Skeletal Anchorage for Vertical Control in Extraction Treatment of Dolichofacial Patients

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Controlling the vertical dimension in high-angle patients has always been a challenge for orthodontists. In a patient with a restricted airway and resultant mouthbreathing, adenoidectomy improves the mandibular growth direction with or without fixed appliance therapy.[1] High-pull headgear[2] or a vertical-pull chin cup[3] can control the eruption of the maxillary molars, but the effectiveness of these techniques depends on patient cooperation. Transpalatal arches were once thought to retard upper molar eruption, but a controlled study found no evidence to support this theory.[4] A modified transpalatal arch, known as a vertical holding appliance, can affect the eruption of upper molars in premolar extraction cases.[5] Lingual arches can inhibit lower molar eruption,[6] and posterior bite blocks can also control the eruption of posterior teeth.[1]

More recently, skeletal anchorage has been shown to be an effective modality for control of the vertical dimension.[7-11] Yao and colleagues found that SN-MP was increased in a group of hyperdivergent patients using headgear, but a comparable group with miniscrew anchorage showed a tendency toward intrusion of the maxillary molars and a reduced mandibular plane angle.[12]

Because nonextraction treatment causes clockwise rotation of the mandible and increased lower facial height in hyperdivergent patients, extractions are commonly employed in such cases.[13] In the past, extraction was believed to induce counterclockwise rotation of the mandible as the posterior teeth move anteriorly into the extraction spaces. Although one study showed a reduction in mandibular plane angle after premolar extractions, the subjects were wearing vertical-pull chin cups.[14] More recent studies have shown that while the posterior teeth do move anteriorly after premolar extractions, the extraction mechanics are eruptive.[15] Two reports[13,16] concluded that the vertical dimension is not reduced after premolar extraction with conventional mechanics, and one noted no significant differences in vertical changes between extraction and nonextraction groups.[16]

Patients with high mandibular plane angles may be more susceptible to dental extrusion and bite opening during orthodontic treatment. Any reverse curve incorporated into the archwires, as

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Fig. 1 Case 1. 10-year-old female with hyperdivergent facial pattern, retrognathia, and severe mandibular arch-length discrepancy before treatment.

TABLE 1
CASE 1 CEPHALOMETRIC DATA

	Pretreatment	Post-Treatment	Difference
SNA	83.0°	81.5°	1.5°
SNB	74.0°	75.0°	1.0°
SN–Go-Gn	48.0°	47.0°	1.0°
FMA	39.0°	38.0°	1.0°
ANB	9.0°	6.5°	2.5°
U1 to NA	3.0mm	1.0mm	2.0mm
U1 to SN	107.0°	93.0°	14.0°
Mx 6-6 (casts)	42.0mm	40.0mm	2.0mm
L1 to NB	10.0mm	8.0mm	2.0mm
L1 to Go-Gn	92.0mm	89.0mm	3.0mm
Md 6-6 (casts)	36.5mm	34.5mm	2.0mm
Md 3-3 (casts)	26.0mm	27.0mm	1.0mm
Soft-tissue esthetic plane	4	3	1

is common in extraction mechanics, can further exacerbate this eruptive potential. Because many high-angle patients also have high ANB angles and clinical retrognathia, reducing the mandibular plane angle and facial height can dramatically improve cosmetic appearance. Unfortunately, long-faced adults exert significantly less maximum occlusal force in chewing than adults with normal-length faces do,[17] and occlusal forces are a source of anchorage during tooth movement, especially when attempting to prevent extrusion.

Growing patients, whether treated or untreated, show significant eruptive potential. Creekmore found that the lower molars erupted an average of 1.5mm over 30 months in an untreated sample and an average of 2.2mm in patients treated without extractions.[18] Pearson noted an average 3.2mm of lower molar eruption with extraction therapy.[19] Iseri and Solow reported an average 8mm of upper molar eruption in a sample of girls over a 16-year period, from age 9 to 25.[20]

The increments of vertical facial growth are antagonists of condylar growth because they push the chin down, while condylar growth causes advancement.[21] Patients whose total condylar growth exceeds the sum of maxillary vertical growth and maxillary and mandibular molar eruption show an improvement in the *y*-axis, with the chin projecting farther over time. On the other hand, when the sum of the vertical increments exceeds condylar growth, the mandible rotates backward and downward. In cases where condylar growth equals incremental facial growth, the chin projects downward and forward relative to the patient's facial pattern.[21] The mandibular plane remains parallel, and the mandible advances by the amount of horizontal condylar growth.[22]

In growing high-angle Class II skeletal patterns, skeletal anchorage can positively affect two of the three clinically significant increments of vertical facial growth (the eruption of maxillary and mandibular molars), thus contributing to a marked improvement in facial balance. In a non-growing, high-angle patient undergoing extraction therapy, counterclockwise rotation of the mandible, and thus forward chin displacement, remain possible by means of active molar intrusion, eliminating the need for extrusion of the upper incisors to close an anterior open bite.

