BMC Oral Health

CASE REPORT Open Access

Camouflage treatment of severe skeletal class III malocclusion with effective torque control in an adolescent combined with forward functional shift and hypodivergent

Ting Yu[1,2], Dongmei Lv[2], Dan Xu[2], Huiyue Wang[2], Xin Xiong[3*] and Qian Cheng[2*]

Skeletal Class III malocclusion, often presenting with anterior crossbite, significantly affects patients' oral function, facial aesthetics, and psychological well-being. Here, we report the case of a 17-year-old male patient with a severe skeletal Class III malocclusion, characterized by a concave profile, anterior crossbite, pronounced curve of Spee, and functional anterior shift. The patient preferred a non-surgical approach, posing a challenge for camouflage treatment. The treatment plan involved sequential steps: initially, aligning the maxillary dentition using a mandibular bite block, followed by aligning the mandibular dentition with a maxillary bite block. During this process, uncontrolled torque of the mandibular anterior teeth was observed. To address this, an anterior root torquing spring was applied to control the torque of the lower anterior teeth. Subsequently, a flat bite plane and vertical elastics were utilized to establish proper posterior occlusion. This approach effectively eliminated the functional mandibular shift, resulting in a clockwise mandibular rotation and significant profile enhancement. Throughout treatment, periodontal health was meticulously monitored, ensuring its preservation. Post-treatment outcomes demonstrated well-aligned dentition and correction of the anterior crossbite. At the one-year follow-up, the treatment outcome remained stable.

Keywords Skeletal class III malocclusion, Camouflage treatment, Torque control, Functional shift, Hypodivergent

Skeletal Class III malocclusion is one of the most complex and challenging conditions in clinical orthodontics. Its etiology typically involves maxillary underdevelopment, mandibular overgrowth, or a combination of both [1, 2, 3]. In addition to discrepancies in maxillomandibular growth, forward functional displacement of the mandible can also contribute to the development of a skeletal Class III malocclusion [4]. Therefore, a concise and effective treatment plan after a thorough evaluation of the patient's condition is a critical step in orthodontic treatment, and a satisfactory orthodontic plan can allow the patient to achieve a more desirable outcome at a lower cost.

Orthodontic camouflage treatment and orthognathic surgery are the two orthodontic options available for

*Correspondence:
Xin Xiong
drxiongxin@scu.edu.cn
Qian Cheng
499780562@qq.com
[1]Department of Stomatology, The Fourth Affiliated Hospital of Southwest Medical University (TianFu Affiliated Hospital), Meishan, China
[2]Department of Orthodontics, The Affiliated Stomatological Hospital of Southwest Medical University, Luzhou 646000, China
[3]State Key Laboratory of Oral Diseases & National Center for Stomatology & National Clinical Research Center for Oral Diseases & Department of Orthodontics, West China Hospital of Stomatology, Sichuan University, Chengdu 610041, China

skeletal Class III patients with no growth potential [5, 6], with the former tending to be the choice of more patients because it is less invasive, less costly, and there is no need to worry about deterioration of the profile during orthodontic treatment. Orthodontic camouflage treatment is suitable for mild cases with a low mandibular plane angle and functional shift, which improves skeletal Class III relationships and corrects anterior crossbite by proclining the maxillary incisors and retroclining the mandibular incisors, as well as rotating the mandible clockwise [7, 8].

Here, we report a case of a patient with severe skeletal Class III malocclusion accompanied by anterior crossbite and functional shift, who was successfully treated with a nonsurgical approach to establish a good occlusion and improve facial aesthetics.

Diagnosis and etiology

The patient was a 17-year-old male who came with the complaint of anterior crossbite. He had a history of crossbite in the primary dentition, no relevant family history or medication history, and no temporomandibular joint disorder symptoms.

Facial examination showed that the patient had a shorter lower anterior face height with a concave profile and a protruding chin at the intercuspal position. And there was no adequate tooth exposure when he smiled. Intraorally, the patient initially presented poor oral hygiene, which improved during orthodontic treatment, and he had an end-on Class III molar relationship, with crossbite on all the anterior teeth and the maxillary right premolars, and the root morphology of the lower anterior teeth could be observed superficially. Model measurements suggested that the patient had a 1 mm spaced lower dentition with a pronounced curve of Spee (6 mm) (Figs. 1 and 2).

