Severe Open Bite Correction and 5-mm Mandibular Arch Distalisation without Skeletal Anchorage: 4-year Follow-up of a Case of Nonsurgical Orthodontic Treatment of Adult Skeletal Class III Malocclusion

Jian Han REN[1], Wei Cai WANG[1], Chen ZHOU[1], De Lan HUANG[1], Run Ze LI[1], Zhi Cai FENG[1], Yi Jia CHEN[1], Xi WANG[1], Yang CAO[1], Bin CAI[1], Bai Cheng BAO[1]

Ideally, orthognathic surgery is indicated to treat skeletal Class III malocclusion with severe open bite in adults. In this borderline case, however, camouflage treatment without any skeletal anchorage was chosen. This report describes the orthodontic treatment of a 23-year-old man who presented with multiple orthodontic problems including severe open bite of the anterior and posterior teeth up to the first molars, bilateral posterior crossbite, bilateral Class III molar relationship, severe crowding, increased vertical dimension, and dental and facial midline deviation. The treatment included the extraction of four wisdom teeth, uprighting and distalisation of the mandibular arch with molar intrusion using curved NiTi wires with intermaxillary elastics. After 36 months of treatment, satisfactory improvements in the vertical overlap, horizontal overlap and sagittal malocclusion were achieved. The design of the mechanical system used in this case confirmed stable results at the 4-year follow-up.

Key words: *anchorage, molar distalisation, open bite, skeletal class III malocclusion*
Chin J Dent Res 2020;23(4):297–307; doi: 10.3290/j.cjdr.b867899

Adult skeletal Class III malocclusion is a challenging problem for orthodontists, especially if it is combined with open bite and increased skeletal vertical dimension for which orthognathic surgery is considered the ideal treatment option[1,2], although orthodontic camouflage may be considered if the patient rejects the surgical option[3,4]. In this case, the treatment objectives should include distalising the mandibular arch and intruding and uprighting the overerupted molars with mesial tipping. To achieve these goals, multiloop edgewise arch wire (MEAW)[5-7] or upper accentuated curve and lower reverse curve nickel titanium (NiTi) arch wires with intermaxillary elastics[8,9] are recommended in conventional methods. However, if there is a large amount of distalisation of mandibular dentition and molar uprighting/intrusion is needed for better control, most orthodontists select temporary anchorage devices (TADs). Although TADs are considered effective and recommended[10-13], their side effects such as difficulties of placement in the posterior area, uncertain stability and inflammation have limited their application in some cases[14].

In the present case, we pushed the limits of reverse curve NiTi archwire and intermaxillary elastics, without any skeletal anchorage, to stably distalise the mandibular arch by 5 mm, rotate the occlusal plane counterclockwise and correct severe open bite. The orthodontic treatment resulted in satisfactory outcomes with improved occlusion and an acceptable profile for the patient, who declined orthognathic surgery and any invasive approach. No further morphological changes of the condyles were observed after treatment and 4 years later.

1 Department of Orthodontics, Guanghua School and Hospital of Stomatology, Sun Yat-sen University, Guangdong Provincial Key Laboratory of Stomatology, Guangzhou, P.R. China.

Corresponding author: Dr Bai Cheng BAO, Department of Orthodontics, Guanghua School and Hospital of Stomatology, Sun Yat-sen University, 56 Lingyuan Road West, Guangzhou, Guangdong 510055, P.R. China. Tel: 86-02-83802802; Fax: 86-02-83822807. Email: baobaicheng@163.com

This work was supported by the National Natural Science Foundation of China (grant number 81600824); Guangdong Provincial Natural Science Foundation (grant number 2016A030310220, 2018A030310278); and Young Teachers Training Program of Sun Yat-sen University (grant number 16ykpy46, 17ykpy73).