The following two cases show the potential of skeletal anchorage to provide vertical control in both growing and non-growing dolichofacial patients after premolar extractions.

Case 1

This 10-year-old girl was a transfer patient undergoing Phase I treatment with upper and lower 2 × 6 appliances to alleviate crowding (Fig. 1). "Appearance and overbite" were the family's chief concerns. Given the severe mandibular crowding, however, including a blocked-out lower left first premolar, the appliances were debonded and the parents were advised of the importance of begin-

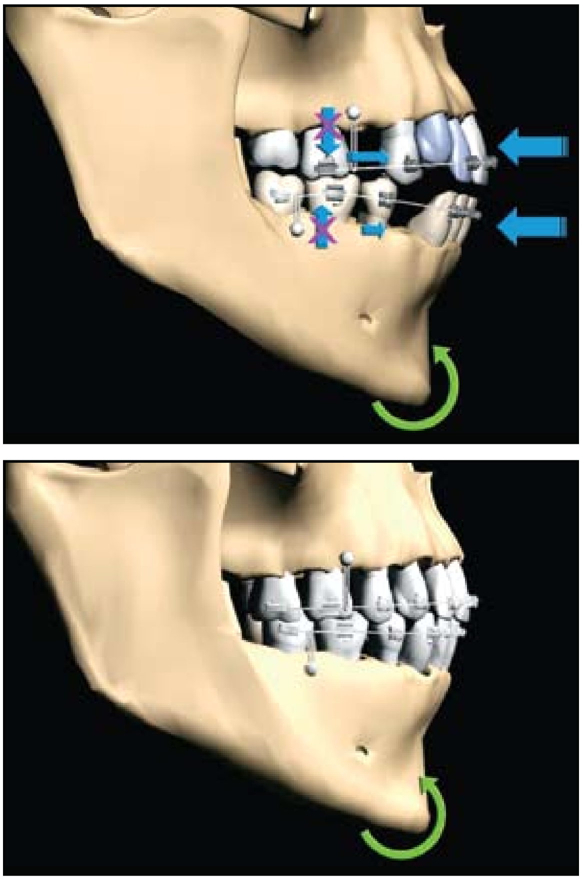

Fig. 2 Case 1. Treatment plan involving control of molar eruption to achieve advancement of pogonion.

ning comprehensive treatment while the patient was still growing.

Cephalometric analysis revealed a Class I malocclusion with a high-angle Class II skeletal base, a 39° FMA, and a 9mm convexity (Table 1). The maxillary midline coincided with the facial midline, but the mandibular midline was 3mm to the left. Anterior guidance was inadequate because of excessive overjet and an anterior open-bite tendency. A buccal crossbite tendency was also noted at the maxillary right first premolar.

Treatment objectives were to eliminate the crowding, establish bilateral Class I molar and canine relationships, and correct the lower midline. The primary objective, considering the patient's growth pattern, was to control the eruption of the posterior teeth and thus allow the chin to project forward (Fig. 2). The parents were advised that surgical intervention might be needed if the anticipated growth did not take place.

After a Class III extraction sequence of maxillary second premolars and mandibular first premolars, .018" Roth-prescription In-Ovation-R*

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Fig. 3 Case 1. After four months of treatment, maxillary miniscrews placed to provide anchorage for maxillary intrusion mechanics; open-coil springs placed between mandibular first and second molars to make additional space for mandibular miniscrews, placed six weeks later; transpalatal arch and .032" × .032" Burstone lingual arch used to maintain torque control during intrusion.

