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ORIGINAL RESEARCH

Uprighting horizontally impacted third molars by super-elastic nickel-titanium wire in patients with an extracted first molar

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Abstract

Protracting lower second molars and uprighting horizontally impacted third molars is a significant orthodontic challenge in patients who require the extraction of severely decayed first molars. Here, we describe the use of biomechanics to upright 90°-tilted lower third molars following second molar protraction. Herein, we introduce a technique for uprighting the lower third molars by (1) the placement of superelastic nickel titanium archwires, (2) bonding, and (3) repositioning of a buccal tube in a tilted position to compensate for the efficiency of Ni-Ti (nickel-titanium) wire. The treatment mechanics used for our two cases showed that even severely impacted third molars can be uprighted by routine continuous straight-wire techniques. This technique proved to be a simple, efficient and reliable treatment option for uprighting horizontally impacted third molars.

Keywords

Upright; Horizontal impaction; Third molar; Orthodontic

1. Introduction

Over evolution, the increased consumption of well-prepared food has reduced the available space for tooth eruption. Due to their late eruption, the third molars are the most commonly impacted teeth in the oral cavity [1]. In a previous radiological study carried out in Hong Kong, patients presented with at least one impacted tooth with mandibular third molars comprising 82.5% of all impacted teeth [2, 3].

With the increased uptake of high calorie carbohydrates, caries in the lower first molars has become increasingly prevalent in Chinese adolescents. This has led to the increased incidence of severely decayed lower first molars; this represents a significant orthodontic challenge for patients who require lower premolar extraction [4]. To obtain appropriate occlusion and prevent further periodontal problems, uprighting the impacted third molars after second molar protraction is the preferred treatment modality. Furthermore, significant attention must be paid to reduce discomfort, reduce treatment time and improve prognosis in these cases. If not properly addressed, many negative events may ensue, such as over-eruption of the second molars in the opposing arch, periodontal problems due to food impaction, and reduced bone height distal to the second molars [5].

Several clinical methods have been proposed to upright tilted second or third molars; these can be divided into two categories: (1) pushing the tilted molars backwards by a spring soldered to bands on the first or second molars [6] or a tip-back cantilever [7] and (2) pulling the tilted molars backwards from the distal side by TADs (Temporary anchorage devices) inserted into the retromolar region [8].

Although the widespread use of skeletal anchorage over the last decade has provided orthodontists with precise and efficient anchorage, several complications have been reported in the literature, such as the fracture of mini-screws, root perforation and the death of pulp tissue in adjacent teeth [9]. Furthermore, such placement of skeletal anchorage units in the retromolar region may bring about much discomfort and unwanted side effects, such as irritation and swelling of the mucosa, pain, infection, blood vessel injury, and fracture of the mini-screws during placement [10, 11]. In addition, the insertion of skeletal anchorage units in the retromolar region involves considerable surgical procedures which represent a demanding task for orthodontists [12].

Several interesting questions remain regarding the methods that can be used to upright the second or third molars. Here, we considered whether it is possible to modify the traditional tip-back spring to apply a gentle and constant force, thus simplifying procedures to upright the impacted molars. Here, we tested this hypothesis and determined whether such a light force could create unwanted movement of the anchor teeth during uprighting.

2. Materials and methods

In this case report, we introduce a biomechanical system to upright horizontally impacted mandibular third molars with super-elastic nickel-titanium (Ni-Ti) wires. This system was designed to provide a simple and efficient technique that could avoid discomfort following the surgical insertion of TADs and the placement of orthodontic tip-back loops.

Using this technique, the 90°-tilted third molar was uprighted after the protraction of second molars rather than before space closure (Fig. 1A). The third molars moved forward with the second molars due to the presence of inter-septal gingival fibers. The spontaneous partial uprighting of the third molars usually provides sufficient space for bonding without surgical procedures. A buccal tube is bonded onto the distal cusp; then a 0.012-in Ni-Ti wire was inserted into the buccal tube. Then, the archwire is tied to the hook on the tube on the second molars by ligatures rather than being inserted into the buccal tube of the second molars (Fig. 1B). Once sufficient buccal surface is exposed after further uprighting, the buccal tube is repositioned mesially with its mesial part over-tilted gingivally to compensate for the space between the buccal tube and the archwire. Then, the tilted third molar is uprighted by the placement of a super-elastic Ni-Ti wire (0.012-in and 0.018-in) (Fig. 1C,D). Our new approach to upright the third molar is minimally invasive and involves fewer surgical procedures than previous techniques.

