Case Report

Total arch extrusion with skeletal anchorage to improve inadequate maxillary incisor display in a case of vertical maxillary deficiency

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ABSTRACT

Inadequate maxillary incisor display can negatively impact facial esthetics. Various treatment options exist depending on the underlying cause and severity of the condition. Skeletal anchorage was used to extrude the maxillary dentition and rotate the mandible backward, enhancing visibility of the maxillary incisors. An extrusion assembly was introduced to achieve orthodontic extrusion. Use of bite raisers and interarch elastics was also discussed. Treatment results demonstrated successful achievement of the treatment goals. In addition to optimal occlusion, the patient's facial profile improved with increased lip fullness. There was an increase in vertical facial height, and maxillary incisor display was significantly improved, resulting in a more pleasant smile. Two-year postretention records evidenced the stability of total arch extrusion to improve maxillary incisor display. (*Angle Orthod*. 2024;94:247–257.)

KEY WORDS: Inadequate incisor display; Total arch extrusion; Skeletal anchorage; Miniscrew; Extrusion assembly

INTRODUCTION

Appropriate maxillary incisor display is crucial for an esthetic smile. Inadequate maxillary incisor display is a condition where the upper front teeth are not adequately visible during smiling or speaking, resulting in a less attractive appearance.[1,2] This can be caused by factors such as inadequate lip support, decreased vertical dimension, increased upper lip length, or a retruded maxilla. Treatment options vary depending on the underlying cause and severity of the condition. Orthodontic treatment, orthognathic surgery, or lip repositioning procedures may be recommended to address the issue.[3–6] It is challenging to attain ideal maxillary incisor display in patients with a reduced lower facial height because of vertical maxillary deficiency. This article focuses on the application of skeletal anchorage to extrude the maxillary dentition and rotate the mandible backward with the intent of improving the visibility of the maxillary incisors.

Diagnosis and Etiology

A 25-year-old female patient presented with chief complaints of malalignment and deep overbite. Upon clinical examination, she displayed a short face with a concave facial profile and inadequate maxillary incisor display on smiling (Figures 1 and 2). During a full smile, there was approximately 4.2 mm of maxillary incisor display with no evident facial asymmetry. Her nasolabial angle was slightly obtuse, with the base of her nose tipped slightly upward. Additionally, the patient had a deep labiomental fold, lower lip retrusion, and a prominent chin. No temporomandibular disorder symptoms were reported.

Intraoral examination showed a deep overbite of 5.3 mm and a large overjet of 7.3 mm. The arch forms were symmetrically square in the maxillary arch and tapering ovoid in the mandibular arch. There was an arch length discrepancy of 5 mm in the maxillary arch and 1 mm in the mandibular arch. The depth of the curve of Spee was 3.7 mm. The bilateral canine and molar relationships were both Class II.

A panoramic radiograph revealed the presence and impaction of the maxillary right, maxillary left,

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Figure 1. Pretreatment facial and intraoral photographs.

and mandibular left third molars (Figure 3). The periodontal support appeared fine on the panoramic radiograph; no other pathological findings were noted. A cephalometric radiograph revealed a skeletal Class I relationship (ANB: 2°) with a Class III tendency (A-Nv: −1.5 mm, Pg-Nv: 0 mm) and a hypodivergent craniofacial pattern (SN-MP: 17.0°) (Table 1). Vertical proportions showed a reduced lower facial height (UFH: LFH = 48.5%: 51.5%). The maxillary incisors were proclined, while the mandibular incisors were upright (U1-SN: 114.5°, L1-MP: 90.5°).

Based on the findings, the patient was diagnosed with a hypodivergent skeletal Class I relationship with a Class III tendency and vertical maxillary deficiency. Additionally, the dental relationship was Class II with a deep overbite and large overjet. The main etiological factor for these conditions was determined to be hereditary.

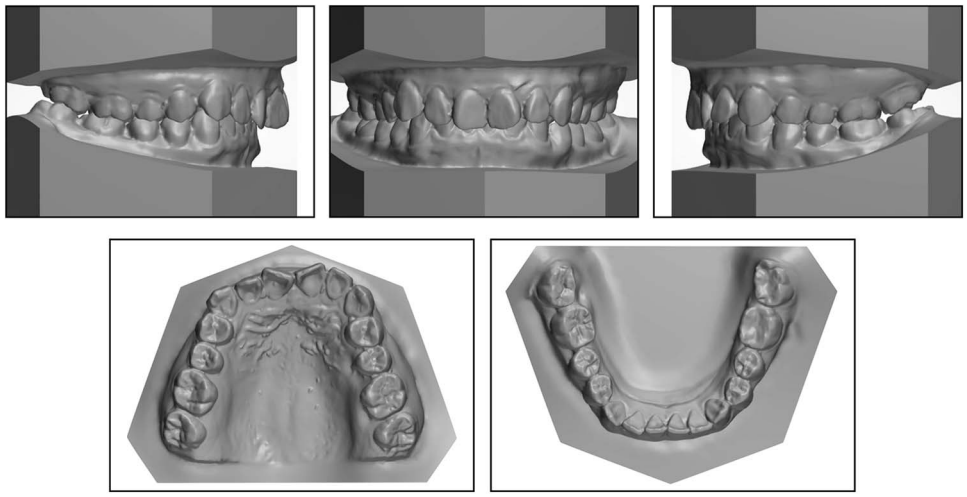

Figure 2. Pretreatment study models.

