Pre-Orthodontic Periodontal Augmentation for Lower Incisor Advancement in Adolescent Patients

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Insufficient mandibular arch length can be addressed by a number of orthodontic methods, including extraction, interproximal reduction (IPR), lateral expansion, and proclination and advancement of the incisors. Depending on the patient, each choice will have different ramifications in terms of the duration and complexity of treatment, the functional occlusion, the periodontium, the facial soft-tissue response, and the stability of the correction.

Orthodontic proclination and protrusion of the lower incisors appears to have relatively few complications, particularly if the attached gingiva is thick enough, but iatrogenic effects and unwanted reciprocal movements are still possible. Lower incisor proclination can negatively impact the interincisal angle and the functional incisal relationships. Moving the teeth away from the integrity of the alveolar complex can lead to alveolar bone fenestrations and dehiscences.[1-4] Because the gingival tissues seem to obtain their blood supply from the underlying alveolar bone, a deficiency of alveolar bone associated with bony dehiscences or fenestrations results in a compromised blood supply to the overlying gingival tissue, making it susceptible to gingival recession. Contributing factors may include preexisting conditions, the height and thickness of the attached gingiva, the shape of the symphysis, the direction and extent of orthodontic tooth movement, and the degree of plaque control.[5-24]

If gingival recession is present or develops as a result of orthodontic movement, mucogingival grafting has traditionally been the treatment of choice.[25] Soft-tissue gingival augmentation is widely used along with mucogingival grafting in cases of gingival recession, but does not address the dehiscence of alveolar bone. Several authors have described alveolar augmentation by means of corticotomies and bone grafting.[26-32]

This article illustrates a similar but more limited technique, called pre-orthodontic periodontal augmentation (POPA), which can be used to prevent gingival recession in growing orthodontic patients.

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Procedure

In each of the three cases presented here, the dentoalveolar complex was insufficient to support the desired anterior movement of the lower incisors. Each patient presented with retrusive, retroclined, or upright lower incisors and excessive overbite. Orthodontic treatment was initiated in the late mixed or early permanent dentition using twin .018" or .022" brackets with a modified Roth prescription.

Orthodontic fixed appliances and active archwires were placed about one month prior to the POPA procedure to take advantage of the regional acceleratory phenomenon (RAP). The RAP is a tissue reaction to a noxious stimulus—in this situation, the POPA surgery—that increases the healing capacities of the affected tissues. In the alveolar bone, cellular activity and bone remodeling increase during the RAP and return to normal after a few months. Placing active appliances prior to POPA therefore maximizes the potential of tooth movement while avoiding the need for the customary three-week healing period after surgery.

Our POPA procedure differed from that of previous reports in that it was applied in growing patients. The gingival flap design, corticotomies, and tissue augmentation were all limited to the facial aspects of the lower anterior alveolar bone and anterior teeth, making this technique less extensive and invasive than others. Essentially, the POPA procedure addressed the discrepancy between root volume and alveolar bone volume by increasing bone volume on the pressure side of the planned tooth movement.

After pretreatment periodontal evaluation, the orthodontist was consulted to determine the direction and amount of tooth movement and, therefore, the amount of augmented bone to be placed. Under either oral or intravenous sedation, a full-thickness facial flap was mobilized through periosteal fenestration from the distal aspect of each lower canine, taking care not to contact the exposed root surfaces. Interproximal vertical corticotomies were performed by piezocision, and interproximal and lingual fiberotomies by the Edwards technique.[33] The bone-grafting material, reconstituted in venous blood, comprised 50% demineralized freeze-dried human allograft and 50% mineralized bovine heterograft. A 2-3mm layer of graft material was applied over the root surfaces, extending apically to cover the symphysis, and the graft was covered with a layer of acellular dermal matrix. The primary flap was then secured 1mm coronal to the cementoenamel junctions of the teeth. Appropriate post-treatment antibiotics and nonsteroidal anti-inflammatory drugs were recommended, along with acetaminophen and chlorhexidine mouthrinses, and a soft diet was prescribed for five days.

SureSmile* finishing procedures were applied in each case during the last six months of active treatment. The SureSmile software uses cone-beam computed tomography (CBCT) to create a three-dimensional virtual model of the teeth, roots, occlusion, bone, nerves, and soft tissues. The individual teeth are digitally placed in the desired positions as these movements are measured in all three planes of space. The program then uses a robot to bend the Copper Ni-Ti** archwires to the customized prescription. These shape-memory wires are activated by body temperature.

Case 1

A 12-year-old female presented with Class I skeletal and dental relationships, mandibular anterior recession, an excessive overbite, crowding in both arches, a large Bolton tooth-size discrepancy with 3.3mm of mandibular excess, and a soft lip posture (Fig. 1, Table 1). Thin attached gingiva and facial root prominence of the lower incisors and canines were noted (Fig. 2). The POPA surgical procedure revealed multiple dehiscences (Fig. 3). In this case, POPA included simultaneous hard- and soft-tissue grafting.