3. Case report

3.1 Patient 1

3.1.1 Diagnosis and objectives

A 16-year-old girl came to the dental clinic with the chief complaint of flared upper and lower teeth. Clinical examination revealed a class I molar and canine relationship with prominent dental protrusion of the upper and lower incisors. The patient had an open bite of 3 mm in the incisor region (Fig. 2). The patient presented with a 90° tilted third molar on the lower right arch with the first and second left mandibular molar severely decayed and filled. The bilateral lower third molars were 90° mesially tilted in a panoramic X-ray (Fig. 3A) and the patient had a hyper-divergent mandibular plane (Fig. 3B,C).

The following treatment objectives were established: (1) to correct protrusion of the front teeth; (2) to correct the open bite in the front teeth and establish good intercuspation in the posterior teeth, and (3) to improve the patient's facial profile and achieve a competent lip seal.

3.1.2 Treatment plan

Two treatment options were considered to reduce the dental protrusion: (1) four first bicuspid extractions with two TADs in the upper arch to retract the front teeth. We considered that it would be easy to improve the patient's facial profile while retaining the severely decayed lower right molar, and (2) extraction of both upper first bicuspids, lower first premolar, and lower right first molar to gain space for front tooth retraction. The lower right second molar would be protracted to replace the first molar and the third molar would be uprighted. Because the patient was concerned with the prognosis of the lower right first molar, we selected the second plan.

3.1.3 Treatment progress

Prior to orthodontic treatment, all three bicuspids and the decayed lower right first molar were extracted. Sequential placement of 0.012-in, 0.018-in, 0.016 × 0.022-in, 0.018 × 0.025-in super-elastic wire was performed to align the arch. In addition, a 0.018 × 0.025-in stainless wire was inserted as the working wire. Two TADs were placed in the upper arch for

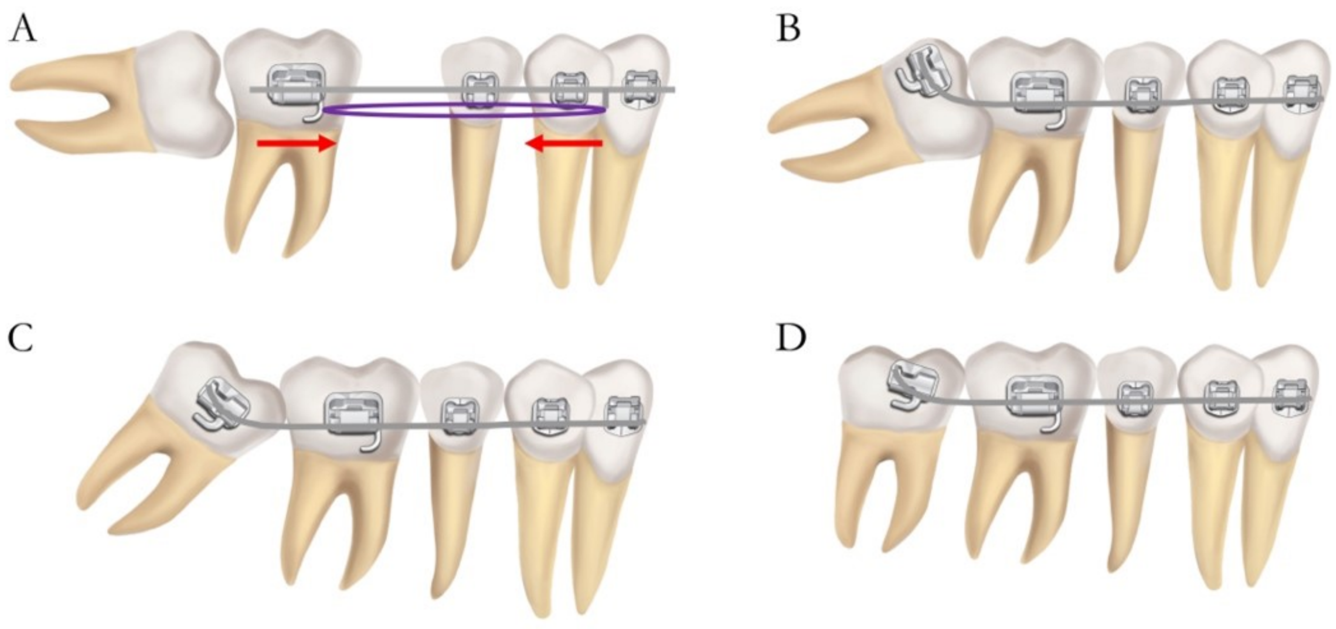


FIGURE 1. Strategies to upright 90° tilted third molars in subjects with extracted first molars. (A) Space closure on a stabilizing 0.0180 × 0.025-in stainless wire. (B) A buccal tube was bonded on the distal cusp of the partially spontaneous uprighted third molar and a 0.012-in super-elastic Ni-Ti archwire was placed. (C) The buccal tube was repositioned and tilted mesially once sufficient tooth surface was exposed after uprighting or by surgical procedures. Then, a 0.012-in Ni-Ti archwire was placed. (D) The tilted third molar was uprighted with a 0.018-in Ni-Ti archwire if needed.