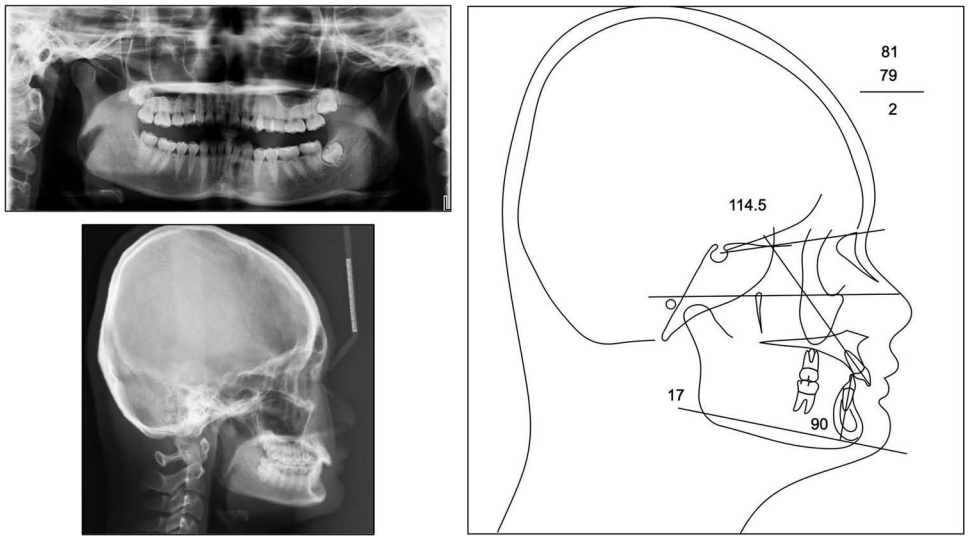

Figure 3. Pretreatment radiographs and lateral cephalogram.

Treatment Objectives

The treatment goals for this patient included correcting the Class II relationship to achieve optimal overjet and overbite, increasing the vertical dimension to harmonize the lower face, and improving the maxillary incisor display. It should be noted that increasing the vertical dimension could pose stability challenges. Therefore, long-term follow-up was considered crucial to monitor the stability of the treatment outcome.

Treatment Alternatives

Two treatment alternatives were considered for this patient:

1. Orthognathic surgery combined with orthodontic treatment. This option is recommended for achieving the best possible treatment outcome with Le Fort I osteotomy to move the maxilla downward and/or forward.
2. Nonextraction orthodontic treatment with skeletal anchorage. This alternative involves using skeletal anchorage to extrude the maxillary dentition and rotate the mandible clockwise.

Considering the patient's concave facial profile and her desire to avoid surgical intervention, the option of nonextraction orthodontic treatment was selected, but it was important to note that aligning the teeth without extractions could result in protrusion. Skeletal anchorage could be considered a potential solution to prevent the proclincation of the maxillary anterior teeth. While extrusion may appear to be a straightforward tooth movement, it can be limited by factors such as occlusion, muscle force, and the original vertical dimension. Implementing extrusion with the support of skeletal anchorage could be a potential breakthrough to address these challenges. Ultimately, the patient declined the surgical approach, leaving the nonextraction orthodontic treatment with skeletal anchorage as the final treatment plan.

Table 1. Cephalometric Measurements

	Taiwanese Norms	Pretreatment	Posttreatment	2-y Retention
Skeletal Analysis				
SNA (°)	81.5 ± 3.5	81.0	81.0	81.0
SNB (°)	77.7 ± 3.2	79.0	80.0	81.0
ANB (°)	4.0 ± 1.8	2.0	1.0	0.0
SN-MP (°)	33.0 ± 1.8	17.0	19.0	21.0
Dental Analysis				
U1- NA (mm)	3.9 ± 2.1	5.0	5.5	6.0
U1-SN (°)	108.2 ± 5.4	114.5	111.5	112.5
L1- NB (mm)	6.6 ± 2.8	1.5	2.5	2.5
L1-MP (°)	96.8 ± 6.4	90.0	105.5	104.5
Facial Analysis				
E-Line/UL (mm)	−1.1 ± 2.2	−2.0	−2.0	−2.0
E-Line/LL (mm)	0.5 ± 2.5	−4.0	−1.0	−0.5

