Submitted: 14 September, 2022 Accepted: 24 October, 2022 Published: 03 January, 2023 DOI:10.22514/jocpd.2022.017

CASE REPORT

Journal of Clinical Pediatric Dentistry

# Combined orthopedic-orthodontic treatments of adolescent skeletal open-bite with severe molar-incisor hypomineralization: a case report and literature review

Jie Chen[1], Yuchan Xu[1], Weihua Guo[1,*]

[1]State Key Laboratory of Oral Diseases, Department of Pediatric Dentistry, Orthodontics Faculty, National Clinical Research Center for Oral Diseases, West China School of Stomatology, Sichuan University, 610041 Chengdu, Sichuan, China

***Correspondence**
guoweihua943019@163.com
(Weihua Guo)

## Abstract

The treatment of adolescent skeletal open-bite malocclusion with severe molar-incisor hypomineralization (MIH) remains challenging. Though conducive to open-bite treatment and endodontic management, early molar extraction may trigger a series of negative impacts on occlusion and stomatognathic development. In addition, molars' crown restoration was shown to worsen open-bite malocclusion considering the intrinsic vertical increment of hyperdivergent growth. This case report describes the successful multidisciplinary therapy combined with orthopedic and orthodontic treatment of a 10.2-year-old girl with mixed dentition, a protruding profile and skeletal open-bite malocclusion with severe MIH and crowding. During the mixed and early permanent dentition, function regulator-4 (FR-4), resin-bonding transpalatal arch (TPA) and modified spring-loaded bite blocks were implemented to correct abnormal swallowing and control the facial vertical growth. Radiographic results, including the counterclockwise rotation of the occlusion plane, decreasing mandibular angle and increasing posterior-anterior face height ratio accompanied by obvious mandibular vertical growth, indicated that the performed orthopedic treatments efficiently controlled hyperdivergent open-bite growth during puberty. After the maxillary and mandibular second molars were occluded, all first permanent molars were extracted, and fixed appliances combined with implant anchorage were used to correct malocclusion and convex profile. Ultimately, a stable Class I functional occlusion and satisfying facial improvement were achieved and maintained following a 2-year follow-up.

## Keywords

Skeletal open bite; Early treatment; Orthodontic mini-implant; Molar-incisor hypomineralization; First permanent molars extraction

## 1. Introduction

Following decay, molar-incisor hypomineralization (MIH) is a frequent compromising factor for the poor prognosis of first permanent molars (FPMs), with a prevalence ranging from 10% to 27% [1]. The treatment approaches for MIH include filling, pre-formed crown restoration and even molar extractions, especially for those with third molars and obvious malocclusion [1]. Nevertheless, the potential of losing FPMs negatively impacts occlusion development, chewing habits and dentofacial symmetry, especially in the mixed dentition stage [2]. Considering its controversial application, clinical guidelines have primarily focused on the optimal FPMs extraction time within different crowding malocclusions [3]. However, there is a lack of data to illustrate the influence of vertical factors on this decision-making process for adolescent skeletal open-bite malocclusion. Meanwhile, although early orthopedic treatment is considered necessary for children and teenagers [4], a systematic review reported insufficient evidence to draw concrete conclusions about the most effective early correction [5]. A lack of direct feedback loops to a patient during the long-term wearing of those passive devices often leads to loss of patient compliance and uncertainty therapeutic outcomes. Here, we present an efficient strategy using active orthopedic modification and fixed appliance after FPMs extraction to treat a girl with skeletal open-bite, protruding incisors and severe MIH, which successfully achieved and maintained a Class I canine and molar occlusion and aesthetic facial results following a 2-year follow-up.

## 2. Case report

A 10.2-year-old girl without any general health problems or menarche was referred by a general dentist regarding "open-bite and protruded incisors" during dental caries therapy (Fig. 1). The patient's mother reported that the patient had mastication difficulties and disliked chewing any hard foods. She presented with a visceral swallowing


  

**FIGURE 1. Pretreatment photographs of facial, intraoral, panoramic and lateral records.**

pattern, displayed as a forward movement of the tongue tip and pressure between the upper-lower incisors. Extraoral examination showed partial long-face features with an increased lower facial height and a highly convex profile in the lateral aspect. Her temporomandibular joint examination was normal. Intraorally, the patient presented with obvious crown filling, bilateral Class II molar relationship and anterior open bite with mixed dentition. Notably, FPMs showed severe MIH with yellowish-brown crowns and occlusal breakdown even with large restorations. Further, hypomineralization was visible on the central maxillary incisors, and she had an overjet of 4.1 mm and an overbite of −2.4 mm. The panoramic radiograph showed some teeth with restorations and incomplete treatments. Cephalometric analysis indicated a skeletal Class I open-bite malocclusion with hyperdivergent growth pattern (ANB = 3.7°, SGn-FH = 67.4°, and SN-MP = 50.2°) in a prepubertal growth spurt (CVMS I) and protruded lower and upper incisors (U1-SN = 116.9°, FMIA = 51.2°) (Table 1).

