Correction of Class II division 2 with crowding and bilateral fully transposed impacted mandibular canines

Lei Han,* Li Mei,† Caixia Zhang,‡ Tuojiang Wu,§ Congyue Wang∥ and Huang Li¶
Department of Orthodontics, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing, Jiangsu, People’s Republic of China*
Discipline of Orthodontics, Department of Oral Sciences, Sir John Walsh Research Institute, Faculty of Dentistry, University of Otago, Dunedin, New Zealand†
Department of Orthodontics, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing, Jiangsu, People’s Republic of China‡
Department of Orthodontics, Lan Cheng Dental Clinic, Kunming, Yunnan, People’s Republic of China§
Department of Oral and Maxillofacial Surgery Department, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing, Jiangsu, People’s Republic of China∥
Department of Orthodontics, Nanjing Stomatological Hospital, Medical School of Nanjing University, Nanjing, Jiangsu, People’s Republic of China¶

Background: Maxillary canine impaction has been extensively reported, but studies of mandibular canine impaction are relatively few. Clinical studies and reports of experience treating mandibular canine impaction are of clinical benefit to both orthodontists and dentists.
Aims: This report introduces a Class II division 2 crowded case with severely impacted, fully transposed, mandibular canines treated by a non-extraction approach and mandibular arch expansion.
Methods: The completely transposed, impacted, mandibular canines were successfully aligned. The crowding was relieved by arch expansion and incisor proclination without obvious radiographic alveolar bone loss. The two severely labially displaced mandibular canines assisted in the expansion of the narrow mandibular arch.
Results: The maxillary and mandibular arches were expanded and well aligned, and Class II molar and canine relationships and a normal overjet and overbite were established. The mandibular canines were aligned in advantageous positions. There was no regional alveolar bone resorption around the mandibular canines.
Conclusion: The treatment approach provided an example of significant bone remodelling. Using the impacted mandibular canines for anchorage, the age of the patient provided an opportunity to adopt a relatively conservative and unique treatment approach which may be applied to relieve crowding.

Introduction
Canine impaction, specifically in the maxilla, is a common dental anomaly and has been extensively reported. In contrast, research of mandibular canine impaction is relatively less common because its prevalence is lower compared with maxillary canine impaction.1,2 Therefore, an examination and experience in treating mandibular canine impaction would be of clinical benefit.
The treatment options to manage mandibular canine impaction usually include surgical extraction, transplantation, or exposure and orthodontic traction.3,4
Of these, orthodontic traction is generally considered to produce the best aesthetic and functional outcome. However, efficiently moving impacted canines into an ideal arch and occlusal position is often a clinical challenge due to the displacement of the crown and root in proximity to adjacent teeth, the amount of space available, the management of root torque and the possibility of ankylosis. It has been suggested that in the case of complete transposition of a canine with an adjacent tooth, aligning the canine into a transposed position can be an accepted option given the likely complexity and duration of the treatment.

An additional challenge for successful management of canine impaction is to regain sufficient space by either extraction or expansion methods. Extraction is commonly used for patients presenting with severe crowding and expansion is applied in patients with mild to moderate crowding. In patients presenting with severe crowding, it is uncommon and unwise to only use expansion to regain space for the impacted canines due to the risk of buccal alveolar bone resorption and a lack of stability of the treatment result, especially in the mandibular arch. Compared with the maxilla, there is no midline bone suture in the mandibular arch, and the density of the cortical bone is relatively thicker. Mandibular expansion is mainly characterised by tooth buccal/labial proclination. To date, studies of mandibular expansion in patients with crowding are still controversial and limited.

The aim of the present study was to report the treatment of a growing patient who presented with a Class II division 2 crowded malocclusion and fully transposed impacted mandibular canines. The case provides an example in which extensive bone remodelling and the age of the patient provided an opportunity to implement a unique treatment plan that may be applied to relieve crowding using impacted mandibular canine anchorage.

**Diagnosis and aetiology**

A 12-year-old female attended the orthodontic clinic with a chief complaint of dental crowding and impacted mandibular canines. There were no significant family nor medical histories related to the impacted canines and no temporo-mandibular joint signs nor symptoms. The pretreatment extraoral photographs (Fig. 1) and model analysis (Fig. 2) revealed severe crowding in the maxilla (8 mm) and mandible (18 mm), two retained deciduous mandibular canines, an increased overbite (100%), a deep curve of Spee (4 mm), and a Class II molar relationship. The patient’s oral hygiene was poor and there was caries affecting the maxillary right first permanent molar.

