Treatment of a twice-relapsed anterior open bite using temporary anchorage devices, myofunctional therapy, and fixed passive self-ligating appliances

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Maxillary LeFort impaction surgery can lead to improvements in facial proportions, smile esthetics, and improved function for patients with long lower facial height and anterior open bite. Sometimes, because of patient wishes, corrective jaw surgery might not be the most appropriate choice for treatment. This report describes the orthodontic retreatment of a 25-year-old woman with a history of 2 orthodontic treatments and 1 corrective jaw surgery, each with anterior open bite relapse. This third orthodontic treatment plan addressed her chief concern and focused on maximizing esthetics, function, and long-term stability. A problem list was used to design a treatment plan that incorporated myofunctional therapy, fixed appliances, and temporary anchorage devices to intrude her maxillary teeth and correct her orthodontic problems. Molar intrusion lasted 8.5 months, and total treatment time in fixed appliances lasted 22 months. The treatment was successful in addressing her chief concerns by shortening her lower facial third, relieving her lip strain, closing her anterior open bite, and achieving a Class I molar and canine occlusion. Overall, posttreatment stability was excellent at approximately 1-year follow-up, and the patient stated that she was very happy with the result. (Am J Orthod Dentofacial Orthop 2020;157:832-42)

Vertical maxillary excess, also known as "long face syndrome,"[1] has clinical hallmarks of long lower facial height, anterior open bite, hyperdivergent skeletal profile, lip incompetence, high palatal vault, and excessive gingival display on smile.[1,2] Vertical maxillary excess has traditionally been treated with fixed appliances combined with maxillary LeFort impaction surgery. In recent years, orthodontists have also corrected vertical maxillary excess using fixed appliances with skeletal anchorage,[3,4] with similar esthetic and functional results. Skeletal anchors (miniscrew implants or miniplates) are placed into the maxillary bone and loaded with an elastomeric chain or spring coils to the brackets or archwire to intrude the maxillary teeth. As maxillary posterior teeth intrude because of forces directed toward the anchorage screw(s) or plates, autorotation of the mandible occurs. This autorotation causes the menton, pogonion, and b-point to move anteriorly and superiorly, creating greater chin projection, shorter lower facial height, smaller interlabial gap, and more lip laxity, for improved lip competence on repose. Reports show this movement to be predictable and stable.[3,4] Light, continuous forces from aberrant tongue position or soft tissues can alter positions of the teeth and jaws,[5] negatively impacting orthodontic posttreatment stability. Retraining an aberrant resting tongue posture through myofunctional therapy leads to improvements in growth and development in patients.[6,7]

This case report describes the treatment of a female patient aged 25 years with vertical maxillary excess and significant orthodontic anterior open bite relapse after 2 previous full treatments of orthodontic therapy. Both orthodontic treatments resulted in anterior open bite relapse. The patient aged 25 years wanted an outcome that would improve her chewing function, gummy smile, and lip strain. Our treatment plan used fixed passive self-ligating appliances, temporary anchorage devices (TADs), and myofunctional therapy.

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The treatment was based on her chief concern, orthodontic history, diagnosis, and problem list.

DIAGNOSIS AND ETIOLOGY

A woman aged 25 years came for orthodontic treatment in August 2015 with a chief concern of anterior open bite, problems with chewing, tongue posture, and esthetic concerns about her gummy smile. She reported a long history of orthodontic care and subsequent relapse from 2 separate orthodontic treatment plans in 2 different countries. She suspected an ongoing issue with her tongue posture that had not been adequately addressed by the previous treatment plans. She had full fixed appliances when aged 12 years to correct a Class II malocclusion and anterior open bite. She reported that the open bite had relapsed soon after her braces were removed. She was told by her orthodontist to wait until growth subsided and then to pursue a second phase of orthodontics involving corrective jaw surgery. Therefore, when aged 19 years, she began a second orthodontic treatment plan with a different orthodontist. The treatment was intended to correct her anterior open bite and Class II malocclusion using fixed appliances combined with a LeFort I maxillary impaction and a mandibular bilateral sagittal split ramus osteotomy advancement corrective jaw surgery. However, the anterior open bite again relapsed soon after this treatment.