According to the treatment suggestion of MIH [6], molars were restored with a pre-formed metal crown to avoid continuous post-eruptive breakdown. The parents refused this approach because of potential harm to the affected molars and open bite correction. Considering the impact of open-bite malocclusion on socio-psychological and craniofacial development, the parents chose two-phase therapy as a combination with orthopedic and orthodontic treatments from mixed dentition instead of one-phase therapy as orthodontic or orthognathic treatment in permanent dentition. The 1-phase objectives in mixed dentition with functional appliances were to (1) cease visceral swallowing habit; (2) correct the anterior open-bite; (3) continuously correct the skeletal discrepancy by controlling the mandibular vertical growth; and (4) perform orofacial myofunctional training. Meanwhile, the 2-phase objectives with orthodontic braces in the permanent dentition were to (1) align, level and coordinate arches to achieve normal overjet and overbite; (2) obtain functional occlusion; and (3) improve the soft tissue profile by implant anchorage to maximally retract the prominent incisor.

The patient maintained a high standard oral hygiene, and the glass ionomer restoration for FPMs was implemented when dentin hypersensitivity occurred. Importantly, professional dental hygiene and specific prophylactic measures were performed before and throughout the orthodontic treatments. In the orthopedic phase, FR-4 was first used to guide somatic swallowing and was worn daily for at least 10 hours. Open-bite was corrected after 5 months of treatment, but the negative swallowing habit persisted. Thus, orofacial myofunctional training with FR-4 was further emphasized until 18 months because the overbite mildly relapsed, and her mother complained about the patient's gradual loss of compliance, long facial appearance and protruding lower lip (Fig. 2). FR-4 increased overbite from -2.6 mm (0 M) to 0.8 mm (12 M) in CVMS I, mainly through lingual inclination and eruption

**TABLE 1. Cephalometric values of different treatment stages.**

| Measurement | Pretreatment | FR-4 | mSLBB | Posttreatment | Norm | Std Dev |
|---|---|---|---|---|---|---|
| Skeletal pattern | | | | | | |
| SNA (°) | 73.7 | 73.2 | 75.5 | 76.2 | 83 | 4 |
| SNB (°) | 70.0 | 71.3 | 73.4 | 74.5 | 80 | 4 |
| ANB (°) | 3.7 | 1.9 | 2.2 | 1.7 | 3 | 2 |
| SN-OP (°) | 24.3 | 23.2 | 16.7 | 14.7 | 19 | 4 |
| Go-Po (mm) | 57.0 | 59 | 68.3 | 70.1 | 73 | 4 |
| Go-Co (mm) | 41.2 | 41.8 | 47.2 | 51.6 | 56 | 3 |
| SN-MP (°) | 50.2 | 45.0 | 45.2 | 44.4 | 30 | 6 |
| Y-Axis (SGn-FH) | 67.4 | 67.9 | 69.0 | 67.4 | 64 | 2 |
| S-Go/N-Me (P-A Face Height) (%) | 57.3 | 58.2 | 62.2 | 62.4 | 64 | 2 |
| ANS-Me/Na-Me (%) | 62.7 | 59.8 | 58.6 | 57.3 | 55 | 3 |
| Wits (mm) | 0.4 | 0.8 | 0.2 | −0.8 | 0 | 2 |
| APDI (°) | 80.4 | 78.9 | 80.9 | 83.9 | 81 | 4 |
| ODI (°) | 65.0 | 68.1 | 71.0 | 70.8 | 73 | 5 |
| Dental pattern | | | | | | |
| U1-L1 (Interincisal Angle) (°) | 101.3 | 110.3 | 108.1 | 128.8 | 124 | 8 |
| U1-SN (°) | 116.9 | 108.5 | 113.5 | 109.2 | 106 | 6 |
| FMIA (L1-FH) (°) | 51.2 | 50.2 | 46.4 | 58.1 | 55 | 2 |
| U1- Apo (°) | 41.5 | 35.9 | 32.4 | 26.8 | 28 | 4 |
| L1- APo (mm) | 4.9 | 4.0 | 5.2 | 2.8 | 1 | 2 |
| U1-PP (mm) | 25.5 | 30.8 | 28.8 | 28.6 | 26 | 2 |
| U6-PP (mm) | 19.8 | 20.1 | 22.8 | 22.9 | 22 | 3 |
| L1-MP (mm) | 38.5 | 40.4 | 41.6 | 41.1 | 40 | 4 |
| L6-MP (mm) | 25.7 | 24.7 | 27.1 | 26.9 | 34 | 2 |
| Overjet (mm) | 3.9 | 2.8 | 3.4 | 3.7 | 2 | 1 |
| Overbite (mm) | −2.6 | 0.8 | 0.1 | 1.9 | 3 | 2 |
| Profile | | | | | | |
| UL-EP (mm) | 5.4 | 2.9 | 4.5 | 0.1 | −1 | 1 |
| LL-EP (mm) | 9.1 | 5.3 | 6.4 | 1.1 | 1 | 2 |
| Z-Angle (°) | 44.1 | 63.6 | 52.7 | 68.2 | 77 | 5 |