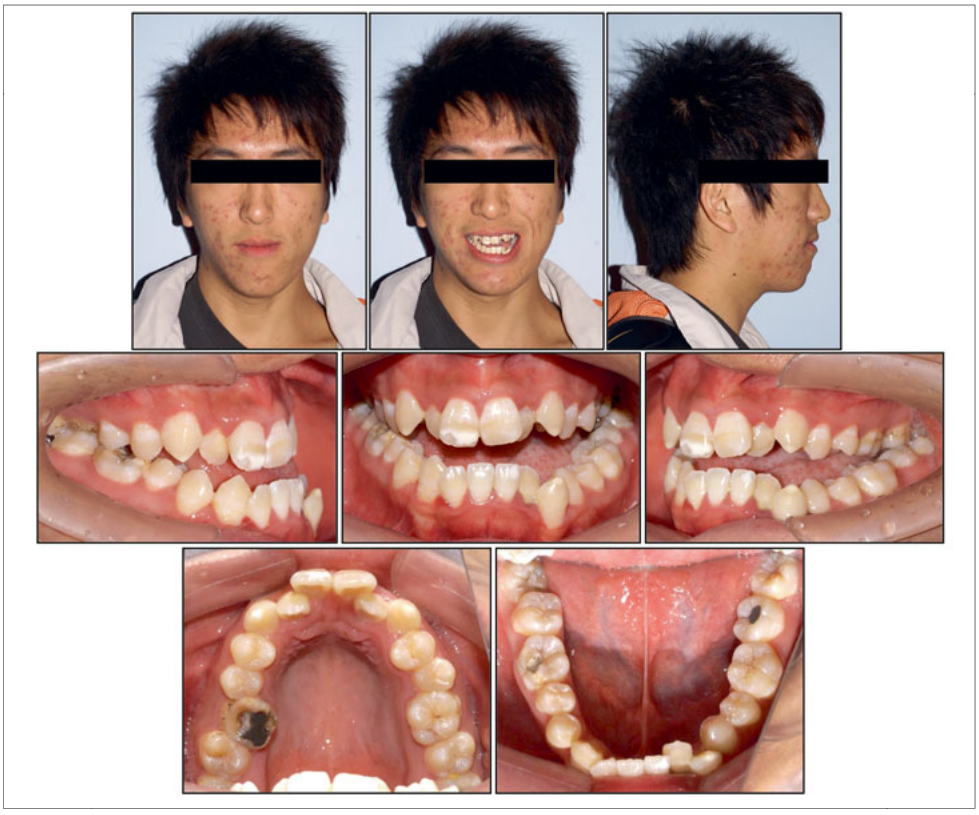

Fig 1 Pretreatment extraoral and intraoral photographs.

Case report

Diagnosis and aetiology

A 23-year-old man presented to the clinic of the Department of Orthodontics, Guanghua School and Hospital of Stomatology at Sun Yat-sen University, complaining of unaesthetic teeth and difficulty in chewing. He had no contributory medical history and expressed a strong desire to avoid orthognathic surgery or any invasive approach. The facial photographs (Fig 1) showed moderate mandibular prognathism, a straight to concave profile, vertical growth pattern, increased lower anterior face height, and asymmetry with the chin deviating to the left. He presented a flat mentolabial sulcus and obvious tension to achieve lip competence. The anterior tooth display was acceptable. There was no history of temporomandibular joint (TMJ) dysfunction, and the clinical examination of the joint revealed no abnormalities.

The intraoral examination (Fig 1) and study models (Fig 2) showed a 10-mm open bite involving the anterior and posterior teeth up to the first molars, bilateral posterior crossbite, full-class Class III on the right, an end-on Class III molar relationship on the left, 9 mm of crowding in the maxilla and 6 mm in the mandible and 4-mm mandibular midline deviation to the left. Overerupted and mesially tipped molars were observed, probably due to the presence of third molars. Both maxillary lateral incisors were palatally malposed (Fig 2). The right maxillary first molar presented a severe defect, clinical crown height reduction and a defective restoration.

Pretreatment cephalometric analysis (Fig 3 and Table 1) showed a skeletal Class III relationship (ANB, −0.5 degrees) with a hyperdivergent growth pattern (FMA, 36.4 degrees) and a steep mandibular occlusal plane. The interincisor angle (129.5 degrees) was within the normal range with a mild increase in mandibular incisor proclination (Md-1-NB, 32.1 degrees). The posteroanterior radiograph (Fig 3) showed a 5-mm deviation of the mentum to the left and moderate mandibular asymmetry. A panoramic radiograph (Fig 3) indicated the presence of all wisdom teeth, and notable morphological changes of the TMJ. A CBCT scan (Fig 4) revealed 'bubbling' below the surface in the lateral upper portion of the right condylar head and a sulcus-like structure on the condylar surface. However, the cortical surface of the condyle was intact which suggested that there was no progressive inflammation and orthodontic treatment was acceptable under close supervision.

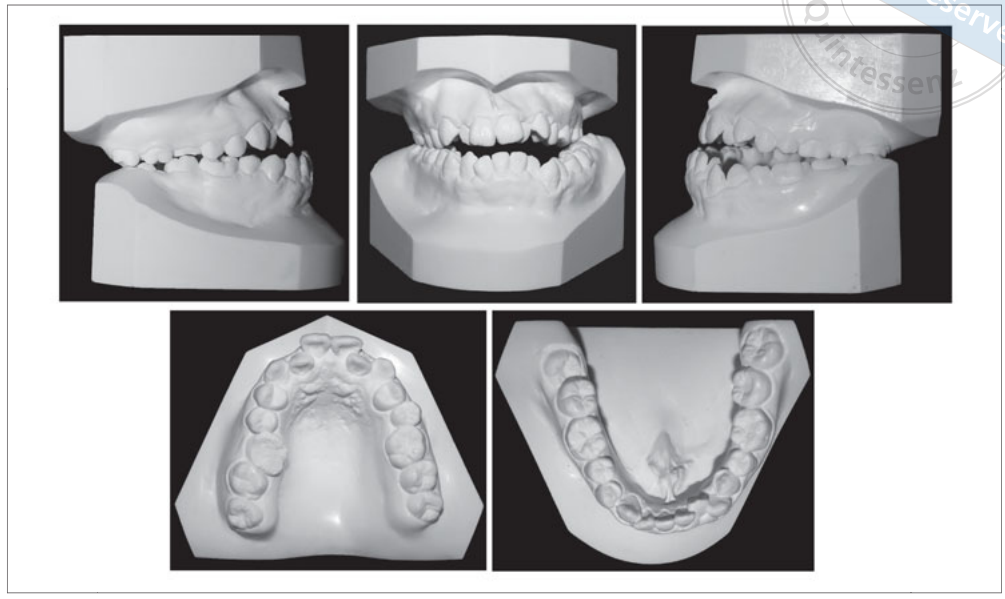

Fig 2 Pretreatment study casts.