FIGURE 2. Intra-oral photographs prior to treatment.

A

B

C

Item	Norms	Value
SNA	82.8±4.0	83.5
SNB	80.1±3.9	77.1
ANB	2.7±2.0	6.4
MP-FH	27.9±4.4	42.2
MP-SN	31.2±5.6	38.5
U1-SN	105.7±6.3	117.0
U1-NA	22.8±5.7	35.1
L1- MP	95.1±6.5	101.2
L1 - NB	25.3±5.7	42.1
Z Angle	61.2±4.3	51.2

FIGURE 3. Pre-treatment X-ray. (A) Panoramic radiograph. (B,C) Cephalograph and cephalometric measurement. Sella nasion subspinale angle (SNA); Sella nasion supramental angle (SNB); Subspinale nasion supramental angle (ANB); Mandibular plane angle (MP-FH); Angle between the anterior cranial base plane and the mandibular plane (MP-SN); Axial inclination of maxillary incisors to the anterior cranial base plane (U1-SN); Axial inclination of maxillary incisors to the nasion to the subspinale (U1-NA); Axial inclination of lower incisors to mandibular plane (L1-MP); Axial inclination of lower incisors to the nasion to the supramental (L1-NB); The posterior lower corner formed by the contour line of the chin lip soft tissue surface and the Frankort horizontal plane (Z Angle).

front tooth retraction but no TADs were placed in the lower arch.

In month 16, the space of the lower left first premolar was closed and the space of the lower first molar was almost closed. The third molar showed spontaneous upright rather than further mesial tilting (Fig. 4A). At this stage, a buccal tube was bonded onto the buccal side of the distal cusp, and a 0.012-in super-elastic Ni-Ti wire was placed. Two months later, the third molar was partially uprighted and the buccal tube was repositioned mesially with the buccal tube mesially over-tilted (Fig. 4B). Sequential placement of 0.012, 0.014 and 0.018-in Ni-Ti archwire was carried out to upright the third molar. The patient completed treatment in month 24.

3.1.4 Treatment results

The patient was satisfied with the results of both dental alignment and facial profile improvement. The patient showed appropriate intercuspation on both sides except that the lower second molar needed re-filling (Fig. 5A–E). After one year of retention, the uprighted third molar showed good stability (Fig. 5F). The lower right third molar was fully uprighted as shown in Fig. 6A. The profile was greatly improved with no clockwise rotation of the mandible (Fig. 6B,C).

3.2 Patient 2

3.2.1 Diagnosis and objectives

A 19-year-old girl came to the dental clinic with the chief complaint of protrusive incisors and lips. The patient had a congenital loss of the lower left lateral incisors. The first and second left mandibular molars were severely decayed and filled. Intraoral examination revealed a class I molar and canine relationship, and the patient had flared upper and lower front teeth with a normal profile (Fig. 7). The patient had a deep bite with a low mandibular angle in the cephalometric radiograph, and the lower third molar on the left side was horizontally impacted (Fig. 8).

The following treatment objectives were established: (1) to correct protrusion of the upper teeth, (2) to correct the deep overbite and overjet, and (3) to improve the facial profile.

As the patient showed severe dental and soft tissue protrusion, extraction of the bilateral upper first molars and lower right premolar was proposed to the patient as the preferred treatment plan. However, the lower left first molar was severely decayed, thus revealing a poor prognosis; therefore, an alternative plan was suggested which involved extracting the lower first molar on the left side, bringing forward the second molar and uprighting the third molar.

3.2.2 Treatment progress

Prior to orthodontic treatment, all three bicuspids and the decayed left right first molar were extracted. Alignment of the upper and lower arch was achieved by placement of 0.012-in, 0.018-in, 0.016× 0.022-in and 0.018 × 0.025-in super-elastic wire and then 0.018 × 0.025-in stainless wire was inserted as the stabilization wire. No TADs were placed in either the upper arch or lower arch as the patient had a hypodivergent mandibular angle.

In month 17, the space of the extracted lower first molar was closed with spontaneous uprighting of the third molar. A buccal tube was bonded onto the buccal side of the distal cusp and a 0.012-in Ni-Ti wire was inserted. Two months later, the third molar was partially uprighted and the buccal tube was repositioned mesially with the buccal tube more mesially tilted than its normal position (Fig. 9A,B). Sequential placement of 0.012, 0.014, 0.018-in Ni-Ti archwire was performed to upright the third molar (Fig. 9C,D).