*FR-4: function regulator-4; mSLBB: modified spring-loaded bite blocks.*

of the incisors: U1-SN decreased by 8.4° (from 116.9° to 108.5°), U1-PP increased by 5.3 mm (from 25.5 mm to 30.8 mm) and L1-MP increased by 1.9 mm (from 38.5 mm to 40.4 mm) (**Supplementary Fig. 1**; Table 1).

For more vertical control and to improve patient compliance, modified spring-loaded bite blocks (mSLBB) and resin bonding-TPA were used (Fig. 3A– 3C). Compared with SLBB, the Adams clasp and tongue crib of mSLBB improved the retentive force and prevented visceral swallowing, respectively. The vertical opening of mSLBB during occlusal reconstruction was approximately 3–4 mm beyond the resting position, thereby maintaining the forces between 300 and 400 g for active myofunctional training. Principally, the total wearing time was at least 4 hours a day (primarily used after three meals and before bedtime), and it was re-activated every 6 weeks. After 9 months of mSLBB treatment, the open bite was alleviated at early permanent dentition (Fig. 3D), and the patient's compliance had improved. After 3 years of orthopedic treatment, the second molars had occluded, but the open bite mildly relapsed with an obvious protruding lower lip (Fig. 3E). The panoramic radiograph showed that the crowns of all third molars were almost completely developed, and cephalometric analysis indicated obvious vertical growth of the mandible ramus in postpuberty (CVMS III) (**Supplementary Fig. 2**). In contrast, mSLBB promoted the occlusal plane in a counterclockwise rotation (SN-OP decreased from 23.2° to 16.7°), with a small increment in mandibular angle (SN-MP changed from 45° to 45.2°) and increased posterior-anterior face height ratio (from 58.2% to 62.2%) even with obvious mandibular vertical growth as the length of Go-Co increased by 5.4 mm (**Supplementary Fig. 2**; Table 1).

Since the parents' urgent wish was to keep more teeth intact,

extracting those FPMs with poor prognoses was the first choice instead of extracting the first permanent premolars. Next, FPMs extraction and the fixed devices with temporary skeletal anchorage devices (TSADs) were performed. Interestingly, the open bite was significantly alleviated after FPMs extraction (Fig. 4A). The 0.022-in slot fixed orthodontic device (Damon Q brackets, high torque, Ormco, US) was bonded, and TSADs (SH1413-08 mm for maxillary dental arch, and SH1615-08 mm for mandibular dental arch, AbsoAnchor®, Korea) in the root apex of all first molars (Fig. 4B) were simultaneously implanted. The teeth were well aligned by sequentially changing the sectioned nickel-titanium archwires (IMD, Shanghai, China). To avoid over-protrusion of the incisors, canine laceback with TSADs was applied in all four quadrants from the initial alignment (partly shown as the lower dental arch in Fig. 4C). After 10 months, 0.018 × 0.025 SS archwires with 100 g—9 mm nickel-titanium tension springs were placed for anterior incisors' retraction (Fig. 4D). In this phase, transversely coordinating bimaxillary arches were necessary to prevent posterior crossbite. After 14.5 months of orthodontic treatment, TSADs in the left maxilla and right mandible were loose, and the extraction space in the maxillary dental arch was completely closed. Because of a small amount of extraction space in the mandibular dental arch and the bilateral Class II canine and molar relationship, all TSADs were removed, and Class II elastic was applied with 3.5 oz 1/4e and 1/8e with 22 h/day to facilitate intercuspation (Fig. 4E). Considering that Class II elastics might increase the anterior vertical dimension, we only used these elastics for three months. After 24 months of orthodontic treatment, the patient was 15.3 years old, the fixed orthodontic appliances were removed, and vacuum-formed clear retainers were used for retention in both arches.