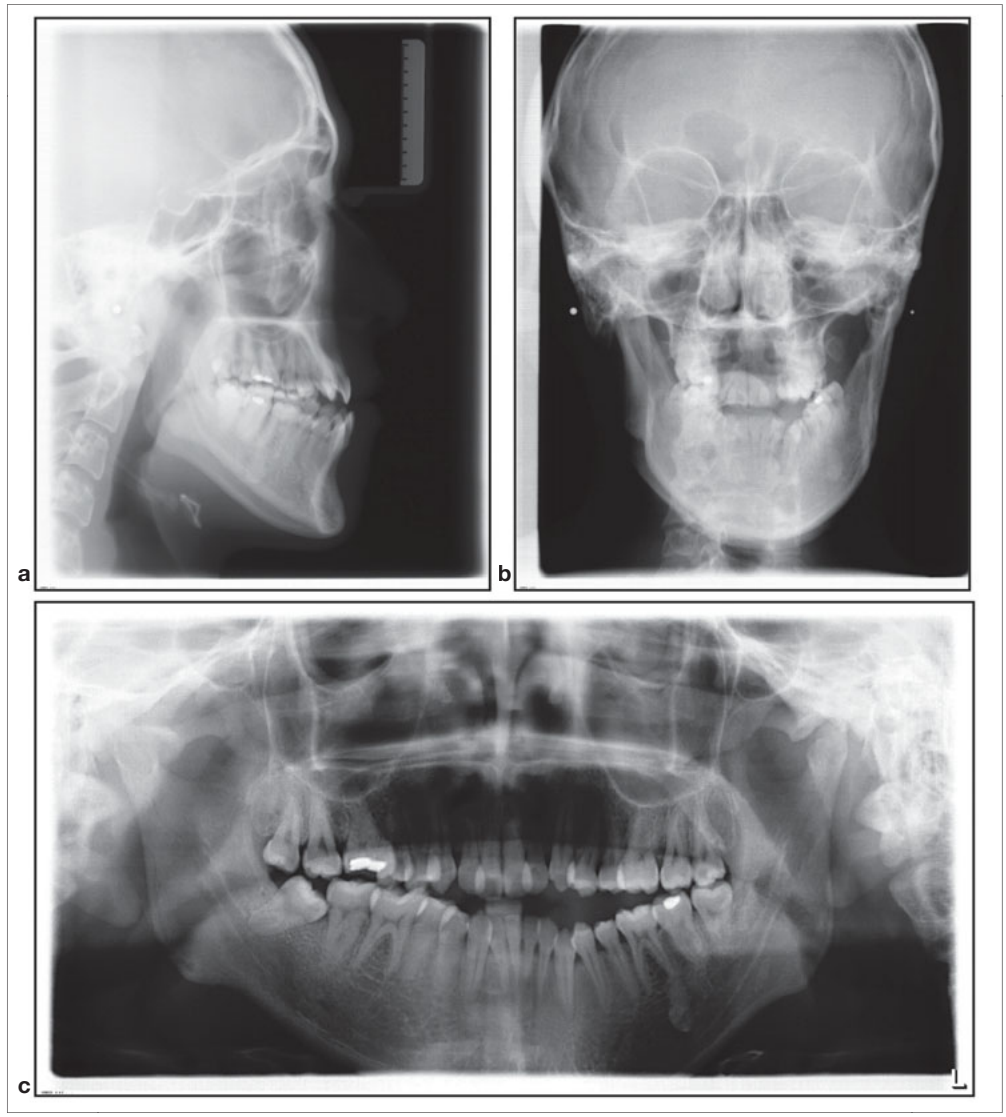

Fig 3 Pretreatment radiographs: **(a)** lateral cephalogram, **(b)** posteroanterior radiograph and **(c)** panoramic radiograph.

Table 1 Lateral cephalometric analysis.

Variable	Norm	Pretreatment	Posttreatment	Difference
SNA, degrees	82.0 ± 3.0	81.0	79.5	–1.5
SNB, degrees	80.0 ± 3.0	81.6	78.9	–2.7
ANB, degrees	2.0 ± 2.0	–0.5	0.7	1.2
Mx-1-NA, mm	4.0 ± 3.0	6.6	7.8	1.2
Mx-1-NA angle, degrees	22.0 ± 6.0	19.0	30.6	11.6
Md-1-NB, mm	4.0 ± 3.0	7.7	6.9	–0.8
Md-1-NB angle, degrees	25.0 ± 6.0	32.1	23.3	–8.8
PO-NB, mm	1.0 ± 1.8	3.3	2.0	–1.3
Occlusal plane-SN, degrees	14.0 ± 3.5	14.5	16.0	1.5
GO-GN-SN, degrees	32.0 ± 4.5	40.9	42.9	2.0
Interincisor angle, degrees	124.0 ± 6.0	129.5	125.4	–4.1
Wits appraisal, mm	1.1 ± 1.9	–5.9	–3.2	2.7
Calculated ANB, degrees	2.0 ± 2.0	5.4	5.2	–0.2
FMA, degrees	25.0 ± 6.0	36.4	36.0	–0.4
FMIA, degrees	65.0 ± 6.0	54.0	62.5	8.5
IMPA, degrees	90.0 ± 6.0	89.6	81.5	–8.1

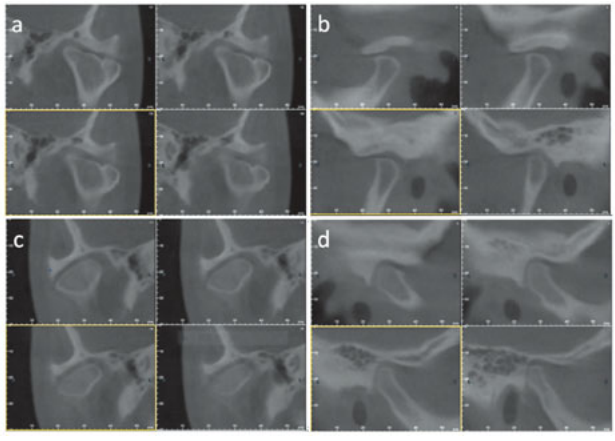

Fig 4 Pretreatment CBCT images of TMJ.

