>
</table>
panoramic radiograph indicated that transpositions were developing. The crowns on both upper canines located between the central and lateral incisors at the level of the root apical third. Their crowns were mesially displaced, and the tooth axes were 30° to the upper dental midline (Figure 2). Both upper canines were identified as being in incomplete transposition because only the crowns had switched with the adjacent lateral incisors. The root apices remained in their relative normal positions, and right canine migrated more mesially to the dental midline, nearly touching the root of central incisor. A lateral cephalometric analysis showed a skeletal Class I relationship with an ANB angle of 2° and a Wit’s appraisal of −2.5 mm (Table 1). Cone-beam computed tomography (CBCT) revealed that the impacted right canine was more severely rotated and more mesially positioned than left canine was (Figure 3). In addition, right canine was embedded in the center of alveolus, whereas left canine was more labially positioned in the labiolingual direction.

Treatment plan and objectives

The first objective of treatment was to align the transposed canines into their normal positions in the arch and to move them into occlusion. The second objective was to achieve a normal canine and molar Class I dental relationship. Both upper canines developed under healthy and esthetically satisfying periodontal conditions, including a properly attached gingival zone and a harmonious gingival line.

The treatment plan consisted of nonextraction and upper arch expansion because the patient’s facial profile was appropriate for the procedure. We developed a stepwise approach involving CE as the first procedure and APF as the second procedure to uncover the impacted canine. Orthodontic traction was also carried out in two steps. The procedure began with the horizontal pulling of the canines away from the roots of the lateral incisors. The canines were then aligned in their normal order in the arch and moved down to occlusion. The APF procedure would be performed before the canine moved into the final position if the gingiva could not be properly attached.

Treatment progress

The treatment began with the interproximal reduction of upper primary second molars both sides. Then, upper first premolars were moved distally, and the posterior anchorage was set with a Nance holding arch to preserve space for the upper canines to erupt (Figure 5). Then, both impacted canines were surgically exposed with CE technique and semilunar incisions were performed on overlying mucosa of impacted canines (Figure 6a and b). Subsequently, both canines were bonded with small lingual buttons on the labial surface of the crowns; 0.09-mm twisted steel ligatures were tied on the button necks for traction (Figure 6c). Finally, the flap was sutured back over the crown, and the wound was closed.

Two weeks later, the stitches were removed, the canine began to retract distally and horizontally, and the power chain was periodically changed (Figure 7a and b). The vertical force was avoided before the transposition had been corrected to normal sequence. The left canine took 7 months to move into a normal position in the arch; the right canine took 15 months because its location was initially more mesially displaced.

The timing of the second operation of APF, as Figure 8a–d shows, was performed before the canine erupted into the oral cavity through movable gingiva. If upper left canine erupted through movable gingiva which would cause periodontal issue due to no adequate attached gingiva zone (Figure 7b). The surgical procedure included elevation of a flap from the attached gingiva at the crest of the ridge (Figure 8a and b), replaced it to cover the CEJ area and 2 to 3 mm of the crown then sutured the flap tightly (Figure 8c and d). Two weeks after the APF procedure, the canines were vertically drawn. The left canine took 7 months to move into occlusion, and the right canine took 11 months (Figure 9). After 38 months of active treatment for the upper arch, we began to bond the lower arch to
coordinate the arches and enhance the torqueing control of the upper front teeth. This stage of treatment took another 10 months to complete.

Results of treatment

Pretreatment and posttreatment cephalometric superimposition showed that the facial growth of the patient was consistently downward and forward during treatment (Figure 10, Figure 11, Table 1). The posttreatment panoramic radiograph indicated that the transposed impaction of both canines had been corrected, well aligned root parallelism was presented (Figure 12). Intraorally, an Angle’s Class I canine and molar dental relationship was achieved with a normal overjet and overbite. Finally, a harmonious gingival line, adequate attached gingiva width, and normal clinical crown height for both canines were also achieved (Figure 13).

DISCUSSION
Considerations for orthodontic treatment

Anchorage control and orthodontic force direction are two factors that are essential for achieving a
satisfactory outcome for impacted high canines with transposition. In our case, a Nance holding arch on palate for anchorage control and a buccal high hook (0.017 × 0.025 beta titanium segmented wire) was inserted in the molar accessory tube, which was a noninvasive design element with regard to the control of the force direction (Figures 5 and 7). The mechanics used in the beginning for the high canine, namely a one-directional force, were relatively easier than the orthodontic mechanics designed for transposed canines already in the oral cavity. Applying a diagonal force would be a convenient approach, but the neighboring root structure could be endangered during traction.