3.2.3 Treatment results

The treatment was completed in month 27 with good intercuspation (Fig. 10). X-ray examination revealed complete uprighting of the horizontally-impacted third molar and retraction of the upper and lower incisors (Fig. 11).

4. Discussion

It is not uncommon to encounter patients with a horizontally impacted third molar and a severely decayed first molar. Uprighting the horizontally impacted third molars after second molar protraction in patients who need first molar extraction

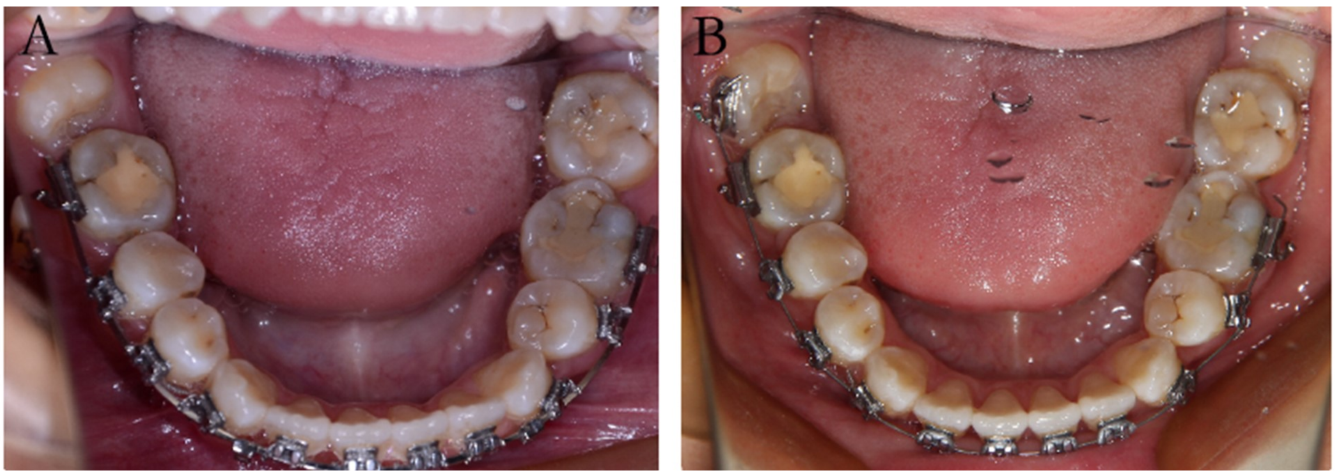


FIGURE 4. Treatment progress. (A) Spontaneous eruption and uprighting of the lower right third molar after second molar protraction. (B) Uprighting the third molar by a 0.012-in Ni-Ti wire after bonding a buccal tube.