The pretreatment radiographs (Fig. 3) showed that the two mandibular permanent canines were impacted. Cone-beam computed tomography (CBCT) scans indicated that the two mandibular canines were labially displaced and fully transposed between the mandibular central and lateral incisors. The mandibular arch was narrow, and the buccal segments were lingually inclined (Figs. 1 and 3).

The cephalometric analysis (Fig. 3A and Table I) revealed a skeletal Class I relationship with a slightly retruded maxilla (SNA 79.9°, SNB 76.0°, ANB 3.9° and a Wits appraisal -1.0 mm), a decreased mandibular plane angle (SN – MP 30.8°, FMA 24.7°), retroclined maxillary and mandibular incisors (U1 – SN 80.7°, U1-NA angle 0.8°, U1-NA distance -3.1 mm, LI – NB angle 12.2°, LI-NB distance -2.1 mm) (Table I). The developmental stage was CVS III (Fig. 3A).

The patient was diagnosed with a skeletal Class I and a dental Class II division 2 malocclusion with significant crowding and the impaction and transposition of the mandibular permanent canines.

**Treatment objectives**

1. To expand, level and align both arches;
2. To align the impacted mandibular canines into the arch;
3. To establish a normal overbite and overjet;
4. To achieve a Class I molar relationship and coincide the dental midlines;
5. To improve the smile aesthetics.

**Treatment options**

Three treatment options were discussed with the patient and her parents. All treatment options required the extraction of the retained mandibular deciduous canines (73 and 83). Option three was chosen because the extraction of healthy permanent teeth was refused.
Figure 1. Pretreatment facial and intraoral photographs.

Figure 2. Pretreatment dental casts.

Option one: The extraction of 16, 25, 35 and 45 to relieve the crowding, align both dental arches, and achieve Class I molar and incisor relationships.

Option two: The extraction of 16, 25, 33 and 43 to relieve the crowding, align both dental arches, and achieve Class I molar and incisor relationships.
Option three: Non-extraction treatment following the removal of the retained mandibular deciduous canines, surgical exposure and repositioning of the impacted mandibular permanent canines. Expansion was used to obtain space because both dental arches were narrow and the patient was in a growth phase which was expected to assist active alveolar bone remodelling. Given the positions of the impacted mandibular canines (Fig. 3), 33 would be moved back to the dental arch between 32 and 34, while 43 would be aligned in its transposed position (the final position of 43 and 42 would be swapped).

The treatment effect and long-term stability of option 3 was considered to be a challenge. There would be a compromise in aesthetics due to the transposition of 43 and 42. Clear retainers and a fixed retainer extending between 35 and 45 would be used for long-term retention. The third molars were planned for removal; however, the maxillary third molars were positioned high, making extraction difficult. Their extraction would be considered during the retention phase. In the mandibular arch, germectomy of the third molars was recommended.

**Treatment progress**

Pre-adjusted fixed appliances (0.022 × 0.028-inch MBT prescription, 3M Unitek, Monrovia, Calif, USA) were bonded. A quad-helix appliance was inserted into the tubes of the maxillary first molars to expand the
maxillary arch. An 0.014-inch nickel-titanium wire was used for alignment, and a coil spring between 11 and 13 was used to regain space for 12. The initial alignment was completed in 12 months with sequential nickel-titanium arch wires (0.014 inch, 0.016 inch, 0.018 inch, 0.016 x 0.022-inch, 0.019 x 0.025-inch) (Figs. 4 and 5). Stainless steel wires (0.018 x 0.025-inches) were used to close the residual spaces (Fig. 6).

A lingual arch was attached to the mandibular first molars to assist with mandibular expansion. After the extraction of 73 and 83 and surgical exposure of 33 and 43, buttons and gold chains were bonded

Table I. Cephalometric analyses before and after treatment.