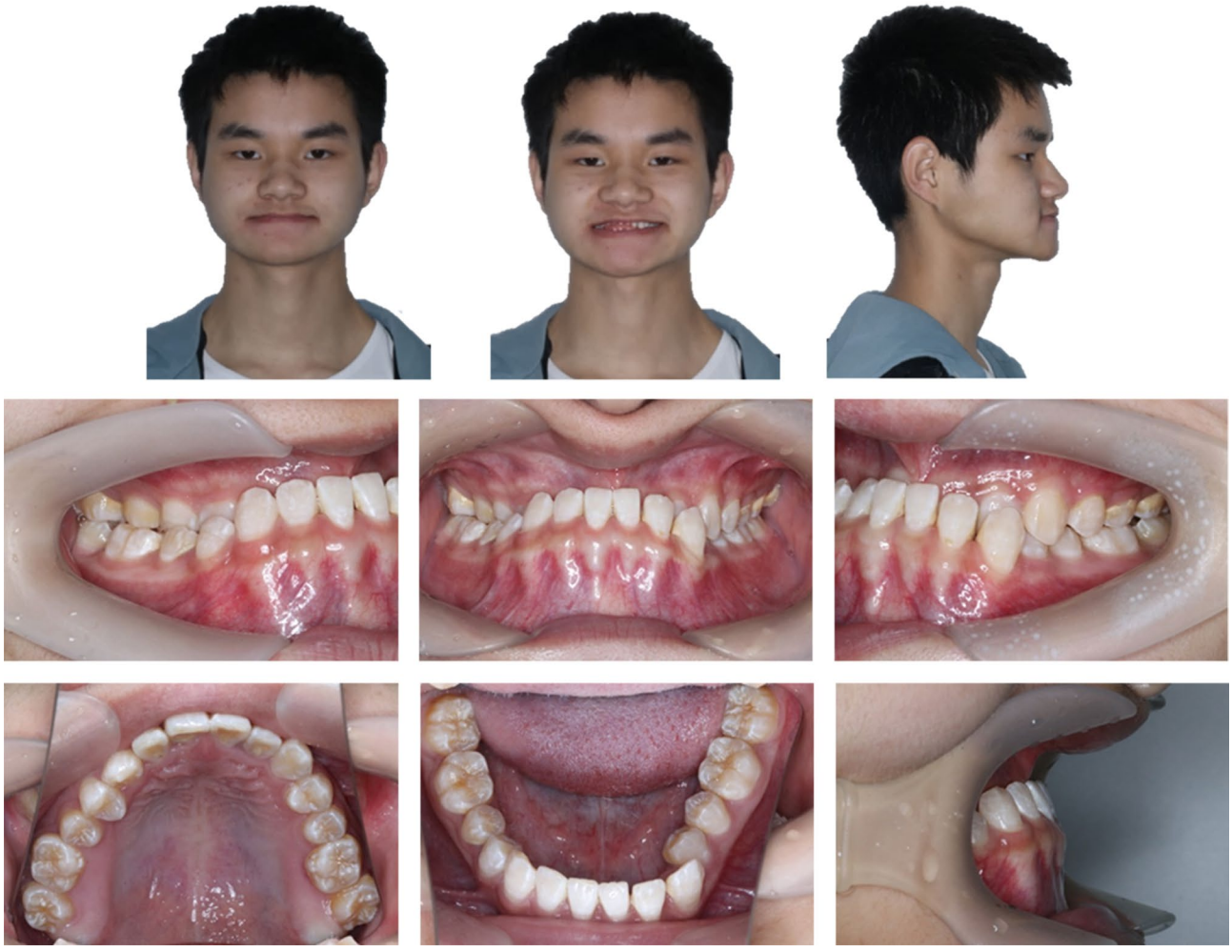

Fig. 1 Pretreatment facial and intraoral photographs taken at the initial visit

Fig. 2 Pretreatment dental casts obtained at the initial visit

Panoramic radiographs showed the presence of two mandibular third molars and one maxillary left third molar (Fig. 3, A). Lateral cephalometric analysis at intercuspal position suggested skeletal Class III, protruded mandible, excessive mandibular length (SNA 85.5°, SNB 92.3°, ANB −6.8°, Wits −7.5 mm, Go-Pog 82.0 mm) with a hypodivergent growth pattern (SN-MP 17.5°). His maxillary incisors were proclined while the mandibular incisors were extremely retroclined (U1-SN 112.8°, L1-MP 72.7°) (Fig. 3, B; Table 1).

Cone-beam computed tomography (CBCT) was used to examine the roots in the alveolar bone, showing thin cortical bone on the labial side of the mandibular anterior teeth with a risk of bone fenestration (Fig. 3, D). Fortunately, alveolar bone width in the anterior maxilla was relatively adequate (Fig. 3, C).

Functional analysis revealed that when the patient's mandible was guided into centric relation, reaching an incisal edge-to-edge contact, his lower face height increased and the concave profile improved significantly. However, the posterior region showed severe open bite, with the maxillary dental midline deviating 1 mm to the left of the facial midline (Fig. 4).

Based on the above measurements, the patient was primarily diagnosed with skeletal class III with functional shift, anterior crossbite and concave profile.

Treatment objectives

The treatment objectives for this patient were (1) to align the upper dentition followed by lower dentition alignment, then control the lower anterior torque; (2) to correct the midline, improve dental and skeletal Class III relationships, and to establish a normal overbite and overjet; and (3) to increase the lower facial height and improve the concave profile.

Treatment alternatives

Based on the patient's examinations, we considered two treatment options. The first option was orthognathic surgery, normalizing the inclination of the upper and lower incisors, and using surgical methods to retract the mandible. This method can better improve the patient's profile and ensure the normal alignment of the teeth, but the disadvantages include the high cost of surgery and associated risks. The second option was orthodontic camouflage treatment, proclining maxillary incisors while rotating the mandible clockwise to improve the severe Class III relationship and correct anterior crossbite. The advantage of this method is that the patient does not have to undergo surgical trauma and high cost, but the teeth may become more proclined. It would be challenging to maintain the treatment outcomes, requiring a longer retention period.

We communicated these two options with the patient and his family, and they ultimately chose the second one: to correct anterior crossbite with traditional orthodontic therapy.

Treatment progress

Prior to initiating orthodontic treatment, the patient underwent full-mouth periodontal scaling and extraction of the mandibular third molars, followed by the fabrication of a mandibular bite block and bonding of the maxillary fixed appliance to align the upper dentition. The crossbite was corrected during this period (Fig. 5, A). When the maxillary archwire progressed to 0.018 × 0.025-in stainless steel, a posterior bite block was fabricated to the maxilla and fixed appliances were bonded on the mandibular arch (Fig. 5, B).

Due to the retroclination of the mandibular anterior teeth and the pronounced curve of Spee, a reverse