A combination of orthopedic and orthodontic treatment, together with the patient's cooperation, permitted a satisfactory appearance with a slightly straight profile, a significant lower lip retraction, a chin contour and no gummy smile. The maxillary and mandibular dental midlines coincided with the facial midline. The bimaxillary arches were aligned, and the second molars showed successful mesial migration. Bilateral Class I canine and molar relationship were achieved with normal overjet (3.7 mm) and overbite (1.9 mm). The temporomandibular joints were asymptomatic to palpation and movement. The lateral cephalogram revealed that vertical maintenance of the maxillary incisors after lingual retraction (U1-PP changed from 28.8 mm to 28.6 mm while the U1-SN decreased from 113.5° to 109.2°) offered an effective torque control by TSADs traction and high torque brackets. The posttreatment panoramic radiograph revealed good root parallelism and no root resorption, and all third permanent molars showed satisfactory growth (Fig. 5). The goal of functional occlusion was also achieved as the bimaxillary occlusal surface presented with simultaneous centric contact and suitable anterior guidance during the mandible's protrusive and lateral excursive movements (**Supplementary Fig. 3**). The satisfying esthetic result and stable functional occlusion were consistent after a 2-year follow-up (Fig. 6). The craniofacial skeleton profile and cephalometric superimpositions results revealed that combined orthopedic-orthodontic treatments had excellent vertical control and facial aesthetics improvement for hyperdivergent open-bite with bimaxillary protrusion (Fig. 7).

## 3. Discussion

Treatment of adolescent skeletal open-bite is controversial and challenging. Much debate has centered on the treatment modalities between two-phase therapy, including early treatment in deciduous or mixed dentition and one-phase therapy in permanent dentition [7]. Presently, there is a lack of strong scientific evidence to show the curative effectiveness and long-term stability of early treatment [7], and it was shown that one-phase therapy was more "clinically stable" in the long-term posttreatment period [7, 8]. However, several authors emphasized that patients with open bites should receive relevant interventions, especially in children [4, 9]. Early treatment is more likely to recover stomatognathic system function and reduce treatment burden in the permanent dentition than passive self-correction [10]. Previously, FR-4 was used to correct swallowing patterns and open-bite by over-eruption of incisors along with orofacial myofunctional training [11]. However, the effectiveness of these approaches remains controversial [12].

The success of functional orthodontic treatment in children depends on many factors, among which patient compliance is one of the most essential factors, especially when removable appliances are used [13]. It was shown that adolescents' cooperation with wearing removable orthodontic devices gradually decreased during long-term treatment [14]. According to the servosystem theory, an increase in patients' active feedback could increase positive reinforcements [15]. Thus, a lack of active feedback when wearing FR-4 could easily lead to relapse (Fig. 2).

Spring-loaded bite-blocks are simple and effective for early correction of skeletal open bite for mixed dentition [16]. As a kind of modified bite block, some researchers have reported that the mechanism of Spring-loaded bite blocks is based on inhibiting vertical development or intrusion of the buccal dentoalveolar structures, thus producing counterclockwise rotation of the mandible into a more horizontal growth direction rather than a vertical one [16, 17]. In this case, mSLBB modified with a tongue crib and anatomic occlusal splint can directly feed the masticatory force back to improve weak masticatory functions, promote adolescents' long-term compliance and relieve anxiety about relapse. Although it may exhibit some inhibition effects on the patient's hyperdivergent growth, a well-designed clinical trial with large sample size is required to validate the effectiveness and course of mSLBB on the skeletal changes.

Open-bite extraction treatment has shown greater stability of overbite than non-extraction treatment during the orthodontic phase [18]. The extraction space offers more viable possibilities for retraction and lingual tipping of incisors, forward movement of molars and decreasing the posterior vertical height through the wedge effect (Fig. 4A), which reduced the clinically significant relapse of anterior open bite [8]. Extraction of FPMs is rarely preferred, but it is not advisable to extract a healthy premolar if FPMs on the same side have poor