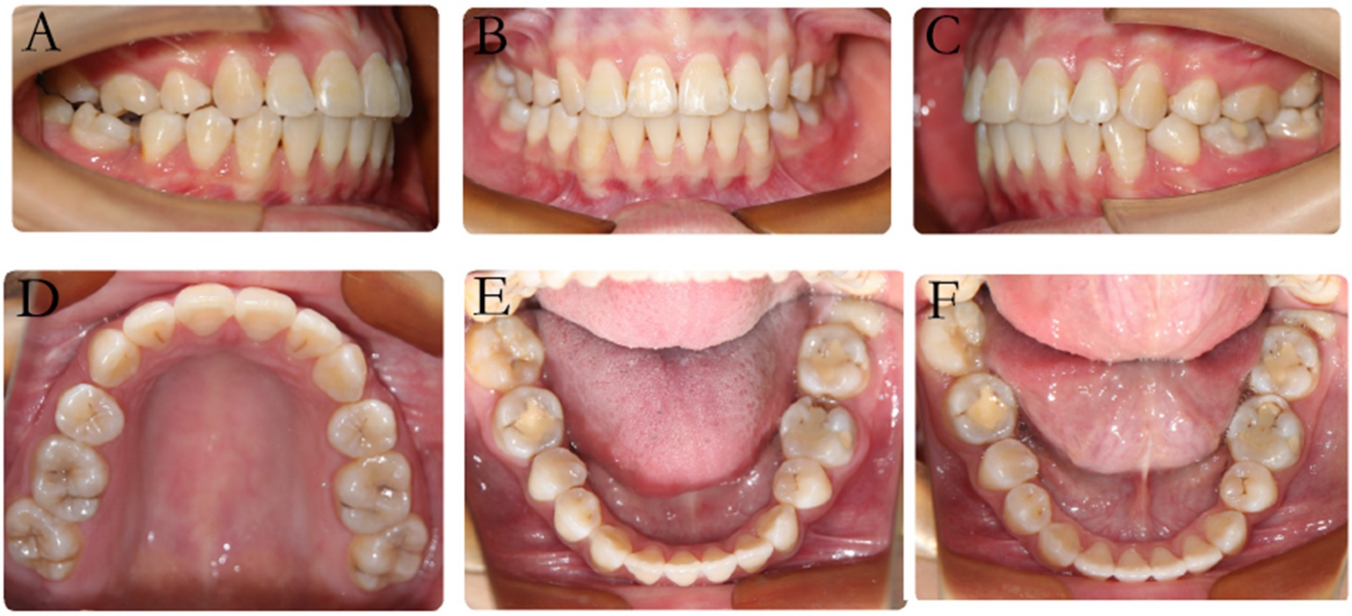


FIGURE 5. Treatment results. (A–E) Post-treatment intra-oral photographs. (F) One year follow-up.

is a significant challenge for orthodontists. Both closing the space of the first molar and uprighting the third molar need careful planning and significant clinical skills.

Previous studies have demonstrated successful protraction of the second molars by 8 mm to 12 mm [13]; this type of space closure is stable and is not associate with space reopening or an increased pocket depth [14]. This may be closely related to the smaller size of the second molar compared to the first molar which reduces cortical bone anchorage and facilitates second molar protraction. One interesting phenomenon is the spontaneous partial uprighting rather than further mesial tilting of the third molar; this is similar to the spontaneous eruption of the third molar after second molar extraction [15]. Such uprighting may be closely related to the existence of inter-septal periodontal fibers between second and third molars that exert evenly distributed gentle forces along the root of the third molars [16, 17].

Various methods of molar uprighting have been described in the literature and are associated with successful treatment results [16, 18]. The most commonly recommended technique is the utilization of a tip-back spring or a coil spring soldered onto the bands of the molars before the impacted teeth [19]. However, due to the anatomical traits of the buccal sulcus and vestibular depth, the placement of such springs may be demanding for orthodontist and irritating for the patient. Our new technique, which involves a super-elastic Ni-Ti wire, greatly reduces surgical difficulties and patient discomfort.

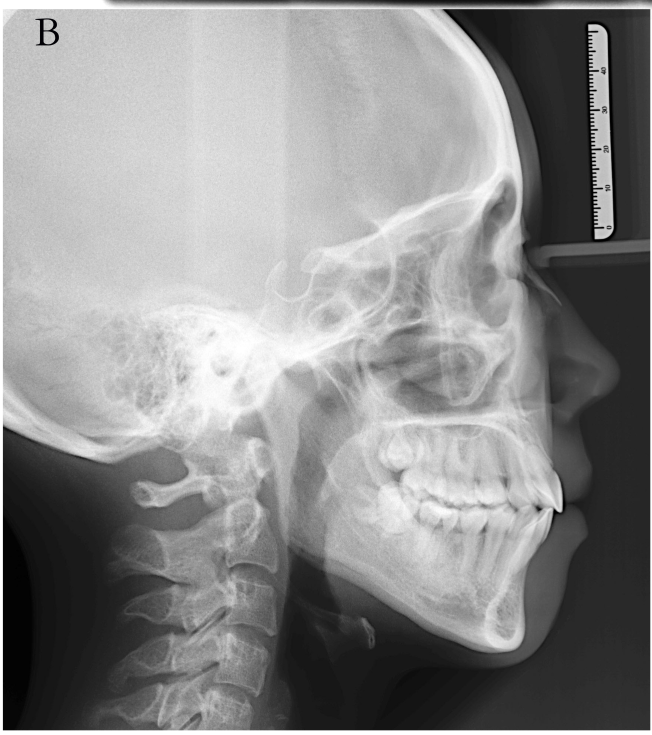
The other major concern in uprighting a horizontally impacted molar is the undesirable movement of the anchorage teeth, such as tipping, rotation, intrusion or extrusion of the adjacent teeth. Segmented mechanics with various types of spring have been designed for this specific purpose. For example, a previous report described the use of a 0.012-inch nickel titanium wire which was compressed and bonded to the first molars and primary second molars to unlock the first molars. The ectopically erupting first molars were unlocked successfully without any substantial movement of the primary teeth [20].

The six teeth before the third molar can counter the light reaction force, and our treatment results demonstrated no unwanted side effects during uprighting. Furthermore, no clockwise rotation of the mandible was observed in cephalometric analyses for the high angle case. To compensate the space between the archwire and buccal tube, we positioned the buccal tube with the mesial part tilted gingivally. This strategy guaranteed constant forces throughout the uprighting process and proved to be simple but efficient. The 90° tilting was corrected in less than 6 months.