The patient was diagnosed with skeletal Class III with severe malocclusion (open bite malocclusion, bilateral posterior crossbite, severe crowding, increased lower anterior face height, steep mandibular plane, dental midline deviations and caries lesions in the right maxillary first molar).

Treatment objectives

The treatment objectives were as follows:

- to distalise the mandibular arch and achieve a functional Class I occlusion with ideal overbite and overjet;
- to correct open bite and upright the mandibular molars without concomitant extrusion;
- to relieve transverse discrepancy and crowding;
- to diminish mild midline deviation and mandible asymmetry;
- to maintain or slightly improve the facial profile.

Treatment alternatives

Based on the treatment objectives, the following treatment options were proposed:

- Orthognathic surgery, the first and ideal option. This option was immediately declined by the patient even though a surgical approach would have produced better occlusal and aesthetic results[3,4].
- Placement of TADs in the mandibular posterior region for arch retraction, intrusion and better vertical control of molars. The patient was reluctant to undergo the risk and side effects of this invasive approach.
- Extraction of maxillary and mandibular impacted third molars and use of upper accentuated curve and lower reverse curve NiTi archwires with intermaxillary elastics. The patient selected this option even though it demanded more time and patient compliance. Therefore, informed consent about the possible orthodontic complications was obtained before the start of treatment.

Treatment progress

Prior to bracket bonding, the right maxillary first molar was restored and all wisdom teeth were extracted.

Preadjusted 0.022 × 0.028-inch MBT brackets (3M Unitek, Monrovia, CA, USA) were bonded to all teeth (Fig 5). With sequential NiTi archwires and full-time light force elastics (1/8-inch, 2 oz, 3M Unitek), alignment and levelling were achieved in 9 months (Fig 5, first column). Then, 0.021 × 0.025-inch NiTi archwires were placed in both dental arches. Both maxillary and mandibular wires had a 30-degree reverse curve of Spee to provide a levelling force to upright and distalise the

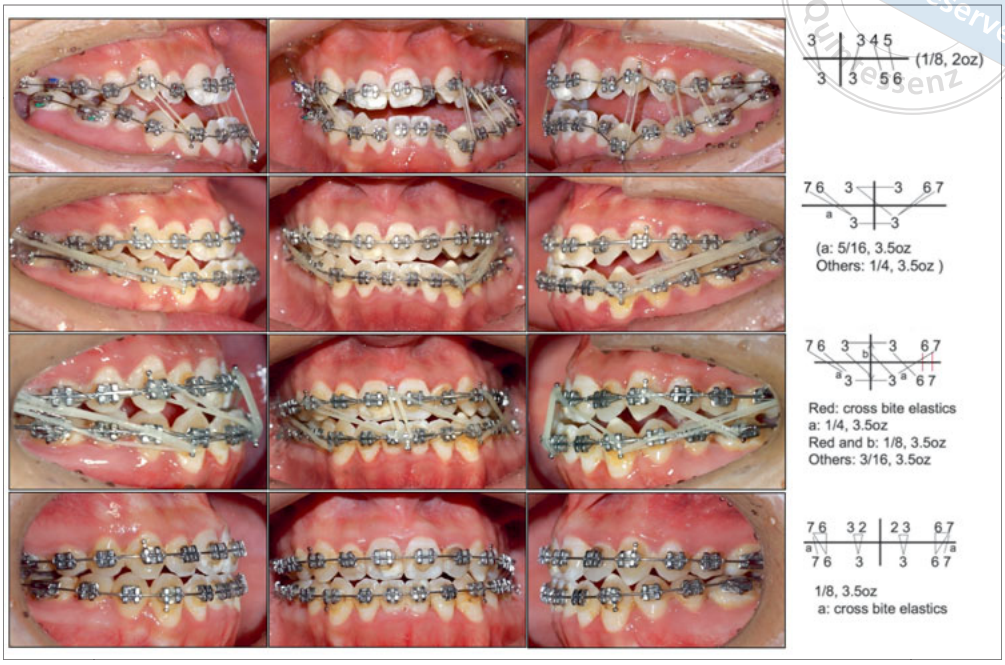

Fig 5 Treatment progress.

molars. Class III and oblique intermaxillary elastics (5/16-inch or 1/4-inch, 3.5 oz) were also prescribed to be used full-time by the patient. The total force of the elastics was controlled at approximately 200 g on each side to prevent the mandibular anterior teeth from flaring with the reverse curve of Spee, distalise the mandibular arch and reduce open bite and midline deviation (Fig 5, second column). After 20 months, the open bite was corrected and arch form was adjusted to correct the crossbite. Class III elastics were combined with posterior transverse elastics (1/8-inch, 3.5 oz) from palatal buttons on the maxillary posterior teeth to the mandibular posterior brackets for a further 12 months (Fig 5, third column). Concurrently, oblique elastics were retained for midline correction. There was no TMJ discomfort, nor any symptoms of temporomandibular disorder (TMD) during the use of intermaxillary elastics. In the final stage, better occlusal interdigitation was achieved after 5 months with 0.018-inch NiTi archwires and triangle elastics (1/8-inch, 3.5 oz) (Fig 5, fourth column).

The whole treatment continued for 36 months with good patient compliance. A Hawley retainer was placed after debonding.