Orthodontic treatment was initiated with indirect bonding of .018" full fixed appliances and application of glass ionomer cement to the occlusal surfaces of the lower first molars for initial bite opening. Alignment started with lower .014"

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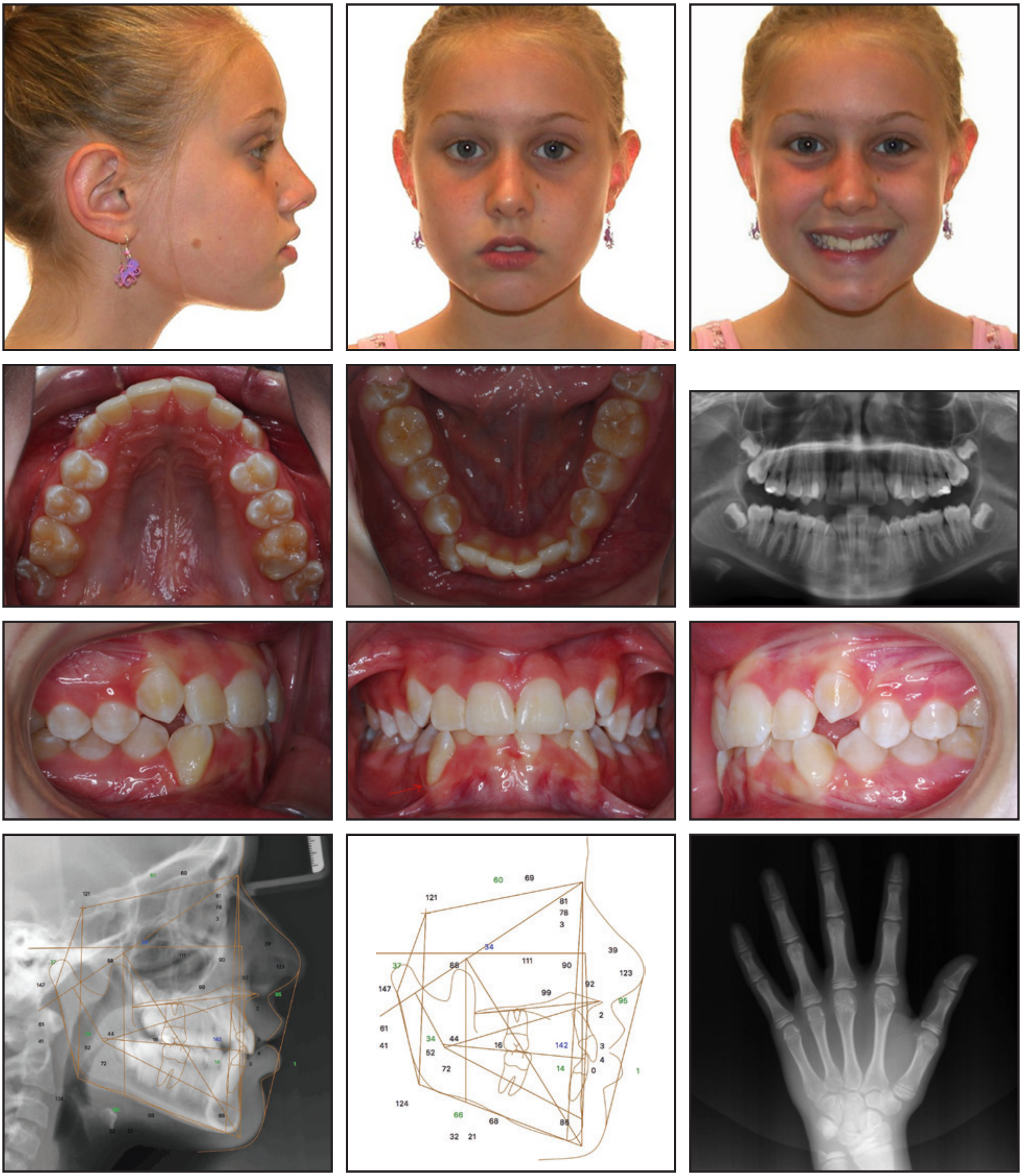

Fig. 1 Case 1. 12-year-old female patient with Class I skeletal and dental relationships, excessive overbite, and upper anterior recession before treatment.

TABLE 1
CASE 1 CEPHALOMETRIC ANALYSIS

	Norm	Pretreatment	Post-Treatment	Difference
SNA	82.0°	80.7°	80.5°	−0.2°
SNB	80.2°	78.1°	79.9°	1.8°
ANB	2.0°	2.6°	0.6°	−2.0°
Facial axis	90.0°	88.1°	87.3°	−0.8°
GoGnSN	32.0°	32.1°	31.8°	−0.3°
U1-NA	4.0mm	3.1mm	6.7mm	3.6mm
L1-APo	0.0mm	0.0mm	3.1mm	3.1mm
U1-SN	104.0°	99.4°	111.6°	12.2°
L1-GoGn	90.0°	86.1°	98.6°	12.5°
Interincisal angle	130.0°	142.4°	118.0°	−24.4°

Fig. 2 Case 1. Thin attached gingiva and prominent roots.