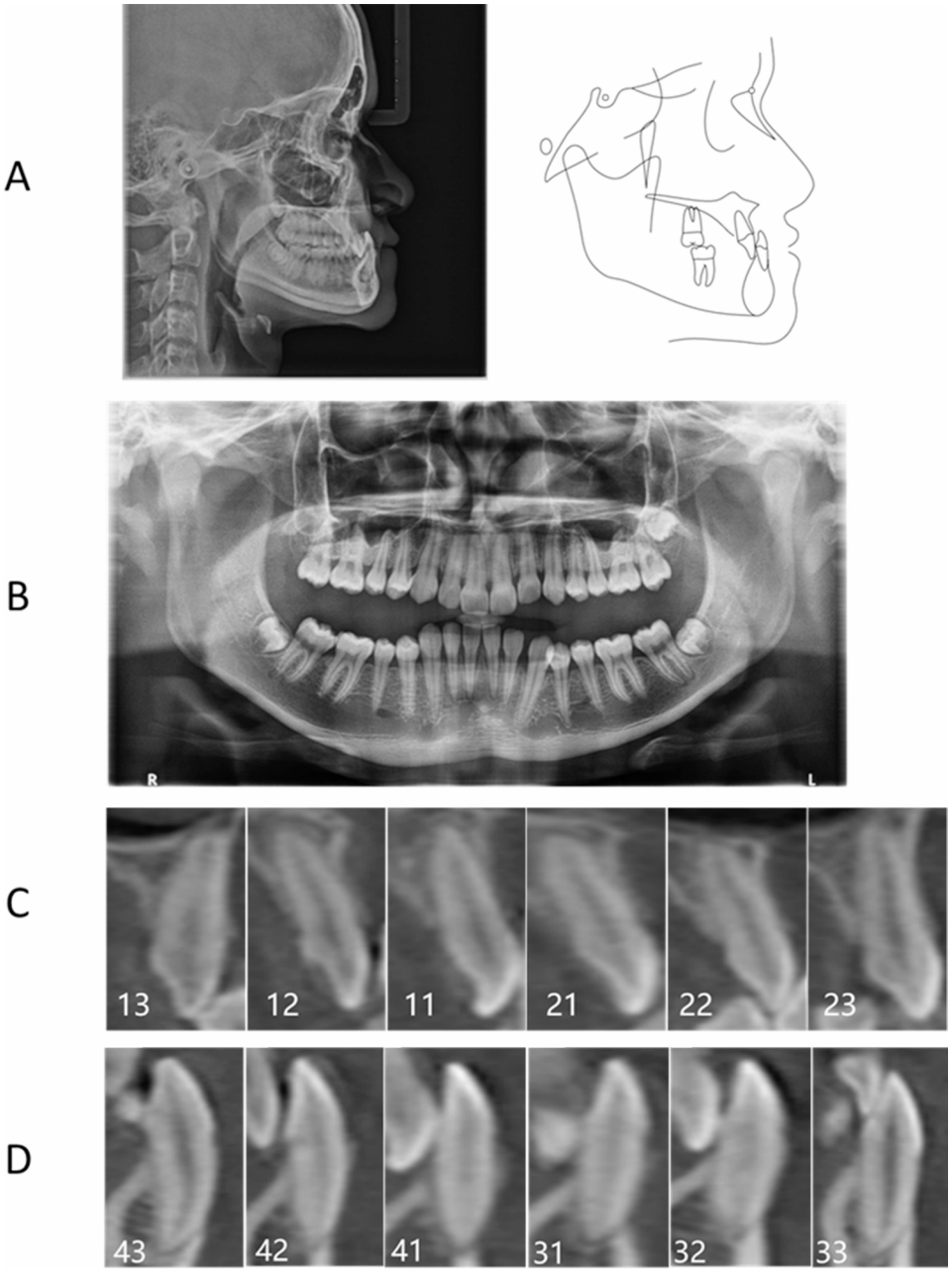

Fig. 3 (**A**) Pretreatment lateral cephalometric radiograph; (**B**) panoramic radiograph; (**C**) CBCT imaging of the maxillary anterior area; and (**D**) CBCT imaging of the mandibular anterior area taken at the initial visit

curve of Spee was incorporated into nickel-titanium rectangular archwires to address these issues. However, it was observed that the crowns of the mandibular anterior teeth labially inclined, while the root morphology remained superficial, indicating inadequate torque control. This posed a potential risk of bone fenestration. To address this, an anterior root torquing spring, a device fabricated from 0.014-in Australian wire, was applied when the mandibular archwire worked up to 0.018 × 0.025-in stainless steel. Meanwhile, passive lacebacks were utilized to limit the proclination of the mandibular incisors (Figs. 5, C and 6).

Subsequent CBCT scans demonstrated that the torque of the lower anterior was under control and the roots were all centered in the alveolar bone (Fig. 5, D), which was a satisfactory outcome. A flat bite plane was then applied to the maxillary anterior region for bite opening, and vertical elastics were used to level the lower dentition and improve the posterior open bite (Fig. 5, C). After consistent treatment, the patient achieved stable

Table 1 Summary of cephalometric analyses

Measurment	Norm	Initial value	Final value
SNA(°)	83.0 ± 4.0	85.5	85.7
SNB(°)	80.0 ± 4.0	92.3	89.6
ANB(°)	3.0 ± 2.0	−6.8	−3.9
Wits (mm)	−0.8 ± 2.8	−7.5	−1.8
Go-Pog (mm)	74.0 ± 5.0	82.0	81.8
OP-SN (°)	19.0 ± 4.0	0.8	3.3
MP-SN (°)	35.0 ± 4.0	17.5	19.4
FMA (°)	29.0 ± 4.0	10.6	13.5
ANS-Me (mm)	63.0 ± 5.0	50.2	56.2
U1-SN (°)	105.7 ± 6.3	112.8	133.4
IMPA(°)	91.6 ± 7.0	72.7	84.3
Upper lip to E-plane (mm)	2.0 ± 2.0	−3.4	−4.3
Lower lip to E-plane (mm)	3.0 ± 3.0	−2.8	−4.0

SNA, sella-nasion-A point; SNB, sella-nasion-B point; ANB, A point-nasion-B point; SN, sella-nasion; Go-Pog, gonion-pogonion; OP-SN, occlusal plane to sella-nasion plane; MP-SN, mandibular plane to sella-nasion plane; FMA, gonion-menton to Frankfort horizontal plane; ANS-Me, anterior nasal spina to menton; U1-SN, upper incisor to sella-nasion; IMPA, lower incisor to gonionmenton; UL-E, upper lip to E line; LL-E, lower lip to E line

occlusion in the posterior regions, followed by space closure and finishing stage.

The total active treatment time was 39 months. Upon removal of the appliances, thermoplastic retainers were provided for retention, and a follow-up evaluation was performed one year later.

Treatment results

At the end of treatment, clinical and radiographic examinations confirmed that all orthodontic objectives were achieved. Facial examination demonstrated a significant improvement in the patient's concave profile and a more harmonized lower anterior face height. Intraoral examination revealed that the upper and lower dentition were leveled, the anterior crossbite was corrected, and the overbite and overjet of the anterior teeth were normalized. Additionally, the upper and lower midlines were aligned, the bilateral posterior occlusion was stable, and a Class I molar and canine relationship was achieved overall (Figs. 7 and 8).

Compared with the pretreatment measurements, posttreatment cephalometric analysis indicated that the mandible was significantly retruded (posttreatment SNB 89.6°). The changes in the ANB angle and the Wits appraisal values reflected a reduction in the severity of the skeletal Class III relationship, and a more harmonized sagittal relationship between the maxilla and mandible (posttreatment ANB −3.8 °, posttreatment Wits −1.8 mm). The mandibular plane angle increased by 2.9°, and the lower anterior facial height increased from 50.2 mm to 56.2 mm. Changes including labial inclination of the upper anterior teeth, torque improvement of the lower anterior teeth (U1-SN 133.4°, L1-MP 84.3°), and significant extrusion of both the upper and lower posterior teeth (U6-PP 22.9 mm, L6-MP 26.2 mm) were noted (Fig. 9, A; Table 1).