**FIGURE 2. Dental and facial images during FR-4 treatment.**

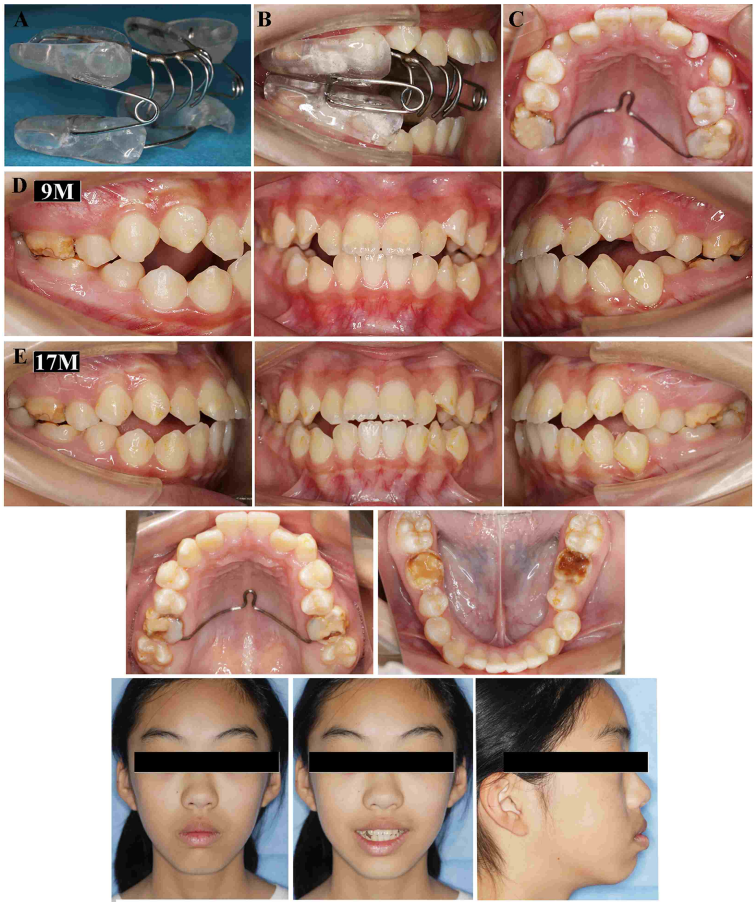


**FIGURE 3. Orthopedic treatment with mSLBB.** (A) Modified spring-loaded bite blocks (mSLBB). (B) Intraoral photographs with mSLBB. (C) Resin bonding-TPA. (D) Intermediate records after 9 months of treatment with mSLBB. (E) Final records after 17 months of treatment using mSLBB.


**FIGURE 4. Dental images of the orthodontic treatment.** (A) Intraoral photographs after FPMs extraction. (B) Placement of miniscrews. (C) Canine laceback with TSADs in the lower dental arch during alignment. (D) Space closure. (E) Final adjustment.