Treatment results

The posttreatment extraoral and intraoral photographs (Fig 6) and study model (Fig 7) showed successful results. The molar and canine relationships were corrected from full-class Class III to a Class I relationship. The open bite was corrected by controlling the mesial tipping of the maxillary and mandibular molars, and an ideal horizontal and vertical overlap were achieved. The frontal appearance, especially when smiling, was considerably improved. The anterior tooth display was satisfactory. The panoramic radiograph and cephalometric analysis (Fig 8 and Table 1) confirmed uprighting of the mandibular molars and 5 mm distalisation with 1.2 mm intrusion. The maxillary incisors were slightly proclined to compensate for the Class III relationship. The posttreatment interincisal angle was within the normal range (125.4 degrees). The root parallelism was favourable. However, the roots of the maxillary anterior teeth showed slight resorption.

The superimposition of pre- and posttreatment cephalograms (Fig 9) revealed that the open bite was corrected by counterclockwise occlusal plane rotation. The mandibular incisors were retracted bodily by 1 mm and extruded by 1.4 mm, with evident dentoalveolar modification in the anterior mandible. Increased crown height of the maxillary first molar due to the restoration but not extrusion could also be observed. The posttreatment panoramic radiograph and CBCT images (Fig 10) revealed unchanged condylar morphology. The cortical bone of condyle remained intact with normal joint space. No progressive pathological TMJ disorders occurred.

The arch width was increased in both the maxilla and mandible (Table 2). Based on model analysis, the

Fig 6 Posttreatment extraoral and intraoral photographs.

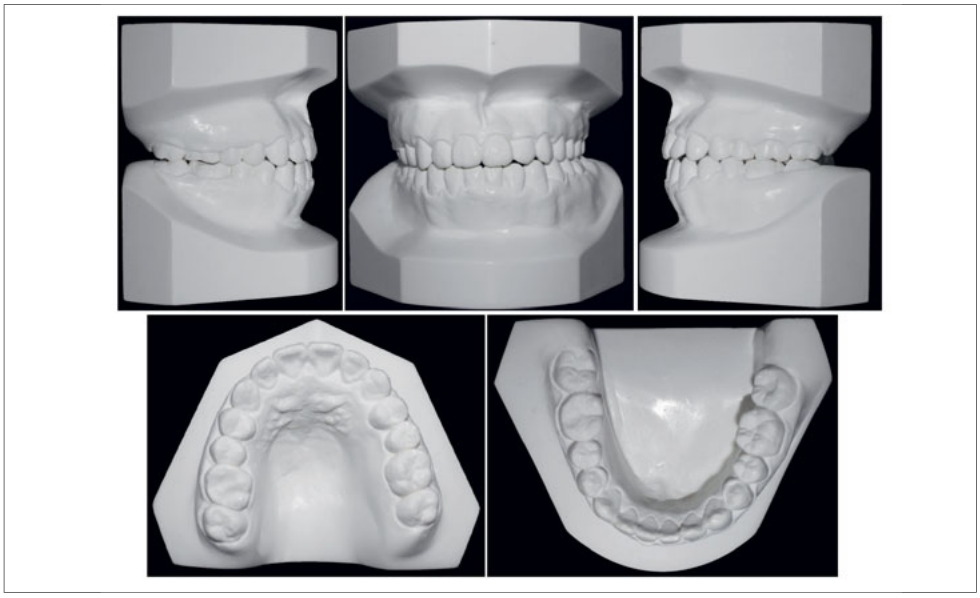

Fig 7 Posttreatment study casts.

width between the maxillary first molars was increased by 9 mm. Maxillary buccal bone modification and cortical bone formation can be seen from the CBCT images (Fig 11).

After 4 years of retention, the facial profile and occlusion were well maintained and the patient was satisfied with the treatment outcomes (Figs 12 and 13). There were no symptoms of TMJ disorder on either side (Fig 14).

Discussion

Typically, for treatment of adult skeletal Class III mal-

Fig 8 Posttreatment radiographs: **(a)** lateral cephalogram, **(b)** posteroanterior radiograph and **(c)** panoramic radiograph.

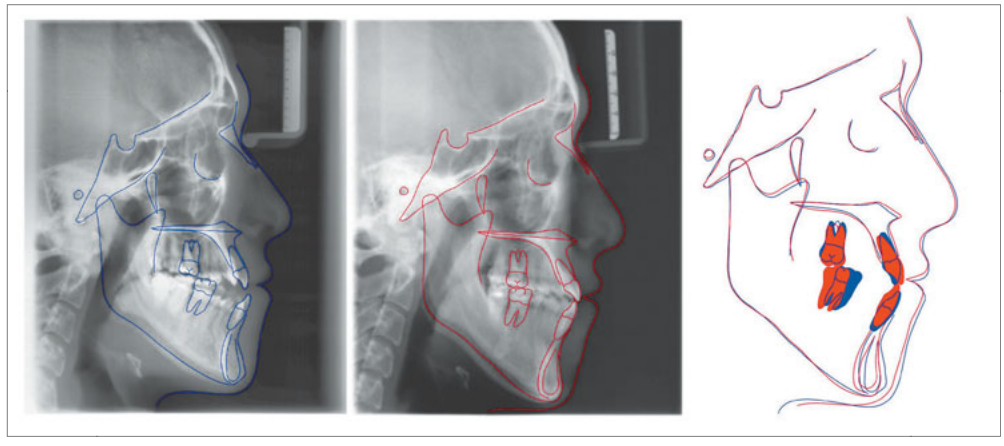

Fig 9 Tracings and superimpositions of lateral cephalogram.