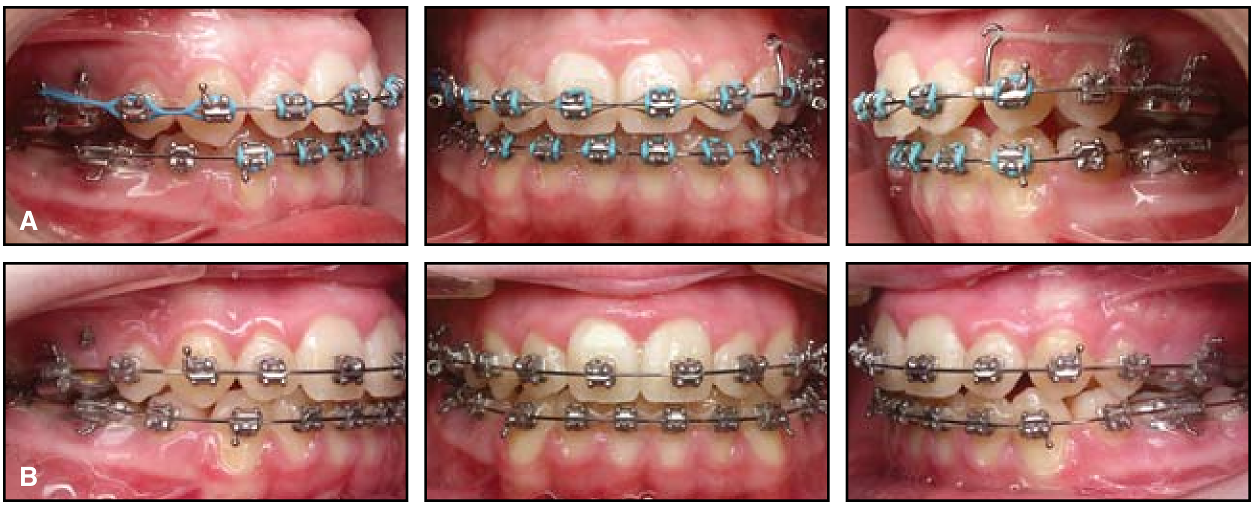

Fig. 4 Case 1. A. After 13 months of treatment, open-coil spring placed between upper left first premolar and first molar to distalize first molar, and power thread attached between miniscrew and archwire hook mesial to upper left canine to prevent mesial movement of anterior teeth. B. Class I occlusion achieved after three months of maxillary left molar distalization.

brackets were bonded in both arches. The archwire sequence consisted of .014" nickel titanium, .018" nickel titanium, .016" × .016" nickel titanium and stainless steel, .017" × .025" nickel titanium, and an .016" × .022" stainless steel maxillary closing arch. Finishing wires were .016" × .022" stainless steel in both arches.

After four months of initial alignment, miniscrews were inserted in the maxillary arch, mesial to the first molars, to begin molar intrusion with .018" × .018" elastic thread from the miniscrews to the maxillary archwire. A transpalatal arch and an .032" × .032" removable Burstone lingual arch were used to control torque during the intrusion process (Fig. 3). Open-coil springs were placed in the mandibular arch between the first and second molars to gain space prior to insertion of miniscrews six weeks later. Minimal Class II mechanics were used, with short-pull Class II elastics worn on the left side for two months.

Thirteen months into treatment, an end-on relationship of the left first molars required distalization mechanics using the maxillary left miniscrew as indirect anchorage. Wire ligation from the miniscrew to the archwire helped prevent the molars from erupting after active intrusion. Indirect anchorage was used by placing an open-coil spring between the maxillary left first premolar and first molar for distalization, while power thread from the miniscrew to an extension hook mesial to the canine prevented mesial movement of the anterior teeth (Fig. 4A). After three months, a Class I relationship was established (Fig. 4B), and .016" × .022" stainless steel finishing wires were placed. Appliances were removed after 17 months of treatment, and 2-2 upper .017" × .017" TMA** and 3-3 lower .0175" braided retainers were bonded.

With two of the three clinically significant increments of vertical facial growth[18] controlled, the patient experienced remarkable facial changes (Fig. 5C, Table 1). Because total condylar growth exceeded the increments of vertical facial growth, there was a significant improvement in the *y*-axis, and the chin projected forward 5mm (Fig. 5B). This extreme chin advancement was aided by a 2.5mm horizontal component of condylar growth. No vertical growth of the maxilla occurred during treatment. Except for the short-term use of short-pull Class II elastics, no conventional Class II