<table>
<thead>
<tr>
<th>Measurement</th>
<th>Chinese norm</th>
<th>Before treatment</th>
<th>After treatment</th>
</tr>
</thead>
<tbody>
<tr>
<td>SNA (°)</td>
<td>82.3 ± 3.5</td>
<td>79.9</td>
<td>79.0</td>
</tr>
<tr>
<td>SNB (°)</td>
<td>78.9 ± 3.5</td>
<td>76.0</td>
<td>77.0</td>
</tr>
<tr>
<td>ANB (°)</td>
<td>3.4 ± 1.8</td>
<td>3.9</td>
<td>2.9</td>
</tr>
<tr>
<td>Wits (mm)</td>
<td>1.0 ± 1.3</td>
<td>-1.0</td>
<td>0.6</td>
</tr>
<tr>
<td>SN-MP (°)</td>
<td>32.8 ± 4.2</td>
<td>30.8</td>
<td>30.9</td>
</tr>
<tr>
<td>Y-axis (°)</td>
<td>64.7 ± 3.3</td>
<td>69.7</td>
<td>69.6</td>
</tr>
<tr>
<td>FMA (°)</td>
<td>31.3 ± 5.0</td>
<td>24.7</td>
<td>24.1</td>
</tr>
<tr>
<td>ANS-Me (mm)</td>
<td>56.8 ± 3.4</td>
<td>52.3</td>
<td>54.0</td>
</tr>
<tr>
<td>S-Go (mm)</td>
<td>68.8 ± 5.7</td>
<td>70.6</td>
<td>75.4</td>
</tr>
<tr>
<td>ANS-Me/N-Me(%)</td>
<td>53.3 ± 1.8</td>
<td>52.5</td>
<td>51.7</td>
</tr>
<tr>
<td>U1 to SN (°)</td>
<td>104.6 ± 6.0</td>
<td>80.7</td>
<td>106.4</td>
</tr>
<tr>
<td>U1 to NA (°)</td>
<td>24.7 ± 5.2</td>
<td>0.8</td>
<td>27.4</td>
</tr>
<tr>
<td>U1 to NA (mm)</td>
<td>6.2 ± 1.9</td>
<td>-3.1</td>
<td>6.3</td>
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<tr>
<td>ll to NB (°)</td>
<td>31.0 ± 6.6</td>
<td>12.2</td>
<td>40.5</td>
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<td>ll to NB (mm)</td>
<td>7.8 ± 2.4</td>
<td>-2.1</td>
<td>6.8</td>
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<tr>
<td>ll to MP (°)</td>
<td>96.3 ± 5.8</td>
<td>85.4</td>
<td>112.6</td>
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<tr>
<td>U1/L1(°)</td>
<td>120.3 ± 10.1</td>
<td>163.1</td>
<td>110.0</td>
</tr>
<tr>
<td>Upper lip (mm)</td>
<td>2.5 ± 1.5</td>
<td>-5.0</td>
<td>0.5</td>
</tr>
<tr>
<td>Lower lip (mm)</td>
<td>2.6 ± 1.5</td>
<td>-6.9</td>
<td>-0.5</td>
</tr>
</tbody>
</table>

Figure 4. Mandibular impacted canines were surgically exposed and bonded with buttons. The Quad-helix appliance was used for maxillary arch expansion; the reaction force when aligning the labially impacted canines assisted the mandibular expansion.
Figure 5. A 0.016 x 0.022 inch stainless steel Ricketts utility arch was inserted into tubes of the mandibular molars to intrude the anterior teeth.

Figure 6. The auxiliary brackets and arch wires were added for torque control of the mandibular canines.
onto the impacted canines to enable orthodontic traction. While aligning the canines, the buccally displaced position provided assistance in generating mandibular expansion. The position of 43 was between 41 and 42, and therefore was aligned in this position; the position of 33, although displaced, was relatively normal and therefore was aligned in the arch between 32 and 34 (Fig. 4). Sequential nickel-titanium arch wires (0.016-inch and 0.018-inch) were inserted to achieve the alignment of 33 and 43.

