Case Report

Nonsurgical treatment of a hyperdivergent skeletal Class III patient with mini-screw–assisted mandibular dentition distalization and flattening of the occlusal plane

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ABSTRACT
Treatment of hyperdivergent skeletal Class III malocclusion is challenging for orthodontists, and orthognathic-orthodontic treatment is usually required. This report presents the successful nonsurgical treatment of a 20-year-old man who had a skeletal Class III malocclusion with anterior open bite, anterior and posterior crossbite, hyperdivergent growth pattern, steep occlusal plane, early loss of three first molars, and an uncommon convex profile with a retruded chin. An orthodontic camouflage treatment plan was chosen based on the etiology and the patient's complaints. Tooth #37 was extracted. Miniscrews were used for uprighting and intruding of the lower molars, distalization of the lower dentition, and flattening of the occlusal plane. After 34 months of active treatment, Class I relationships, proper anterior overjet and overbite, flat occlusal plane, and an esthetic facial profile were achieved. The results demonstrated that the biomechanics involved in the nonsurgical treatment assisted with miniscrews to distalize the mandibular dentition and flatten the occlusal plane while keeping the mandibular plane stable was effective for treating this hyperdivergent skeletal Class III patient with a convex profile and anterior open bite. (*Angle Orthod.* 2022;92:287–293.)

KEY WORDS: Class III malocclusion; Anterior open bite; Hyperdivergent growth pattern; Nonsurgical treatment

INTRODUCTION

The prevalence of skeletal Class III malocclusion is as high as 14% in the Asian population, among which nongrowing patients could be treated through orthognathic-orthodontic treatment or orthodontic camouflage treatment.[1,2] Some researchers investigated a large sample of Class III adult patients and found approximately 30% had open bite, although the etiology was complex.[3] These patients tended to show a hyperdivergent growth pattern with characteristics of steep mandibular plane, larger gonial angle, decreased mandibular protrusion, posterior vertical excess of the maxilla and mandible, and increased facial height. When the Class III malocclusion was combined with open bite and hyperdivergent growth pattern, it became more challenging to achieve desirable outcomes.[4–6] Since abnormalities existed in both jaws in most of these cases, orthodontic-orthognathic procedures were usually the recommended option for correcting complicated skeletal and dental discrepancies as well as to improve facial esthetics.[7] However, some patients might refuse the surgical option for various reasons. In these cases, orthodontic camouflage could be attempted with caution, depending on the etiology of the individual malocclusion.

This report describes the diagnosis and treatment of an adult skeletal Class III male patient with anterior open bite, hyperdivergent growth pattern, convex profile with retruded chin, and early loss of three first

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Figure 1. Pretreatment intraoral and extraoral photographs and radiographs.

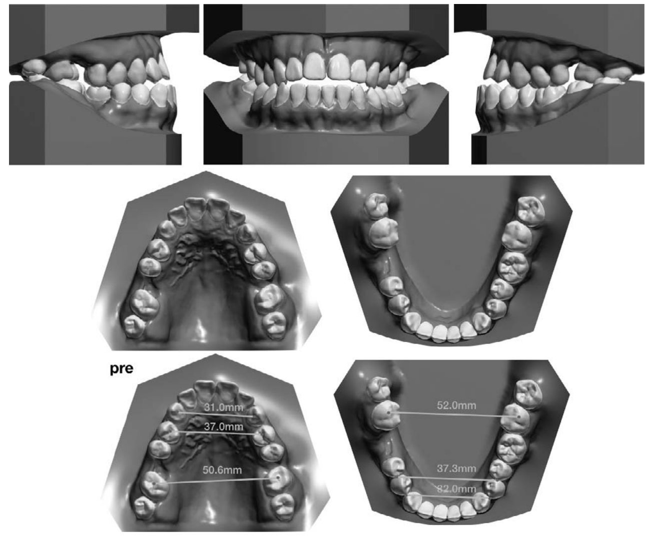

Figure 2. Pretreatment dental casts and arch width measurements. The landmarks were chosen based on the core line. Intercanine width, interpremolar width, and intermolar width were measured.

molars. Treatment alternatives were planned based on the etiology, patient complaints, as well as risk prediction and prevention. The extraction of a second molar, distalization of the mandibular dentition, and flattening of the occlusal plane assisted with mini-screws were used.

