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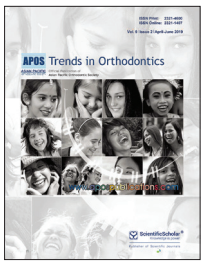

Case Report

Preformed intrusion bulbs on clear aligners facilitate active vertical control in a hyperdivergent skeletal Class II case with extraction: A case report with 4-year follow-up

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ABSTRACT

Active vertical control is critical in the treatment of hyperdivergent skeletal Class II malocclusion. The mechanics have been well shown as successful in the fixed appliance system with temporary anchorage devices (TADs); however, there are few relevant case reports in clear aligner therapy (CAT). The present case report describes the treatment of a severe hyperdivergent skeletal Class II case using CAT with the extraction of four premolars. Active vertical control was performed with TADs, which was facilitated by intrusion bulbs (IBs), that is, digitally designed and preformed vacuum bulbs on clear aligners for wearing intrusive elastics. The challenging camouflage case was finished with an improved profile and occlusion; specifically, the upper central incisors were intruded for 3 mm and the first molars for 1.8 mm, with counter-clockwise rotation of the mandible for 2.2° and a decrease of the ∠ANB for 2.6°. After a 4-year follow-up (the latter 2 years without retainers), the treatment results remain stable on the whole. According to the case report, camouflage treatment of hyperdivergent skeletal Class II case can be successfully achieved with active vertical control using TADs, facilitated by preformed IBs on the clear aligners.

Keywords: Clear aligner, Temporary anchorage device, Intrusion

INTRODUCTION

For camouflage treatment of hyperdivergent skeletal Class II malocclusion, active vertical control is critical, which comprises intrusion of the dentition to induce counter-clockwise rotation of the mandible.[1] Conventionally, the maxillary intrusion force is exerted through the high-pull J-hook. In recent years, temporary anchorage devices (TADs) have been widely used for active vertical control in fixed orthodontic treatment.[2] The TADs have apparent advantages over the high-pull J-hook for active vertical control and thus have further promoted the camouflage treatment of hyperdivergent skeletal Class II malocclusion.[3]

On the other hand, clear aligner therapy (CAT) has become increasingly popular due to its aesthetics and comfortableness. However, extraction cases, especially those with mild crowding while protrusion, remain problematic in CAT, with a high risk of the "roller coaster" effects due to the softness of the thermoplastic aligners.[4] Therefore, anterior vertical control is of particular importance in CAT extraction cases. A bimaxillary protrusion case with a gummy smile has been successfully treated with TADs for anterior vertical control.[5] In the treatment of hyperdivergent skeletal Class II malocclusion with CAT, active vertical control is even more challenging, since it relies on the patient's best compliance for wearing elastics persistently to intrude the whole dentition.

Here, we report a severe hyperdivergent skeletal Class II case treated using CAT with four premolars extraction, in which active vertical control was successfully achieved with TADs and preformed intrusion bulbs (IBs) on the aligners.

CASE REPORT

Diagnosis and etiology

A 31-year-old female came to our office with the chief complaint of her protrusive profile. She claimed no medical, family, or psycho-social history. The clinical examination showed incompetent lips, an average nasolabial angle, an obtuse chin-throat angle, and a convex lateral profile. No temporomandibular disorder symptom was observed during the consultation and clinical examination. Intraoral examination showed a 4.1 mm overjet and a 2.4 mm overbite, with a slight angle Class II molar relationship on both sides. There was slight crowding in both arches. The patient had silver amalgam fillings in the mandibular left first and second molars. All third molars were presented in the oral cavity [Figure 1].

The cephalometric analysis [Table 1] showed a skeletal Class II relationship (∠ANB 9.6°) with a hyperdivergent growth pattern (SN-MP 41.7°, FMA 33.4°). The maxillary anterior teeth were already retroclination slightly (U1-SN 100.3°), while mandibular anterior teeth were proclined (L1-MP 107.6°). An excessive height of the maxillary incisors (U1-PP 30.8 mm) was observed.

The patient was diagnosed with Class II, mild crowding, mandibular retrusion, and hyperdivergent growth pattern. Informed consent from the patient was obtained before treatment.

Treatment alternatives

Based on the diagnosis, two treatment options were discussed with the patient. Orthodontic treatment combined with orthognathic surgery was recommended as option one for the patient who had a severe skeletal Class II relationship with obvious mandibular retrusion. Orthodontic treatment with extraction of four first premolars and retraction and intrusion of anterior teeth with TADs was proposed as option two. Both treatment options required the extraction of four third molars. The patient refused surgery and chose option two. The patient was informed of the relatively limited improvement of the facial profile of orthodontic camouflage treatment compared with orthodontic treatment combined with orthognathic surgery and adhered to option two.