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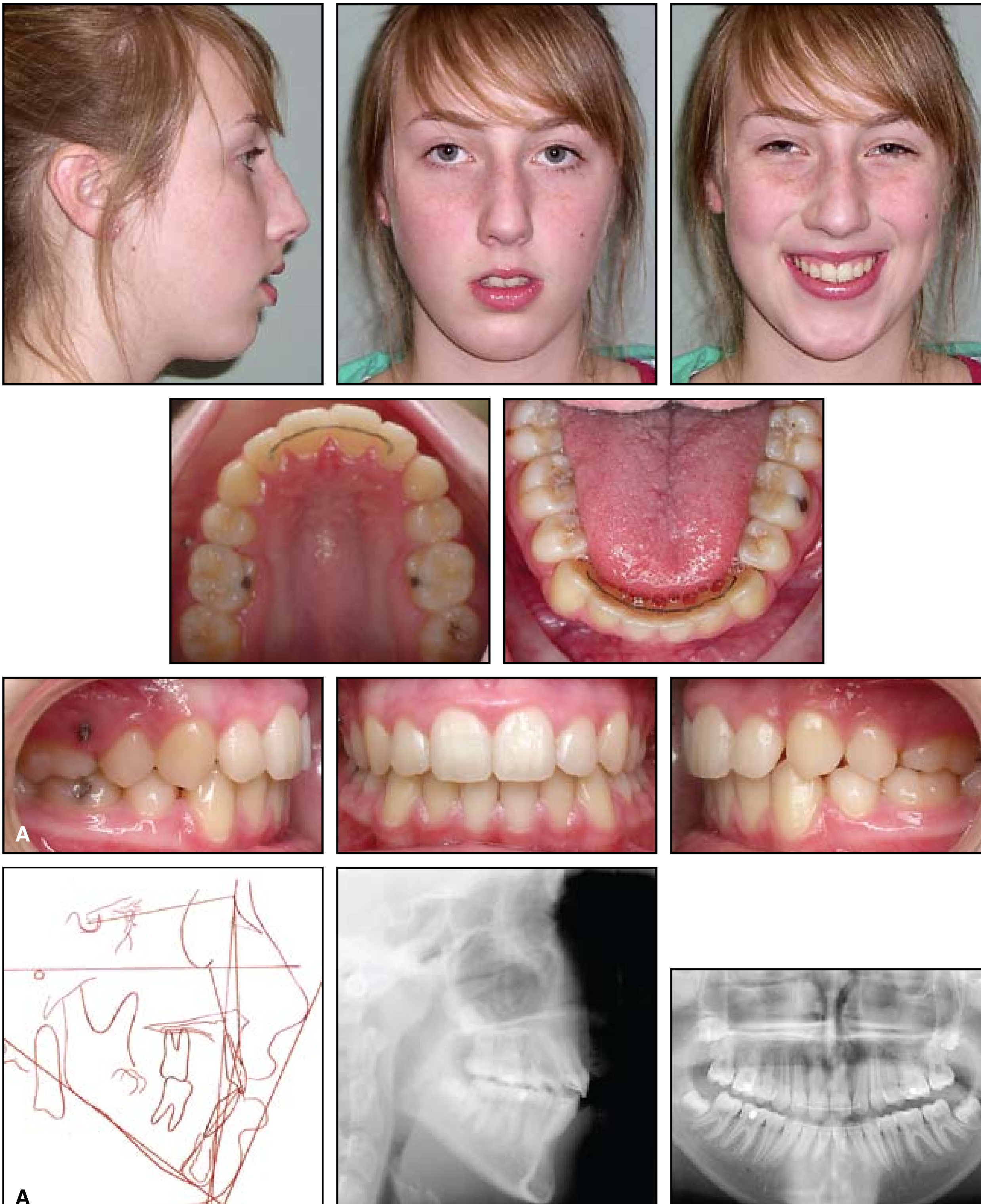

Fig. 5 Case 1. A. Patient after 17 months of treatment, showing remarkable profile change with favorable facial growth (continued on next page).

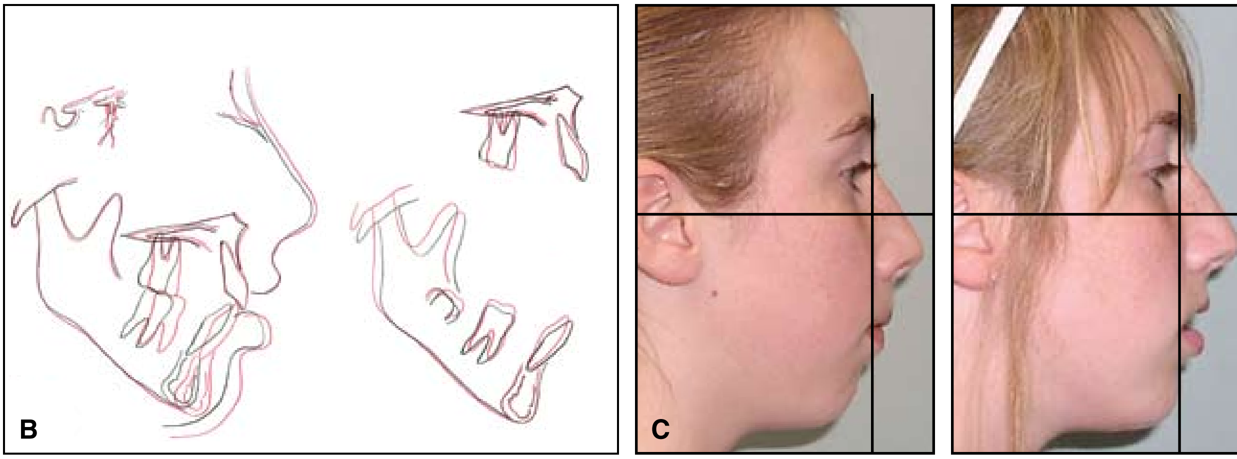

Fig. 5 Case 1 (cont.). B. Superimposition of pre- and post-treatment cephalometric tracings, showing 5mm advancement of pogonion due to molar eruption control during condylar growth. C. Comparison of pre- and post-treatment profiles.

Fig. 6 Case 1. Patient 12 months after debonding.