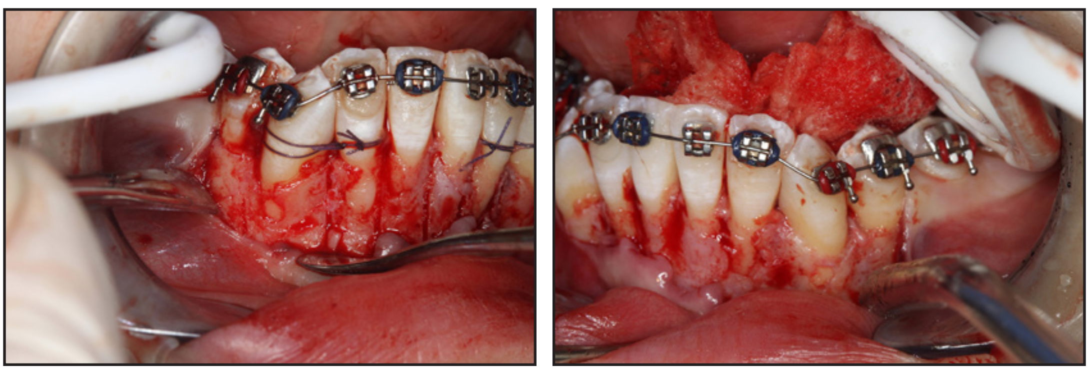

Fig. 3 Case 1. Dehiscences and fenestrations revealed during pre-orthodontic periodontal augmentation (POPA) surgery.

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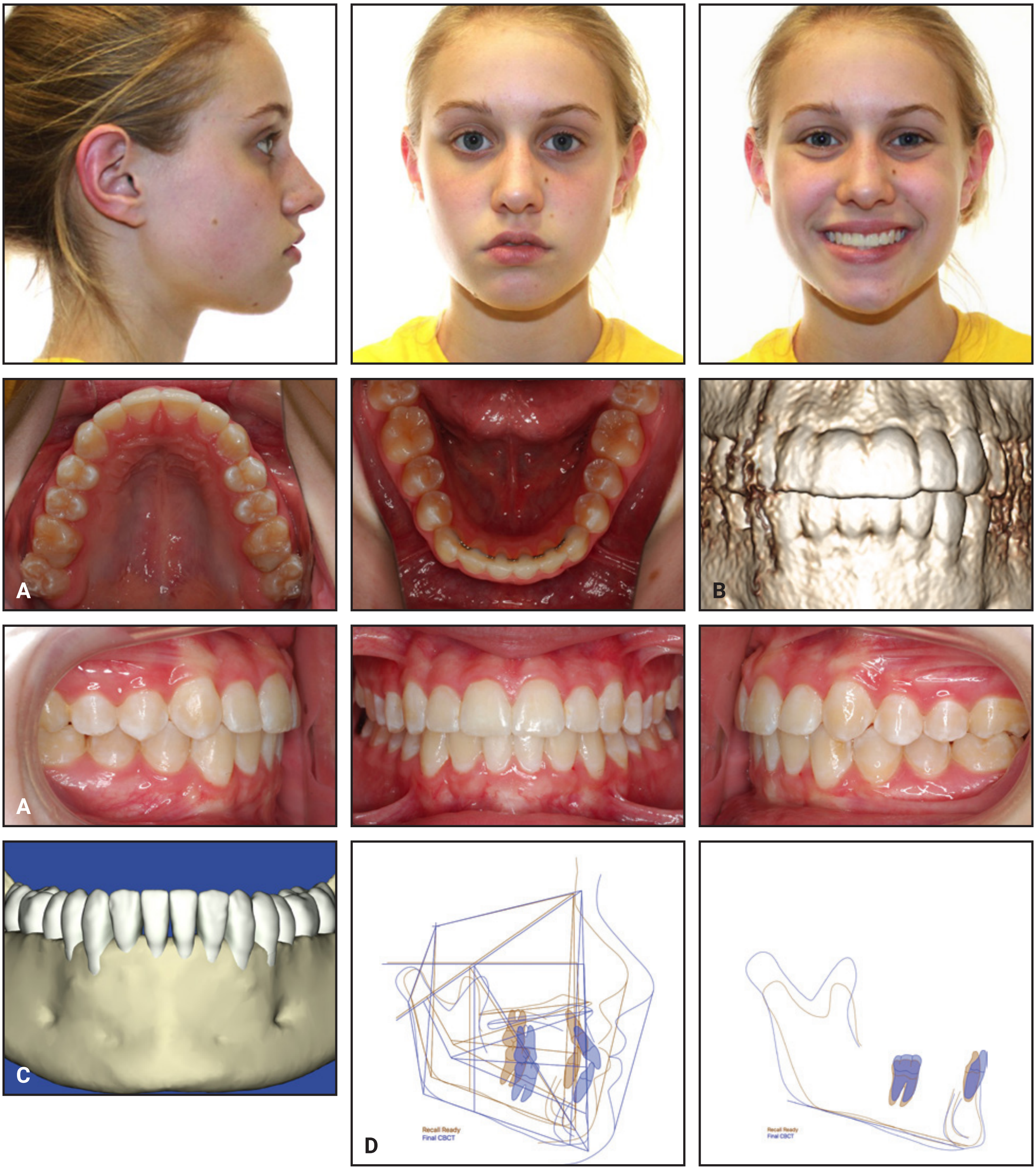

Fig. 4 Case 1. A. Patient after 15 months of orthodontic treatment. B. Cone-beam computed tomography (CBCT) image. C. Final SureSmile* scan (taken 21 months after treatment), documenting retention of grafted bone. D. Superimposition of pre- and post-treatment cephalometric tracings.