DIAGNOSIS AND ETIOLOGY

The patient, a 20-year-old man with family history of skeletal Class III malocclusion, visited the orthodontic department at West China Hospital of Stomatology in Chengdu, China. His chief complaints were that his anterior teeth could not contact and his mandibular anterior teeth were protruding.

Extraoral examination (Figure 1) showed a relatively longer lower third face height, dental midline discrepancy with the mandibular midline deviated 2.5 mm to the right, circumoral muscle strain on lip closure, and a convex profile with a retruded chin, which was uncommon in Class III patients. No temporomandibular disorder symptoms were detected, and no noticeable abnormality of tongue volume or position was observed.

Intraoral examination showed that teeth #16, #26 and #46 (FDI World Dental Federation ISO-3950) were missing, which had been previously extracted due to extensive caries and subsequent periapical periodontitis. The second molars were lingually and mesially inclined into the edentulous spaces. Anterior open bite as well as anterior and posterior crossbite were observed. Canines and molars on both sides showed full step Class III relationships. All third molars were present, but the mandibular third molars were lingually inclined and extruded. In addition, his oral hygiene was unsatisfactory with calculus on the cervical surface of anterior teeth.

Dental casts (Figure 2) confirmed the Class III relationships, anterior open bite, anterior and posterior crossbite, and midline discrepancy. His anterior overjet and overbite were –2.5 mm and –3.0 mm, respectively, and the curve of Spee was accentuated (2.5 mm). Measurements of the dental arch width confirmed the transverse discrepancy between the upper and lower. The widths of the edentulous spaces were 6.0 mm for tooth #16, 2.5 mm for tooth #26, and 10.5 mm for tooth #46.

Cephalometric analysis (Table 1) showed that the patient had a skeletal Class III relationship (ANB: –3.6°, Wits: –18.7 mm) with maxillary deficiency (SNA: 76.8°), a hyperdivergent growth pattern (S-Go/N-Me: 62.7%, MP-SN: 46.2°) with a retruded chin (Pog-NB:

Table 1. Cephalometric Measurements

Measurement	Normal	Pretreatment	Posttreatment
SNA, °	84 ± 3	76.8	76.9
SNB, °	80 ± 3	80.4	80.1
ANB, °	4 ± 2	–3.6	–3.2
SN-MP, °	35 ± 4	46.2	44.9
OP-SN, °	19 ± 3	23.8	18.6
U1-L1, °	121 ± 9	122.5	133.1
U1-SN, °	107 ± 6	108.7	105.3
L1-MP, °	95 ± 7	84.5	76.9
U1-NA, °	24 ± 6	32.5	28.9
L1-NB, °	32 ± 6	31.0	21.8
Y axis, °	65 ± 4	68.0	68.7
S-Go/N-Me	67% ± 4%	62.7%	64.7%
Pog-NB, mm	1	–4.8	–2.5
U1-NA, mm	4 ± 2	14.0	11.8
L1-NB, mm	7 ± 3	8.0	3.3
Wits appraisal, mm	1 ± 1.5	–18.7	–11.0
UL-EP, mm	2 ± 2	–2.9	–1.2
LL-EP, mm	3 ± 3	3.2	0

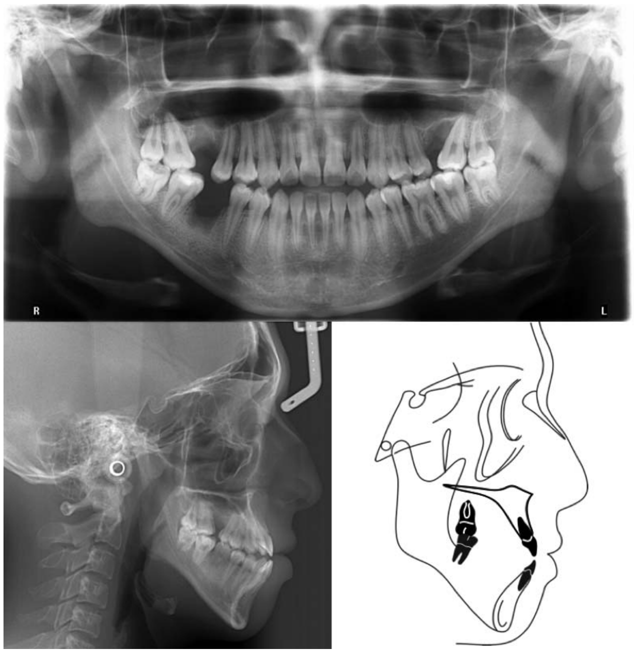

Figure 3. Pretreatment panoramic radiograph, lateral cephalogram and tracing.