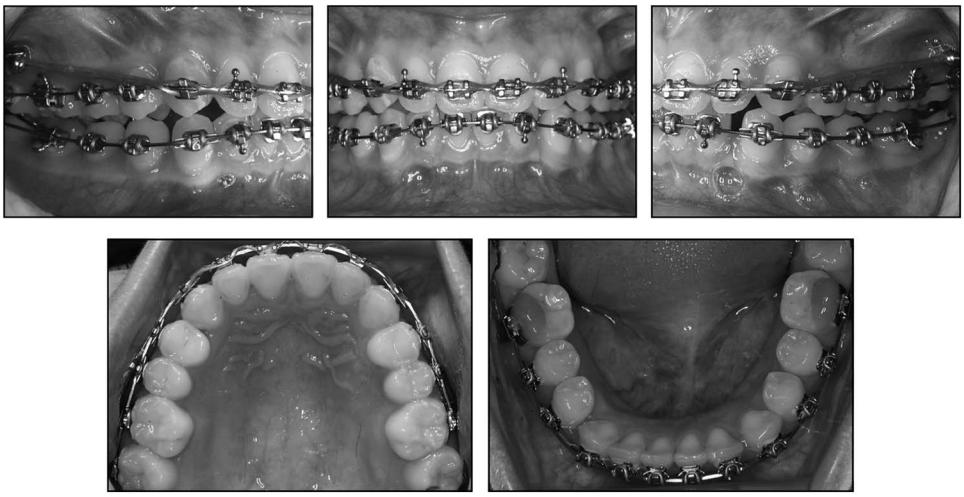

Figure 4. Two upper posterior miniscrews were installed at the infrazygomatic crest for Class II correction. Bite raisers were bonded to the occlusal surface of the mandibular first molars for disocclusion.

Treatment Progress

A modified Alexander prescription fixed-bracket system was employed for this treatment. The slot sizes of the anterior teeth (canine to canine) were 0.018-inch, whereas the slot sizes of the posterior teeth were 0.022-inch. Two miniscrews (2.0 × 10 mm, A1-P, Bioray Biotech Corp., Taipei, Taiwan) were inserted bilaterally at the infrazygomatic crest (IZC) 2 weeks after initial bonding to distalize the maxillary canines on a 0.014-inch copper-nickel-titanium (Cu-NiTi) archwire. Bite raisers were placed on the occlusal surfaces of both mandibular first molars immediately after initial bonding of the mandibular arch to avoid bracket interference (Figure 4). By the 4th month, the entire maxillary arch was retracted with IZC miniscrews and elastomeric chains for Class II correction on the 0.016 × 0.022-inch stainless steel (SS) archwire. In the 6th month, after achieving the desired flattened curve of Spee, the mandibular archwire was switched to a 0.016 × 0.022-inch SS archwire.

In the 9th month, two buccal shelf miniscrews (2.0 × 17 mm, A1-P, Bioray Biotech) were installed bilaterally between the mandibular first and second molars, slanted forward (Figure 5). Elastomeric chains were attached from the terminal molars to the heads of the buccal shelf miniscrews to protract the entire mandibular dentition to address the Class II dental relationship further.

To enhance the display of the maxillary incisors, two anterior miniscrews (1.4 × 8 mm, A1-V, Bioray Biotech) were placed between the maxillary central and lateral incisors on both sides in the 14th month (Figure 6). Two cross tubes (2 mm in length, 0.022 × 0.025-inch, Ortho Technology Inc, Tampa, FL, US) were inserted along the maxillary archwire and positioned where extrusive forces were to be applied. The extrusion assembly consisted of a 0.016 × 0.022-inch SS wire as a guide bar featuring a circular loop at the top. A stopper was placed

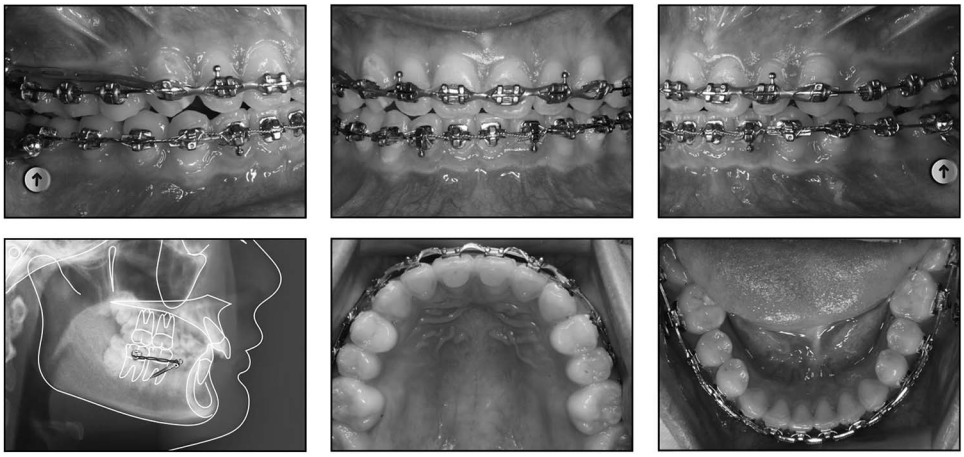

Figure 5. Two slanted buccal shelf miniscrews were installed for protraction of the mandibular molars.