Clinical examination and analysis of facial photos and dental casts revealed a maximum anterior open bite at the central incisors of 4 mm transitioning from the first premolar to first premolar (Figs 1 and 2). The molar occlusion was approximately 20% Class II on the right and 50% Class II on the left. She had an end-to-end transverse molar relationship and a narrow intermolar width (32.3 mm) at the first molars,[8,9] with significant cuspal attrition into dentin on the maxillary and mandibular first molar cusp tips. The patient also had cicatricial tissue high along the maxillary vestibule consistent with previous corrective jaw surgery. Her frontal smiling photograph revealed excessive anterior (+4 mm) and posterior (+7 mm) gingival display. She had a flat, nonconsonant smile arc and obvious mentalis strain on lip closure, with a large estimated 16-mm interlabial gap on full smile.

Initial dental cast measurements (Fig 2) showed a high palatal vault (palatine height, 18.16 mm) and narrow palatal width (palatine width, 31.84 mm), resulting in an excessive palatine height index (palatine height × 100/palatine width = 57.03).[10] Photo measurements revealed an excessively long lower facial third (upper [Tr-G′]: middle [G′-Sn′]: lower [Sn′-Me′], 1.00:1.07:1.23]. The initial cephalometric radiograph (Fig 3; Table) showed vertical maxillary excess (Burstone PP-U1, 28.7 mm), a hyperdivergent skeletal pattern (Go-Gn–SN angle, 50.4°; FMA angle, 37.2°), and radiographic and clinically diagnosed mentalis strain on lip closure. She had a skeletal Class II malocclusion (ANB angle, 8.3°; Wits, 4.8 mm) and an acute facial contour angle[11] (G′-N′-P′, 153°). The lateral cephalogram and panoramic radiograph (Fig 3) showed radiopaque outlines in the shape of 4 separate surgical plates in the maxilla, with 1 on each of the right and left zygomatic buttresses, and 1 each in the location of the right and left sides of the anterior maxilla. There were 3 radiopaque screws on the left and right posterior-inferior mandibular corpus, presumably from the bilateral sagittal split ramus osteotomy. These radiopaque screws and plates were not in proximity to root apices. The panoramic radiograph showed generalized short roots and missing third molars. The airway appeared patent on the lateral cephalogram (minimum airway, 9.1 mm).

The patient was referred to a myofunctional therapist, who made a diagnosis of anterior tongue thrust for all foods, liquids, and saliva.

TREATMENT OBJECTIVES

Treatment objectives were to (1) close the anterior open bite, (2) improve the gingival display on smile, (3) correct the dental Class II malocclusion, (4) improve the mentalis strain on closure, (5) shorten the lower facial third toward more normative values, and (6) maintain a stable occlusion long-term.

TREATMENT ALTERNATIVES

The following alternatives were presented to the patient:

(1) no treatment (the patient declined this option).
(2) full fixed passive self-ligating appliances with variable torque (Damon Clear2 [Ormco, Orange, Calif] on the 6 maxillary anterior teeth and Damon Q [Ormco] on the all the remaining teeth in both arches); low-couple brackets on the lateral and central incisors in both arches; standard couple brackets on the maxillary canines and high couple brackets on the mandibular canines; bonded posterior bite turbos (Triad gel clear pink, Dentsply, Hanau Germany) on palatal cusps of the maxillary second molars; and lingual teardrop button attachments (GC Orthodontics, Alsip, Ill) on the lingual surfaces of teeth the maxillary first molars. Full-time crossbite elastics (Rabbit; force, 3.5 oz; diameter, 0.1875-in; Ormco) were used early in treatment to improve the buccal overjet.

Fig 1. Pretreatment facial and intraoral photos.