–4.8 mm). Mandibular incisors were slightly inclined lingually (L1-MP: 84.5°). Panoramic radiograph (Figure 3) showed alveolar deficiency in the edentulous spaces, slight alveolar ridge resorption in the anterior region, mesial inclination of the upper second molars, and eruption of all third molars.

TREATMENT OBJECTIVES

The treatment objectives were to achieve (1) Class I relationships and a proper overjet in the sagittal dimension, (2) a proper anterior overbite in the vertical dimension, (3) coordination of transverse relationships between the maxillary and mandibular arches, (4) improvement of facial esthetics, and (5) restoration of masticatory and articulation functions of the occlusal system.

TREATMENT ALTERNATIVES

The first alternative was combined orthodontic-orthognathic treatment. In this plan, teeth #38 and #48 needed to be extracted, and the edentulous spaces in the upper would be closed while the space for tooth #46 would be increased for future restoration. The skeletal abnormalities would be eliminated through maxillary LeFort I advancement, mandibular BSSO setback with closing rotation, and genioplasty. Ultimately, the open bite could be corrected, a Class I occlusion with normal buccal-lingual inclination of the anterior teeth achieved, and an esthetic lateral profile realized.

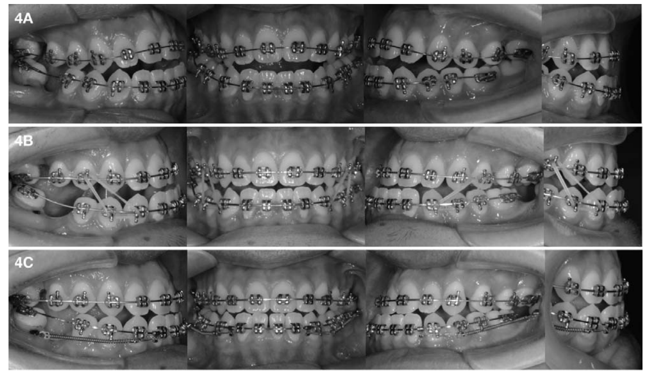

Figure 4. Intraoral photographs during active treatment. (A) Buccal uprighting and intruding of tooth 47 with the aid of the miniscrew. (B) Triangle Class III traction was used in premolar and canine regions. (C) Mandibular distalization with the aid of miniscrews.

The second alternative was orthodontic camouflage treatment. In this proposal, tooth #37 would be extracted to provide space for mandibular distalization with the aid of miniscrews in the buccal retromolar regions bilaterally. Risk prediction and prevention called for attention to possibly negative outcomes in this strategy, such as alveolar reduction, fenestration, or dehiscence in the mandibular anterior region after distal movement and lingual inclination of anterior teeth, and gingival recession or dehiscence in the closing of atrophic edentulous molar spaces. To reduce and prevent these complications, periodontal flapping and bone grafting would be performed in the anterior and edentulous regions when necessary.

Generally, combined orthodontic-orthognathic treatment has been recognized as the gold standard for skeletal Class III open bite cases similar to this one. However, the patient firmly opposed undergoing orthognathic surgical procedures because of the fear of the surgical risks and the cost. He was also reluctant to receive an artificial restoration for tooth #46. In addition, he accepted the possibility of a treatment result that could be less than ideal. Therefore, after a detailed discussion of each option, the second option was selected and well-accepted by the patient with an adequate understanding of the risks and possible outcomes.

TREATMENT PROGRESS

Before orthodontic treatment started, periodontal scaling was performed. Two 1.6- × 10-mm miniscrew implants (Ormco, Brea, Calif) were initially inserted into the mesial and distal alveolar bone of tooth #47 from the buccal side. HX straight wire brackets with 0.022 × 0.028-inch slot size (Shinye, China) were bonded.