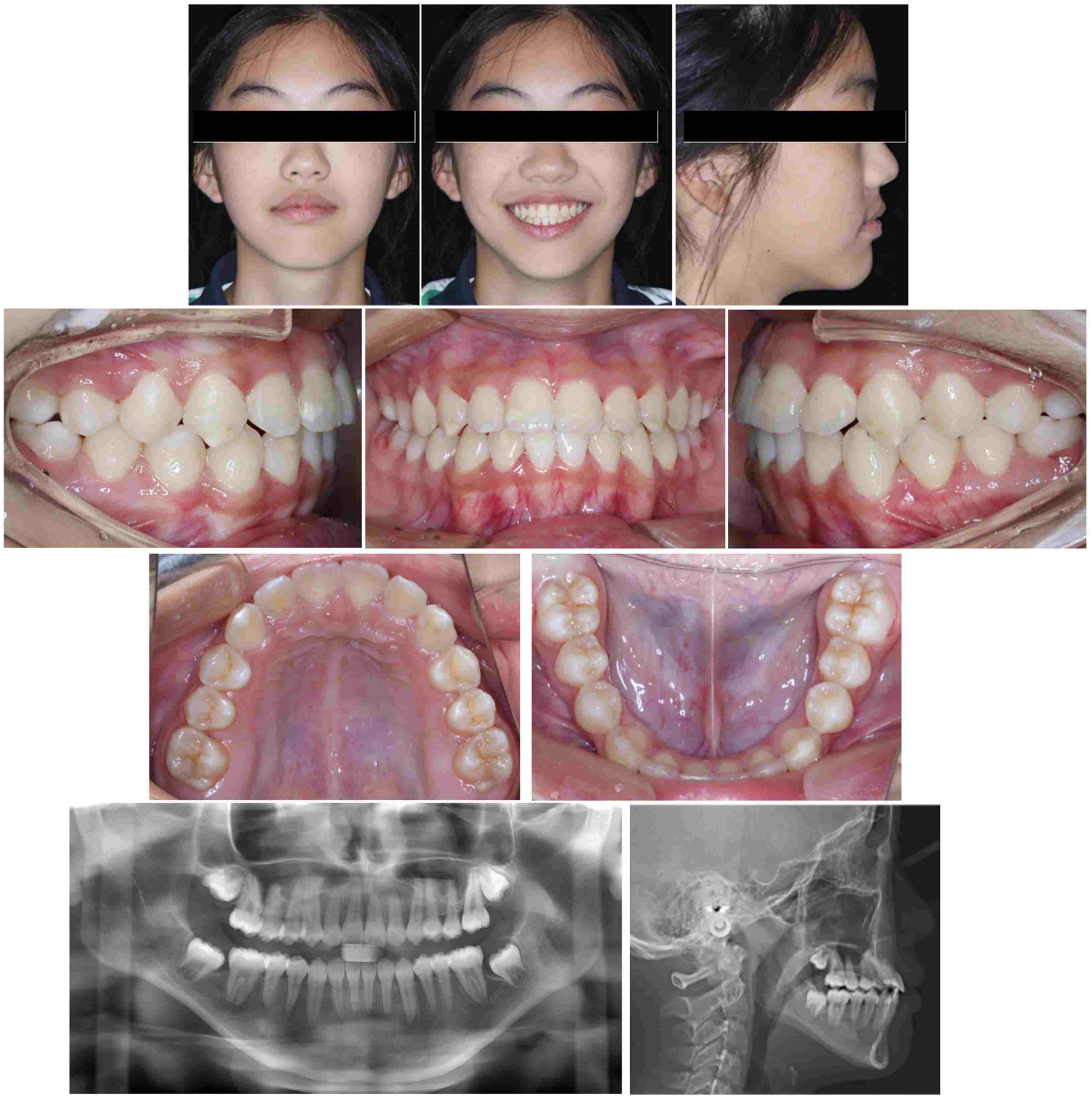

**FIGURE 5. Posttreatment records after orthodontic treatment.**

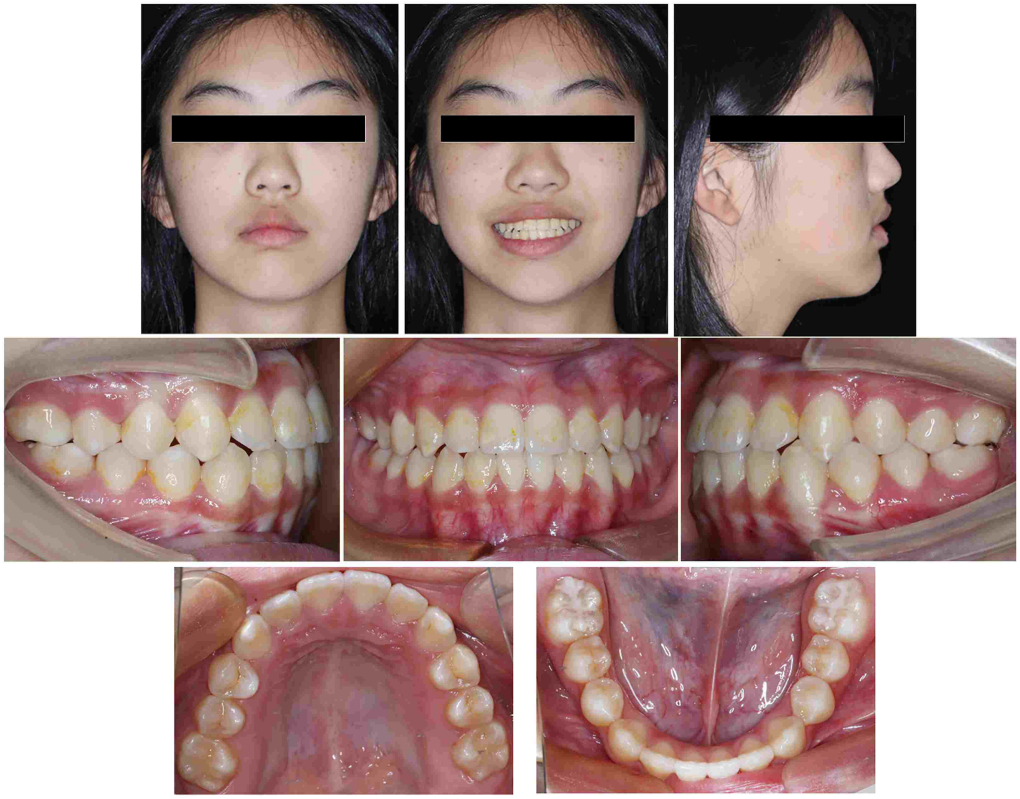

**FIGURE 6. Facial and intraoral photographs following the 2-year follow-up.**

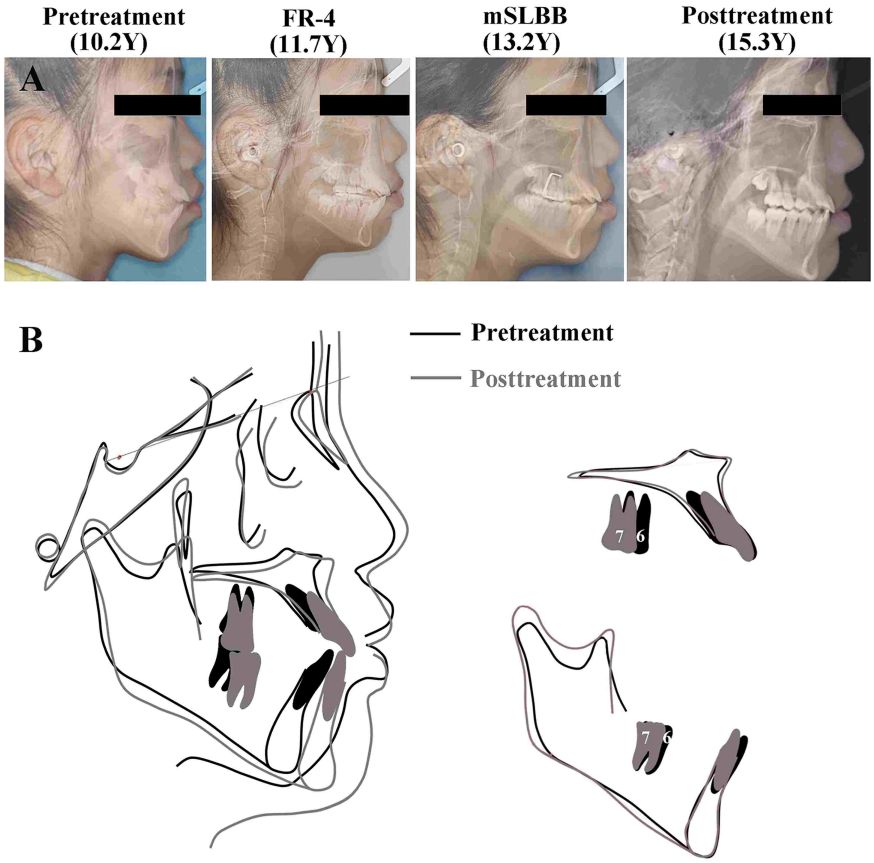


**FIGURE 7. Pretreatment and posttreatment comparison.** (A) Craniofacial skeleton profile and (B) cephalometric superimpositions of pretreatment and posttreatment. Here, "6" represents the first permanent molar, and "7" represents the second permanent molar.

prognoses. However, this decision can be complicated by two important factors: (1) when to extract, and (2) how to close the extraction space. It is generally accepted that FPMs can influence occlusal stress distribution and displacement in the human skull. Unless it could achieve spontaneous closure for mandibular second molars, the FPMs extraction time should be delayed until the second molars occlude, especially in hyperdivergent patients with weakened masticatory functions. By this stage, orthodontic intervention may not only prevent second molars from mesial tipping and rotating but also continuously promote more myofunctional training. Conversely, premature FPMs extraction accompanied by fixed appliances is bound to weaken chewing habits, and postmature FPMs extraction may increase the first molars' hypersensitivity risk, producing inappropriate effects on stomatognathic system growth.

In addition, it is recommended to pay more attention to the mesial movement of second molars and the torque control of maxillary incisors if more space is needed for the anterior arch after FPMs extraction. It is widely accepted that molar anchorage loss may easily happen in hyperdivergent skeletal patterns as a relatively small cancellous bone density in the interradicular regions [19]. In this study, the young girl's upper and lower second molars exhibited obvious spontaneous mesial movement during alignment, even with TSADs-laceback traction (Fig. 4C). Generally, the orthodontic mechanisms of open bite in permanent dentition mainly include intrusion of the posterior teeth, extrusion of the anterior teeth or a combination of both. Although simple extrusion of the anterior teeth can efficiently correct open-bite, it is usually criticized for being unstable and compromising facial aesthetics with a gummy smile, especially in patients with an excessive anterior dentoalveolar eruption height [17]. Thus, precautionary measures, including high torque brackets and maxillary miniscrew placement at a high level, were implemented in this patient to prevent over-eruption of her maxillary incisors and clockwise rotation of occlusal plane caused by the pendulum-like effect during lingual retraction [20].