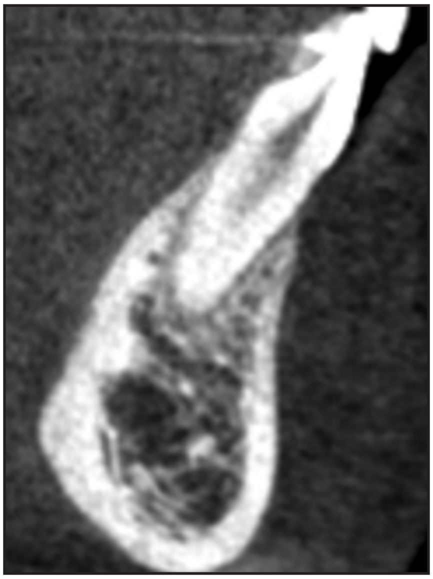

Fig. 5 Case 1. CBCT image showing bony apposition on facial aspect of lower anterior teeth, with well-defined labial cortex.

Copper Ni-Ti and upper .016" Copper Ni-Ti archwires. After two months, the lower wire was replaced with .018" Copper Ni-Ti, and an auxiliary .016" × .022" stainless steel intrusion arch was added using the gingival double buccal tubes to assist in leveling of the mandibular arch by incisor intrusion. During this period, IPR was performed from lower premolar to premolar to improve the tooth-size discrepancy. The wire sequence continued with mandibular .017" × .025" Copper Ni-Ti and maxillary .016" × .022" Copper Ni-Ti archwires. IPR was also performed on the mesial surfaces of the upper central incisors to improve the soft-tissue window. Short 3mm, 4oz Class II elastics were worn for two months from the upper canines to the lower first premolars.

Once the basic leveling and alignment were completed, the residual glass ionomer cement from the initial bite opening was removed. A CBCT scan, bite registrations, and intraoral and extraoral photographs were taken for the SureSmile process, and the final, robotically fabricated .017" × .025" Copper Ni-Ti archwires were worn in both arches for three months.

With excellent patient compliance, active orthodontic treatment time was 15 months (Fig. 4). Post-treatment evaluation demonstrated a healthy and robust dentoalveolar complex, advancement and proclination of the lower incisors, bony apposition on the facial aspect of the lower anterior teeth, with a well-defined labial cortex (Fig. 5), and forward positioning of the symphysis and B point (Table 1).

A lower 3-3 .032" stainless steel twisted lingual wire was bonded for retention, and an upper Hawley retainer with a circumferential labial bow was delivered for full-time use, leading to night-only wear after six months.

Case 2

A 13-year-old male in the late mixed dentition presented with a concave facial profile, a mild Class II skeletal pattern, end-on Class II molar relationships, an excessive overbite, bidental retrusion, retroclined incisors, crowding in both arches, unerupted and blocked-out upper canines, and thin attached gingiva on the lower anterior teeth (Fig. 6, Table 2).

Orthodontic treatment started with a banded rapid palatal expander, .022" brackets on the upper incisors and all lower teeth, and anterior turbos for initial bite opening. Alignment began in the mandibular arch on an .018" Copper Ni-Ti wire. To take advantage of the RAP, the lower teeth were retied or archwires changed at an accelerated schedule of two to three weeks during the first four months of treatment. The sequence of lower archwires was .016" × .025" Copper Ni-Ti, .019" × .025" Copper Ni-Ti, .017" × .025" stainless steel, and .019" × .025" stainless steel with reverse curve of Spee. An auxiliary .016" × .022" stainless steel wire in the gingival double buccal tubes assisted in leveling of the mandibular arch and in molar expansion.

In the maxillary arch, while the expander remained in place, incisor alignment and canine spacing were carried out on an .018" Copper Ni-Ti archwire and then an .016" stainless steel wire with open-coil springs for the canines. After five months and about 8mm of expansion, the palatal expander was removed and the upper premolars were bracketed. The maxillary archwire sequence was .018"