TABLE 2
CASE 2 CEPHALOMETRIC DATA

	Pretreatment	Post-Treatment	Difference
SNA	77.0°	76.0°	1.0°
SNB	73.0°	73.0°	0.0°
SN–Go-Gn	45.0°	42.0°	3.0°
FMA	33.0°	31.0°	2.0°
ANB	4.0°	3.0°	1.0°
U1 to NA	6.0mm	4.0mm	2.0mm
U1 to SN	101.0°	96.0°	5.0°
Mx 6-6 (casts)	40.0mm	42.0mm	2.0mm
L1 to NB	6.0mm	5.0mm	1.0mm
L1 to Go-Gn	88.0°	87.0°	1.0°
Md 6-6 (casts)	35.0mm	36.0mm	1.0mm
Md 3-3 (casts)	24.0mm	26.0mm	2.0mm
Soft-tissue esthetic plane	–2	–4	2

mechanics were used. In other words, simply limiting the eruption of the posterior teeth provided the vertical control needed for skeletal Class II correction.

Final occlusal results and root angulation were acceptable, although the buccal overjet was inadequate at the left second molars, and a stronger Class I relationship could have been established on the left side. The maxillary and mandibular midlines finished slightly off, but midline elastics were not used because of their potential vertical component. After taking such care to control the vertical dimension, it is wise to avoid any vertical eruptive mechanics, whether anterior or posterior.

Three of the four miniscrews came loose during treatment: the maxillary right miniscrew was replaced, but both mandibular miniscrews were removed after three months. The clinical changes were favorable enough at that point that the lower miniscrews were not replaced; instead, band cement was placed on the occlusal surfaces of the mandibular first molars to prevent compensatory eruption. Had the lower miniscrews been replaced, better vertical control of the lower molars might have enhanced the correction at pogonion.

Twelve months after debonding, the patient showed minimal changes in occlusion, although a slight space had opened between the maxillary left lateral incisor and canine (Fig. 6).

Case 2

A 17-year-old female presented with the chief complaint of "crooked teeth". The patient had a Class II, division 1 subdivision left malocclusion with severe maxillary and mandibular crowding, in which both maxillary canines and the mandibular right canine were blocked out (Fig. 7). The mandibular arch-length discrepancy was 7mm, and the maxillary arch was constricted in the first premolar area. Molar and canine relationships were Class I on the left and end-on on the right. The upper midline coincided with the facial midline, but the lower midline was deviated 5mm to the right, probably due to premature loss of a mandibular right deciduous tooth. A maxillary midline diastema was caused by a high labial frenum.

The patient displayed a dolichofacial skeletal pattern with an FMA of 32° and a skeletal anterior open bite, resulting in a lack of anterior guidance (Table 2). Her airway seemed adequate on review of the cephalometric radiograph. Lip incompetence was noted in full repose. She had a fairly straight profile, with some mandibular border asymmetry and the chin deviated to the right of the facial midline.

Treatment objectives were to eliminate the crowding, establish bilateral Class I molar and canine relationships, and correct the lower midline. The greatest challenge, and most important objec-