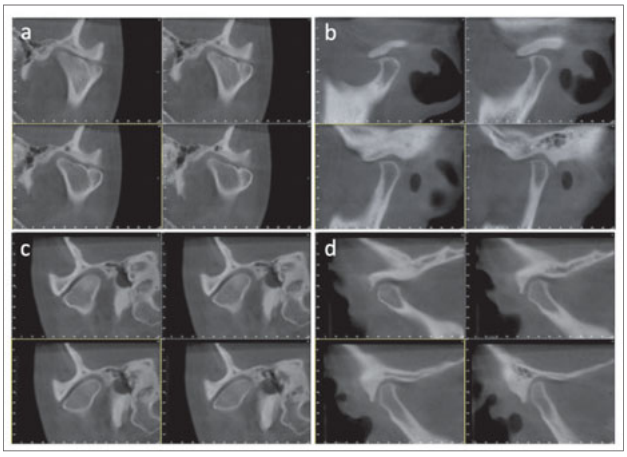

Fig 10 CBCT images of TMJ after debonding.

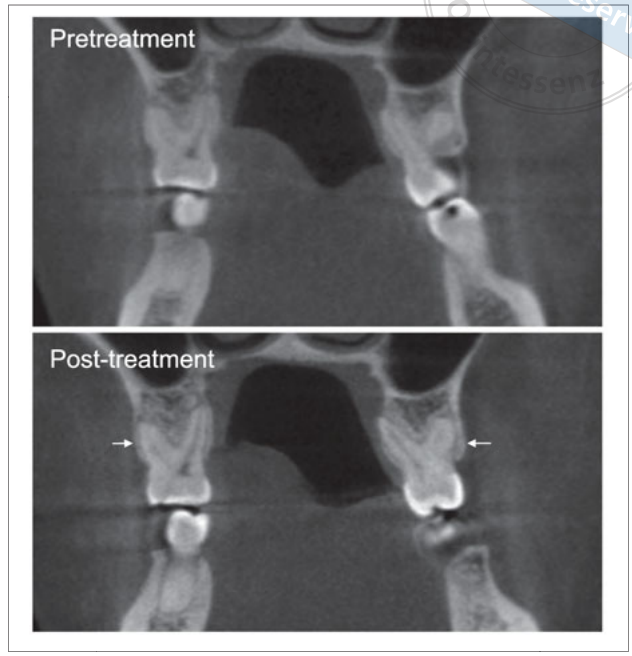

Fig 11 CBCT images of arch width and dentoalveolar modification.

Fig 12 Extraoral and intraoral photographs taken 4 years after treatment.

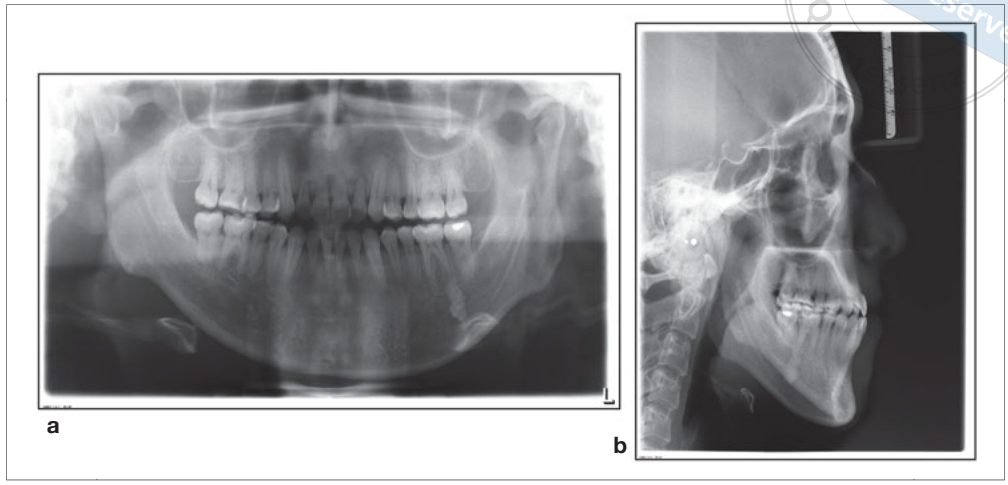

Fig 13 Radiographs taken 4 years after treatment: **(a)** panoramic radiograph and **(b)** lateral cephalogram.

occlusion with vertical growth pattern and open bite, orthognathic surgery is the ideal option[3,4,15,16]. This patient, unfortunately, did not accept an invasive approach. Even though it was believed that a mild to moderate skeletal Class III malocclusion could also be successfully corrected with camouflage treatment[10,11,17-19], few cases exhibited this size of open bite or the need to distalise the mandibular arch to such an extent. To accomplish the treatment objectives, the mandibular molars needed to be distalised and intruded with the maxillary molars not extruded. Premolar extraction was not appropriate in this case as it would have led to excessive crown lingual torque of the mandibular anterior teeth; thus, we needed to move the mandibular teeth distally after third molar extraction to relieve crowding. This would have made the open bite worse.

In similar cases, TADs are favoured for vertical control during uprighting and distalisation of the mandibular molars. Previous studies reported the achievement of 4 to 5 mm of mandibular molar distalisation using miniscrews or miniplates in the retromolar area[10,11,13,17]. Bone-borne anchorage provides a support to retract the dentition and maximise the intrusive force on the molar region in the meantime. Nevertheless, any invasive manipulation including TADs was not accepted by the patient, to whom a less than ideal treatment result was acceptable.

Conventional choices were then taken into consideration. Compared to MEAW, the upper accentuated curve and lower reverse curve NiTi archwires combined with intermaxillary elastics are more hygienic, with reduced chair time and soft tissue irritation. Therefore, we adopted this treatment method in this case and obviously challenged the limits successfully.