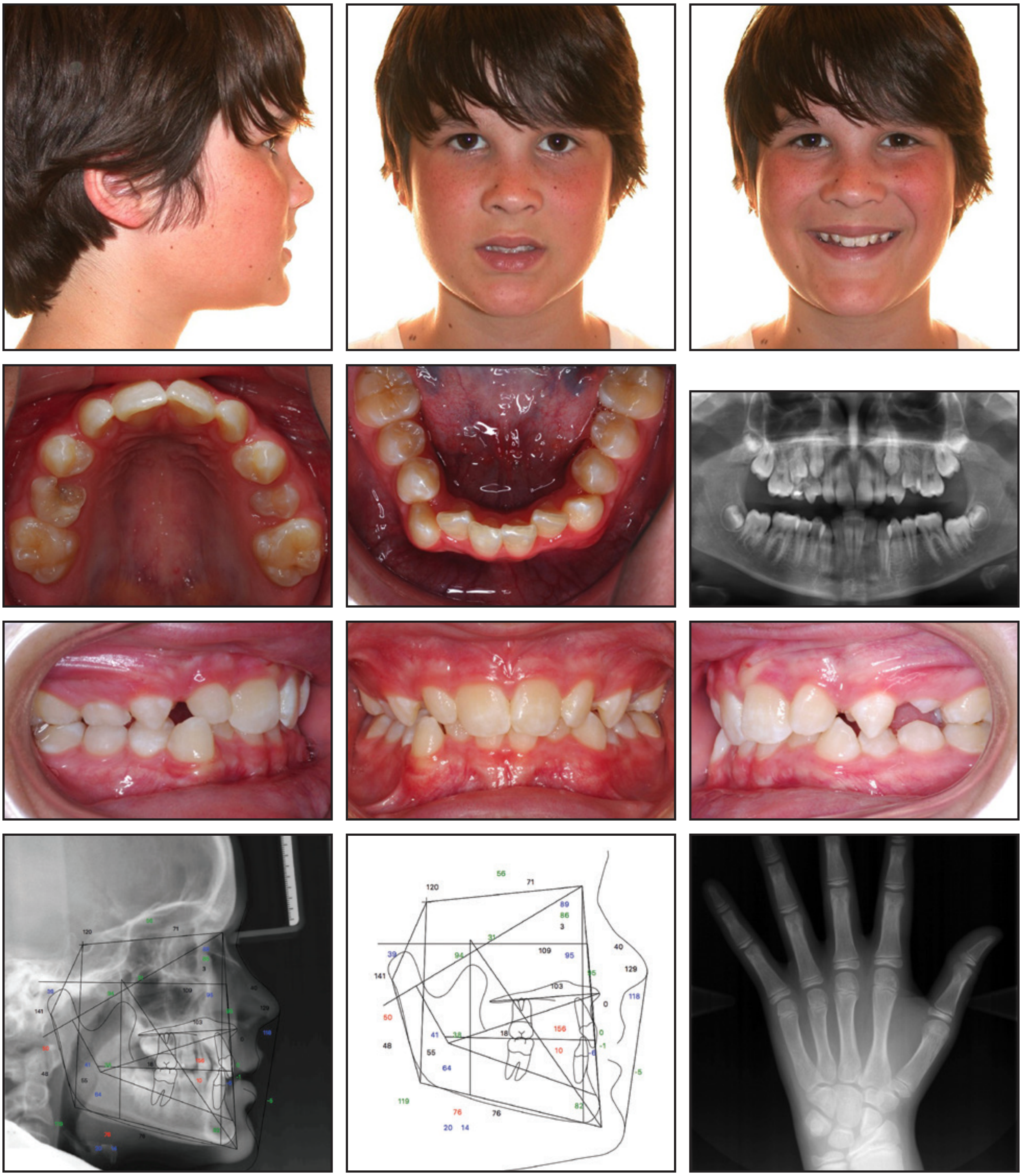

Fig. 6 Case 2. 13-year-old male patient with mild Class II skeletal relationship, excessive overbite, retroclined incisors, and thin attached gingiva on lower anterior teeth before treatment.