Treatment objectives

The treatment objectives were to (1) level and align both dental arches; (2) retract and intrude anterior teeth; (3) achieve Class I canine and molar relationship; and (4) improve the facial and dental aesthetics.

Treatment progress

The patient chose clear aligners (Angelalign, Wuxi, China) for aesthetics under the awareness of potential effects and risks. The clear aligner software named iOrtho was used to previsualize the treatment progress and design the required tooth movement.

Initial treatment (R0)

In the initial treatment, a total of 60 sets of aligners were used to level and align both dentitions and retract anterior teeth.

The setup model had been deliberately designed to finish with 1.5 mm overbite and overjet, and proclined upper incisors (10–13° lingual torque for root) for over-correction. The designed amount of posterior teeth mesialization was about 1.5 mm in the maxillary arch, and 2.1 mm in the mandibular arch. Vertical rectangle attachments were prescribed on posterior teeth and canines to optimize teeth angulation during space closure. The patient was required to wear each aligner for at least 22 h/day for 10 days.

In total, 4 TADs were implanted for maxillary AP and vertical control. Two TADs (length, 8 mm and diameter, 1.4 mm; Ormco Corporation, Glendora, CA, USA) were implanted between the maxillary lateral incisors and canines to improve active vertical control, with elastics on the IBs incorporated in the aligners. IB is a special type of attachment incorporated in some clear aligner systems, which is a bulb-shaped vacuum prominence designed by the orthodontist in the digital simulation and then preformed on the aligners by the factory, especially intended for wearing intrusion elastics [Figure 2]. The patient was required to wear elastics (3/16 inch, 3.5 oz; 3M Unitek, Monrovia, CA, USA) for at least 22 h/day. The other two TADs (length, 10 mm and diameter, 2 mm; Ormco Corporation, Glendora, CA, USA) were implanted at the interdental sites of the maxillary first and second molars to reinforce the AP and vertical control. Elastics (1/4 inch, 6 oz; 3M Unitek, Monrovia, CA, USA) were used between the TADs and cut hooks on the maxillary canines [Figure 3].

After 21-month treatment (#55), the extraction spaces were almost closed and the patient's profile was significantly improved. A slight Class II molar relationship was observed on the right side, and the maxillary and mandibular midlines shifted to the right side about 0.5 mm. The panoramic radiograph showed the roots of the 4 canines were not paralleling [Figure 3]. According to the cephalometric analysis, the actual intrusion of the upper incisors was as