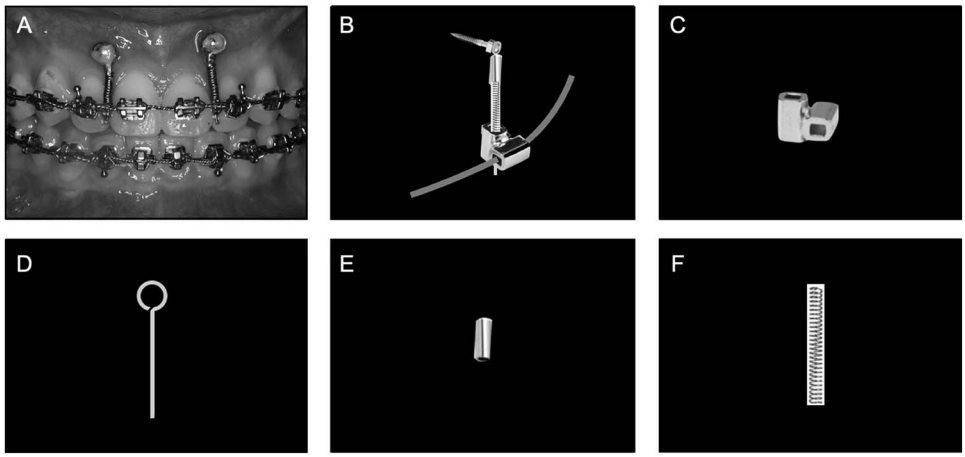

Figure 6. Design of maxillary incisor extrusion with TSADs. (A) Bilateral interradicular miniscrews between maxillary central incisors and lateral incisors. (B) Close-up view of the extrusion assembly. (C) The cross-tube joins the archwire and guiding bar for the open coil spring. (D) The guiding bar connects the miniscrew and archwire and accommodates the open coil spring. (E) A crimpable stop prevents the coil spring from slipping into the circular part that wraps around the head of the miniscrew. (F) A segment of NiTi open coil spring to generate the extrusive force. NiTi indicates nickel-titanium.

along the guide bar, just below the circular loop. Additionally, a segment of NiTi open coil spring (light, Ormco Corp., Orange, Calif), slightly longer than the distance between the stopper and the vertical tube of the cross tube, was inserted around the guide bar.

To install the extrusion assembly, the guide bar was inserted into the vertical tube of the cross tube, with the circular loop hooked around the interdental miniscrew. Flowable composite resin was applied to secure the attachment, preventing irritation. An inward bend was made at the tail of the guide bar to control the desired amount of extrusion while also avoiding disarticulation of the extrusion assembly and irritation of the oral mucosa. The open coil spring could be reactivated by adding flowable composite resin beneath the crimpable stoppers.

The maxillary incisor display showed significant improvement 2 months after the initiation of treatment (Figure 7). The extrusion assembly was then discontinued, and the anterior miniscrews were removed. Subsequently, the bite raisers were removed, and short interarch elastics were employed to settle the occlusion. Unfortunately, noticeable relapse was observed in maxillary incisor display (Figure 7).

The treatment approach was based on the previous study on redirecting mandibular growth through the clockwise rotation of the maxillomandibular complex with orthodontic dentoalveolar height development.[7] In the 25th month, two anterior miniscrews were inserted again bilaterally between the maxillary central and lateral incisors, while two posterior miniscrews were placed between the maxillary second premolars and first molars (Figure 8). These miniscrews served as anchors for the extrusion assemblies, which were used for a period of five months to extrude the entire maxillary dentition. The extrusion assemblies and miniscrews were removed in the 30th month of treatment. After a total of 32 months of active treatment, all appliances were removed. Vacuum-formed clear retainers were delivered for full-time wear during the first 6 months, followed by nighttime use thereafter.

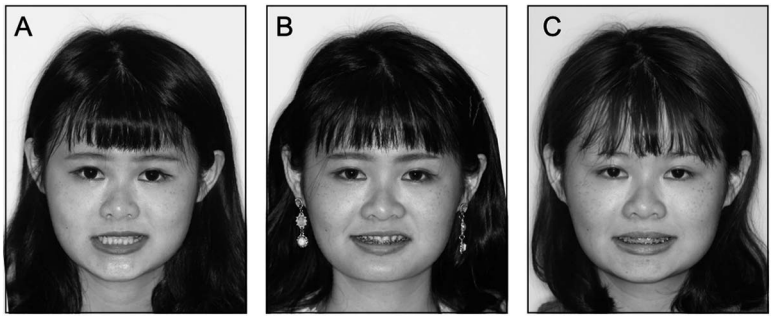

Figure 7. Maxillary incisor display at different stages: (A) Pretreatment, (B) 15th month, and (C) 25th month. Images demonstrate the improvement achieved after using the anterior extrusion assembly for a period of 2 months. However, it also reveals the subsequent relapse that occurred after discontinuing use of the extrusion assembly.

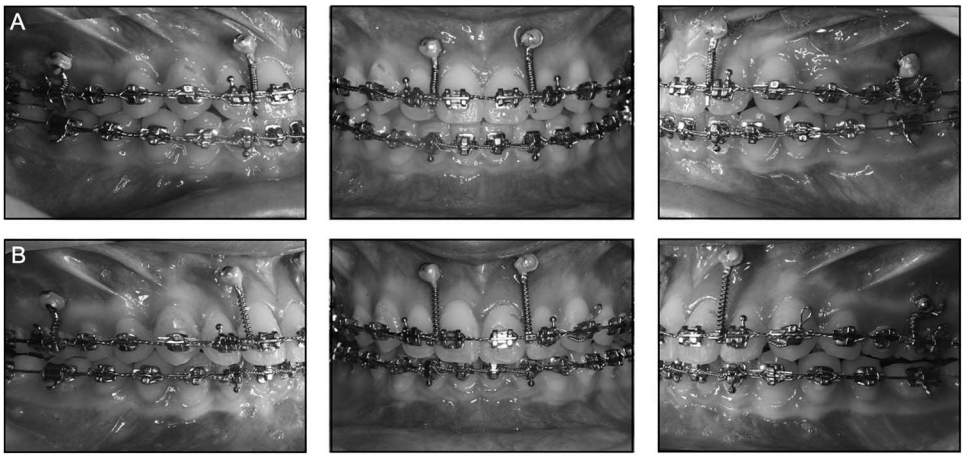

Figure 8. (A) In the 25th month of treatment, four interdental miniscrews were inserted between the maxillary central and lateral incisors and between the second premolars and first molars bilaterally to extrude the maxillary dentition to improve the incisor display at smile. (B) 4 months later, the length of open coil springs demonstrated significant dental extrusion of the maxillary arch.