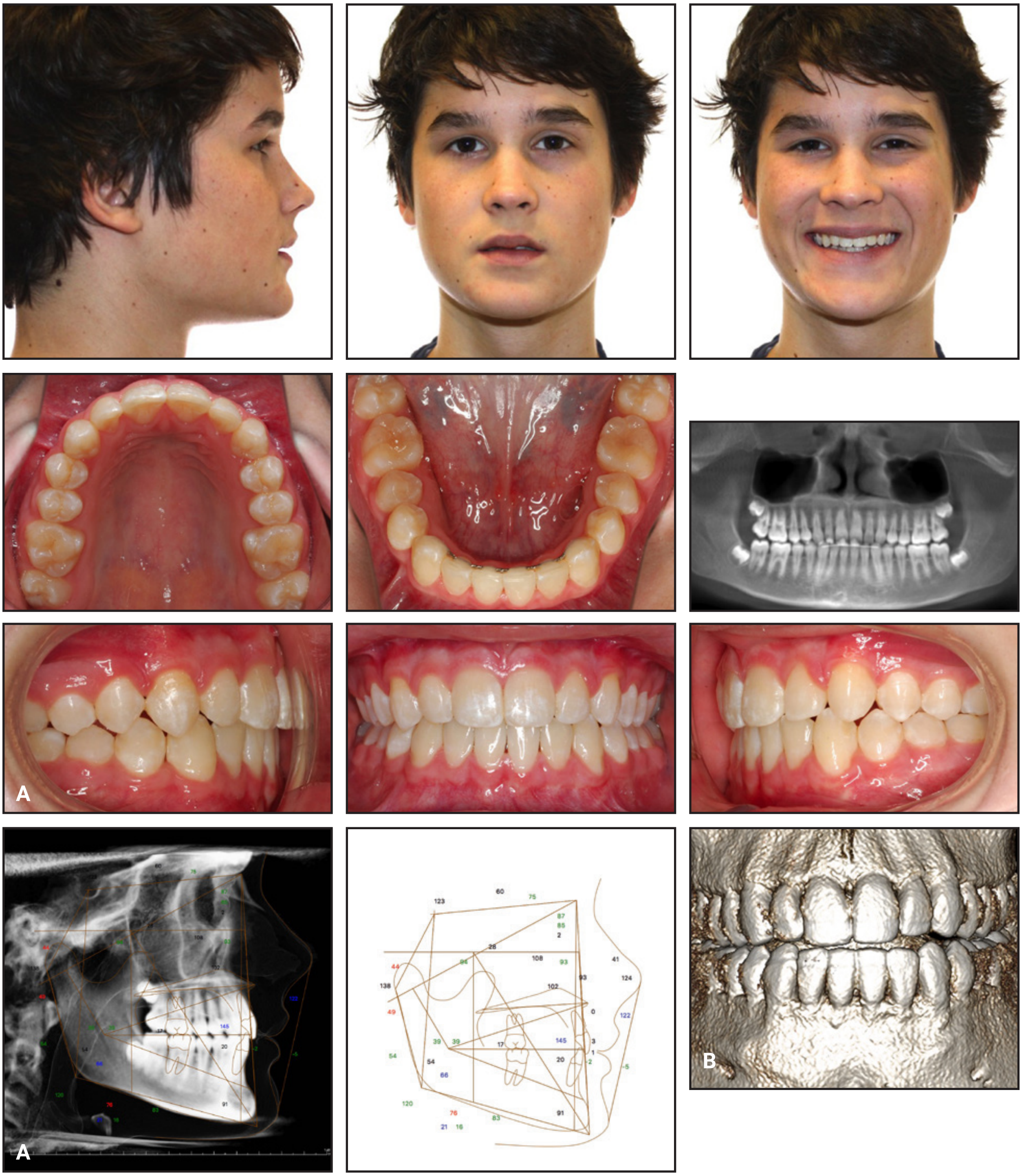

Fig. 7 Case 2. A. Patient after POPA and 27 months of orthodontic treatment. B. CBCT image (continued on next page).

Fig. 7 (cont.) Case 2. C. Final SureSmile scan (taken 37 months after treatment), documenting retention of grafted bone. D. Superimposition of pre- and post-treatment cephalometric tracings.

Copper Ni-Ti, .018" stainless steel, .017" × .025" Copper Ni-Ti, .019" × .025" Copper Ni-Ti, .018" stainless steel, and .020" stainless steel. The anterior turbos were removed when bracket interferences from the occlusion were eliminated.

The second molar and maxillary canine brackets were added as the teeth erupted and sufficient clinical crown height became available. Class II mechanics were applied for two months with bilateral Class II springs using mandibular .019" × .025" Copper Ni-Ti and maxillary .018" stainless steel archwires. Sequential .019" × .025" Copper Ni-Ti, .021" × .025" Copper Ni-Ti, and .020" stainless steel archwires were used for continued leveling of the mandibular arch after the addition of the second molar brackets.

A CBCT scan, bite registrations, and intraoral and extraoral photographs were taken for the SureSmile process. IPR of the lower premolars was applied to equalize tooth sizes, and a sequence of SureSmile Copper Ni-Ti wires was inserted: .016" × .022" and .019" × .025" in the mandibular arch and .016" × .016", .016" × .022", and .019" × .025" in the maxillary arch. The upper lateral incisors

TABLE 2
CASE 2 CEPHALOMETRIC ANALYSIS

	Norm	Pretreatment	Post-Treatment	Difference
SNA	82.0°	89.1°	87.2°	−1.9°
SNB	80.2°	85.6°	85.1°	−0.5°
ANB	2.0°	3.5°	2.1°	1.4°
Facial axis	90.0°	94.0°	94.1°	0.1°
GoGnSN	32.0°	19.6°	21.2°	1.6°
U1-NA	4.0mm	−0.2mm	2.6mm	2.8mm
L1-APo	0.0mm	−5.5mm	−1.9mm	3.6mm
U1-SN	104.0°	103.1°	102.4°	−0.7°
L1-GoGn	90.0°	81.7°	91.1°	9.4°
Interincisal angle	130.0°	155.5°	145.3°	−10.2°

Fig. 8 Case 2. CBCT image showing bony apposition on facial aspect of lower anterior teeth, with well-defined labial cortex.

were built up with composite to improve tooth size and crown morphology.

Active treatment time was 27 months; patient compliance was good (Fig. 7). Post-treatment evaluation showed a healthy and robust dentoalveolar complex, advancement of the lower incisors, bony apposition on the facial aspect of the lower anterior teeth, with a well-defined labial cortex (Fig. 8), and a reduction in the mentolabial fold (Table 2).

A 3-3 .032" stainless steel twisted lingual wire was bonded for retention of the mandibular arch. A maxillary Hawley retainer with a circumferential labial bow was delivered for full-time wear, transitioning to night-only after six months.