During the initial stage of leveling and alignment, an elastomeric chain from tooth #47 to the two buccal miniscrew implants was used (Figure 4A) to buccally upright and intrude tooth #47 (the distal miniscrew

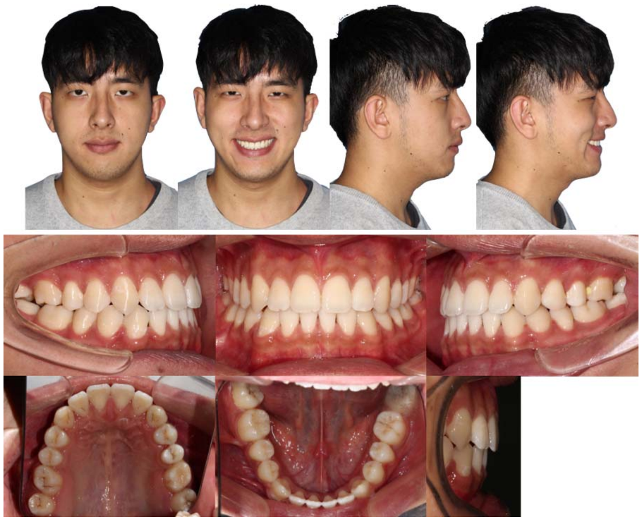

Figure 5. Posttreatment intraoral and extraoral photographs and radiographs.

became loose and was removed 1 month later). Triangle Class III elastic traction (3/16, 3.5 oz) was used in the premolar and canine regions on both sides (Figure 4B). After 3 months of leveling and alignment, tooth #37 was extracted, and a 1.6 × 10-mm miniscrew (Ormco) was inserted in the alveolar bone distobuccal to the extraction site. Stainless steel archwires of 0.018 × 0.025-inch were engaged, and miniscrew implants in the mandible were used for mandibular distalization. Simultaneously, the upper archwires were expanded to coordinate the width between the upper and lower arches. After the anterior crossbite was corrected and Class I canine relationships were achieved, the residual spaces were closed primarily by mesial movement of the second and third molars. Intra- and intermaxillary traction was used to coordinate the molar and canine relationships. To prevent excessive lingual inclination of the lower anterior teeth, a positive torque of 20–25° was added to the archwire in the lower anterior region during distalization (Figure 4C).

After 8 months of mandibular distalization and intramaxillary traction, positive overbite and overjet were achieved. After a total of 34 months of active treatment, adequate results were achieved, and the appliances were removed. The maxillary and mandibular teeth were then stabilized with clear thermoplastic retainers.

TREATMENT RESULTS

The posttreatment photographs confirmed that satisfactory facial esthetics and dental relationships were achieved. Intraoral photographs and dental casts showed Class I relationships with good intercuspal occlusal contacts, positive overlapping of the anterior teeth (overjet: 2.5 mm, overbite: 2.5 mm), satisfactory dental alignment, harmonious relationship of dental

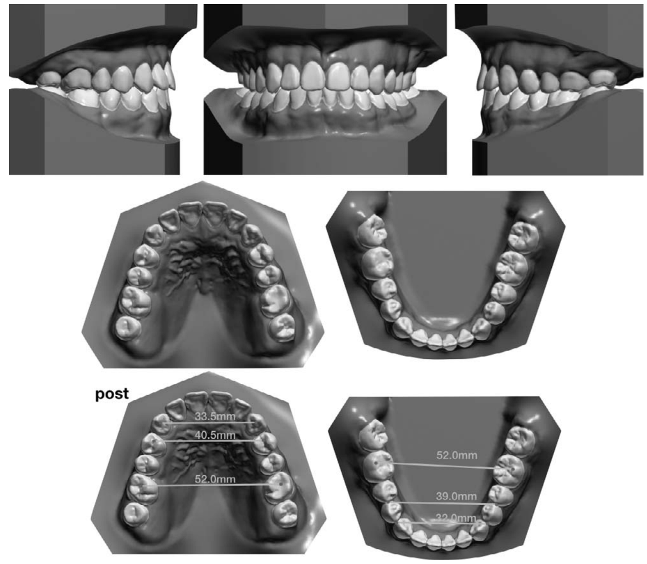

Figure 6. Posttreatment dental casts and arch width measurements.

arch widths, and symmetric arches (Figures 5–7). The patient reported no temporomandibular joint discomfort or changes in breathing after orthodontic treatment.