Treatment Results

Occlusion was successfully corrected to achieve a Class I dental relationship, accompanied by optimal overjet and overbite (Figures 9 and 10). The previously concave profile became straighter with an enhancement in lip support, resulting in a fuller appearance. Additionally, vertical facial proportions showed some improvement and a better display of the maxillary incisors. This improvement in incisor display contributed to a more pleasant smile, significantly enhancing overall esthetics of the patient's smile. Crown length increased significantly during extrusion as the gingiva did not fully follow the extrusive tooth movement.

Cephalometric superimpositions revealed several key changes in the dental and skeletal relationships (Figures 11 and 12):

1. Maxillary incisors: The forward movement of the maxillary incisors by 1.3 mm, accompanied by 3.6 mm of extrusion, improved the maxillary incisor display significantly.

Figure 9. Posttreatment facial and intraoral photographs.

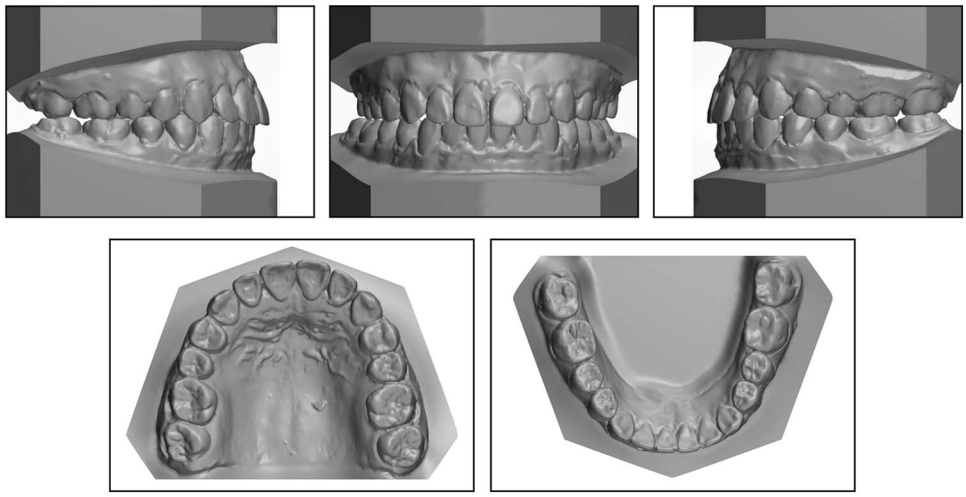

Figure 10. Posttreatment study models.

2. Maxillary first molars: The maxillary first molars exhibited distalization of 1.5 mm and extrusion of 2.8 mm, which may have contributed to an increase in the vertical dimension.
3. Mandibular incisors: Relative intrusion of the mandibular incisors was noted with proclination by 10.5° (IMPA: 90.0° to 100.5°) and 4.0 mm intrusion at the incisal edge. Additionally, the mandibular incisors moved forward by 4.3 mm.
4. Mandibular first molars: The mandibular first molars experienced distalization of 1.8 mm and extrusion of 1.3 mm, contributing significantly to an increase in the vertical dimension, specifically in the lower anterior facial height by 3.0 mm.
5. Occlusal plane rotation: There was significant clockwise rotation of the occlusal plane by 7.5° (SN-OP: 8° to 15.5°).
6. Mandibular plane rotation: Extrusion of the maxillary dentition rotated the mandible clockwise and increased the mandibular plane by 2.0° (SN-MP: 17.0° to 19.0°).

DISCUSSION

Theoretically, vertical dimension has been considered as being genetically determined and unchangeable due to the influence of muscular forces.[8,9] Any increase in the vertical dimension can result in relapse over time. In cases where esthetic improvement is desired without resorting to orthognathic surgery involving downward grafting of the maxilla, clinicians are now exploring the possibility of increasing the vertical dimension through orthodontic extrusion with the assistance of skeletal anchorage.