Case 3

A 16-year-old male presented with a Class I skeletal pattern, an excessive overbite, severe lower incisor retrusion, and thin attached gingiva on the lower anterior teeth (Fig. 9, Table 3). He had undergone Phase I maxillary expansion and previous serial extraction of the upper left first premolar.

Orthodontic treatment was initiated with indirect bonding of .018" full fixed appliances and application of glass ionomer cement to the occlusal surfaces of the lower first molars for initial bite opening. Alignment began with lower .014" Copper Ni-Ti and upper .016" Copper Ni-Ti archwires. To take advantage of the RAP, the lower teeth were retied or archwires changed at an accelerated schedule of two to three weeks during the first four months of treatment. An auxiliary .016" × .022" stainless steel wire was placed in the gingival double buccal tubes to help level the mandibular arch. Leveling and alignment continued with lower .016" × .022" Copper Ni-Ti, .017" × .025" Copper Ni-Ti, and .016" × .022" stainless steel archwires. The upper archwire sequence was .016" stainless steel, .016" × .022" Copper Ni-Ti, and .016" × .022" stainless steel.

The residual glass ionomer cement was removed when bracket interferences from the occlusion were eliminated. Short 4mm, 4oz Class II elastics were worn for nine months from the upper canines to the lower first molars.

A CBCT scan, bite registrations, and intraoral and extraoral photographs were taken for the SureSmile process. IPR was performed on the lower premolars to equalize tooth sizes. A sequence of SureSmile .016" × .016", .016" × .022", and .017" × .025" Copper Ni-Ti archwires was followed in both arches.

The active treatment time of 21 months was longer than expected because of inconsistent Class II elastic wear and broken appliances (Fig. 10). Post-treatment evaluation, including CBCT superimposition, showed a healthy and robust dentoalveolar complex, advancement of the lower incisors, bony apposition on the facial aspect of the lower anterior teeth (Fig. 11), and a reduction in the mentolabial fold (Table 3).

A lower 3-3 .032" stainless steel twisted lingual wire was bonded for retention, and an upper Hawley retainer with a circumferential labial bow was prescribed for full-time use, changing to night-only after six months.