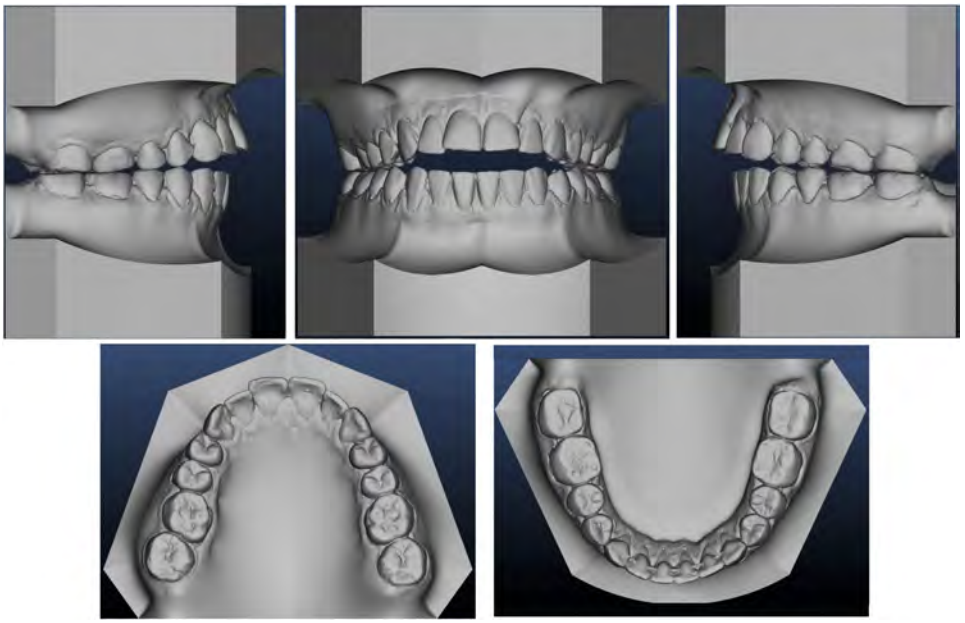

Fig 2. Pretreatment dental casts.

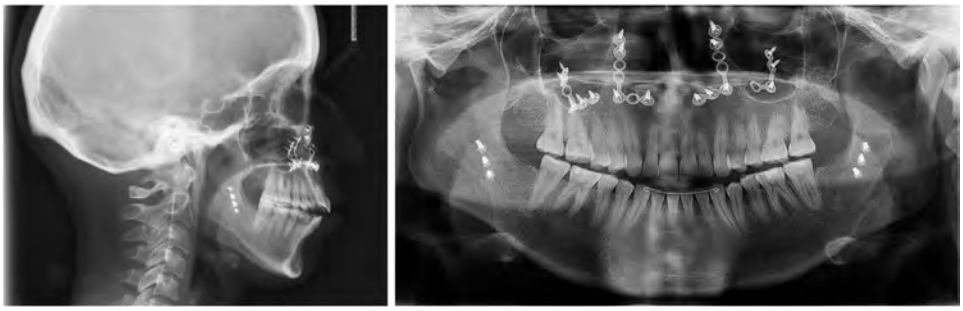

Fig 3. Pretreatment cephalometric and panoramic radiographs.

Table. Cephalometric measurements at pretreatment and posttreatment

Measurement	*Pretreatment*	*Posttreatment*
Angular (°)		
SNA	77.4	77.1
SNB	69.1	70.0
ANB	8.3	7.1
Facial contour angle (G-Sn-Pog)	158.8	161
FMA	37.2	32.5
MP angle (SN-Go-Gn)	50.4	46.5
Occlusal plane to Frankfort Horizontal	18.5	18.0
SN-U1	102.0	95.0
IMPA	102.0	95.5
FMIA	49.0	51.0
Interincisal angle	112.6	125.0
Linear (mm)		
Overjet	6.0	1.6
Overbite	−4.0	2.0
Burstone UDH (U6-PP)	25.5	23.0
Burstone LDH (L6-gonial angle)	36.0	36.0

After evaluation of tongue posture, the myofunctional therapist proposed a 6-month myofunctional therapy program to retrain the resting tongue posture, followed by a 3-month maintenance program during the initial months of her orthodontic care.

Orthodontic treatment consisted of the following steps: Start with light, round 0.014-in diameter, copper nickel-titanium archwire (Ormco) with midline stops to preserve free sliding mechanics, but to prevent excessive archwire sliding. Level and align, work into 19 × 25-mm stainless steel archwires. Perform cone-beam computed tomography (CBCT) scan to evaluate skeletal anchorage sites. Place 5 TADs (VectorTAS, Ormco): 2 high in the zygomatic buttresses, 2 in the anterior maxilla high and just apical between the roots of the maxillary laterals and canines, and 1 into the midpalatal raphe to both intrude the maxilla and control buccal molar tipping. Use intrusion forces from 250 g closed coil springs (Ormco), 0.030-in diameter clear elastic thread (Ormco), and energy power chain (Rocky Mountain Orthodontics, Denver, Colo) for TAD-supported intrusion of the maxillary anterior and posterior dentition. After open-bite closure and lip strain improvement, remove TADs, and finish treatment. Use diode laser gingivectomy as needed to manage redundant tissue caused by the intrusion; detail and finish in 24-30 months. The patient chose this option and gave consent on the day of bonding.