The satisfactory outcome of using this technique resulted from the optimisation and adaptation of this system of upper accentuated curve and lower reverse curve NiTi archwires combined with intermaxillary elastics.

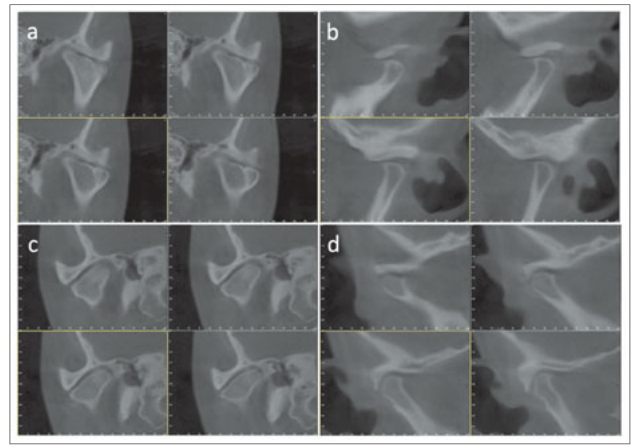

Fig 14 CBCT images of TMJ taken 4 years after debonding.

Firstly, during both distalisation and maxillary expansion, management of the mandibular anterior teeth and maxillary posterior teeth within the alveolar bone was essential and larger NiTi rectangular archwire (0.021 × 0.022-inch) was critical to control the torque and counterclockwise rotation and consequently avoid undesired tipping of the teeth. For the mandibular arch, the vertical force component of Class III elastics in the sagittal plane counteracted the flaring effect on the mandibular incisors from the force by reverse curve of Spee on NiTi wire, allowing mild controlled extrusion of these incisors. At the same time, the horizontal force component of Class III elastics distalised the mandibular molars and retracted the incisors. These mechanics caused a combination of translation and counterclockwise rotation of the mandibular occlusal plane. Therefore, 5 mm distalisation was achieved in this case, without TADs.

For the maxillary arch, the vertical force component of Class III elastics was counteracted by the accentuated curve in the maxillary wire so that the maxillary molars were not elongated. The controlled proclination of the maxillary incisors by the horizontal force component of Class III elastics was favourable to the correction of the anterior crossbite and Class III relationship.

Secondly, the anterior oblique elastics applied starting from the tenth month were important because they corrected the midline by dentoalveolar compensation, counteracted the vertical force from the maxillary accentuated curve of Spee and also allowed minimum extrusion and retraction of the mandibular incisors with dentoalveolar modification and Class III elastics.

Thirdly, intermaxillary elastics were applied from palatal buttons on the maxillary molars to buccal side of mandibular molars and placed with 0.021 × 0.022-inch NiTi wires to reduce the posterior crossbite. Slow and steady expansion of the maxilla and dental arch can be achieved through sequential use of rectangular archwires with adjusted arch form and coordination with intermaxillary elastics. A study on bony adaptation after maxillary expansion with light to moderate continuous forces reported bone formation on the periosteal surfaces of cortical bone, indicating that apposition is possible on the outermost edge in the direction of tooth movements[20]. In this case, the main contributor to the increased intermolar width was buccal bodily movement of the maxillary posterior teeth and concurrent alveolar remodelling by the light force from the NiTi rectangular archwires. The modification and new bone formation can be seen in the CBCT images (Fig 11).

Fourthly, the force of intermaxillary elastics needed to be controlled below 200 g. During treatment of the present case, the force from the elastics and patient discomfort were carefully monitored. The morphology of the bilateral condyles remained unchanged after debonding as well as 2 years after orthodontic treatment, as shown in the CBCT images, perhaps indicating that pathological changes in the TMJ are not inevitable if well-designed and balanced intermaxillary elastics are applied and patient compliance is good, although further studies are needed to assess TMJ modification in adult patients with skeletal malocclusion.

The root resorption observed in the anterior area may have resulted from the long treatment period considering that there was no intrusion of the maxillary incisors and the force applied was not too heavy[21-23]; this highlights the importance of paying close attention during the whole treatment period. Fortunately, the root resorption was shown to have stabilised by the 4-year follow-up radiographic examination.

Conclusion

The treatment outcome of this case suggested that the application limit of curved NiTi wires with elastics in molar uprighting and mandibular arch distalisation can be extended and may be highly effective in camouflage treatment of skeletal Class III malocclusion with severe open bite, crossbite, midline deviation and crowding, with the risk of TMJ symptoms being reduced when carefully addressed and closely monitored. Although there was no further morphological change in the condyles after treatment or 4 years later in this case, the relationship between orthodontic treatment and the TMJ remains unclear, and further studies are needed to assess TMJ modification in adult patients with skeletal malocclusion.

The findings from this case with a long treatment time suggest that precise diagnosis, communication with the patient and patient compliance are crucial, and the plan followed in the present study should not be used as a routine plan, especially not in a patient with a history of caries or hypoplastic enamel or a tendency for root resorption. To achieve satisfactory results, the biomechanics in the present case should be comprehensively designed and carefully applied.

Acknowledgements

The authors thank Yi LIU for her technical assistance with CBCT.

Conflicts of interest

The authors declare no conflicts of interest related to this study.

Author contribution

Dr Bai Cheng BAO diagnosed the patient, made the treatment plan, treated the patient and checked and revised the manuscript; Dr Jian Han REN treated the patient, recorded the materials and completed the manuscript; Drs Wei Cai WANG and Chen ZHOU treated the patient and checked and revised the manuscript. All other authors, Drs De Lan HUANG, Run Ze LI, Zhi Cai FENG, Yi Jia CHEN, Xi WANG, Yang CAO and Bin CAI, attended the case discussion for this patient, gave valuable suggestions and checked the manuscript.