## 4. Conclusions

Combined orthopedic-orthodontic treatments are suggested for young patients suffering from skeletal open-bite malocclusion with severe MIH. More active feedback on the orthopedic force by mSLBB is conducive to promoting adolescents' long-term compliance and reducing the risk of relapse. Extracting FPMs with severe MIH until the maxillary and mandibular second molars are occluded can achieve good vertical control and does not hinder occlusion development. After FPMs extraction, fixed devices with TSAD anchorage reinforcement are advisable to solve the three-dimensional skeletal and dental discrepancy of hyperdivergent open-bite with bimaxillary protrusion.

### AUTHOR CONTRIBUTIONS

JC—contributed to the treatment, analysis, and interpretation of data, original draft preparation, and manuscript review and editing; YX—contributed to the interpretation of data and manuscript editing; WG—contributed to study conception and design and manuscript review and editing. All authors read and approved the final manuscript.

### ETHICS APPROVAL AND CONSENT TO PARTICIPATE

The study was approved by the ethics committee of West China Hospital of Stomatology (WCHSIRB-D-2017-073-R1) and accepted by parents who chose modified spring-loaded bite blocks appliance for the children. Parents gave written informed consent to participate in the study.

### ACKNOWLEDGMENT

Not applicable.

### FUNDING

This research received no external funding.

### CONFLICT OF INTEREST

The authors declare no conflict of interest.

### SUPPLEMENTARY MATERIAL

Supplementary material associated with this article can be found, in the online version, at https://oss.jocpd.com/files/article/1592085180828270592/attachment/Supplementary%20materials.pdf.

### REFERENCES

[1] Schneider PM, Silva M. Endemic molar incisor hypomineralization: a pandemic problem that requires monitoring by the entire health care community. Current Osteoporosis Reports. 2018; 16: 283–288.

[2] Hatami A, Dreyer C. The extraction of first, second or third permanent molar teeth and its effect on the dentofacial complex. Australian Dental Journal. 2019; 64: 302–311.