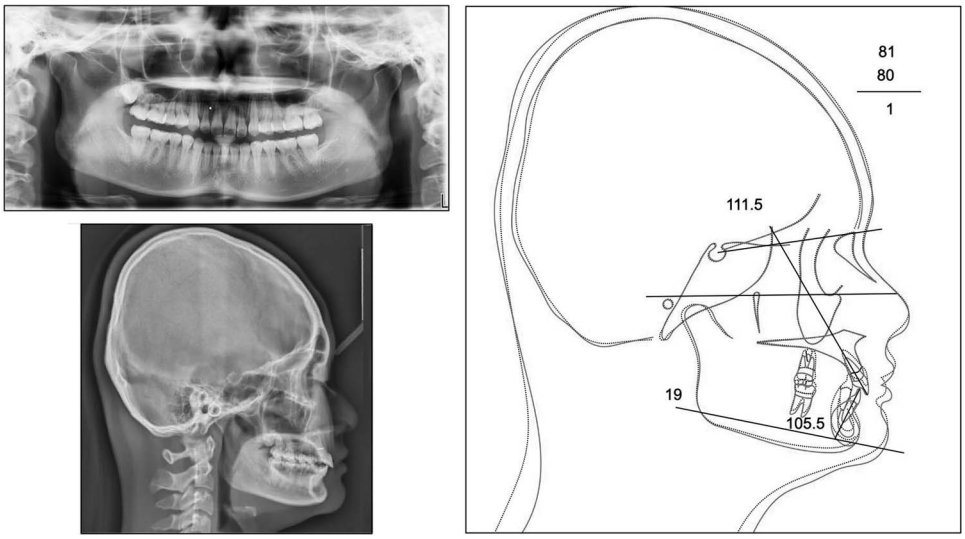

Figure 11. Posttreatment radiographs and lateral cephalogram. The Pretreatment cephalogram is traced as dotted lines.

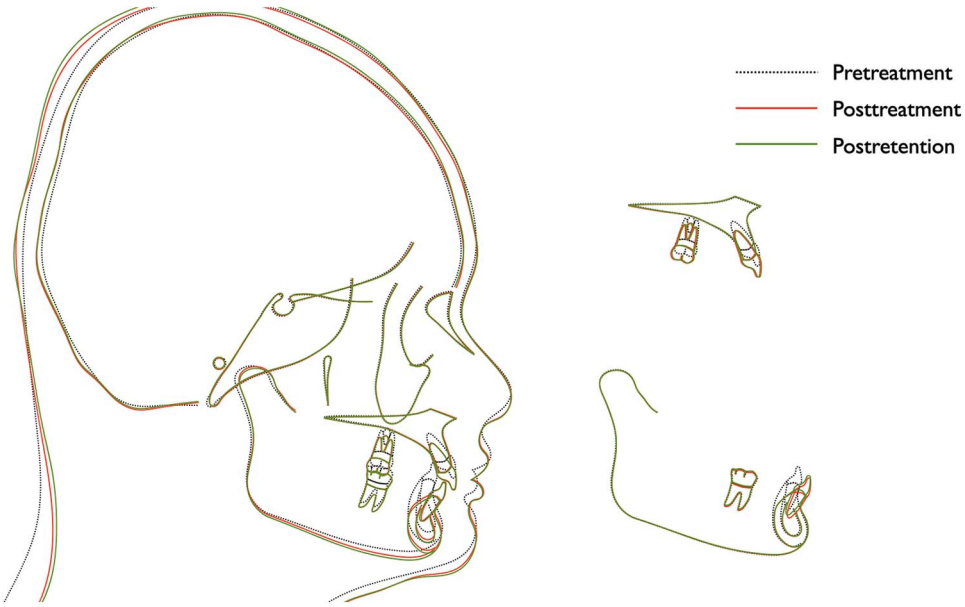

Figure 12. Cephalometric superimposition showed a great amount of total arch extrusion in maxillary dentition and significant mandibular incisor intrusion, which resulted in clockwise rotation of the occlusal plane and mandible. Treatment effects remained stable at 2-year follow-up.

Orthodontic extrusion of the maxillary incisors in such situations can be challenging, as the extruded maxillary incisors may interfere with the mandibular incisors, impeding the desired extrusion.[1–3,10] While improvements in maxillary incisor display can be achieved temporarily, there is a tendency for relapse due to occlusal forces. One possible strategy for enhancing maxillary incisor display is to consider total arch extrusion of the maxillary arch, effectively increasing the vertical dimension. It is worth noting that the stability of molar extrusion might be more reliable than incisor extrusion. Extruding the maxillary molars to a certain extent creates additional interarch spaces, allowing for extrusion of the maxillary incisors.

Figure 13. Facial and intraoral photographs at 2-year follow-up.

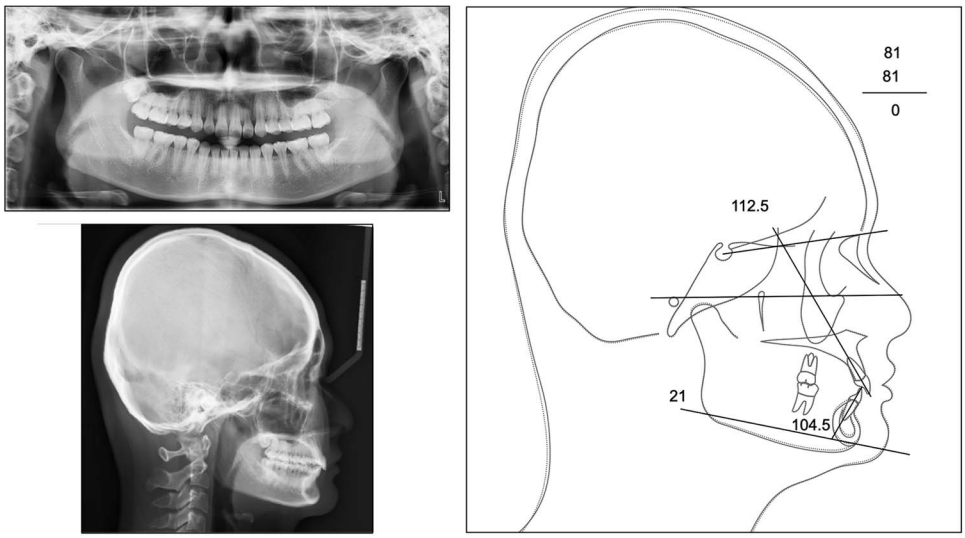

Figure 14. 2-year postretention panoramic radiograph and lateral cephalogram. The posttreatment cephalogram was traced as a dotted line. The cephalometric superimposition showed good stability.