(Received Feb 01, 2020; accepted Jul 10, 2020)

References

1. Tseng LL, Chang CH, Roberts WE. Diagnosis and conservative treatment of skeletal Class III malocclusion with anterior crossbite and asymmetric maxillary crowding. Am J Orthod Dentofacial Orthop 2016;149:555–566.
2. Ngan P, Moon W. Evolution of Class III treatment in orthodontics. Am J Orthod Dentofacial Orthop 2015;148:22–36.
3. de Almeida Cardoso M, de Molon RS, de Avila ED, et al. Facial and occlusal esthetic improvements of an adult skeletal Class III malocclusion using surgical, orthodontic, and implant treatment. Korean J Orthod 2016;46:42–54.
4. Jokić D, Jokić D, Uglešić V, Macan D, Knežević P. Soft tissue changes after mandibular setback and bimaxillary surgery in Class III patients. Angle Orthod 2013;83:817–823.
5. Freitas BV, Abas Frazão MC, Dias L, Fernandes Dos Santos PC, Freitas HV, Bosio JA. Nonsurgical correction of a severe anterior open bite with mandibular molar intrusion using mini-implants and the multiloop edgewise archwire technique. Am J Orthod Dentofacial Orthop 2018;153:577–587.
6. Marañón-Vásquez GA, Soldevilla Galarza LC, Tolentino Solis FA, Wilson C, Romano FL. Aesthetic and functional outcomes using a multiloop edgewise archwire for camouflage orthodontic treatment of a severe Class III open bite malocclusion. J Orthod 2017;44:199–208.
7. Ribeiro GL, Regis S Jr, da Cunha T de M, Sabatoski MA, Guariza-Filho O, Tanaka OM. Multiloop edgewise archwire in the treatment of a patient with an anterior open bite and a long face. Am J Orthod Dentofacial Orthop 2010;138:89–95.
8. Küçükkeleş N, Acar A, Demirkaya AA, Evrenol B, Enacar A. Cephalometric evaluation of open bite treatment with NiTi arch wires and anterior elastics. Am J Orthod Dentofacial Orthop 1999;116:555–562.
9. Janson G, Valarelli FP, Beltrão RT, de Freitas MR, Henriques JF. Stability of anterior open-bite extraction and nonextraction treatment in the permanent dentition. Am J Orthod Dentofacial Orthop 2006;129:768–774.
10. Kook YA, Park JH, Bayome M, Kim S, Han E, Kim CH. Distalization of the mandibular dentition with a ramal plate for skeletal Class III malocclusion correction. Am J Orthod Dentofacial Orthop 2016;150:364–377.
11. Chen K, Cao Y. Class III malocclusion treated with distalization of the mandibular dentition with miniscrew anchorage: a 2-year follow-up. Am J Orthod Dentofacial Orthop 2015;148:1043–1053.
12. Ahn HW, Chung KR, Kang SM, Lin L, Nelson G, Kim SH. Correction of dental Class III with posterior open bite by simple biomechanics using an anterior C-tube miniplate. Korean J Orthod 2012;42:270–278.
13. Yu J, Park JH, Bayome M, et al. Treatment effects of mandibular total arch distalization using a ramal plate. Korean J Orthod 2016;46:212–219.
14. Alharbi F, Almuzian M, Bearn D. Miniscrews failure rate in orthodontics: systematic review and meta-analysis. Eur J Orthod 2018;40:519–530.
15. Song HS, Choi SH, Cha JY, Lee KJ, Yu HS. Comparison of changes in the transverse dental axis between patients with skeletal Class III malocclusion and facial asymmetry treated by orthognathic surgery with and without presurgical orthodontic treatment. Korean J Orthod 2017;47:256–267.
16. Conley RS, Edwards SP. Three-dimensional treatment planning for maxillary and mandibular segmental surgery for an adult Class III: where old meets new. Angle Orthod 2019;89:138–148.
17. Jing Y, Han X, Guo Y, Li J, Bai D. Nonsurgical correction of a Class III malocclusion in an adult by miniscrew-assisted mandibular dentition distalization. Am J Orthod Dentofacial Orthop 2013;143:877–887.
18. He S, Gao J, Wamalwa P, Wang Y, Zou S, Chen S. Camouflage treatment of skeletal Class III malocclusion with multiloop edgewise arch wire and modified Class III elastics by maxillary mini-implant anchorage. Angle Orthod 2013;83:630–640.
19. Farret MM, Benitez Farret MM. Skeletal class III malocclusion treated using a non-surgical approach supplemented with mini-implants: a case report. J Orthod 2013;40:256–263.
20. Kraus CD, Campbell PM, Spears R, Taylor RW, Buschang PH. Bony adaptation after expansion with light-to-moderate continuous forces. Am J Orthod Dentofacial Orthop 2014;145:655–666.
21. Roscoe MG, Meira JB, Cattaneo PM. Association of orthodontic force system and root resorption: a systematic review. Am J Orthod Dentofacial Orthop 2015;147:610–626.
22. Weltman B, Vig KW, Fields HW, Shanker S, Kaizar EE. Root resorption associated with orthodontic tooth movement: a systematic review. Am J Orthod Dentofacial Orthop 2010;137(4):462–476; discussion 12A.
23. Han G, Huang S, Von den Hoff JW, Zeng X, Kuijpers-Jagtman AM. Root resorption after orthodontic intrusion and extrusion: an intraindividual study. Angle Orthod 2005;75:912–918.