After 12 months, a 0.016 × 0.022-inch nickel-titanium arch wire was inserted into the main slot followed by a 0.016 × 0.022-inch stainless steel Ricketts utility arch inserted into the mandibular first molar tubes. Anteriorly, the Ricketts utility arch was ligated below the main arch wire between the mandibular incisors in order to reduce the overbite (Fig. 5). After 20 months, the mandibular arch was aligned and levelled, but the roots of 33 and 43 were still buccally inclined. A Warren spring and auxiliary brackets and arch wires were applied to deliver lingual root torque to the mandibular canines and the lateral incisor (Fig. 6) which subsequently improved. After 32 months, the quad-helix appliance and mandibular lingual arch were removed, which was followed by detailing and finishing (bracket repositioning and inter-arch elastics) before debonding.

The total active treatment time was 40 months. Clear and fixed retainers were inserted for retention. The patient was reviewed for two years.

**Treatment results**

A posttreatment examination demonstrated that the treatment objectives were achieved. The extraoral photographs (Fig. 7) showed an improved profile with coincident dental and facial midlines and a balanced aesthetic smile. The intraoral photos indicated that the maxillary and mandibular arches were expanded and well aligned, and Class I molar and canine relationships and a normal overjet and overbite were established. The mandibular canines were aligned in advantageous positions (Figs. 7, 8, and 9).

The posttreatment CBCT scan (Fig. 10) showed that there was no buccal alveolar bone resorption around

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Figure 7. Post-treatment facial and intraoral photographs.
Figure 8. The occlusion changes of mandibular arch during the treatment (A: before treatment, B: 6 months, C: 12 months, D: 15 months, E: 20 months, F: 24 months, G: 30 months, H: 40 months).

Figure 9. Posttreatment dental casts.

Figure 10. The roots cross section view from the pre (A) and post (B) treatment CBCT (A: 44, B: 42, C: 83, D: 43, E: 41, F: 31, G: 33, H: 32, I: 34).
the mandibular canines after arch expansion and that
the canine roots were well aligned in the middle of the
alveolar bone. The posttreatment ANB angle (2.0°)
and Wits appraisal (0.6 mm) indicated that the sagittal
evolutionary relationship improved (Table I and Fig. 11).
After treatment, the incisor-mandibular plane angle
(L1 to MP) increased by 27.2° and U1-SN increased
by 25.7°; the maxillary and mandibular incisors were
proclined (1-NA 6.3 mm, 1-NA 27.4°, LI-NB 6.6
mm, and L1-NB 40.5°) and lip fullness improved
(upper lip 0.5 mm, lower lip 0.5 mm). The transverse
width between the first molars increased in both
arches and the mandibular anterior basal bone had
expanded (Fig. 8). All second molars had been tipped
distally because of the presence of the third molars.
The root torque of 42 and 43 was not completely
corrected to normal during treatment. After two years
of review, the patient exhibited stable molar and canine
relationships and good periodontal health around 43
and 33 (Fig. 12). However, there was irregularity of the
mandibular incisors due to incorrect root torque and
the loss of the fixed and clear retainers.

**Discussion**

The present case report described the non-extraction
treatment of a 12-year-old growing female with
bilaterally impacted, fully transposed mandibular
canines and constricted maxillary and mandibular
arches. The treatment included gaining space by
arch expansion, surgical exposure of the impacted
mandibular canines, and levelling and aligning the
arches using fixed appliances. The auxiliary brackets
and arch wires were used for torque control of the
mandibular canines. A CBCT scan confirmed that
there was no obvious alveolar bone resorption follow-
ing arch expansion.

The aetiology of mandibular canine impaction is
unclear. It has been found to be associated with heredity
factors, trauma, cysts, long eruption paths of canine
tooth germs, filling of the canine space by adjacent
teeth, premature loss of deciduous teeth, disharmony
of the teeth and basal bone and an unfavourable
alveolar arch length.15–17 The narrow mandibular arch
and insufficient eruption space might be the reason for
mandibular canine impaction in the presented case.