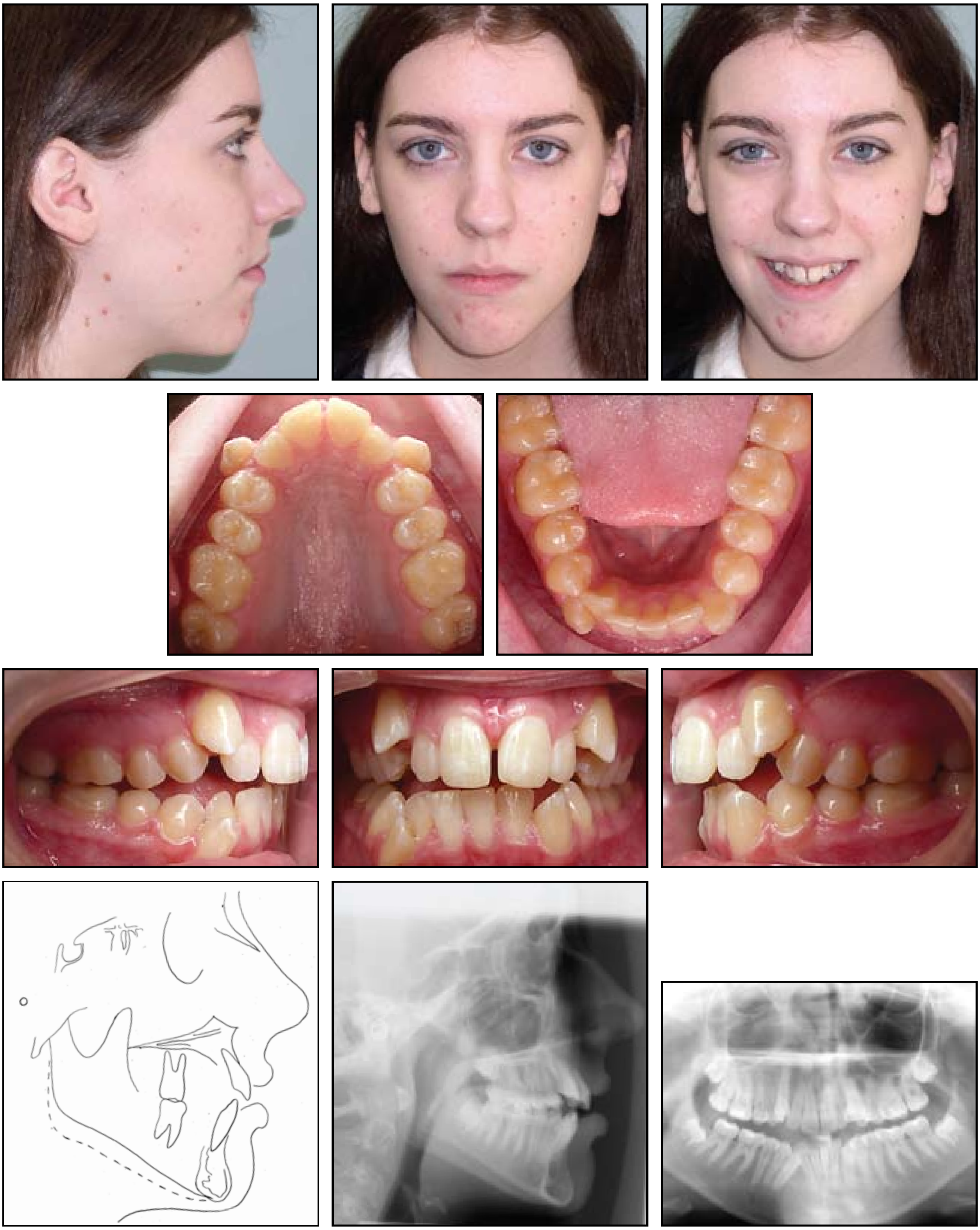

Fig. 7 Case 2. 17-year-old female with severe arch-length discrepancy, severe lower midline discrepancy, anterior skeletal open bite, and hyperdivergent facial pattern before treatment.

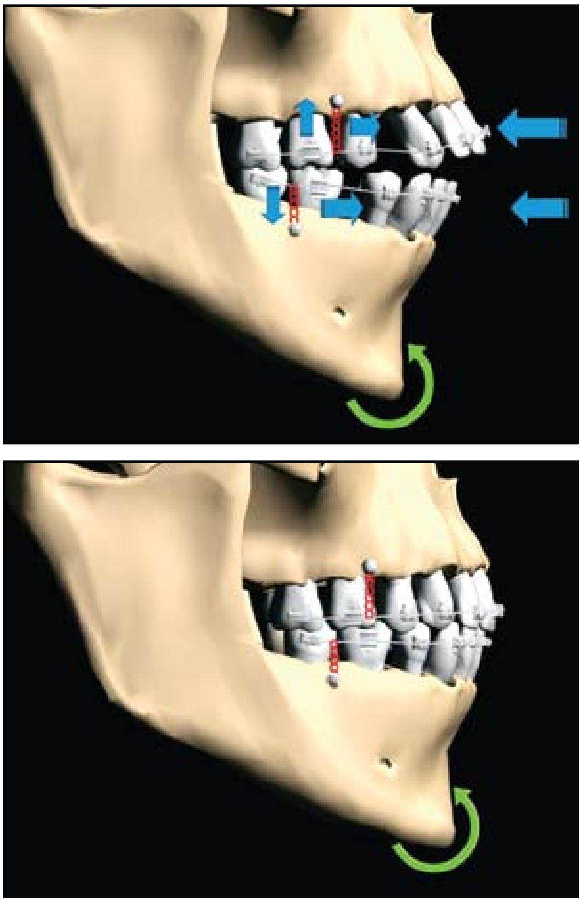

Fig. 8 Case 2. Treatment plan involving prevention of clockwise mandibular rotation and possible achievement of mandibular autorotation.

tive, was to prevent eruption of the posterior teeth during space closure. In traditional orthodontic space closure with no condylar growth potential, the posterior teeth erupt, which in dolichofacial patients can lead to a backward, downward rotation of the mandible. In open-bite extraction cases, the anterior open bite is often closed by eruption of the maxillary anterior teeth. Because this patient showed an appropriate upper incisor display before treatment, an important esthetic objective was to avoid extrusion of the upper incisors. Intrusion of the posterior teeth would also aid in correction of the open bite (Fig. 8).

After extraction of both maxillary first premolars and the mandibular left first premolar and right second premolar, miniscrews were inserted in the maxillary arch between the second premolars and first molars and in the mandibular arch between the first and second molars. A labial frenectomy was planned for a later appointment.

Both arches were bonded with .018" Roth-prescription In-Ovation-R brackets, except that Bioprogressive*** torque brackets (+22°/14°) were

***Ormco Corporation, 1717 W. Collins, Orange, CA 92867; www.ormco.com.

Fig. 9 Case 2. After six months of treatment, transpalatal arch and Burstone lingual arch used to maintain torque control during intrusion.