Fig. 4 Facial and intraoral photographs in centric relation taken at the initial visit

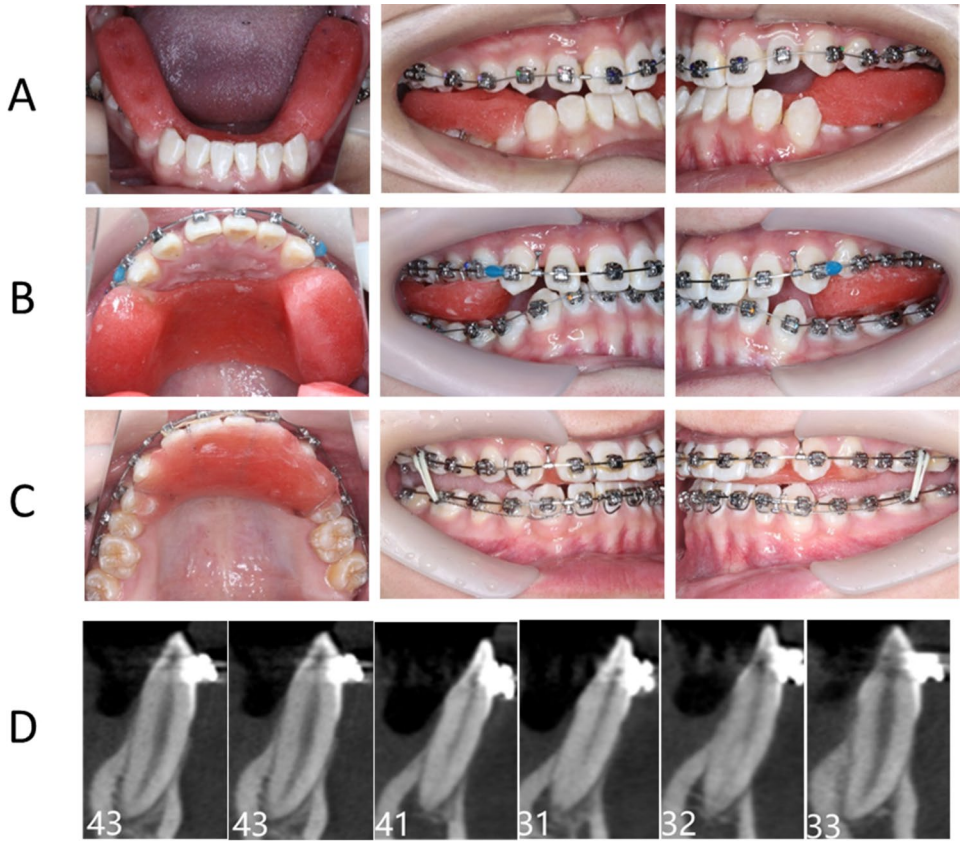

Fig. 5 (**A,B**) Sequential alignment of the upper and lower dentitions; (**C**) anterior root torquing spring used for lower anterior torque management, and vertical elastics for posterior occlusal contact; and (**D**) CBCT imaging of the mandibular anterior area taken during treatment progress

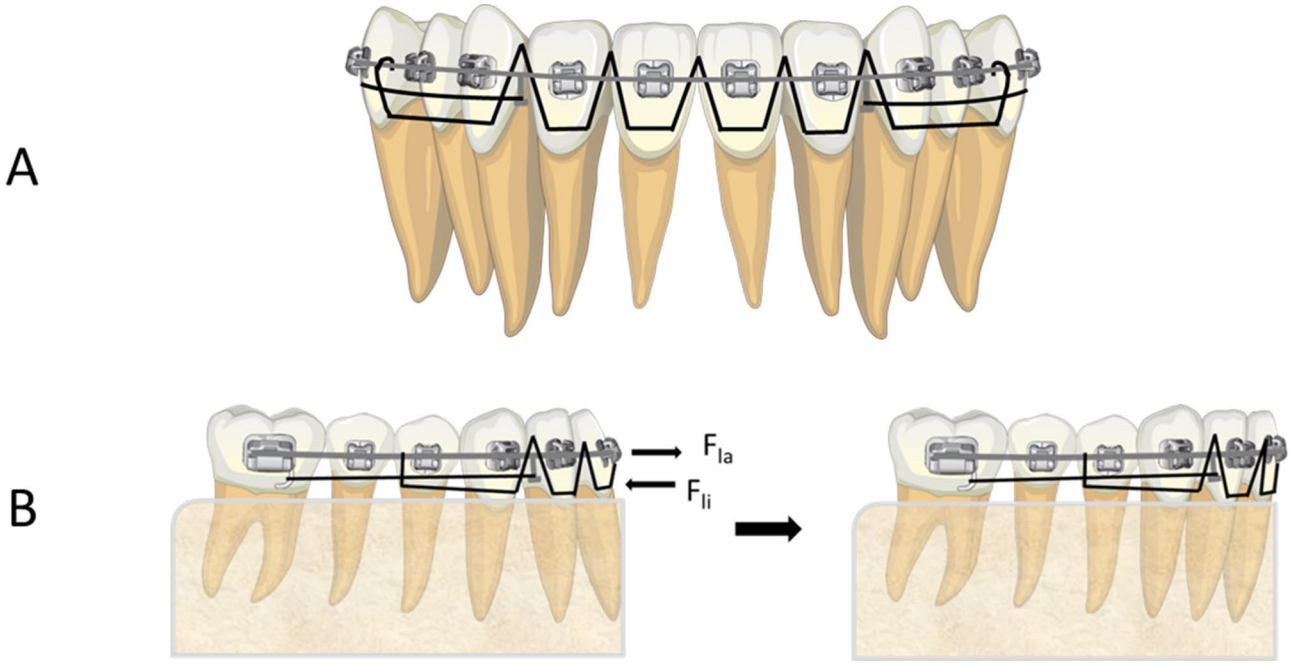

Fig. 6 (**A** Illustration of the anterior root torquing spring from the front; (**B**) biomechanical illustration of the anterior root torquing spring, F_{la} and F_{li} represent the couple generated by the torquing spring, where F_{la} denotes the labial force and F_{li} denotes the lingual force