[3] Cobourne MT, Williams A, Harrison M. National clinical guidelines for the extraction of first permanent molars in children. British Dental Journal. 2014; 217: 643–648.

[4] Klocke A, Nanda RS, Kahl-Nieke B. Anterior open bite in the deciduous dentition: longitudinal follow-up and craniofacial growth considerations. American Journal of Orthodontics and Dentofacial Orthopedics. 2002; 122: 353–358.

[5] Marcilio Santos E, Kalil Bussadori S, Ratto Tempestini Horliana AC, Moraes Moriyama C, Jansiski Motta L, Pecoraro C, *et al*. Functional orthopedic treatment for anterior open bite in children. A systematic review of randomized clinical trials. To be published in Journal of Orofacial Orthopedics. 2022. [Preprint].

[6] Dashash M, Yeung CA, Jamous I, Blinkhorn A. Interventions for the restorative care of amelogenesis imperfecta in children and adolescents. The Cochrane Database of Systematic Reviews. 2013; 2013: CD007157.

[7] Lentini-Oliveira DA, Carvalho FR, Rodrigues CG, Ye Q, Prado LB, Prado GF, *et al*. Orthodontic and orthopaedic treatment for anterior open bite in children. The Cochrane Database of Systematic Reviews. 2014; CD005515.

[8] de Freitas MR, Beltrão RTS, Janson G, Henriques JFC, Cançado RH. Long-term stability of anterior open bite extraction treatment in the permanent dentition. American Journal of Orthodontics and Dentofacial Orthopedics. 2004; 125: 78–87.

[9] Sankey WL, Buschang PH, English J, Owen AH. Early treatment of vertical skeletal dysplasia: the hyperdivergent phenotype. American Journal of Orthodontics and Dentofacial Orthopedics. 2000; 118: 317–327.
[10] English JD. Early treatment of skeletal open bite malocclusions. American Journal of Orthodontics and Dentofacial Orthopedics. 2002; 121: 563–565.
[11] Erbay E, Ugur T, Ülgen M. The effects of frankel's function regulator (FR-4) therapy on the treatment of angle class I skeletal anterior open bite malocclusion. American Journal of Orthodontics and Dentofacial Orthopedics. 1995; 108: 9–21.
[12] Koletsi D, Makou M, Pandis N. Effect of orthodontic management and orofacial muscle training protocols on the correction of myofunctional and myoskeletal problems in developing dentition. A systematic review and meta-analysis. Orthodontics & Craniofacial Research. 2018; 21: 202–215.
[13] Stefanovic NL, Uhac M, Brumini M, Zigante M, Perkovic V, Spalj S. Predictors of patient compliance during class II division 1 malocclusion functional orthodontic treatment. The Angle Orthodontist. 2021; 91: 502–508.
[14] Al-Moghrabi D, Salazar FC, Pandis N, Fleming PS. Compliance with removable orthodontic appliances and adjuncts: a systematic review and meta-analysis. American Journal of Orthodontics and Dentofacial Orthopedics. 2017; 152: 17–32.
[15] Attanasio JS. Relationships between oral sensory feedback skills and adaptation to delayed auditory feedback. Journal of Communication Disorders. 1987; 20: 391–402.
[16] Doshi UH, Bhad WA. Spring-loaded bite-blocks for early correction of skeletal open bite associated with thumb sucking. American Journal of Orthodontics and Dentofacial Orthopedics. 2011; 140: 115–120.
[17] Pisani L, Bonaccorso L, Fastuca R, Spena R, Lombardo L, Caprioglio A. Systematic review for orthodontic and orthopedic treatments for anterior open bite in the mixed dentition. Progress in Orthodontics. 2016; 17: 28.
[18] Janson G, Valarelli FP, Beltrão RTS, de Freitas MR, Henriques JFC. Stability of anterior open-bite extraction and nonextraction treatment in the permanent dentition. American Journal of Orthodontics and Dentofacial Orthopedics. 2006; 129: 768–774.
[19] Ozdemir F, Tozlu M, Germec Cakan D. Quantitative evaluation of alveolar cortical bone density in adults with different vertical facial types using cone-beam computed tomography. The Korean Journal of Orthodontics. 2014; 44: 36.
[20] Li Y, Tang N, Xu Z, Feng X, Yang L, Zhao Z. Bidimensional techniques for stronger anterior torque control in extraction cases: a combined clinical and typodont study. The Angle Orthodontist. 2012; 82: 715–722.

**How to cite this article:** Jie Chen, Yuchan Xu, Weihua Guo. Combined orthopedic-orthodontic treatments of adolescent skeletal open-bite with severe molar-incisor hypomineralization: a case report and literature review. Journal of Clinical Pediatric Dentistry. 2023; 47(1): 91-99. doi: 10.22514/jocpd.2022.017.