Fig. 10 Case 2. After 18 months of treatment, miniscrew implant placed distal to mandibular right canine to complete lower midline correction.

placed on the maxillary anterior teeth in mid-treatment to further establish anterior torque during retraction. The archwire sequence included .014" nickel titanium, .018" nickel titanium, .016" × .016" nickel titanium, .017" × .025" nickel titanium, and .016" × .022" stainless steel closing arches. Finishing wires were .016" × .022" stainless steel in both arches.

Intrusive forces were applied with power thread from the miniscrews to the archwires. A transpalatal maxillary arch and an .032" × .032" removable Burstone lingual arch were used to control torque during intrusion (Fig. 9). Class II elastics were used to help burn lower anchorage, but the lower posterior intrusive force of the skeletal anchorage negated the vertical vectors of the elastics. Although an asymmetrical extraction sequence was chosen to help correct the lower midline, an additional miniscrew was needed between the mandibular right canine and first premolar to provide anchorage for protraction of the right posterior teeth and completion of the midline correction (Fig. 10).

Total treatment time was 22 months. Fixed 2-2 maxillary .017" × .017" TMA and 3-3 mandibular .0175" braided retainers were placed, and a maxillary Essix retainer was fabricated for nighttime wear.

Significant mandibular autorotation occurred, lower facial height was reduced by 3mm, and pogonion advanced by 2mm (Fig. 11, Table 2). These beneficial skeletal changes were made possible by 2mm of upper posterior intrusion and by the prevention of lower posterior eruption during space closure. Notably, the maxillary anterior teeth were also intruded by 1mm, and some maxillary anterior root resorption was seen. The midline was almost fully corrected. The lower intercanine distance increased from 23.5mm to 26mm, but this reflected the canines' being retracted posteriorly into a wider portion of the arch. The upper premolar transverse dimension increased from 32mm to 36mm.

The final intercuspation was reasonable, although a stronger Class I canine and premolar relationship might have been obtained with additional maxillary anterior torque, followed by posterior distalization using the upper miniscrew anchorage. Posterior vertical seating elastics were not used in this case because some vertical relapse is always anticipated.[7] In high-angle cases, it is prudent to avoid the vertical forces of seating elastics.

The use of conventional mechanics most likely would have precluded achievement of a Class I molar and canine relationship in this case, because the mandibular autorotation was critical. Without skeletal anchorage, the maxillary incisors would probably have been extruded, thus creating an excessive gingival display. The lower facial height would not have decreased; at best, it would have remained the same.

Records taken 15 months after treatment showed no appreciable changes (Fig. 12).

Discussion

These cases show the value of incorporating skeletal anchorage into extraction treatment in growing and non-growing dolichofacial patients. Relative posterior intrusion is often seen with the use of skeletal anchorage in growing patients, and