(3) Maxillary impaction surgery in combination with full fixed, variable torque passive self-ligating appliances (Damon Clear2 and Damon Q, Ormco) appliances and myofunctional therapy. The patient declined this option.

TREATMENT PROGRESS

Full maxillary and mandibular passive self-ligating appliances were placed along with 0.014-in Damon copper nickel-titanium wires (Ormco). Looped teardrop attachments (GC Orthodontics, Alsip, Ill) were placed on the lingual surfaces of maxillary first molars. Triad gel bite turbos were placed on the mesiopalatal cusps of the maxillary second molars. Light, early crossbite elastics (Rabbit; force, 3.5 oz; diameter, 0.1875-in) were placed from the lingual attachment on the maxillary right first molar and worn over the arch to the bracket on the buccal side of mandibular right first molar (and replicated on the contralateral side, maxillary left first molar, lingual, to mandibular left first molar, buccal).

The next 3 appointments consisted of gaining maxillary posterior arch width and working into heavier archwires while the patient progressed with her myofunctional therapy. Molar bite turbos were bonded onto the occlusal surfaces of maxillary

Fig 4. Initial TAD placement and 8.5 months in fixed appliances.

posterior teeth to inhibit vertical eruption. At month 8, the patient demonstrated positive buccal overjet from the crossbite elastics. Therefore, a 19 × 25-mm stainless steel archwire was inserted, and the patient was sent for a CBCT scan. Active myofunctional therapy was discontinued before TAD placement and reported as successful.

Using the CBCT as a guide, 5 VectorTAS TADs (Ormco) were then placed (Fig 4) to provide anchorage to intrude the maxillary dentition. After application of topical and local anesthetic, the following TADs were placed: two 10 mm × 2 mm (midpalatal, zygomatic buttress left), one 6 mm × 1.4 mm (maxillary anterior left), one 8 mm × 1.4 mm (maxillary anterior right), and one 12 mm × 2 mm (zygomatic buttress right). Intrusion forces came from 250 g closed coil springs and also from 0.030-in diameter elastomeric thread (Ormco) throughout the 8.5 months of posterior intrusion. Elastomeric thread from the midpalatal TAD to lingual buttons on the maxillary first molars helped keep the maxillary molars from rolling to the buccal aspect during the intrusion. After 2.5 months of intrusion of the maxillary anterior TADs, the left anterior device failed. The anterior intrusion was judged to be sufficient at this point, so only the 3 remaining posterior and palatal TADs remained loaded.

After 8.5 months of maxillary posterior intrusion, a 2-mm positive anterior overbite was achieved, and all TADs were removed. Because of a shorter occlusogingival height of maxillary left lateral incisor (vs maxillary right lateral incisor), a gingivectomy of approximately 1.5 mm was performed on the left, using the NV Microlaser diode laser (DenMat, Lompoc, Calif). Following intrusion, time was spent idealizing the torque of the maxillary incisors, then detailing and finishing the treatment.

After removal of the fixed appliances, Ortho-Flextech stainless steel bonded retainers were placed (Reliance Ortho, Itasca, Ill) on the 4 incisors in the maxilla and from canine to canine in the mandible, and these were to be maintained indefinitely. Clear vacuum-formed retainers were given for nightly wear. Light enameloplasty was performed using a carbide finishing bur to maximize even, centric occlusal contacts. Anterior crown recontouring was completed with the EP System (Brasseler USA, Savannah, Ga) to achieve symmetrically rounded embrasures and more pleasant overall tooth shapes and microesthetics.[12-14]

TREATMENT RESULTS

The patient's 4 mm anterior open bite was closed by posterior molar intrusion until 2 mm of positive overbite was achieved. The partial Class II malocclusion was completely corrected to Class I (Fig 5). These movements occurred without the use of any anterior or Class II intermaxillary elastics. The end-to-end relationship of the first molars was corrected to a positive 2 mm of maxillary buccal overjet. The intermolar width (linear segment between right and left mesiopalatal gingival margins of maxillary first molars) was 31.84 mm before treatment and 35.10 mm after treatment, resulting in 3.26 mm greater intermolar width. The occlusion remained stable at 11 months after

Fig 5. Final facial and intraoral photographs, 22 months in fixed appliances.

treatment (Fig 6). Posterior gingival display on smile decreased from an initial maximum value of 7 mm down to a final maximum value of 3 mm. The anterior gingival display remained similar before and after treatment for the maxillary central incisors and the right lateral incisor, and it improved for maxillary left lateral because of the crown-lengthening diode laser procedure on the facial gingival margin. The gingival display on maxillary canines decreased from before to after treatment by 2-3 mm. The interlabial gap decreased by approximately 4 mm, resulting in a more esthetic smile. The patient's pretreatment lip incompetence was completely resolved after treatment, both by photographic analysis and her self-report. The flat smile arc improved and was consonant with the lower lip line after treatment.