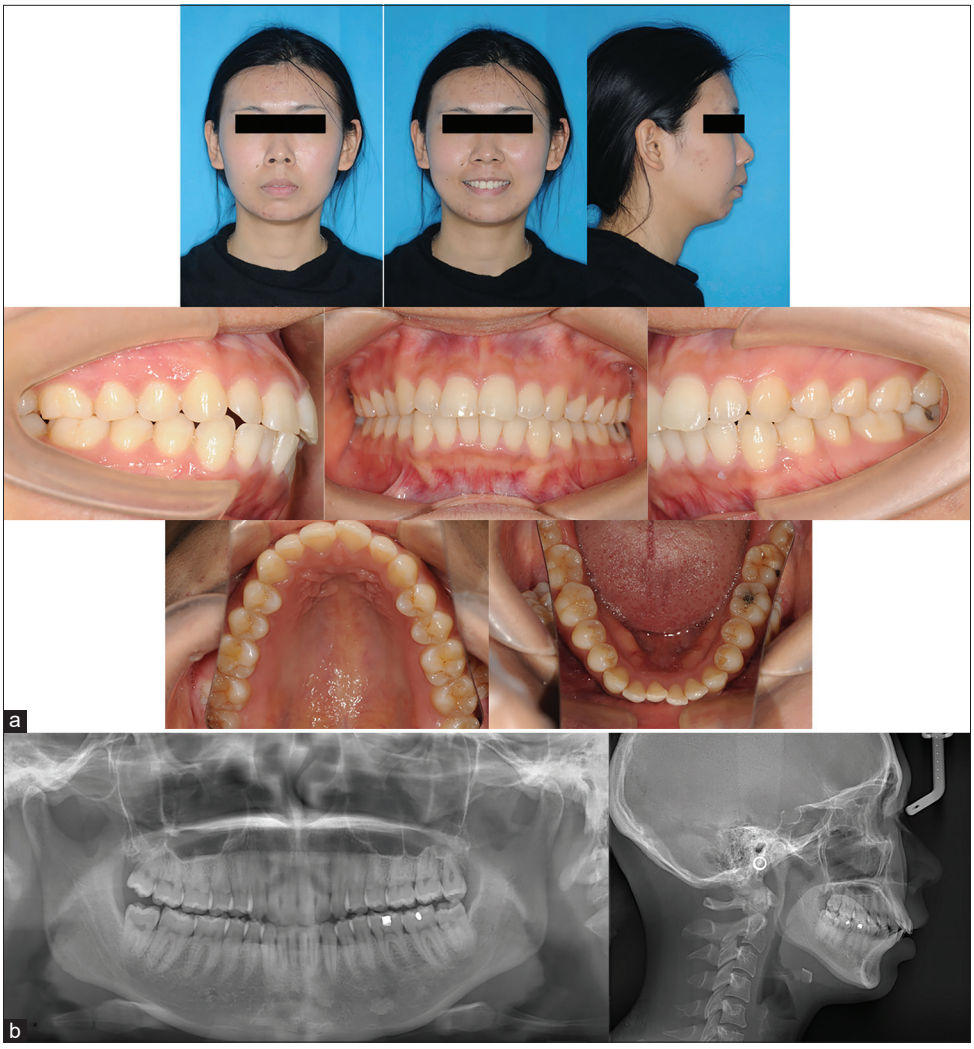

Figure 1: The patient was diagnosed with Class II, mild crowding, mandibular retrusion, and hyperdivergent growth pattern. (a) Pretreatment facial and intraoral photographs. (b) Panoramic and cephalometric radiographs.

large as 2.8 mm [Table 1]. Aligners #56–60 were not used, and the refinement was prescribed for further improvement.

Refinement phase (R1)

The first refinement involved 16 sets of aligners. On the mandibular first molars, the mesial vertical rectangle attachments were replaced with the cut-outs to bond buttons for Class II elastics; on the maxillary canines, the vertical rectangle attachments were changed to horizontal rectangle attachments to improve the root angulation, and the cut-outs were added to bond buttons for Class II elastics. To maintain the effects of active vertical control, the IBs were reserved in R1, and elastics were used as previously. About 5° root tipping was added on teeth adjacent to the extraction space for root paralleling. The remaining minor spaces in both dentitions were used to improve the dental midlines. Class II elastics (3/16 inch, 3.5oz; 3M Unitek, Monrovia, Calif) between the clear buttons on the maxillary canines and the buttons on the mandibular first molars were used to improve the molar relationship [Figure 4].

Treatment results

After a total of 71 sets of aligners (55 sets for R0 and 16 sets for R1), all attachments were debonded and the TADs were removed. The post-treatment photographs showed an improved profile and an aesthetic smile. A satisfactory dental alignment and Class I canine and molar relationships were obtained [Figure 4]. The patient was satisfied with the treatment results.

The panoramic radiograph showed paralleled roots, except that the lateral incisors were slightly tipped distally,

Table 1: Cephalometric analyses before, during and after the treatment.

Measurement	Normal	Before	R0 finish	R1 finish	4-year follow-up
Skeletal					
SNA (°)	83.0	84.3	82.3	82.4	81.7
SNB (°)	80.0	74.7	75.9	75.4	74.8
ANB (°)	3.0	9.6	6.4	7.0	6.9
SN-MP (°)	30.0	41.7	38.6	39.5	39.9
FMA (°)	26.0	33.4	30.5	31.2	31.6
S-Go/N-Me (%)	64.0	58.8	58.6	59.7	62.6
Dental					
U1-L1 (°)	124.0	110.4	142.9	145.8	140.0
U1-SN (°)	106.0	100.3	89.7	85.8	88.0
U1-NA (mm)	5.0	2.1	2.2	2.4	2.5
U1-NA (°)	23.0	16.0	6.2	3.4	6.3
L1-NB (mm)	7.0	12.5	5.0	5.4	6.4
L1-NB (°)	30.0	44.0	23.3	23.8	26.8
U1-PP (mm)	28.0	30.8	28.0	27.8	28.1
U6-PP (mm)	22.0	19.2	19.7	17.4	18.0
L1-MP (°)	97.0	107.6	88.7	89.0	92.0
L1-MP (mm)	42.0	42.4	41.2	40.2	41.0
L6-MP (mm)	34.0	34.3	33.1	32.3	32.4
Overjet (mm)	2.0	4.1	4.0	2.6	2.7
Overbite (mm)	3.0	2.4	2.4	2.5	3.4
Profile					
UL to E-plane (mm)	−1.0	3.4	1.0	0.6	0.4
LL to E-plane (mm)	1.0	5.7	1.3	0.6	1.4
Nasolabial angle (°)	95.0	92.7	111.2	109.8	108.0
Z-angle (°)	77.0	48.2	63.3	64.0	60.6