Figure 8. a, b) The second surgical procedure, namely APF, was performed after the canines returned to a normal sequence in the arch. The procedure for 23 was performed (b, d) 8 months earlier than the procedure for 13 (a, c) because of the difference in severity. (c, d) The rotated 13 had been corrected during the distal shift, but 23 became rotated distally and outward. The flap should be replaced to cover the CEJ area and 2 to 3 mm of the crown.

Figure 9. Vertically setting 23 and 13 in their final positions took approximately 7 months and 11 months, respectively. (a) The root of 13 tended to be labially positioned as the tooth came into occlusion; (c) Application of palatal root torque for 13 with a torqueing spring; (d) After 23 moved down to occlusion, the palatal root angulation of 22 was corrected using a torqueing spring.
Thus, the vector of the force should be carefully considered. In this case, high and horizontal force vectors were designed to avoid hitting the root of the lateral incisor during horizontal traction. Besides, we did not bond the adjacent lateral incisor to limit its movement in labiolingual direction (Figure 7a and b). After the canine was moved back to its normal position in the arch, it was drawn down vertically, and a long open coil spring was used to offset the unfavorable movement produced by wire distortion (Figure 14). A satisfactory outcome was achieved with superior mechanical control through a stepwise approach involving changing the force vectors at two stages.

To the best of our knowledge, the orthodontic mechanics applied to the impacted tooth were under poor control when the tooth was embedded in the alveolus. When comparing Figure 6a and b with Figure 8c and d, one point force control from the labial attachments of the canines caused them rotated distally, which resulted in the correction of the rotated right canine and caused the unwanted distal and outward crown movements of left canine. For this reason, bonding positions should be determined in advance. For right canine, the bonding site should be as mesial as possible on the labial surface. For left canine, the bonding site should be on the distal half of the labial surface to prevent adverse rotation. The concomitant benefit was canine uprighting in the mesiodistal dimension and correction of incomplete transposition. The torque should be carefully designed as soon as the impaction comes into occlusion; the torqueing springs were used to correct the unfavorable root angulation in the labiolingual dimension (Figure 9c and d). Becker et al. noted that the deviation of the root apex, particularly in the buccal–lingual plane, demands complicated uprighting and torqueing mechanotherapy, which is difficult to perform and could reduce the periodontal prognosis of the tooth in the long term.9,10 Vermette et al. also noted that it is crucial for labially impacted canines with thin labial plate bone, which can lead to a high risk of attachment loss if uncovered by APF.5 Experienced predecessors have noted that the torqueing control of impaction in the labiolingual direction influences long-term periodontal prognosis.
Considerations for surgical exposure

When uncovering an impaction, a conservative attitude toward the dental follicle is recommended.\(^4,5\) Otherwise, a long clinical crown and a reduction in alveolar crest may result.\(^4\) Sufficient area for only the placement of the attachment is required; the rest of the follicle should be kept intact.\(^4,5\) As Figure 6a and b shows, the soft tissue that during the operation was sufficiently extended...
for bonding with minimal bone removal; and the complete removal of the follicle tissue, which can cause irreversible damage to the periodontium and the cementum layer of the root, was avoided. For the pathway through which the transposed canine passes, we avoided removing all bone obstacles, which may have provided an easy path for orthodontic traction and accelerated the movement of the tooth but could potentially lead to considerable bone loss after orthodontic treatment.8,11 We also avoided bone channeling, which is highly likely to inflict irreversible damage to the periodontium or the cementum layer of the root.10 The exposure area was kept coronal to the cementoenamel junction (CEJ) to maintain alveolar bone support.9 The combined effects of conservative surgical exposure and light orthodontic movement forces were beneficial for the periodontal health of the tooth because they minimized the loss of alveolar bone support and the potential tooth injury during traction.4,5,8,9,11 Kohavi et al. suggested that light orthodontic movements (e.g., tipping) cause significantly less bone loss than heavy movements (e.g., torque) during the traction of the impacted tooth.9 Because of these concerns, we took 15 months to move upper right canine back to its normal position in the arch.