Fig. 7 Posttreatment facial and intraoral photographs

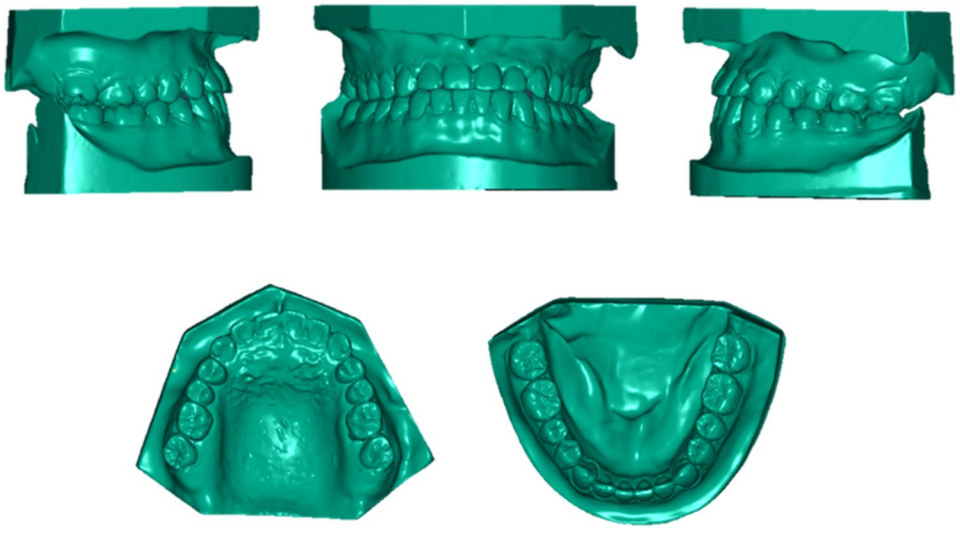

Fig. 8 Posttreatment dental casts

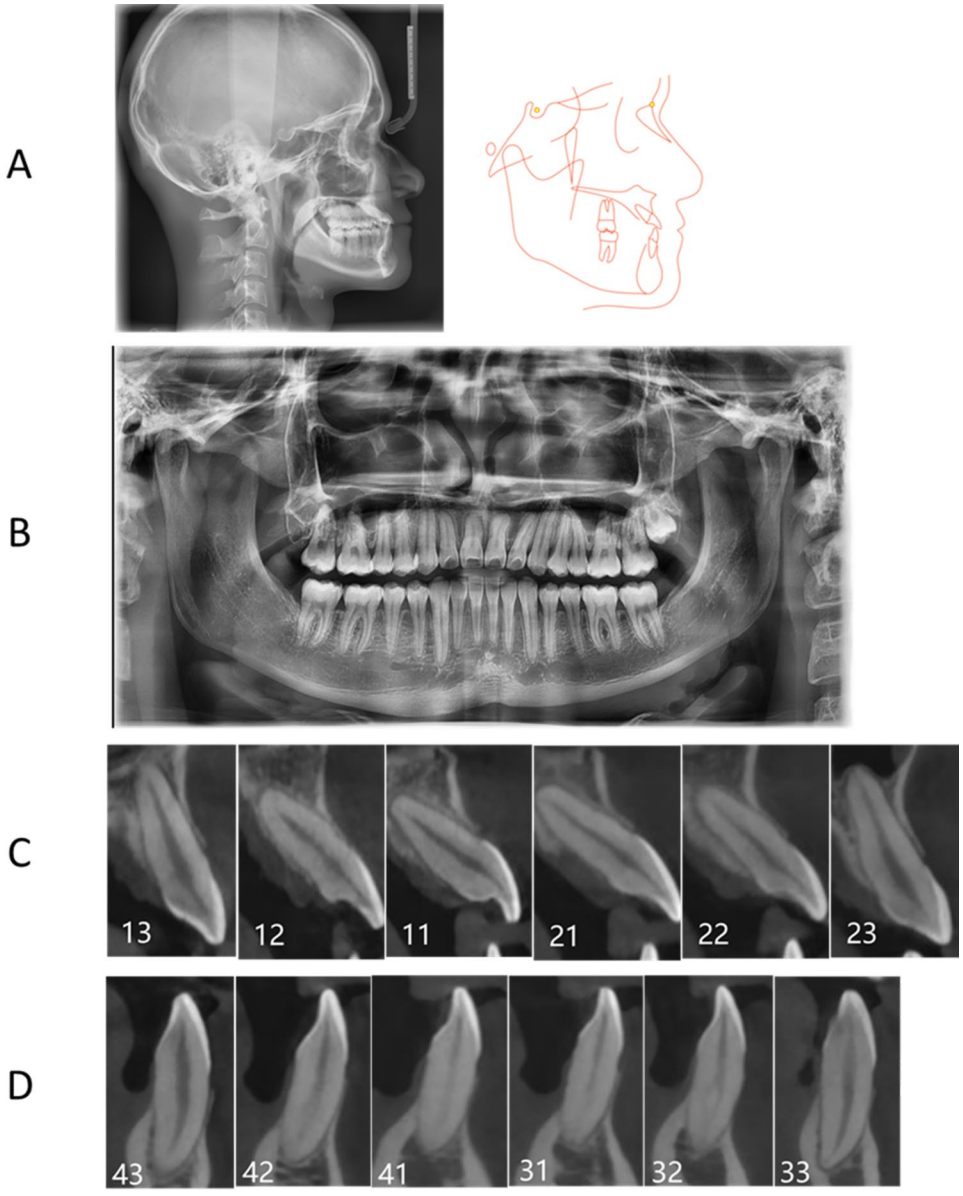

Fig. 9 (**A**) Posttreatment lateral cephalometric radiograph; (**B**) panoramic radiograph; (**C**) CBCT imaging of the maxillary anterior area; and (**D**) CBCT imaging of the mandibular anterior area after treatment

Posttreatment panoramic radiograph suggested no significant alveolar bone loss, the extraction of the mandibular third molars and the distal uprighting of the mandibular molars. However, suboptimal root parallelism was observed, and a radiographic appearance suggestive of potential root resorption was observed in the anterior maxilla (Fig. 9, B).

CBCT imaging revealed that the maxillary anterior teeth were proclined, with all roots within the alveolar bone. The root apices of the maxillary incisors became rounded, but there was no significant change in root length (Fig. 9, C). Surprisingly, the torque of the mandibular anterior teeth was well-managed, and the thickness of the labial cortical bone had increased (Fig. 9, D), which was beneficial to the patient's periodontal health.

Superimposed cephalometric tracings demonstrated that the malocclusion was corrected through proclination of the maxillary anterior teeth and clockwise rotation of the mandible (Fig. 10).

At the 1-year follow-up, the treatment outcomes remained stable, with a favorable occlusal relationship and improved facial aesthetics (Fig. 11).