The myofunctional therapy report stated that an overall correct resting lip and tongue posture of 98% during the day and 100% correct conscious swallow had been achieved after therapy.

The pretreatment lower facial height (initial SN-Me, 71 mm) decreased by 2.5 mm (final Sn′-Me′, 68.5 mm). The pretreatment facial rule of thirds ratio (Tr-G′:G′-Sn′:Sn′-Me′, 1.00:1.07:1.23) improved to (Tr-G′:G′-Sn′:Sn′-Me′, 1.00:1.07:1.11) (Fig 7).

Final dental cast measurements from plaster models showed a shorter palate (palatine height, 16.98 mm compared with 18.16 mm pretreatment) and a wider palatal width (palatine width, 35.10 compared with 31.86 mm pretreatment), resulting in a significant decrease in the palatine height index from the pretreatment value of 57.03 to a final value of 48.37. The final occlusion showed a positive 2 mm of vertical overbite (Fig 8). Mild root blunting of the maxillary anterior roots was radiographically detectable (Fig 9).

No periodontal problems occurred during treatment. Maxillary posterior intrusion lasted 8.5 months, and total treatment time lasted 22 months. The treatment was successful in addressing the patient's chief concerns by

Fig 6. Retainer check facial and intraoral photos. Approximately 1-year retention.

Fig 7. Changes in the lower face and interlabial gap on smiling. Images superimposed over pupils. Pretreatment (*black*) and posttreatment (*red*).

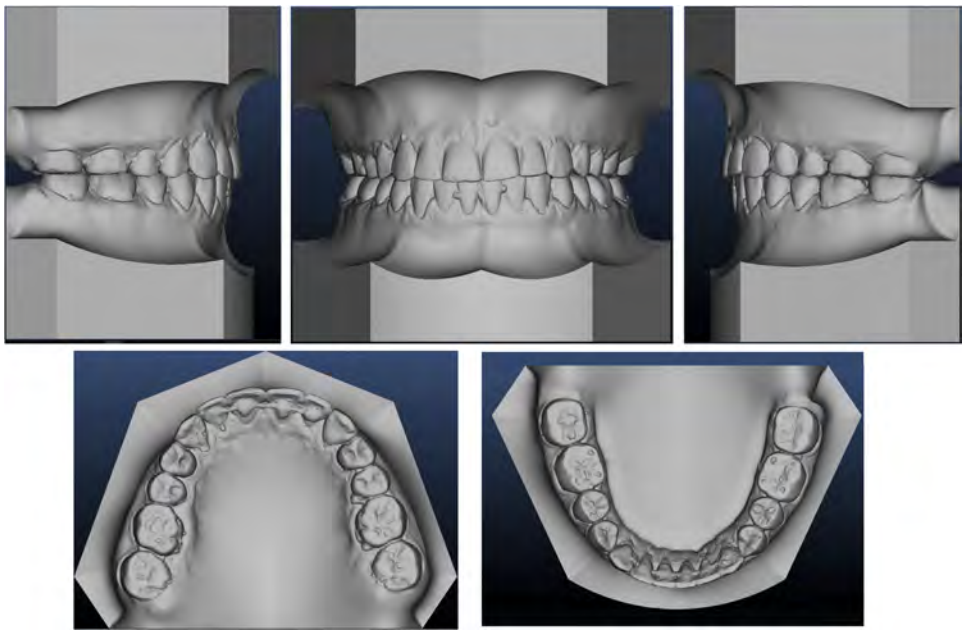

Fig 8. Posttreatment dental casts.