In this case, upper right canine was impacted in the center of the alveolus, and upper left canine was labially positioned. Their high positions were notably apical to the mucogingival junction. According to Kokitch’s four criteria, CE is an appropriate procedure for beginning to uncover an impacted canine.6 Kokitch also described a case of a transposed high canine displaced mesially and over the root of the lateral incisor that would not have been able to move through the alveolus without APF.5 In addition, Vermette et al. addressed that CE has been recognized as one of the best methods for uncovering labially impacted teeth, especially when the tooth is located high above the mucogingival junction or deep in the alveolus where APF may be unviable.7,12 Becker et al. also noted that CE is universally applicable when the labial canine is displaced in the mesiodistal plane.10 Accordingly, we performed CE to uncover the impacted canine before starting the orthodontic traction.

The second surgical procedure, namely APF, was performed by a periodontist after upper left canine moved back into its normal location and before it emerged into the oral cavity (Figures 7b and 8b). We performed APF for two reasons. First, CE incurred narrow attached gingiva, and the crestal bone was located apically.5 When teeth are moved under poor oral hygiene conditions, inflammation can lead to alveolar bone loss, especially for teeth with little or no attached gingiva.7,8 Second, sufficient attached gingiva must be supplied for a healthy periodontal condition. Becker et al. noted that APF is suitable only for labially impacted canines in their normal locations in the arch.10

Instead of a single procedure, we used a stepwise approach to reduce the difficulties of the first operation and increase the likelihood of a healthy and esthetically satisfying periodontal result. We initially selected CE because of its ease of access under extreme conditions, and APF was performed to secure enough attached gingiva and to ensure a healthy periodontal condition during vertical pulling. APF is highly technique sensitive, and periodontal conditions such as gingival height, clinical crown length, attached gingiva width, gingival scarring, relapse potential, and attachment levels require clinical evaluation. Gingival scarring is one of the major drawbacks of APF and requires years of follow-up, with no guarantee that the unpleasant scarring will subside. Figure 15 shows that gingival scarring had subsided on upper right canine at the 35-month follow-up (from the date when right
canine had been moved into occlusion until the last date color photos were taken), yet the scarring remained severe on upper left canine at the 47-month follow-up despite the fact that APF had been performed 8 months earlier on left canine than on right canine. The reason for this difference was not completely clear and requires further investigation. The tendency for relapse is another drawback. The prolonged treatment period was due in part to the extreme difficulty of the case and the long distance the teeth had to be moved and in part to the fact that the retention period was intentionally maintained longer to prevent the relapse tendency.

The phrase “to mimic normal eruption” has been repeatedly mentioned in the literatures of impaction. Several authors have emphasized that treatment outcomes must be satisfactory from periodontal perspective. The authors drew particular attention to the following points: 1) a conservative attitude toward dental follicles to create normal gingival attachments; 2) in flap design, CE is appropriate for mid-alveolar impaction associated with normal eruption by treatment with tunnel traction. APF is performed by tooth remained exposed after apical repositioning, and an active orthodontic force was applied to the tooth to prompt its eruption through the attached gingiva area, which the flap became attached to the tooth and the surrounding alveolar process; 3) for the proper design of mechanics in orthodontic treatment, the impacted teeth should be pulled through the center of the alveolar ridge or attached gingiva through methods including loop design, power arm and TADs application.

**CONCLUSION**

The strategy we used to successfully treat a transposed high canine, namely a stepwise approach, simplified the complexity of our case with two steps of treatment and incorporated considerations from both the orthodontic and the periodontal perspectives. In orthodontic treatment, the mechanics design, control of the direction of the force, anchorage control, and the effects on the surrounding hard and soft tissues should be considered. Accordingly, to achieve esthetic
harmony and healthy periodontal soft tissue, the method in which CE and APF are performed at different stages to uncover impactions should be considered. In other words, the successful treatment of impacted teeth depends on the cooperation of orthodontists with periodontists and surgeons.

Conflict of interest statement

The authors declare no conflicts of interest.

ETHICAL APPROVAL

This study was approved by the Institutional Review Board of Cathay General Hospital (CGH-P110011).

PATIENT CONSENT

Provided.

REFERENCES