Discussion

The management of skeletal Class III malocclusion is determined by the patient's examination results and treatment expectations. There are some surgical indications to

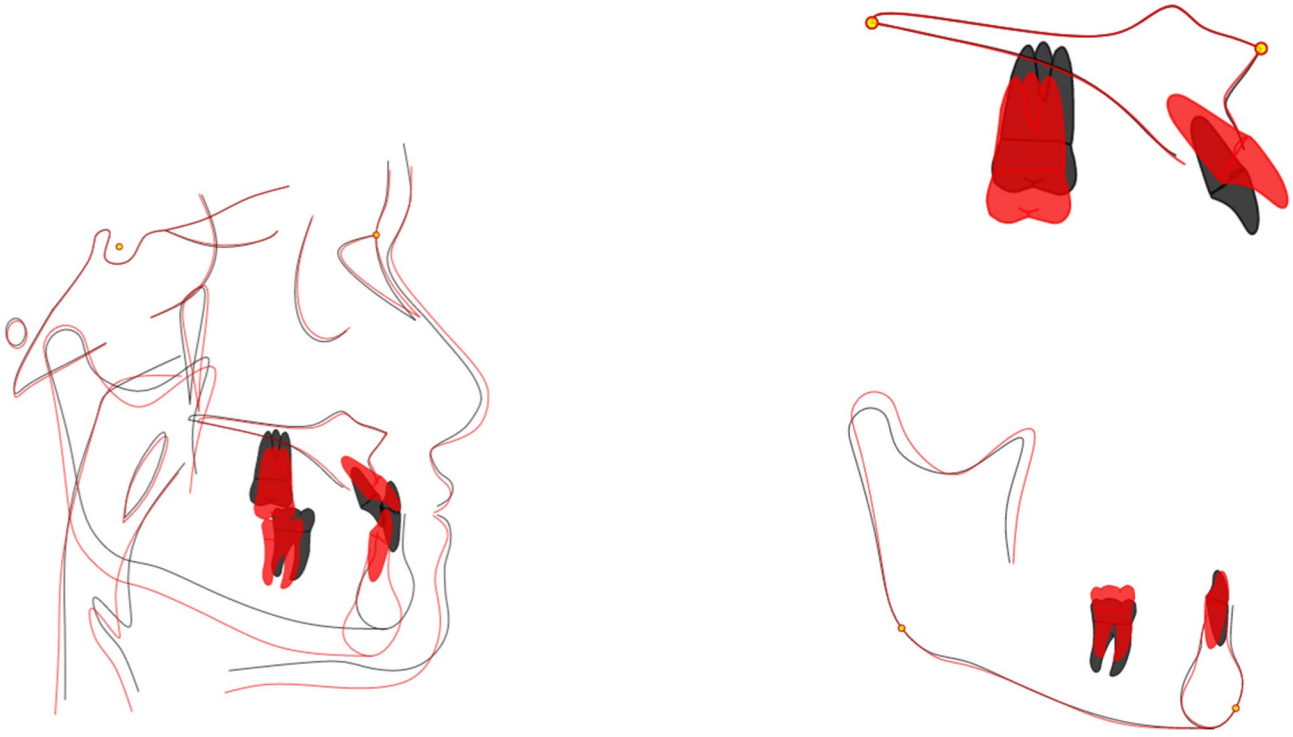

Fig. 10 Pretreatment (black lines) and posttreatment (red lines) cephalometric superimposition, superimposed on the sella-nasion plane, palatal plane, and mandibular plane, respectively

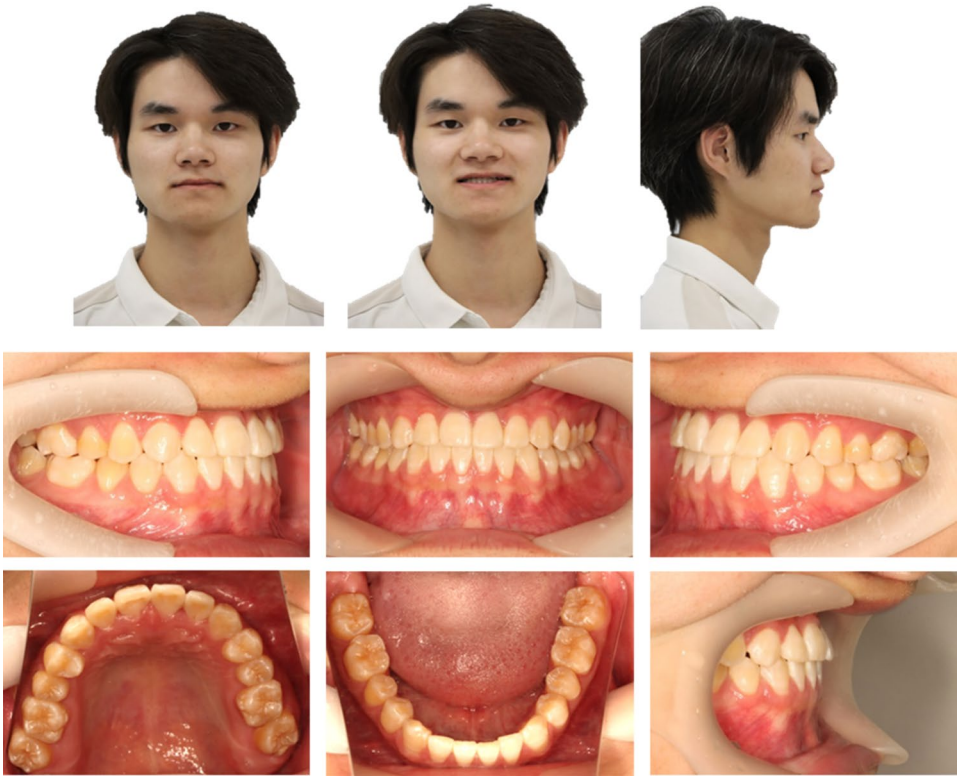

Fig. 11 Postretention facial and intraoral photographs

meet before orthognathic surgery for skeletal Class III patients [9, 10, 11], such as an ANB angle less than −4°, a Wits appraisal value less than −6.3 mm, and an L1-MP angle less than 82°. In this case, examination results of the patient primarily met the surgical criteria, suggesting that surgical correction could achieve a superior result. However, the presence of an anterior functional crossbite indicated the potential for orthodontic compensation [12]. Meanwhile, the patient's hypodivergent growth pattern, low mandibular plane angle, and reduced anterior facial height suggested that it was feasible and rational to achieve clockwise rotation of the mandible, thereby increasing the efficacy of orthodontic camouflage treatment [8, 13]. After thorough communication, the patient and his family declined the surgical option and strongly preferred nonsurgical treatment. Based on these considerations, the orthodontic camouflage treatment was finally proceeded, anticipating a desired improvement in the patient's facial profile after treatment.

To ensure the safety and efficacy of orthodontic treatment for this patient, sequential treatment approach was implemented. Typically, there are two methods for bite opening during dental alignment: (1) resins bonded to the lingual side of the lower anterior teeth [14], and (2) cushioning materials used in the posterior region [15]. Due to the severe lingual inclination of the lower anterior teeth in this case, the first method posed a risk of further trauma. Considering the stability and effectiveness of cushioning materials, a mandibular bite block was fabricated, with initiated alignment of the upper dentition simultaneously. Once the upper dentition was leveled with stainless steel archwire, a maxillary bite block was fabricated, followed by alignment of the lower dentition. This sequential alignment strategy not only preserved the patient's masticatory function but also minimized the risk of root resorption.