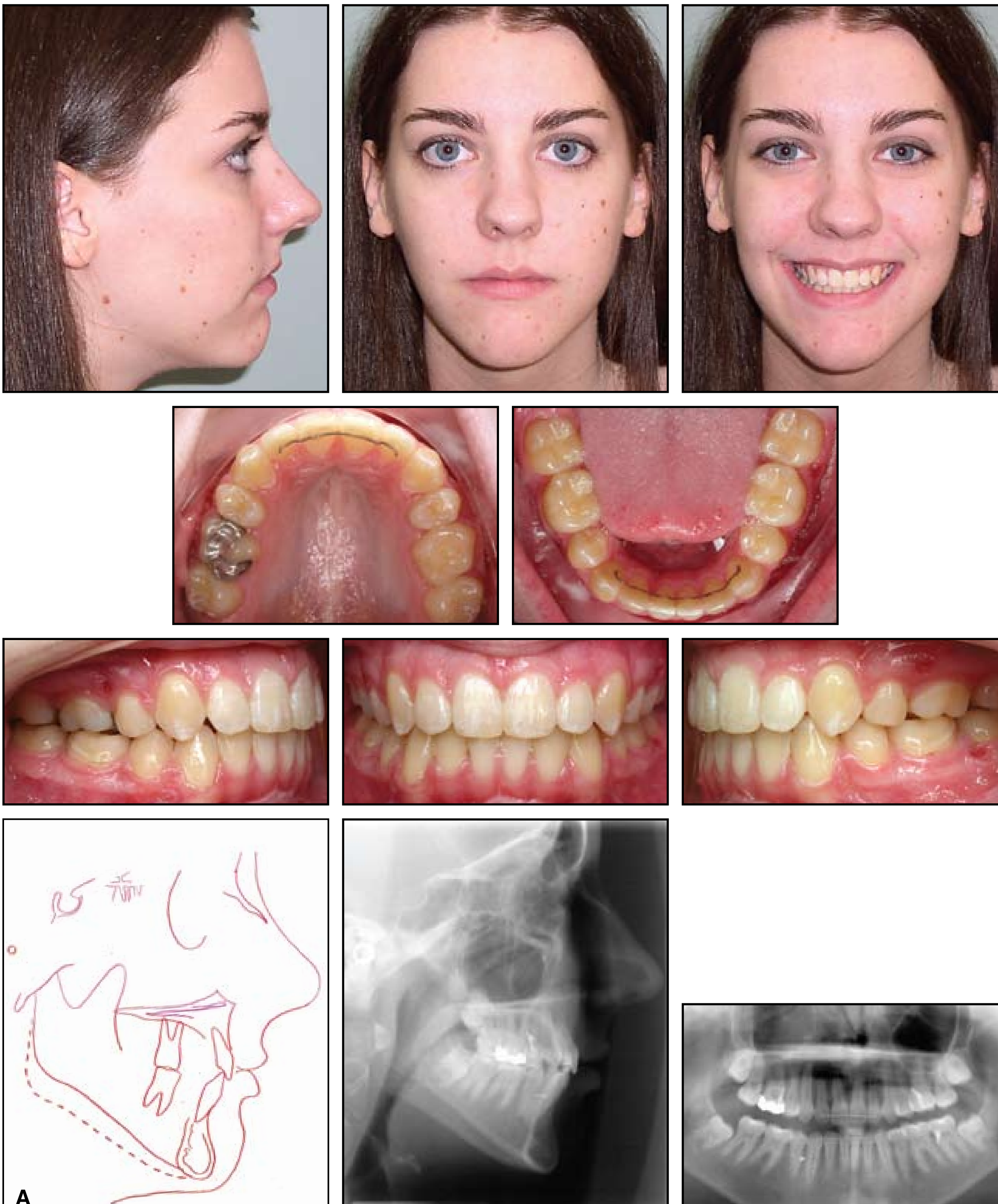

Fig. 11 Case 2. A. Patient after 22 months of treatment (continued on next page).

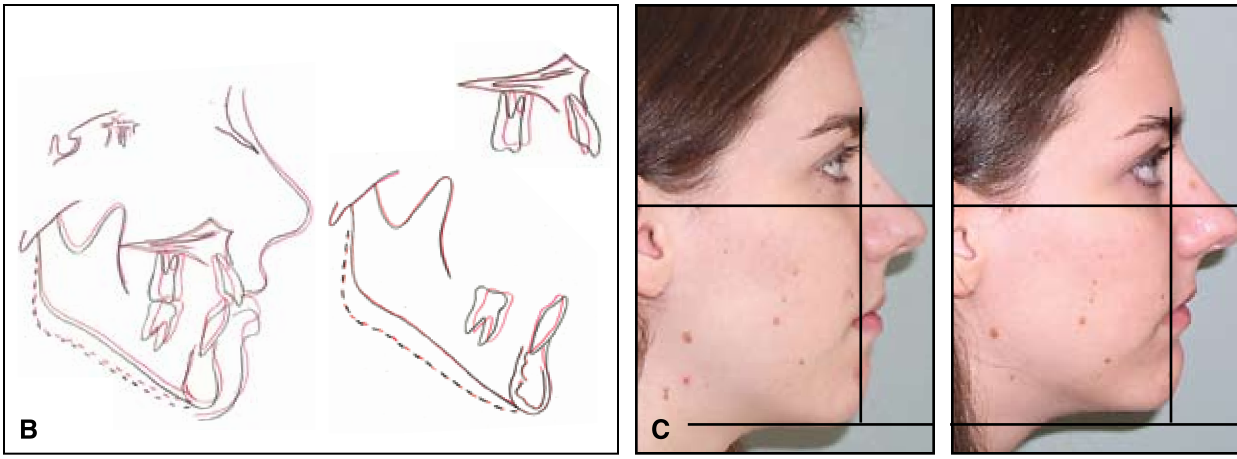

Fig. 11 Case 2 (cont.). B. Superimposition of pre- and post-treatment cephalometric tracings, showing vertical control of lower molar, upper molar intrusion, and resulting mandibular autorotation. C. Comparison of pre- and post-treatment profiles.

Fig. 12 Case 2. Patient 15 months after debonding.

the *y*-axis can be improved by influencing the dynamics of facial growth during treatment. The active or passive intrusion of skeletal anchorage gives better control of the eruption of maxillary and mandibular posterior teeth. The uncontrollable vertical growth increment is the growth of the maxilla. With minimal maxillary vertical growth, facial changes can be highly positive. If either significant maxillary vertical growth or minimal total condylar growth occurs, any positive facial changes from the molar intrusion can be negated. Still, without the posterior intrusion, such facial changes would be extremely negative.

In non-growing patients, any active posterior intrusion will result in closure of the mandibular plane angle. The incorporation of intrusion mechanics in high-angle open-bite cases can prevent the molar eruption commonly seen with extraction mechanics, thus preventing any backward and downward mandibular rotation. With greater intrusion, counterclockwise mandibular rotation can be induced, resulting in chin advancement and favorable facial changes.

Although further study of the vertical control provided by skeletal anchorage during extraction treatment is needed, we believe such treatment of high-angle cases may become routine in the future.

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