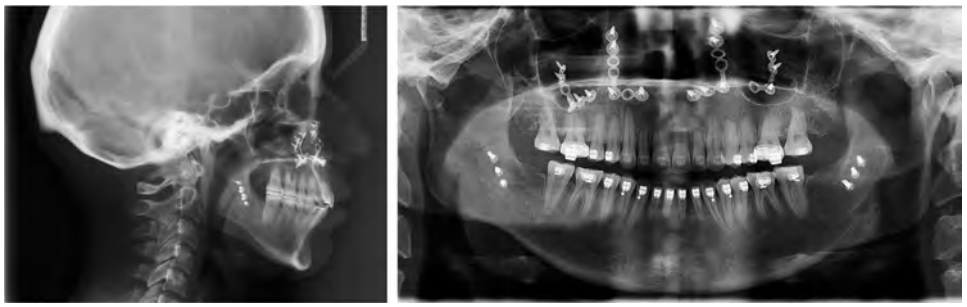

Fig 9. Final cephalometric (3 months after debond) and panoramic radiographs (1 week before debonding).

shortening her lower facial third, relieving her lip strain, closing her anterior open bite, and achieving a Class I molar and canine occlusion. Overall, posttreatment stability was excellent at approximately 1-year follow-up, and the patient stated that she was very happy with her result.

DISCUSSION

The rule of thirds has been a known canon of facial proportions since the beginning of the renaissance. Perhaps the most profound thinker of proportions in all of history was Leonardo DaVinci, whose pen and ink *Vitruvian Man* clearly shows horizontal lines passing through the hairline (trichion), midbrow (soft tissue glabella), nasal base (subnasale), and chin tangent (soft tissue menton) on frontal view in near-perfectly measured thirds.[15] Scheideman et al[16] showed that a sample of 24 young adult female subjects had a middle:lower facial ratio of 1.02:1.00. Male subjects showed a slightly longer lower face. Farkas studied a large North American white female population and reported an average ratio of 1:1:1 for facial thirds.[17] In addition, in his book *Esthetic Orthodontics and Orthognathic Surgery*,[2] Sarver concluded that the vertical thirds ratio should be roughly 1:1:1 in the ideal female face. Our patient began with a long lower facial third in the ratio of (upper:middle:lower) of 1.00:1.07:1.23. Concomitant with this long lower face were lip incompetence, excessive posterior gingival display on smile, anterior open bite, and excessive interlabial gap. Interlabial gap is positively correlated with lower facial height.[18]

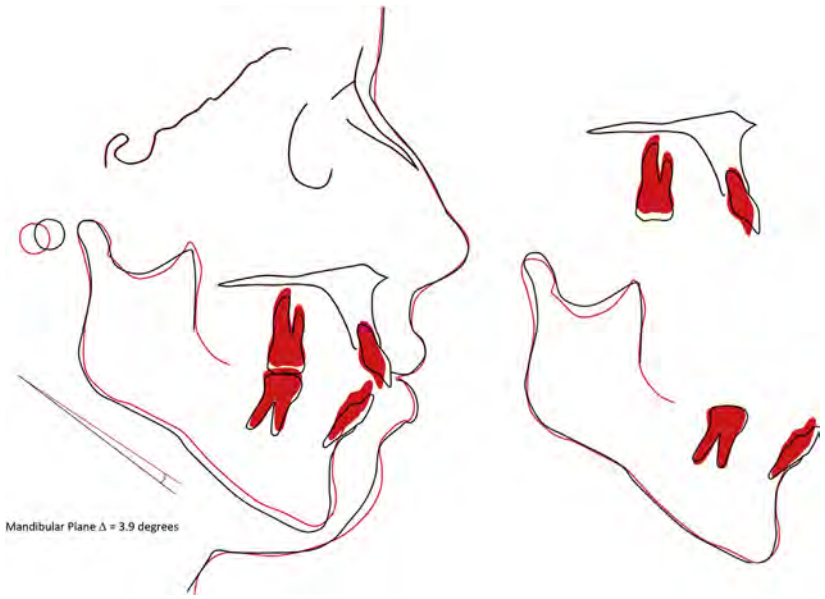

Fig 10. Cephalometric superimposition. Pretreatment (*black*) and posttreatment (*red*).