S: Sella, N: Nasion, Go: Gonion, Me: Menton, A: A point, B: B point, U1: Upper central incisor, L1: Lower central incisor, U6: Upper first molar, MP: Mandibular plane, FMA: Frankfort-mandibular plane angle, UL to E-plane: Distance from the upper lip to the E line, LL to E-plane: Distance from the lower lip to the E line

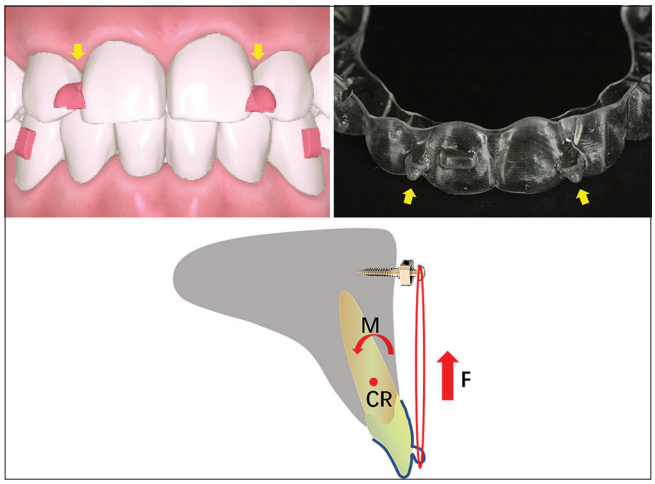

Figure 2: Models and mechanics of intrusion bulbs (IBs). The labial intrusive force between IBs and temporary anchorage devices produces active vertical control and labial-crown torque. F: Force; M: Moment, CR: Center of resistance. Yellow arrows indicate IBs.

which would be discussed later [Figure 4]. According to cephalometric analysis [Table 1], the U1-PP decreased by 3 mm, and the U6-PP decreased by 1.8 mm; notably, the FMA decreased from 33.4°to 31.2°, indicating mandibular counter-clockwise rotation of 2.2°. While the ∠ANB decreased from 9.6° to 7.0°, indicating improvement of the skeletal Cl II relationship. The superimpositions also manifested intrusion of the upper dentition and the mandibular counter-clockwise rotation, leading to the advancement of the chin [Figure 4]. Worthy of mention, no significant root resorption was observed even after such a large amount of dental intrusion [Figure 4].

The patient was instructed to wear clear retainers full-time for the 1st year followed by night wearing for another year. No significant relapse was observed in her profile and occlusion after 1-year retention [Figure 5]. After 4-year follow-up (the latter 2 years without retainers), although a slight relapse was detected, the treatment results remained stable on the whole [Figure 6]. Of note, the FMA had no significant change 4 years after the treatment, implying good stability of the mechanics used for active vertical control in the present case [Table 1]. To our surprise, the panoramic radiograph showed even more paralleled roots of the upper lateral incisors, which would be discussed later [Figure 6].