The force (F) delivered by the wire is expressed by the formula: $F \approx dr4/l3$, where “d” represents deflection of the wire, “r” represents the radius of the wire, and “l” represents the length. In the initial stage of uprighting, we did not insert the archwire into the buccal tube of the second molars. These minor modifications in surgical procedures significantly increased the effective length of the archwire, and the applied force levels subsequently reduced by the power of three [16]. Furthermore, the utilization of super-soft Ni-Ti wire rather than bending complicated loops or springs significantly reduce the initial forces and provide a constant force. No wire bending is needed during this process; this means less chair time and does not require extensive surgical skills. In a previous study, Lau *et al.* [24] reported the successful uprighting of severely impacted mandibular second molars by a continuous archwire by pushing the second molar back with a 0.016 × 0.022-in wire which bypassed the first molar. Our technique further simplified the wire-bending process, and incorporated the second molar into the anchorage system, thus providing better control over reaction force.

A

B



C

Item	Norms	Value
SNA	82.8±4.0	80.5
SNB	80.1±3.9	75.2
ANB	2.7±2.0	5.3
MP-FH	27.9±4.4	33.5
MP-SN	31.2±5.6	40.7
U1-SN	105.7±6.3	97.2
U1-NA	22.8±5.7	16.9
L1- MP	95.1±6.5	93.3
L1 - NB	25.3±5.7	30.1
Z Angle	61.2±4.3	62.1

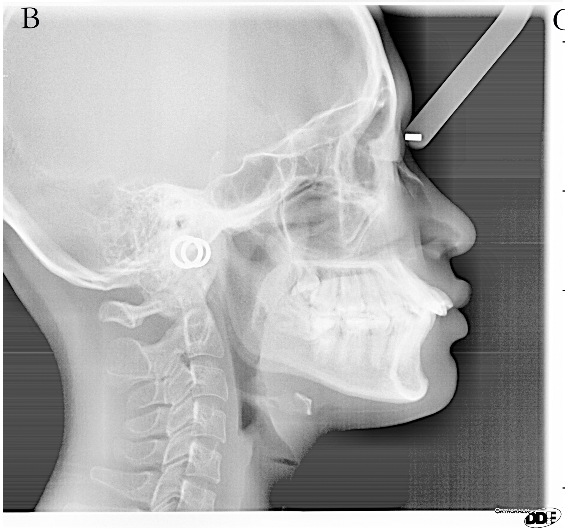
FIGURE 6. Radiographic examination after treatment. (A) Panoramic radiograph. (B,C) Cephalograph and cephalometric measurement. Sella nasion subspinale angle (SNA); Sella nasion supramental angle (SNB); Subspinale nasion supramental angle (ANB); Mandibular plane angle (MP-FH); Angle between the anterior cranial base plane and the mandibular plane (MP-SN); Axial inclination of maxillary incisors to the anterior cranial base plane (U1-SN); Axial inclination of maxillary incisors to the nasion to the subspinale (U1-NA); Axial inclination of lower incisors to mandibular plane (L1-MP); Axial inclination of lower incisors to the nasion to the supramental (L1-NB); The posterior lower corner formed by the contour line of the chin lip soft tissue surface and the Frankort horizontal plane (Z Angle).

Fear of anchorage control in uprighting mesially impacted second or third molars leads to the widespread use of TADs in the uprighting process. For example, Lorente *et al.* [10, 21] utilized miniplates in the retromolar region as skeletal anchorage for treating second molar impactions. However, it must be noted that miniplates have high rates of failure and mobility, difficulty with regards to maintaining oral hygiene, discomfort because of the size of the device in the retro-molar region [22]. Su-Jung reported the placement of two 2 mini-screws with slots that could accommodate rectangular orthodontic wires to push the horizontally impacted teeth backwards to upright tilted molars [18]. However, we must consider the risk of placing the mini-screw between the first and second premolars; furthermore, the overall failure rate is 24.2% for TADs [23].

FIGURE 7. Intra-oral photographs before treatment. Note the congenital loss of the lower left incisor and the largely-filled lower left first molar.

A

B



C

Item	Norms	Value
SNA	82.8±4.0	88.7
SNB	80.1±3.9	85.8
ANB	2.7±2.0	2.9
MP-FH	27.9±4.4	23.2
MP-SN	31.2±5.6	26.0
U1-SN	105.7±6.3	137.4
U1-NA	22.8±5.7	49.1
L1- MP	95.1±6.5	100.2
L1 - NB	25.3±5.7	32.1
Z Angle	61.2±4.3	71.0

FIGURE 8. Radiographic data before treatment. (A) Pre-treatment panoramic X-ray. Note the horizontally impacted lower left third molar. (B,C) Cephalometric radiograph and measurement. Sella nasion subspinale angle (SNA); Sella nasion supramental angle (SNB); Subspinale nasion supramental angle (ANB); Mandibular plane angle (MP-FH); Angle between the anterior cranial base plane and the mandibular plane (MP-SN); Axial inclination of maxillary incisors to the anterior cranial base plane (U1-SN); Axial inclination of maxillary incisors to the nasion to the subspinale (U1-NA); Axial inclination of lower incisors to mandibular plane (L1-MP); Axial inclination of lower incisors to the nasion to the supramental (L1-NB); The posterior lower corner formed by the contour line of the chin lip soft tissue surface and the Frankort horizontal plane (Z Angle).