Temporary skeletal anchorage devices have become routine for the correction of anterior open bite in recent years. Molar intrusion from maxillary skeletal miniplates has been reported in the range of 1.45-3.32 mm with a mean intrusion of 1.99 mm.[3] Similarly, others have reported from 2 to 4 mm molar intrusion using TADs, with a mean of 2.3 mm.[4] These intruded teeth demonstrated little extrusive relapse, especially in younger patients. We used 5 maxillary temporary skeletal anchorage devices to intrude the maxillary teeth, which autorotated the mandible to a more forward position and also lessened the mandibular plane angle by 3.9°. The 4-mm anterior open bite was closed until 2 mm of positive overbite was achieved. This correction occurred during the 8.5 months of active TAD-anchored molar intrusion without any anterior interarch elastics. The changes in the palatine height suggested a molar intrusion at the palatal gingival margin of the first molars of 1.18 mm. After treatment, the axial inclination of the maxillary molars was more proclined, and the vertical position of the buccal cusps was approximately 3 mm more superior compared with the pretreatment position. Cephalometric superimposition showed a molar intrusion of approximately 2 mm, with positive concomitant changes to the patient's profile, lip posture, and interlabial gap on smile (Fig 10).[19]

Proffit et al[5] noted that 4-8 hours per day of continuous forces are enough to commence tooth movement. Short-duration activities such as swallowing, speaking, or chewing are thought to be inadequate to change tooth position.[1] The aberrant resting posture of the lips, cheeks, and tongue is thought to produce light continuous forces on the teeth. These forces are known to impact both tooth position and sometimes cause craniofacial growth abnormalities.[5-7] Fränkel and Fränkel[6] reported that open bites could be corrected or improved by controlling resting posture. The goal of modern myofunctional therapy is to correct resting tongue posture so that negative sequelae can be avoided.

Whenever cephalometric radiographs are traced or superimposed, there can be some degree of discrepancy between tracing events and between doctors doing the tracing. These inherent discrepancies should be acknowledged in any case report in which tracing is attempted. Extreme care was taken in our case to achieve an honest representation of the traced structures (Figs 7 and 10).

The time dimension of orthodontics should not be taken lightly. Mamandras showed a lengthening of the lips throughout adolescence.[20] Vig and Brundo[21] showed that, on repose, humans lose approximately 50% of their maxillary incisor display per decade of life from under 29 years through 60 years. Loss of incisor display is thought to arise from a decrease in subcutaneous fat and moisture content from the lips, among other causes.[1] This circumstance should be taken into account in planning treatment for adolescent and young adult patients. In the treatment of young patients, we should err on the side of more incisor display with perhaps some gingival display on a social smile to help patients age more gracefully. Our patient's anterior gingival display remained similar from before to after treatment

for her maxillary anterior teeth, despite intrusion temporary skeletal anchorage devices in her anterior maxilla for 2.5 months. The gingival display on teeth numbers 6 and 11 decreased from before to after treatment by 2-3 mm.

Other important aspects of a well-rounded smile are minimal buccal corridors, a consonant smile arc, upright maxillary incisor torque, a transverse dimension of adequate width, and ideal tooth shapes. Our patient showed improvement in each of these areas.

Before treatment, our patient had an end-to-end (zero mm) buccal overjet relationship of the maxillary and mandibular first molars and attrition on the first molar cusp tips. Buccal overjet was improved early in treatment by the influence of early *over the arch* posterior crossbite elastics (force, 3.5 oz; diameter, 0.375-in) from the first molar to first molar bilaterally while on light round copper nickel-titanium archwires. Buccal overjet improved to positive 2 mm after treatment. She gained 3 mm of transverse arch width. This improvement in arch width combined with maxillary molar, premolar, and canine intrusion led to improvements in buccal corridor appearance, smile arc, and posterior gingival display on smile. Midtreatment diode laser treatment on the maxillary left lateral incisor with posttreatment recontouring on all 6 maxillary anterior teeth gave improved tooth shapes and improved microesthetics.

Our patient's angle Class II malocclusion was corrected to a Class I position, which occurred without the use of Class II elastics. As maxillary molars intrude from forces directed toward the anchorage screw(s) or plates, autorotation of the mandible is known to occur in a counterclockwise direction on a right-sided lateral cephalometric radiograph. This counterclockwise rotation causes both superior and anterior displacement of the mandible in a Class III direction.

Arguably, no treatment can be considered successful unless the patient is happy. Our patient left treatment pleased with her esthetics, function, and, most recently, her stability. Treatment was, therefore, judged a success.

CONCLUSIONS

The use of TADs, in combination with passive self-ligating appliances, can reliably correct negative sequelae associated with vertical maxillary excess in patients with Class II malocclusion. Such sequelae include anterior open bite, lip incompetence, excessive posterior gingival display on smile, excessive interlabial gap, and long lower facial height. Myofunctional therapy helps eliminate tongue postural issues and ensures long-term stability.

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