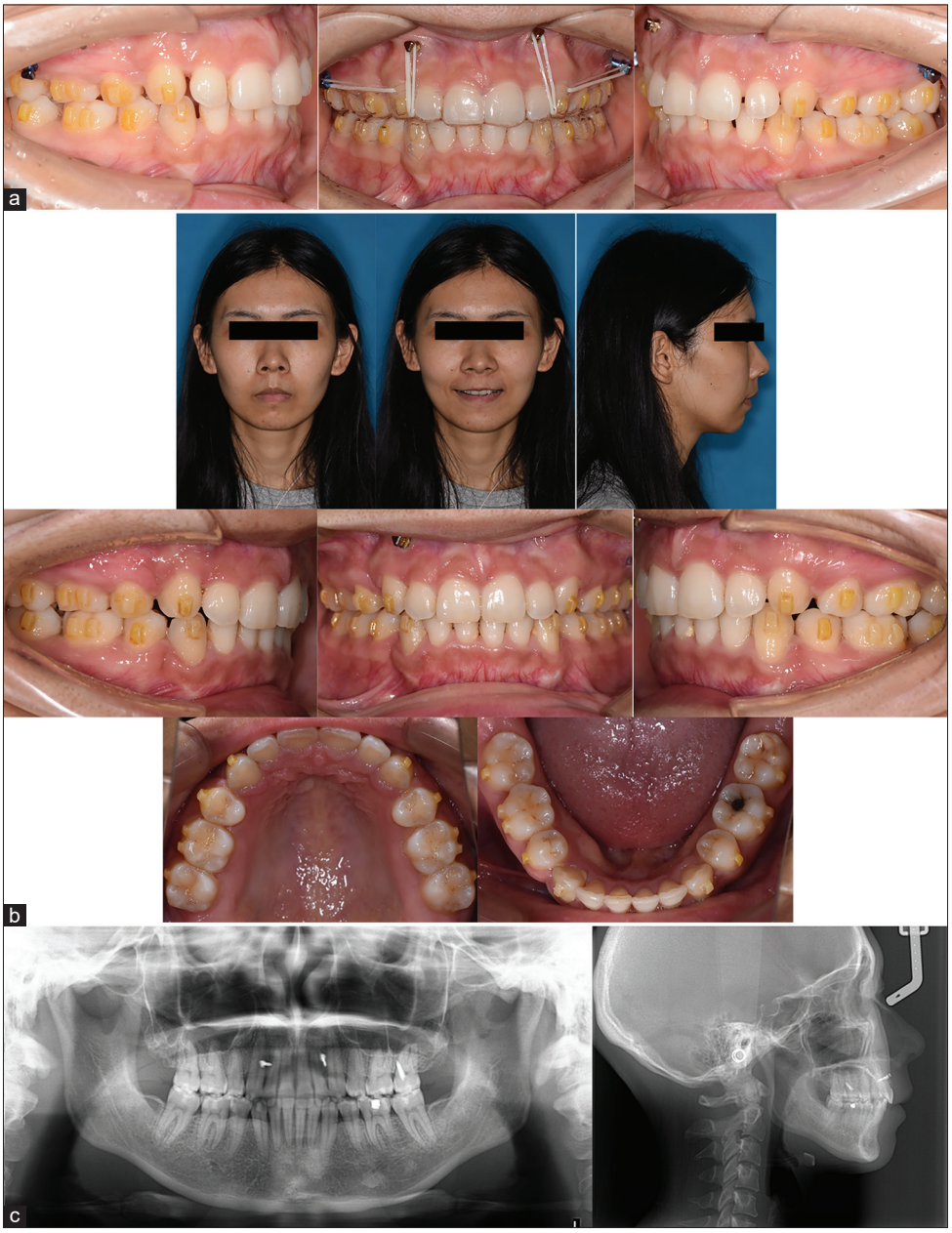

Figure 3: Treatment progress and treatment results of R0. (a) Intrude and retract anterior teeth with 4 temporary anchorage devices during R0. (b) Facial and intraoral photographs. (c) Panoramic and cephalometric radiographs.

DISCUSSION

At present, the treatment of premolar extraction cases using clear aligners remains challenging. It has been found that central incisors have more lingual/palatal tipping and extrusion, and less retraction compared with the designed movement in the software in premolar extraction cases, resulting in deepening overbite, and sometimes even anterior premature contact coupled with posterior open bite, which greatly ruins the treatment results.[6] Maxillary labial TADs might be the most effective way to prevent extrusion of the maxillary anterior teeth during retraction, thus avoiding the so-called "roller coaster" effects.[7]

"Active vertical control" in this context, means not only preventing extrusion but also eliciting true intrusion of the teeth, which is the effective mechanic for the treatment of the gummy smile and/or hyperdivergent malocclusion.[2,5] Hyperdivergent skeletal Class II malocclusion with mandibular retrognathia requires counter-clockwise rotation of the mandible through active