In this case report, orthodontic extrusion was achieved through an extrusion assembly anchored on interdental miniscrews. The guide bar of the extrusion assembly was custom-made by the clinician chairside. Extrusive force was generated by de-activating a light open coil spring segment of NiTi, around 100 gm.

To achieve effective extrusion of the maxillary incisors, it was crucial to ensure the appropriate interincisal clearance in overjet and overbite. To provide necessary interincisal clearance for the maxillary incisors to extrude, posterior bite raisers can be employed to hinge the mandible backward. If there had been contraindications for increasing facial height, intrusion of the mandibular incisors could have been considered. However, the rate of intrusion is generally slower than that of extrusion. Therefore, using bite raisers to provide interincisal clearance proves to be a more efficient approach when feasible.

Another important consideration when using bite raisers is the influence of muscle force. Patients with a low mandibular plane angle often exhibit greater muscular forces, leading to a common occurrence of posterior tooth intrusion when bonded with bite raisers, while the rest of the dentition undergoes extrusion.[11,12] To address this, one potential approach would be to adjust the location of the bite raisers on the extruded molars in an alternating fashion to alleviate intrusion of those teeth.

In cases where patients present with a low mandibular angle and inadequate maxillary incisor display, injection of Botulinum toxin type A into the masseter muscle is often considered.[13] This can be a potential solution to address challenges posed by strong occlusal forces and

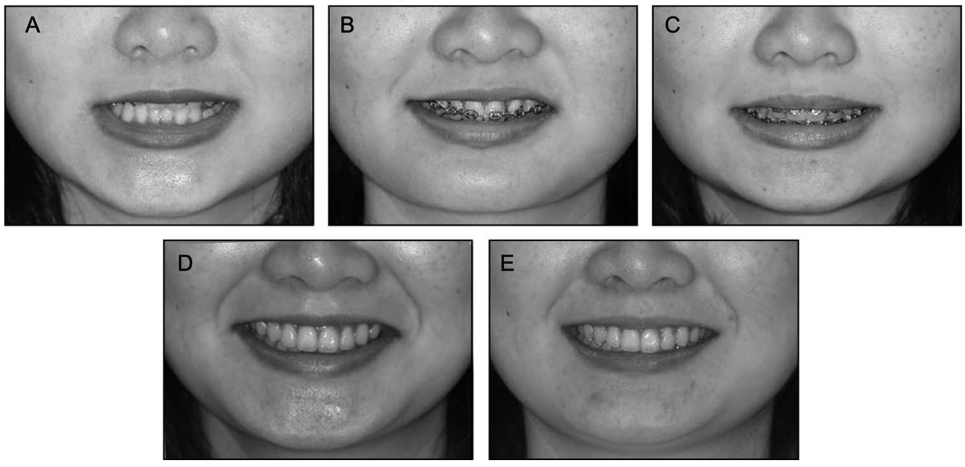

Figure 15. Evaluation of the treatment effect and stability on maxillary incisor display after extrusion with TSADs at different stages. (A) Pretreatment; (B) 2 months after maxillary anterior extrusion; (C) 9 months after maxillary anterior extrusion; (D) Posttreatment; (E) 2-year follow-up. TSADs indicates temporary skeletal anchorage devices.

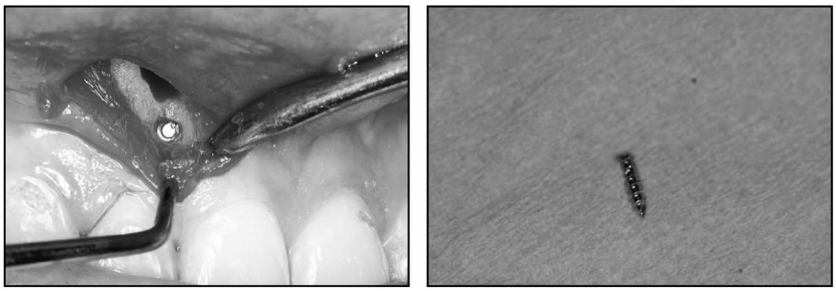

Figure 16. A flap was reflected to remove the broken tip of the miniscrew.

avoid reintrusion after extrusion as much as possible. Since the effects of muscle paralysis resulting from injections typically last approximately 6 months, repeated injections may be necessary to maintain desired outcomes over time.

In addition, interarch vertical elastics can be employed to promote extrusion of the remaining dentition that was initially out of occlusion due to the presence of bite raisers. This technique allows for comprehensive and uniform extrusion throughout the entire dentition, resulting in positive treatment outcomes. However, using interarch vertical elastics highly depends on patient compliance with the treatment protocol.[14]

During the initial attempt to extrude the maxillary incisors, some improvement in their display was observed. Unfortunately, there was a relapse during the treatment process. Subsequently, a simultaneous extrusion approach for the maxillary incisors and maxillary molars was adopted.[7,15] This strategy resulted in a more stable enhancement in the display of the maxillary incisors over 2 years (Figures 13–15). The total arch extrusion technique is applied to the posterior and anterior regions of the maxillary arch, allowing for extrusion of the entire maxillary dentition through use of a labial archwire in the bracket slots. The interarch elastics were not used much in this reported case.