The panoramic radiograph confirmed the satisfactory parallelism of roots, space closure, slight root resorption, and acceptable alveolar ridge height in the mandibular anterior and molar regions (Figure 7). The significant cephalometric changes were the mesial movement and extrusion of upper molars (4.1 mm and 1.0 mm, respectively), mesial movement and intrusion of the lower molars (3.9 mm and 1.1 mm, respectively), as well

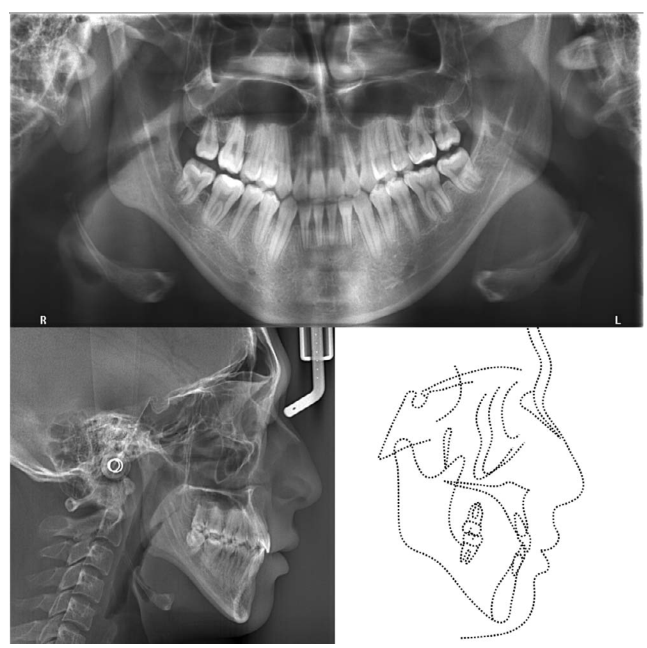

Figure 7. Posttreatment panoramic radiograph, lateral cephalogram and tracing.

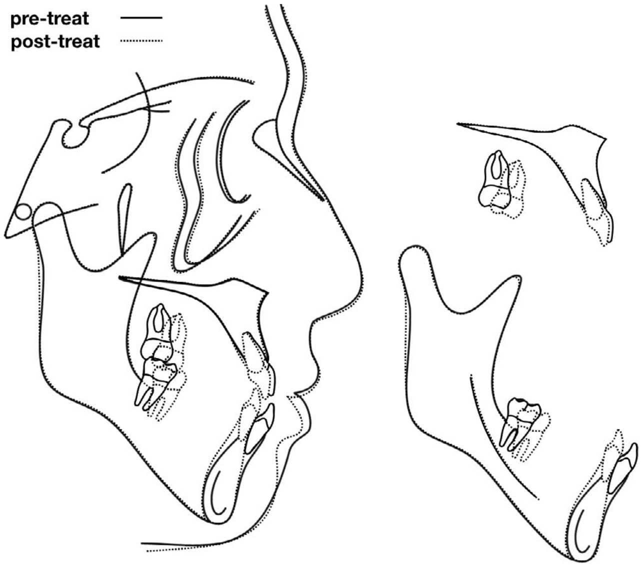

Figure 8. Cephalometric superimpositions between pretreatment and posttreatment.

as distal movement and extrusion of the anterior teeth (5.1 mm and 1.3 mm, respectively; Figure 8). The mandibular plane was maintained without clockwise or counterclockwise rotation. A flat occlusal plane, acceptable overbite, and Class I relationships were obtained (Figure 9; Table 1). The patient's profile was improved by the retraction of the lower lip, which came close to average values relative to the E-line (UL-EP: −1.2 mm, LL-EP: 0).

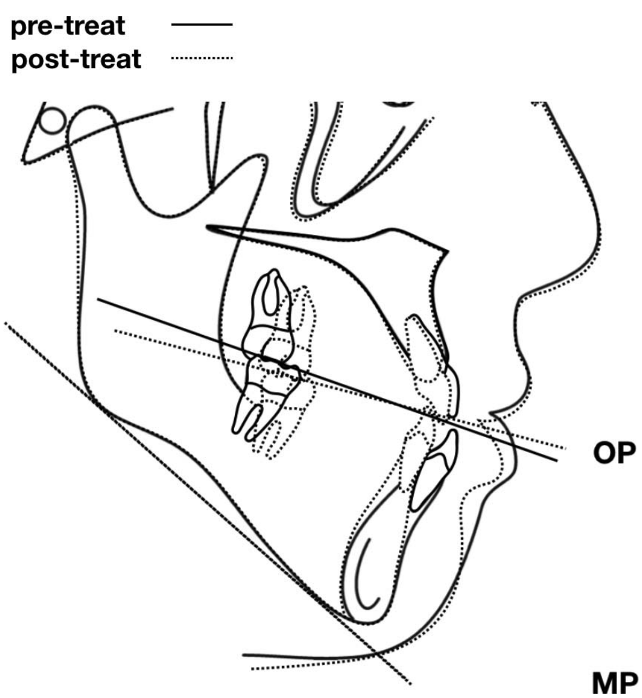

Figure 9. A flat occlusal plane was obtained while the mandible plane remained stable after treatment.