After both the upper and lower dentition were aligned, the treatment focused on torque control of the lower anterior teeth. Patients with skeletal Class III malocclusion often exhibit thin labial alveolar bone thickness in the anterior mandible and a limited safe range of movement [16, 17], making it critical to closely monitor the root position in the alveolar bone using CBCT. In cases of lingual inclination of the teeth, the routine use of a reverse curve archwire alone may result in excessive labial crown proclination and poor lingual root torque of the lower anterior teeth [18]. While the third-order bend is a conventional method for torque management of multiple teeth [19], its efficacy may be insufficient [20]. Additionally, the short force arm of the third-order bend may lead to excessive stress on the teeth [21], potentially compromising periodontal health.

When the mandibular dentition was aligned and leveled with a 0.018 × 0.025-in stainless steel archwire, a root torquing spring was applied to this patient. The spring generates a force couple, providing lingual force at the cervical area of the crown and labial force at the middle area. This mechanism achieved lingual root torque in the anterior mandible [22], while the crowns moved labially. Importantly, passive lacebacks were necessary to limit the labial movement of the crowns while promoting lingual root movement. It is clear that the force arm of the torquing spring is longer than that of the third-order bend, allowing for the application of milder and more controlled forces to the teeth. This approach reduced the risk of bone fenestration and root resorption [23, 24]. As a result, the torque of the mandibular anterior teeth was managed with high efficiency and safety. Moreover, torque management of the lower anterior teeth was a critical focus during the later stages of treatment.

In skeletal Class III malocclusion cases with functional shift, establishing a stable posterior occlusal relationship is the key to the success of treatment and serves as a foundation for achieving therapeutic goals. In this case, to prevent anterior occlusal trauma, posterior bite blocks were applied for 21 months, which resulted in molar intrusion and counterclockwise rotation of the mandible. To address these concerns, molar extrusion was necessary. Following the correction of the anterior crossbite and effective torque management, a maxillary flat bite plane was utilized to open the bite in the posterior region. Vertical elastics were employed to extrude the intruded molars, facilitating the establishment of a stable occlusal relationship. This approach not only aided in leveling the curve of Spee but also promoted clockwise rotation of the mandible, increasing both the occlusal plane angle and the mandibular plane angle. These changes contributed to an increase in lower facial height, improvement of the skeletal Class III relationship, and enhancement of the patient's concave profile [25, 26].

It is important to note that the anterior flat bite plane should not be applied until the torque of the lower anterior teeth has been adequately controlled. Premature use of the bite plane may exacerbate the lingual inclination of the lower anterior teeth and worsen periodontal health.

It is undeniable that camouflage treatment in such severe cases has certain limitations [9, 27]. For instance, excessive proclination of the maxillary anterior teeth may occur to compensate for the skeletal discrepancies, potentially compromising the stability of the treatment outcome. In fact, skeletal anchorage-based distalization of the lower dentition could provide better control over the inclination of the maxillary anterior teeth, enabling the patient to obtain a more harmonious and aesthetic smile. However, distalization is only suitable for patients with adequate alveolar bone width. In this case, the patient exhibited a limited safe range of movement in the

anterior mandible, necessitating the abandonment of this approach.

It should be noted that early intervention, such as the use of a maxillary protraction appliance or Fränkel III appliance [28], might have provided better control of the skeletal discrepancies. Nonetheless, in the present case, the patient's chief complaints were addressed through orthodontic camouflage treatment. Before treatment, only the lower anterior gingiva was exposed when the patient smiled; however, this condition significantly improved post-treatment. The patient expressed high satisfaction with the final outcome.

Following treatment, the patient was instructed to wear retainers full-time. At the one-year follow-up, the outcome remained stable, consistent with findings reported in similar cases [29, 30]. However, considering potential relapse risks such as molar intrusion and counterclockwise rotation of the mandible, the patient was advised to switch from thermoplastic retainers to Hawley retainers to better mitigate these risks. Interestingly, minor relapse during the retention phase may allow for slight adjustments in tooth positioning, potentially improving root parallelism over time. Additionally, some studies have suggested that increasing the occlusal vertical dimension and vertical facial height can reduce the masticatory muscle activity and occlusal forces [31, 32], which may contribute to long-term stability.

Conclusions

- Camouflage treatment for severe skeletal discrepancies has certain limitations. Accurate diagnosis and a well-designed treatment plan are critical to successful outcomes in such complex malocclusions.
- This case highlights the importance of maintaining periodontal health through a carefully planned, step-by-step treatment approach. Treatment results achieved a balance between aesthetics and functional improvement.
- The anterior root torquing spring is an effective tool for precise torque control of anterior teeth, helping to prevent bone fenestration in the anterior mandible.

Acknowledgements
Not applicable.

Author contributions
A wrote the main manuscript text, prepared Fig. 6 and data analysis; b prepared Figs. 1, 2, 3, 4, 5 and made the table; c prepared Figs. 7, 8, 9, 10 and 11, d and e supervised the writing of the article, reviewed and edited the article during revising the manuscript. All authors have reviewed and agreed to the published version of the manuscript.

Funding
Not applicable.

Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was conducted in accordance with the Helsinki Declaration. The study was approved by the Ethics Committee of the Affiliated Stomatological Hospital of Southwest Medical University (Approval No. 20230406001). Written informed consent was obtained from the patient, and the consent form is available for review by the Editor of this journal.

Consent for publication
Written informed consent for the publication of clinical images was obtained from the patient.

Competing interests
The authors declare no competing interests.