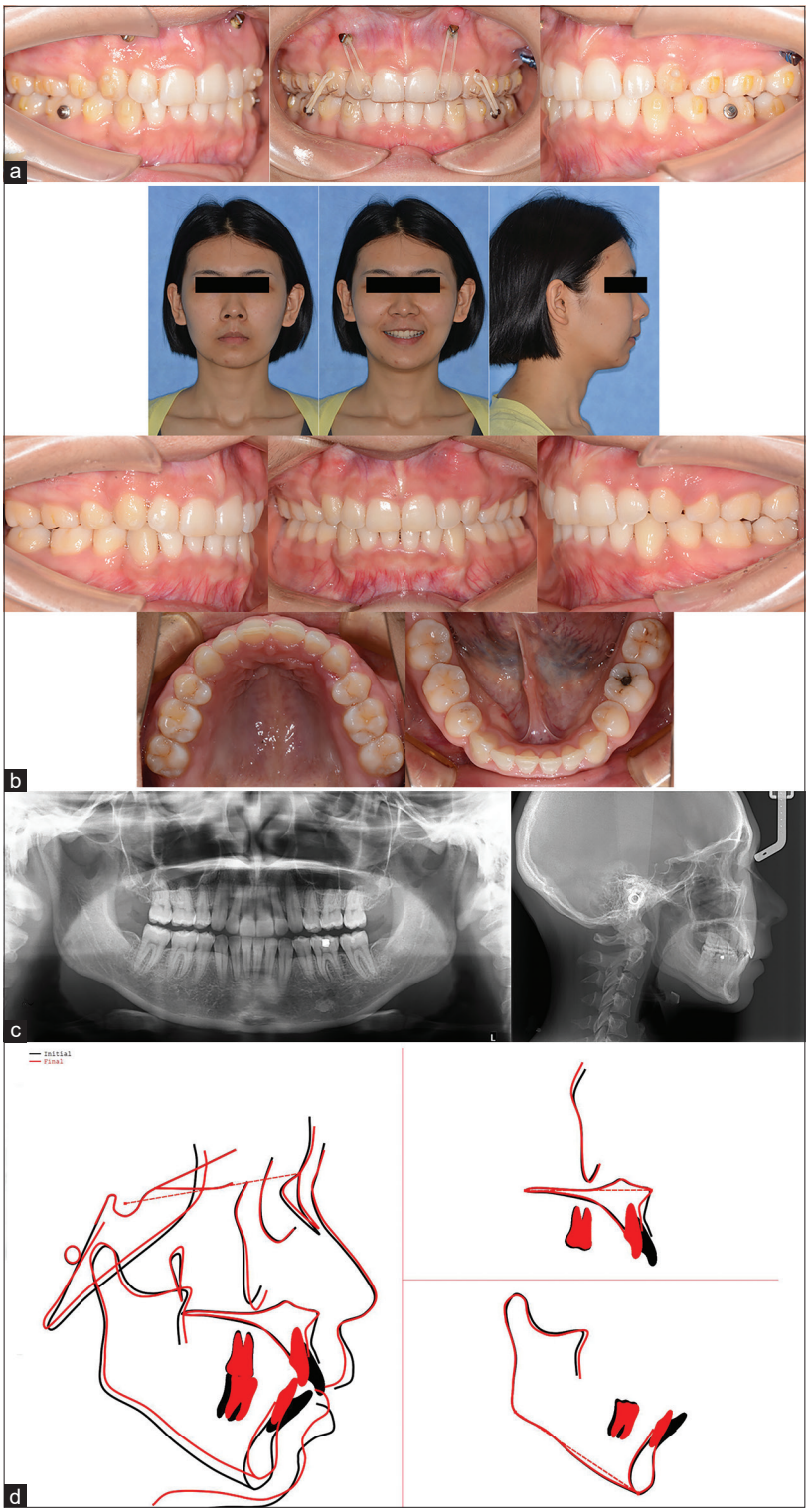

Figure 4: Treatment progress and treatment results of R1. A satisfactory profile, dental alignment and Class I canine and molar relationships were obtained along with improved skeletal relationship and counter-clockwise rotation of the mandible. (a) Class II elastics to establish Class I occlusion during R1. (b) Facial and intraoral photographs. (c) Panoramic and cephalometric radiographs. (d) Cephalometric superimpositions. Black, pretreatment; Red, post-treatment.