The treatment options to manage impacted canines
usually depend on factors related to crowding, the posi-
tion of the root, canine morphology, facial aesthetics,
treatment time and the patient’s desires.18,19 As an
ease, incompletely transposed canines could be
repositioned into their normal positions, but moving
completely transposed canines back into normal
alignment is difficult and usually not recommended. Few reported studies of completely transposed canines are available, and the treatment of impacted canines is often complex, with an increased risk of alveolar bone resorption and damage to adjacent teeth. In the present case, 33 and 43 were labially positioned with their crowns and roots completely transposed. After surgical exposure, 33 and 43 were bracketed and extruded by ligation to the mandibular arch wires. After eruption, the crown and root of 33 were placed between 32 and 34, and so 33 was aligned into its normal position. However, the root of 43 was well positioned between 42 and 41, and it was thought wise to maintain the swapped root relationship to prevent root contact during alignment. Although the mandibular incisors were aligned, the inclination of 42 and 43 were opposite which led to a poorly aligned cervical and occlusal region of their crowns. Warren springs were applied to deliver lingual root torque to 42 and 43; however, these were not totally effective. The “twin-brackets-twin-wires” approach was therefore used to generate the reciprocal torque required on the adjacent teeth. Using this approach, additional brackets and wires were bonded and used at the cervical region of 33, 43 and 42, to generate the required opposite root torque, which would simultaneously cease when the crowns were aligned. However, the limitations of this method, related to an increased difficulty in tooth brushing and discomfort, cannot be ignored.

Several approaches may be used to obtain space to relieve crowding, and include anterior proclination, molar distalisation, arch expansion, interproximal reduction and tooth extraction. Severe crowding is usually a clinical indicator for extraction. In the present case, extractions were considered (options 1 and 2) because of the potential detrimental effect on the supporting alveolar bone if the crowding was relieved by expansion only. However, the patient and parents strongly refused the extraction of any permanent teeth. Considering that the dental arches were very narrow with retroclined incisors and there was growth potential, the patient and her parents were happy to accept a relatively conservative treatment plan to align the teeth with the provision.
of later extractions if signs of alveolar bone resorption or ankylosis occurred. It has been found that thinner investing bone and severe crowding increase the risk of alveolar bone loss. Fortunately, the progress and posttreatment radiography confirmed that there was no obvious bone loss after the expansion. Retroclined incisors, sufficient basal bone support, wide buccal corridors and active alveolar bone remodelling may be favourable factors indicating the success of treatment. The present result showed how expansion could be utilised to relieve crowding using anchorage provided by the impacted mandibular canines, especially in growing patients.

Since the introduction of maxillary expansion by Emerson Angel in the 1860s, expansion techniques have been widely used. Mandibular expanders, such as the Bihelix appliance, the Crozat and the Schwarz appliances, are relatively less commonly used. The Schwarz appliance has a large base that may cause a foreign body sensation. The Crozat appliance has a removable base that requires good cooperation from the patient. A quad-helix appliance was used in the present patient to expand the maxillary arch and an expansion arch wire was used to widen the mandibular arch. Additionally, the labially impacted canines were used as anchorage to assist mandibular expansion during alignment.

At the end of the active appliance phase, there was obvious expansion and mandibular anterior proclination which required a consideration of stability. There was a compromise in aesthetics due to the transposition of 43 and 42. The root torque of 42 and 43 were lingual and labial, respectively, after treatment. Therefore, a fixed retainer extending between 35 and 45 and clear retainers were used for long-term retention. However, there was irregularity of the mandibular incisors after 2 years due to the loss of the retainers and the incorrect root torque. All second molars were tipped distally pre- and post-treatment which was likely due to the presence of the developing third molars. All third molars were recommended for removal during the retention phase.

Although the expansion was successful and there was no obvious buccal alveolar bone resorption, the aim of this case report was to provide a relatively conservative and unique treatment plan for relieving crowding using anchorage provided by impacted mandibular canines. More high-quality clinical trials and CBCT studies are needed to accurately define the level of expansion that can be achieved without significant alveolar bone loss.

Conclusion
The completely transposed and impacted mandibular canines were successfully aligned in positions in the arch based on their specific relationship with the adjacent teeth. Non-extraction treatment by arch expansion and incisor proclination resolved the crowding without obvious alveolar bone loss. The two labially displaced mandibular canines were used as anchorage to assist with expansion of the narrowed mandibular arch.

Conflict of Interest
The authors declare that there is no conflict of interest.

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Corresponding author
Professor Huang Li
Nanjing Stomatological Hospital
Medical School of Nanjing University, Nanjing Jiangsu, People’s Republic of China, 210008,
Email: lihuang76@nju.edu.cn
*These authors contributed equally to this work: Lei Han and Li Mei.

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