Received: 21 November 2024 / Accepted: 5 May 2025
Published online: 22 May 2025

References

1. Spalj S, Mestrovic S, Lapter Varga M, Slaj M. Skeletal components of class III malocclusions and compensation mechanisms. J Oral Rehabil. 2008;35(8):629–37.
2. Faria-Teixeira MC, Tordera C, Salvado E, Silva F, Vaz-Carneiro A, Iglesias-Linares A. Craniofacial syndromes and class III phenotype: common genotype fingerprints? A scoping review and meta-analysis. Pediatr Res. 2024;95(6):1455–75.
3. Celikoglu M, Yavuz I, Unal T, Oktay H, Erdem A. Comparison of the soft and hard tissue effects of two different Protraction mechanisms in class III patients: a randomized clinical trial. Clin Oral Investig. 2015;19(8):2115–22.
4. Tagawa DT, Franco AA, Puchnick A, Wolosker AMB, Florez BM, Dominguez GC, Yamashita HK, Cevidanes LHS, Aidar LAA, Junior HC. Temporomandibular joint articular disc position and shape in skeletal class III. Orthod Craniofac Res. 2023;26(2):185–96.
5. Ngan P, Moon W. Evolution of class III treatment in orthodontics. Am J Orthod Dentofac Orthop. 2015;148(1):22–36.
6. Araujo MTS, Squeff LR. Orthodontic camouflage as a treatment alternative for skeletal class III. Dent Press J Orthod. 2021;26(4):e21bbo4.
7. Benyahia H, Azaroual MF, Garcia C, Hamou E, Abouqal R, Zaoui F. Treatment of skeletal class III malocclusions: orthognathic surgery or orthodontic camouflage? How to decide. Int Orthod. 2011;9(2):196–209.
8. Park JH, Yu J, Bullen R. Camouflage treatment of skeletal class III malocclusion with conventional orthodontic therapy. Am J Orthod Dentofac Orthop. 2017;151(4):804–11.
9. Stellzig-Eisenhauer A, Lux CJ, Schuster G. Treatment decision in adult patients with class III malocclusion: orthodontic therapy or orthognathic surgery? Am J Orthod Dentofac Orthop. 2002;122(1):27–37. discussion 37– 8.
10. Eslami S, Faber J, Fateh A, Sheikholaemmeh F, Grassia V, Jamilian A. Treatment decision in adult patients with class III malocclusion: surgery versus orthodontics. Prog Orthod. 2018;19(1):28.
11. Haryani J, Nagar A, Mehrotra D, Ranabhatt R. Management of severe skeletal class III malocclusion with bimaxillary orthognathic surgery. Contemp Clin Dent. 2016;7(4):574–8.
12. Alotaibi S. Orthodontic camouflage treatment of pseudo-Class III malocclusion on skeletal class III base complicated with canine impaction treated with temporary anchorage devices: A case report. Clin Case Rep. 2023;11(6):e7394.
13. Park JH, Emamy M, Lee SH. Adult skeletal class III correction with camouflage orthodontic treatment. Am J Orthod Dentofac Orthop. 2019;156(6):858–69.
14. 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 Dentofac Orthop. 2016;149(4):555–66.
15. Bellot-Arcís C, García-Sanz V, Paredes-Gallardo V. Nonsurgical treatment of an adult with skeletal class III malocclusion, anterior crossbite, and an impacted canine. Am J Orthod Dentofac Orthop. 2021;159(4):522–35.
16. Lu CL, Li BW, Yang M, Wang XQ. Relationship between alveolar-bone morphology at the mandibular incisors and their inclination in adults with

low-angle, skeletal class III malocclusion-A retrospective CBCT study. PLoS ONE. 2022;17(3):e0264788.
17. Zhang X, Gao J, Sun W, Zhang H, Qin W, Jin Z. Evaluation of alveolar bone morphology of incisors with different sagittal skeletal facial types by cone beam computed tomography: A retrospective study. Heliyon. 2023;9(4):e15369.
18. Park JH, Choo H, Choi JY, Chung KR, Kim SH. Evaluation of strategic uprighting of the mandibular molars using an orthodontic miniplate and a nickel-titanium reverse curve arch wire: preliminary cephalometric study. Korean J Orthod. 2021;51(3):179–88.
19. Kim KA, Hwang HS, Chung KR, Kim SH, Nelson G. Recovery of multiple impacted maxillary teeth in a hyperdivergent class I patient using temporary skeletal anchorage devices and augmented corticotomy. Angle Orthod. 2018;88(1):107–21.
20. Jiang Q, Yang R, Mei L, Ma Q, Wu T, Li H. A novel approach of torque control for maxillary displaced incisors. Am J Orthod Dentofac Orthop. 2019;155(6):860–70.
21. Wagner JA, Nikolai RJ. Stiffness of incisor segments of Edgewise arches in torsion and bending. Angle Orthod. 1985;55(1):37–50.
22. Balisany BH, Chawshli OF, Omer ZQ. A hypothesis testing of archwire rounding for the efficacy of torque springs in orthodontics: A finite element study. Cureus. 2024;16(3):e57292.
23. Roscoe MG, Meira JB, Cattaneo PM. Association of orthodontic force system and root resorption: A systematic review. Am J Orthod Dentofac Orthop. 2015;147(5):610–26.
24. Yassir YA, McIntyre GT, Bearn DR. Orthodontic treatment and root resorption: an overview of systematic reviews. Eur J Orthod. 2021;43(4):442–56.
25. Tsai IM, Lin CH, Wang YC. Correction of skeletal class III malocclusion with clockwise rotation of the maxillomandibular complex. Am J Orthod Dentofac Orthop. 2012;141(2):219–27.
26. Wu TY, Chang TF, Wu CH. True vertical changes in patients with skeletal class III malocclusion after nonsurgical orthodontic treatment-a retrospective study comparing different vertical facial patterns. J Dent Sci. 2022;17(3):1096–101.
27. Burns NR, Musich DR, Martin C, Razmus T, Gunel E, Ngan P. Class III camouflage treatment: what are the limits? Am J Orthod Dentofacial Orthop. 2010;137(1):9.e1-13; discussion 9–11.
28. Jamilian A, Cannavale R, Piancino MG, Eslami S, Perillo L. Methodological quality and outcome of systematic reviews reporting on orthopaedic treatment for class III malocclusion: overview of systematic reviews. J Orthod. 2016;43(2):102–20.
29. Büyükçavuş MH, Sari ÖF, Findik Y. Correction of late adolescent skeletal class III using the Alt-RAMEC protocol and skeletal anchorage. Korean J Orthod. 2023;53(1):54–64.
30. Kook YA, Choi TH, Park JH, Kim SH, Lee NK. Comparison of posttreatment stability after total mandibular arch distalization with mini-implants and mandibular setback surgery. Angle Orthod. 2024;94(2):159–67.
31. Sierpinska T, Golebiewska M, Kuc J, Lapuc M. The influence of the occlusal vertical dimension on masticatory muscle activities and hyoid bone position in complete denture wearers. Adv Med Sci. 2009;54(1):104–8.
32. Custodio W, Gomes SG, Faot F, Garcia RC, Del Bel Cury AA. Occlusal force, electromyographic activity of masticatory muscles and mandibular flexure of subjects with different facial types. J Appl Oral Sci. 2011;19(4):343–9.

Publisher's note