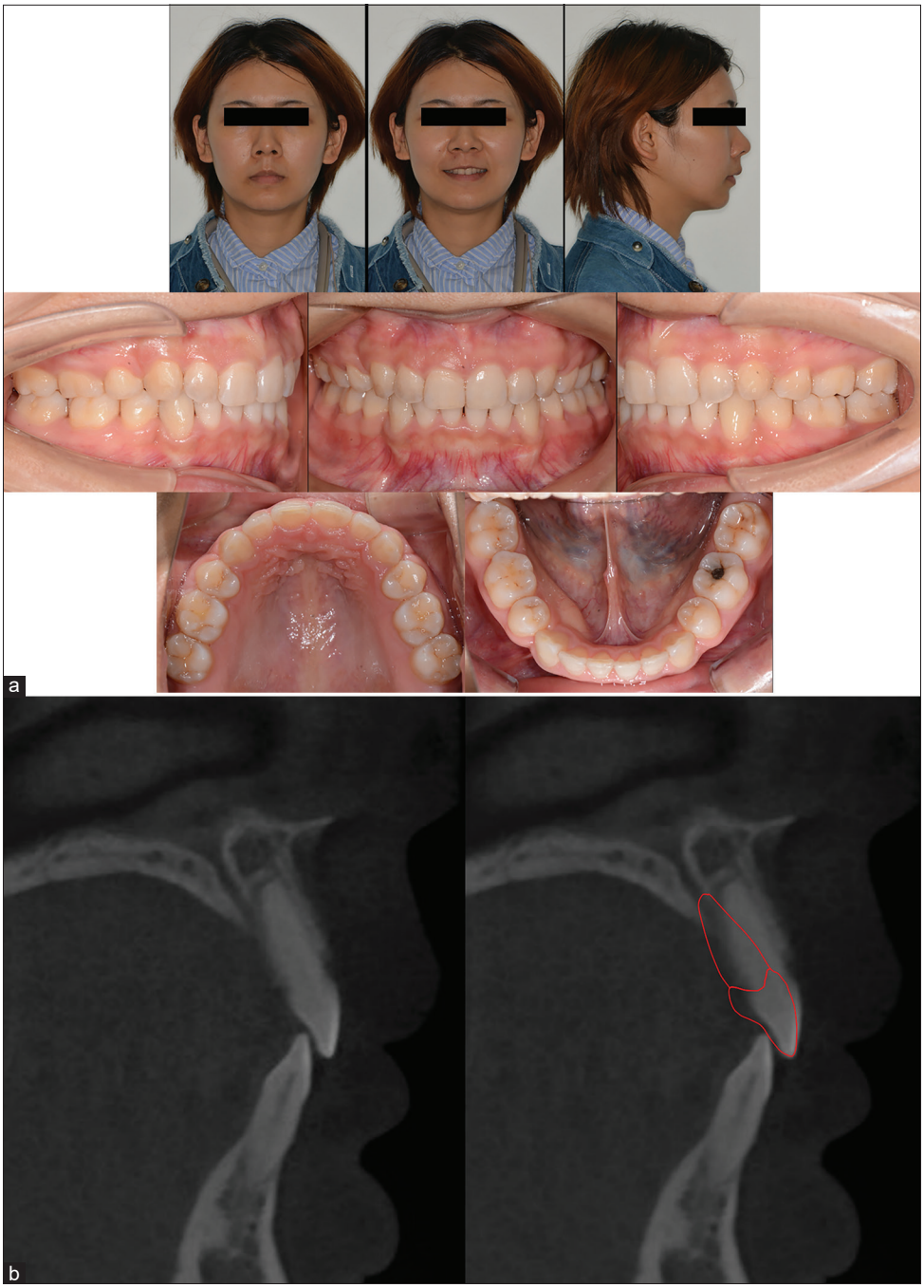

Figure 5: (a) Facial and intraoral photographs after 1-year follow-up. (b) The cone beam computed tomography of the upper incisor after treatment (left) and schematic diagram of retroclination upper incisors for skeletal Class II relationship compensation. The red outline indicates that if the upper central incisors had been finished with "normal" labiolingual inclination, the roots may well have moved out of the thin alveolar bone (right).

vertical control to improve the facial profile.[8] In the present case, elastics on the 4 TADs intruded U1 for 3 mm and U6 for 1.8 mm, leading to counter-clockwise rotation of the mandible for 2.2° and a decrease of the ∠ANB for 2.6°. The effects of active vertical control remained stable 4 years after the treatment. Collectively, the mechanics of active vertical control works well in hyperdivergent skeletal Class II malocclusion treated with CAT.

On the other hand, although CAT generally has better vertical control for posterior teeth thanks to its occlusal splint effect,