Figure 10. Intraoral and extraoral photographs at 26-month follow-up.

The patient achieved satisfactory occlusion and facial esthetics. These results remained stable at the 26-month follow-up appointment (Figure 10).

DISCUSSION

Etiology was the basis for making the diagnosis and treatment decisions. Although genetic factors contribute significantly to the etiology for development of malocclusions, acquired factors could also play important roles. Previous studies showed that greater hyperdivergence was associated with lower maximum bite force, decreased masseter volume and activity, as well as reduced maxillary arch width.[8–10] This might help explain the etiology, at least in part, for the present patient, who developed a skeletal Class III open bite malocclusion with posterior crossbite and a convex profile. The early extensive caries history and subsequent loss of the three first molars in the present patient would significantly impair bite function and decrease bite force during development. Lower bite force could result in excessive posterior tooth eruption, therefore resulting in an anterior open bite and clockwise rotation of the occlusal plane and the mandible plane, leading to a retruded chin, which was unlike most skeletal Class III patients. Previous studies found that hyperdivergent patients tended to have lower masseter volume and activity, which was positively correlated with maxillary intermolar width. This might have contributed to the formation of the posterior crossbite in the present case.

When complicated abnormalities exist in both jaws of an adult patient with skeletal Class III open bite, two-jaw orthodontic-orthognathic treatment would usually be the optimal strategy to achieve desirable results.[5,6,11] Nevertheless, this patient showed an uncommon,

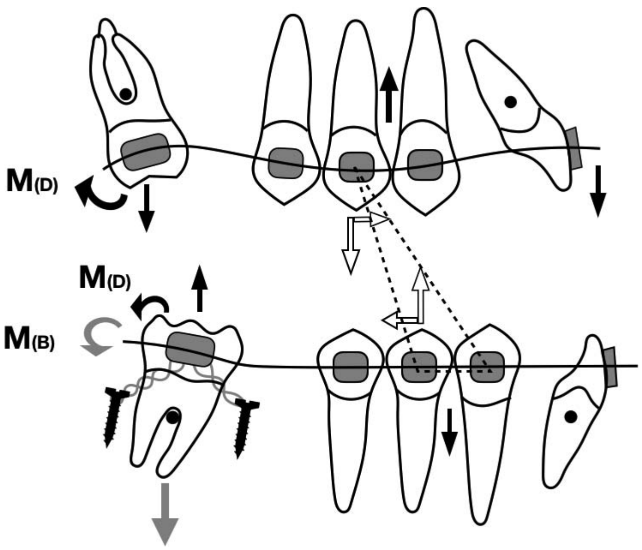

Figure 11. Force analysis during leveling and alignment: The hollow arrows indicate the force from triangular Class III elastics. The black arrows indicate the force and distal moment (M_D) from archwires. The gray arrows indicate the buccal moment (M_B) and intrusive force from the elastic to the miniscrews. The black dots indicate the tooth centers of resistance.

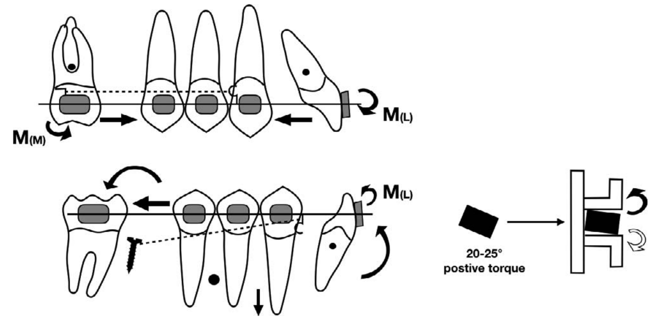

Figure 12. Force analysis during space closure. The black arrows indicate the force and moment during mandibular distalization and intramaxillary traction. The hollow arrow indicates positive torque from archwires. The black dots represent the centers of resistance of teeth (small) and the mandibular dental arch (large).

convex profile with a retruded chin, and the soft tissue of the upper lip concealed the maxillary deficiency, contributing to an esthetically acceptable profile. If orthognathic surgery was performed as in most skeletal Class III patients, maxillary advancement might have caused a protruded maxillary lateral profile, while mandibular setback would have resulted in mandibular retrognathism and the need for supplementary chin advancement. These factors could make the surgery plan complicated, and the outcome might not have been as optimal as expected for facial profile improvement. Considering the possible etiology of the abnormalities and the patient's objection to surgery, orthodontic camouflage treatment might also be an appropriate option despite the periodontal risks.