The extrusive forces exerted tended to rotate the maxillary posterior teeth toward the palate. It is advantageous to introduce some expansion in the maxillary archwire with palatal root torque or using a transpalatal arch. By controlling the extent of maxillary incisor extrusion more than that of the maxillary molars, it was possible to achieve clockwise rotation of the occlusal plane, which not only improved the maxillary incisor display and smile arc but also contributed to good occlusion and stability.

During the second round of maxillary incisor extrusion, one miniscrew fractured during insertion (Figure 16).[16] However, it was decided not to remove the fractured miniscrew immediately to maintain the planned biomechanics and, instead, it was addressed during the follow-up period. Throughout treatment and follow-up, no symptoms or signs of complications were observed. Upon reflection of the flap, it was observed that the fractured portion of the miniscrew had been wedged into the periodontal ligament space of the right maxillary lateral incisor. A high-speed round diamond bur was used to remove a small amount of alveolar bone surrounding the fracture segment. Then the fracture segment was carefully removed by counterclockwise rotation using a Weingart plier (Dentaurum GmbH & Co. KG, Ispringen, Germany). Fortunately, no further complications were observed after the removal of the miniscrew. It is important to avoid contact with the roots of the incisors when inserting interdental miniscrews in the future.

CONCLUSIONS

- This case report demonstrated the successful use of skeletal anchorage and total arch extrusion to improve maxillary incisor display and enhance facial esthetics in a patient with vertical maxillary deficiency. Treatment goals were achieved with extrusion assemblies anchored with miniscrews.
- The patient's occlusion was corrected, and significant improvements were observed in her facial profile, lip support, vertical facial proportions, and maxillary incisor display.
- Stability of the total arch extrusion was evidenced through 2-year postretention records.
- Further research and larger-scale studies are warranted to validate findings of this case report.

REFERENCES

1. Opdebeeck H, Bell W. The short face syndrome. *Am J Orthod*. 1978;73:499–511.
2. Spear F. Diagnosing and treatment planning inadequate tooth display. *Br Dent J*. 2016;221:463–472.
3. Turley PK. Orthodontic management of the short face patient. *Semin Orthod*. 1996;2:138–152.
4. van Otterloo JdM, Tuinzing D, Kostense P. Inferior positioning of the maxilla by a Le Fort I osteotomy: a review of 25 patients with vertical maxillary deficiency. *J Maxillofac*. 1996;24:69–77.

5. Talei B. The modified upper lip lift: advanced approach with deep-plane release and secure suspension: 823-patient series. *Facial Plast*. 2019;27:385–398.
6. Paik C-H, Park K-H, Park JH. New orthopedic and orthodontic treatment modality for adult patients with skeletal Class III malocclusion with insufficient maxillary incisor exposure. *AJO-DO Clinical Companion*. 2021;1:22–30.
7. Loca-Apichai P, Liou EJ-W. Redirecting mandibular growth through orthodontic dentoalveolar height development in growing patients with Class III malocclusion undergoing maxillary orthopedic protraction. *Am J Orthod Dentofacial Orthop.* 2022;162:510–519.
8. Bloom D, Padayachy J. Increasing occlusal vertical dimension—Why, when and how. *Br Dent J*. 2006;200:251–256.
9. Abduo J, Lyons K. Clinical considerations for increasing occlusal vertical dimension: a review. *Aust Dent J*. 2012;57:2–10.
10. Paolone MG, Kaitsas R. Orthodontic-periodontal interactions: orthodontic extrusion in interdisciplinary regenerative treatments. *Int Orthod*. 2018;16:217–245.
11. Ueda HM, Miyamoto K, Saifuddin M, Ishizuka Y, Tanne K. Masticatory muscle activity in children and adults with different facial types. *Am J Orthod Dentofacial Orthop*. 2000;118:63–68.
12. El-Bokle D, Abbas NH. A novel method for the treatment of Class II malocclusion. *Am J Orthod Dentofacial Orthop*. 2020;158:599–611.
13. Mücke T, Löffel A, Kanatas A, et al. Botulinum toxin as a therapeutic agent to prevent relapse in deep bite patients. *J Maxillofac*. 2016;44:584–589.
14. Derton N, Derton R, Perini A. Forced eruption with miniscrews; intra-arch method with vertical elastics versus intra-arch method using the Derton-Perini technique: two case reports. *Int Orthod*. 2011;9:179–195.
15. Atsawasuwan P, Hohlt W, Evans CA. Nonsurgical approach to Class I open-bite malocclusion with extrusion mechanics: a 3-year retention case report. *Am J Orthod Dentofacial Orthop*. 2015;147:499–508.
16. Kadioglu O, Büyükyilmaz T, Zachrisson BU, Maino BG. Contact damage to root surfaces of premolars touching miniscrews during orthodontic treatment. *Am J Orthod Dentofacial Orthop*. 2008;134:353–360.