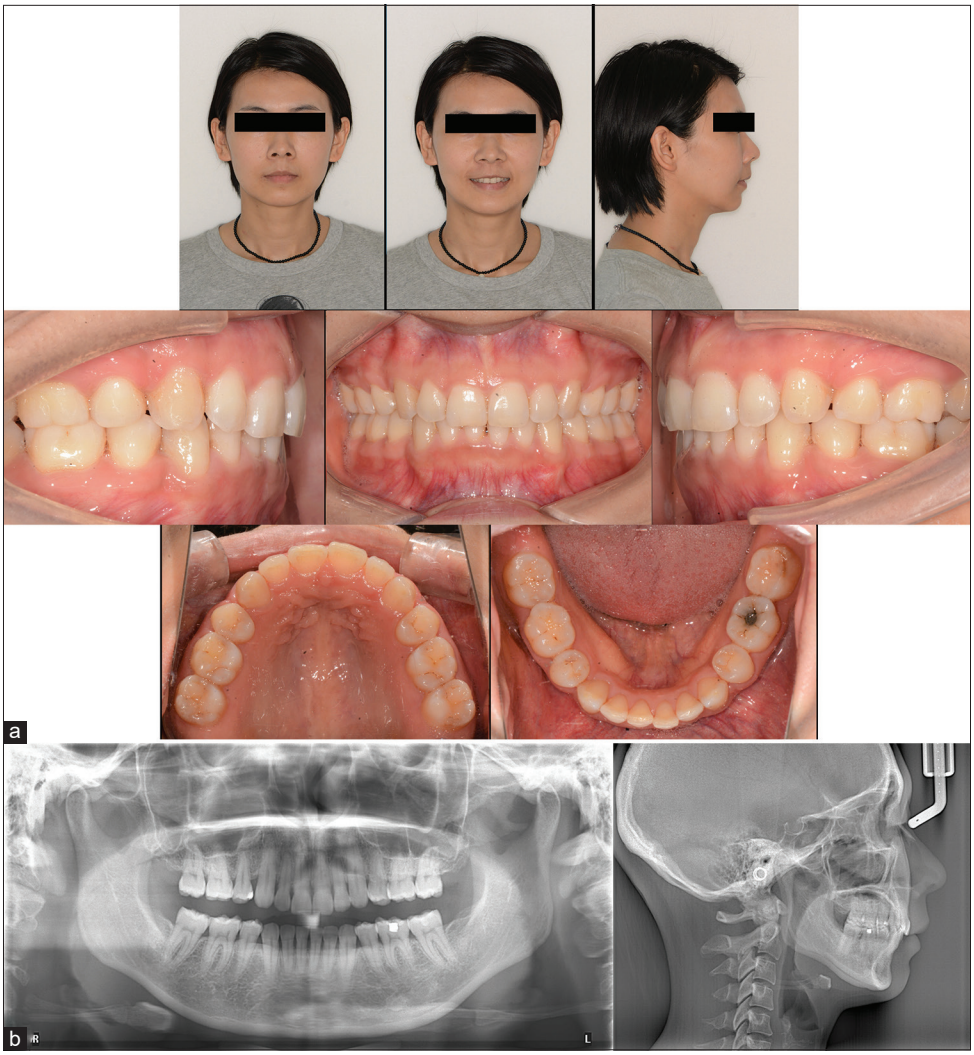

Figure 6: Stable treatment results after 4-year follow-up. The panoramic radiograph showed improved root parallelism of the upper lateral incisors. (a) Facial and intraoral photographs. (b) Panoramic and cephalometric radiographs.

it might be less efficient for the true intrusion of the dentition by TADs, since the effect relies on the patient's compliance to wear elastics and the pulling force can never be continuous like that in the fixed appliance system with a power chain. Just as a coin has two sides, though the intermittent force in CAT might be less efficient for substantial intrusion, it might lead to less root resorption.[9]

The intrusive force line generated by the IBs-TADs elastics passed labially to the center of resistance of the upper incisors, theoretically providing a labial crown torque moment for maxillary anterior teeth [Figure 2]. Although the upper central incisors seem to be somewhat retroclination, the roots of the upper incisors were safely located in the alveolar bone, as shown in the post-treatment cone beam computed tomography images. And if the present normal overjet was kept while the lingual root/labial crown torque of the upper incisors was added, the roots might move out of the alveolar bone followed by risks of palatal dehiscence [Figure 5]. Thus, the relative retroclination of upper incisors was acceptable for the present case. Notably, in the fixed appliance system, torque control can be easily supplemented with axillaries like the crimpable gate spring.[10] In CAT, however, approaches for incisor torque control during retraction are quite limited, including attachments, power ridges and over-correction set-up, the effects of which remain to be elucidated.

The finish panoramic radiograph showed slight distal tipping of the upper lateral incisors [Figure 4]. Interestingly, 4 years later (the latter 2 years without retainers), the tipping seemed to improve with better root paralleling [Figure 6], indicating that the previous tipping might be caused by the interdental TADs interfering with the roots of the incisors. Such interferences must be taken into consideration when determining the

position of implantation. Extra-alveolar TADs are advocated by some orthodontists.[2] The assistant position system for TADs is helpful as well. For the present case, another option might be putting just one mini-implant between the central incisors, to avoid interferences with the roots during anterior retraction.

Since intensive elastics wearing is pivotal for active vertical control in CAT, an "easy-going" way for this purpose is also important. As there are no such things as crimpable hooks in CAT, intrusive elastics are usually put on the plier-made hooks on aligners. Lin *et al.*[5] also reported "inwardly inclined" cuts on the palatal surface of aligners to wear intrusion elastics. Nevertheless, these hand-made hooks are somehow time-consuming and relatively technique sensitive. Therefore, the IBs used in the present case, which are bulb-shaped structures predesigned and thermoformed on the aligners, provide an easy option for vertical control with TADs in CAT.

CONCLUSION

Camouflage treatment of a severe hyperdivergent skeletal Class II case with the extraction of four premolars was successfully achieved with active vertical control using TADs, facilitated by preformed IBs on the clear aligners.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent.

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Nil.

Conflicts of interest

There are no conflicts of interest.

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