Special consideration of the risk factors is critical to achieve satisfactory results from camouflage treatment. First, closing the mandibular molar space would be difficult and time-consuming or even might not be accomplished because of the atrophic edentulous alveolar ridge.[12–14] Second, excessive lingual inclination of the lower anterior teeth might result in root exposure and periodontal fenestration during distalization.[15] Thus, periodontal flapping and bone grafting might be needed in the anterior and edentulous regions. Third, clockwise rotation of the mandible should be avoided, as it would aggravate the open bite and increase chin retrusion, although it would be helpful for correction of the anterior crossbite. Fourth, counterclockwise rotation of the mandible should also be avoided, since the Class III relationships and the crossbite would be aggravated, although it was beneficial to alleviate the hyperdivergent mandible. Therefore, it was critical to prevent either clockwise or counterclockwise rotation of the mandible, and the treatment strategy relied on dental-alveolar changes with the assistance of miniscrews.

The use of proper biomechanics is also critical to achieve desired results. During leveling and alignment (Figure 11), the NiTi wire produced intrusive force to the premolars, extrusive force to the incisors and molars, as well as distal moment to the molars. Short Class III elastics in the premolar and canine regions were used and were effective for extruding anterior teeth, preventing premolar open bite, and alleviating the Class III relationships in this stage. The elastics also delivered the required moment for molar distal uprighting.[16,17] Simultaneously, miniscrews were used to buccally upright and intrude tooth #47.[18] During mandibular distalization (Figure 12), the mandibular occlusal plane was rotated counterclockwise as the retraction force from the miniscrews was above the center of resistance of the mandibular arch, leading to a downward rotation of the posterior occlusal plane and upward rotation anteriorly (Figures 8 and 12). These biomechanics were beneficial for increasing overbite through counterclockwise rotation of the occlusal plane[18] and correcting the crossbite through simultaneous retraction of the lower anterior teeth while keeping the mandible plane stable (Figures 9, 11, and 12).

With regard to the stability of Class III and anterior open bite treatment results, the greatest percentage of relapse had been shown to occur usually during the first posttreatment year.[16,19] It was common to see a slight space reopening of the extraction sites and slight relapse of transverse dimensions during this period.[20] In open bite relapse, it was also suggested that the relapse rate of the incisor extrusion was higher than in molar intrusion,[21] and the counterclockwise rotation of the occlusal plane would favor less relapse of the open bite compared with maintenance of the occlusal plane.[22] The effect of tongue volume and posture on the stability of the occlusion should also be considered.[23] In the present case, satisfactory stability was observed at 26-month follow-up (Figure 9). Long-term stability could also be expected with a greater retention time.

CONCLUSIONS

- This case report described the nonsurgical treatment of a male adult with a hyperdivergent skeletal Class III malocclusion with a convex profile and retruded chin, anterior open bite, and previous loss of the three first molars. For treatment, a mandibular second molar was extracted, and short Class III elastics and miniscrews were used to obtain Class I relationships and proper overjet and overbite as well as to flatten the occlusal plane. A more attractive profile and desirable occlusion were achieved.
- Stable results after 26 months of retention indicated that the therapeutic strategy used for correction of the hyperdivergent skeletal Class III open bite was effective by retraction of the lower anterior teeth and flattening of the occlusal plane, while keeping the mandible plane stable.