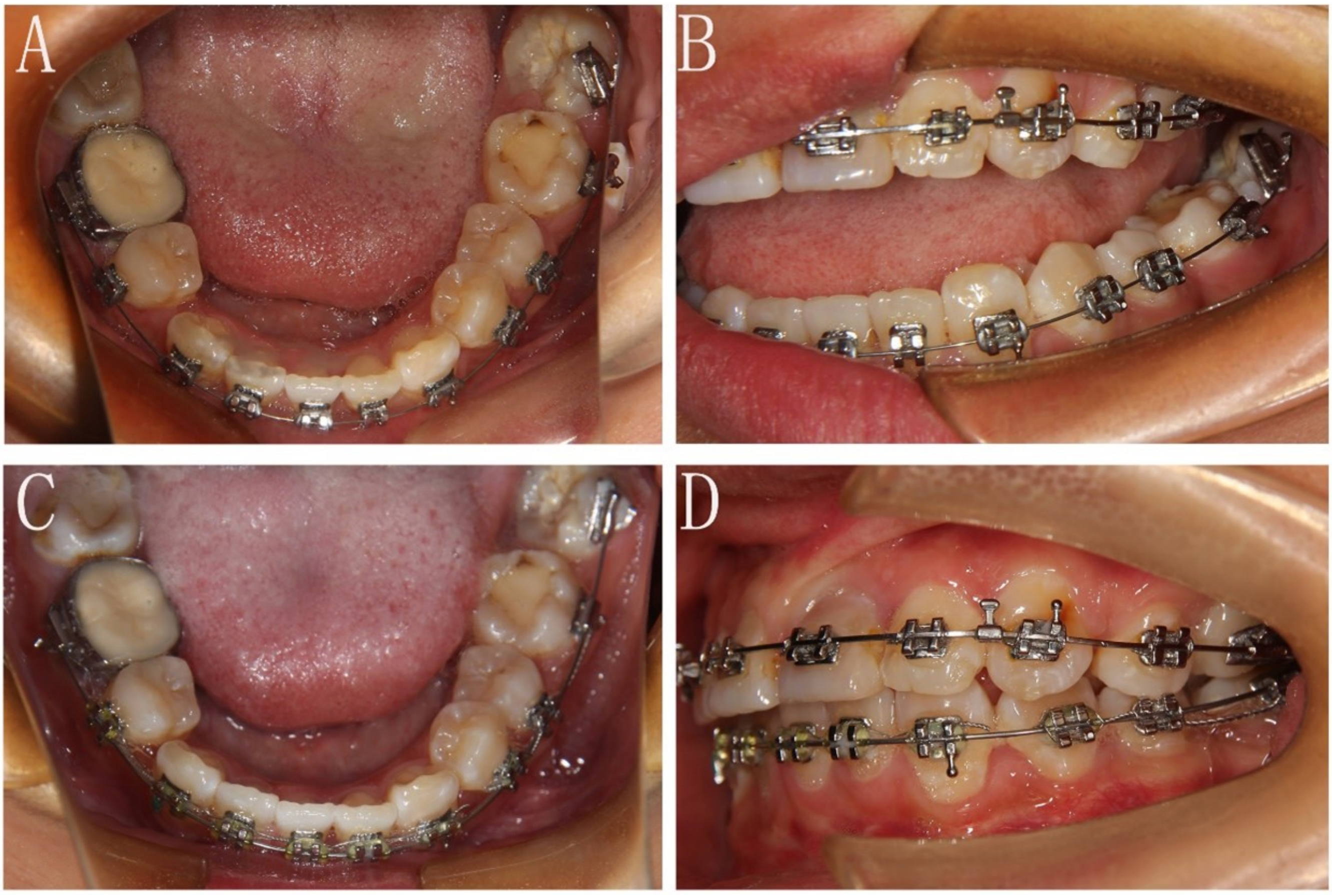
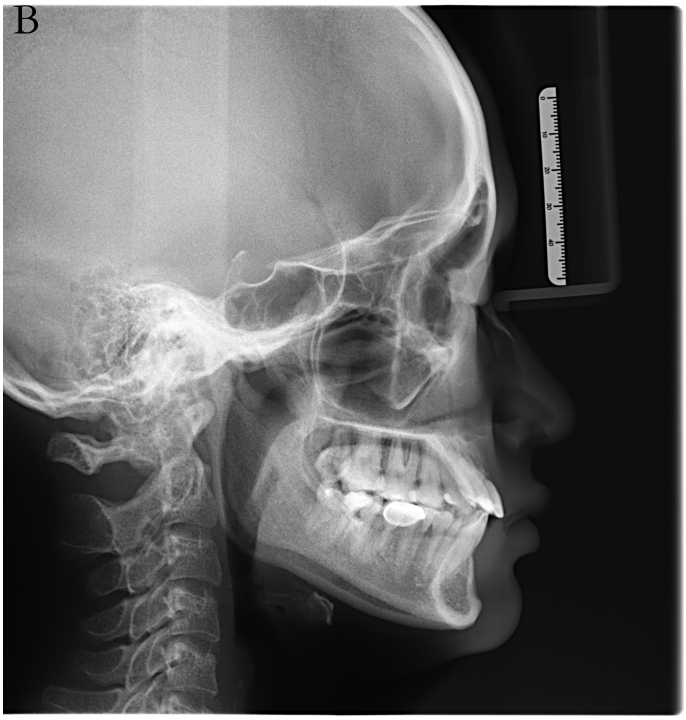