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REFERENCES

1. Lin M, Xie C, Yang H, Wu C, Ren A. Prevalence of malocclusion in Chinese schoolchildren from 1991 to 2018: a systematic review and meta-analysis. *Int J Paediatr Dent*. 2019;30:144–155.
2. Baccetti T, Reyes BC, McNamara JA, Jr. Gender differences in Class III malocclusion. *Angle Orthod*. 2005;75:510–520.
3. Franchi L, Baccetti T, Tollaro I. Predictive variables for the outcome of early functional treatment of Class III malocclusion. *Am J Orthod Dentofacial Orthop*. 1997;112:80–86.
4. Moullas AT, Palomo JM, Gass JR, Amberman BD, White J, Gustovich D. Nonsurgical treatment of a patient with a Class III malocclusion. *Am J Orthod Dentofacial Orthop*. 2006; 129(4 suppl):S111–S118.
5. Sugawara Y, Kuroda S, Tamamura N, Takano-Yamamoto T. Adult patient with mandibular protrusion and unstable occlusion treated with titanium screw anchorage. *Am J Orthod Dentofacial Orthop*. 2008;133(1):102–111.
6. Sakai Y, Kuroda S, Murshid SA, Takano-Yamamoto T. Skeletal Class lll severe openbite treatment using implant anchorage. *Angle Orthod*. 2008;78(1):157–166.
7. Sankey WL, Buschang PH, English J, Iii AHO. Early treatment of vertical skeletal dysplasia: the hyperdivergent phenotype. *Am J Orthod Dentofacial Orthop*. 2000;118(3): 317–327.
8. García-Morales P, Buschang PH, Throckmorton GS, English JD. Maximum bite force, muscle efficiency and mechanical advantage in children with vertical growth patterns. *Eur J Orthod* 2003;25:265–272.
9. Woods MG. The mandibular muscles in contemporary orthodontic practice: a review. *Aust Dent J*. 2017;62(suppl 1): 78–85.
10. Biondi K, Lorusso P, Fastuca R, et al. Evaluation of masseter muscle in different vertical skeletal patterns in growing patients. *Eur J Paediatr Dent*. 2016;17:47–52.
11. Proffit WR, White J, Raymond P. Combined surgical-orthodontic treatment: how did it evolve and what are the best practices now? *Am J Orthod Dentofacial Orthop*. 2015; 147:S205–S215.
12. Baik UB, Chun YS, Jung MH, Sugawara J. Protraction of mandibular second and third molars into missing first molar spaces for a patient with an anterior open bite and anterior spacing. *Am J Orthod Dentofacial Orthop*. 2012;141:783–795.
13. Nagaraj K, Upadhyay M, Yadav S. Titanium screw anchorage for protraction of mandibular second molars into first molar extraction sites. *Am J Orthod Dentofacial Orthop*. 2008;134:583–591.
14. Saga AY, Maruo IT, Maruo H, Guariza Filho O, Camargo ES, Tanaka OM. Treatment of an adult with several missing teeth and atrophic old mandibular first molar extraction sites. *Am J Orthod Dentofacial Orthop*. 2011;140:869–878.
15. Chiu GS, Chang CH, Roberts WE. Bimaxillary protrusion with an atrophic alveolar defect: orthodontics, autogenous chin-block graft, soft tissue augmentation, and an implant. *Am J Orthod Dentofacial Orthop*. 2015;147:97–113.
16. 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.
17. Park JH, Yu J, Bullen R. Camouflage treatment of skeletal Class III malocclusion with conventional orthodontic therapy. *Am J Orthod Dentofacial Orthop* 2017;151:804–811.
18. Roberts WE, Viecilli RF, Chang C, Katona TR, Paydare NH. Biology of biomechanics: Finite element analysis of a statically determinate system to rotate the occlusal plane for correction of a skeletal Class III open-bite malocclusion. *Am J Orthod Dentofacial Orthop*. 2015;148:943–955.
19. Ruellas AC, Baratieri C, Roma MB, et al. Angle Class III malocclusion treated with mandibular first molar extractions. *Am J Orthod Dentofacial Orthop*. 2012;142:384–392.
20. Zuccati G, Casci S, Doldo T, Clauser C. Expansion of maxillary arches with crossbite: a systematic review of RCTs in the last 12 years. *Eur J Orthod*. 2013;35:29–37.
21. Farret MM, Farret MM, Farret AM. Skeletal Class III and anterior open bite treatment with different retention protocols: a report of three cases. *J Orthod*. 2012;39:212–223.
22. Raymond JL, Matern O, Grollemund B, Bacon W. Treatment of Class III malocclusion: the key role of the occlusal plane. *Prog Orthod*. 2010;11:53–61.
23. Kawakami M, Yamamoto K, Fujimoto M, Ohgi K, Inoue M, Kirita T. Changes in tongue and hyoid positions, and posterior airway space following mandibular setback surgery. *J Craniomaxillofacial Surg*. 2005;33(2):107–110.