FIGURE 9. Procedures for uprighting horizontally impacted third molars. (A,B) Occlusal and buccal view of mechanics in month 18 after closing the extraction space of the lower left first molar. (C,D) The third molar was fully uprighted with a 0.018-in Ni-Ti wire.

FIGURE 10. Treatment results. Post-treatment intra-oral photographs.

A

B



C

Item	Norms	Value
SNA	82.8±4.0	88.2
SNB	80.1±3.9	85.77
ANB	2.7±2.0	2.5
MP-FH	27.9±4.4	25.5
MP-SN	31.2±5.6	35.0
U1-SN	105.7±6.3	120.0
U1-NA	22.8±5.7	31.3
L1- MP	95.1±6.5	100.2
L1 - NB	25.3±5.7	34.1
Z Angle	61.2±4.3	74.0

FIGURE 11. Radiographic examination after treatment. (A) Panoramic radiograph. (B,C) Cephalograph and cephalometric measurement. Sella nasion subspinale angle (SNA); Sella nasion supramental angle (SNB); Subspinale nasion supramental angle (ANB); Mandibular plane angle (MP-FH); Angle between the anterior cranial base plane and the mandibular plane (MP-SN); Axial inclination of maxillary incisors to the anterior cranial base plane (U1-SN); Axial inclination of maxillary incisors to the nasion to the subspinale (U1-NA); Axial inclination of lower incisors to mandibular plane (L1-MP); Axial inclination of lower incisors to the nasion to the supramental (L1-NB); The posterior lower corner formed by the contour line of the chin lip soft tissue surface and the Frankort horizontal plane (Z Angle).

The light forces in our biomechanical system minimized the anchorage burden on the teeth before the third molars.

This case report demonstrates that third or second molar uprighting can be completed by using a routine continuous wire system without bringing about unwanted biomechanical side effects. Such biomechanics eliminate the complicated wire-bending associated with traditional tip-back loops, and can be easily understood and mastered by both orthodontists and general dentists. Furthermore, such biomechanics significantly reduced surgical procedures and avoid the cost and risk of placing TADs in the lower arch.

5. Conclusions

The management of horizontally impacted third molars in cases with first molar extraction and second molar protraction is a significant orthodontic challenge. Our biomechanics method demonstrated that super-elastic Ni-Ti wire can be utilized to replace the traditional tip-back loop or cantilever, thus significantly reducing anchorage burden and can be used as an alternative to the routine straight wire system.

AVAILABILITY OF DATA AND MATERIALS

Not applicable.

AUTHOR CONTRIBUTIONS

LL and HXL—designed the research study, conception and design and manuscript final approval. YHZ—acquisition of data, drafting and revising of the manuscript. HMM—analyzed the data. All authors have read and agreed to the published version of the manuscript.

ETHICS APPROVAL AND CONSENT TO PARTICIPATE

This study was approved by the Ethics Committee of Nanjing Stomatological Hospital (approval number: 2019NL-064(KS)). Patients completed their treatment in Nanjing Stomatological Hospital at the Medical School of Nanjing University between 2015 and 2019. All patients began and finished their treatment in the University Hospital. All participants were informed that personal questions would be included and assured that their privacy would be protected. Participants were given the option to proceed or decline after reading this notice.

ACKNOWLEDGMENT

Not applicable.

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CONFLICT OF INTEREST

The authors declare no conflict of interest.

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