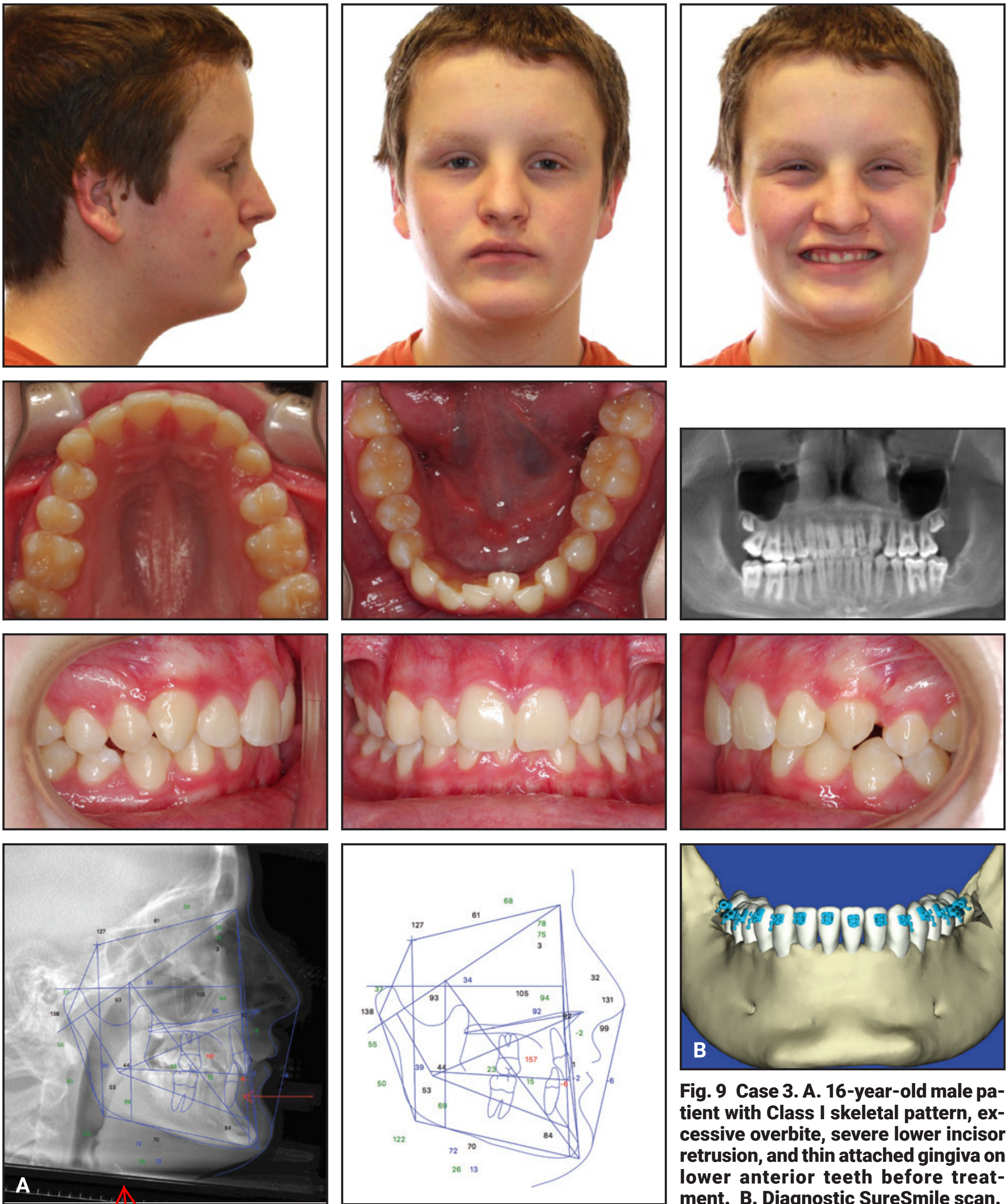

Fig. 9 Case 3. A. 16-year-old male patient with Class I skeletal pattern, excessive overbite, severe lower incisor retrusion, and thin attached gingiva on lower anterior teeth before treatment. B. Diagnostic SureSmile scan.

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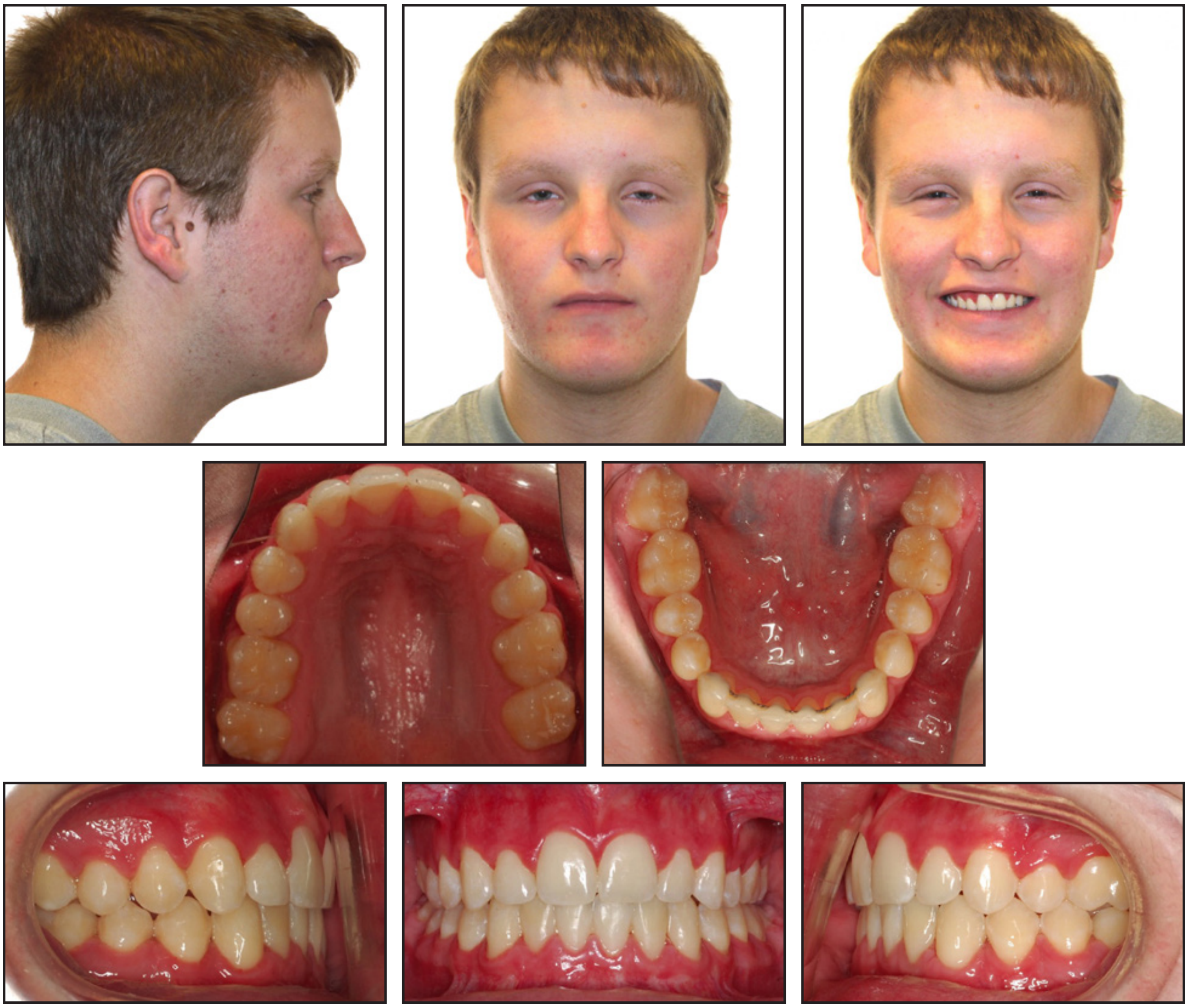


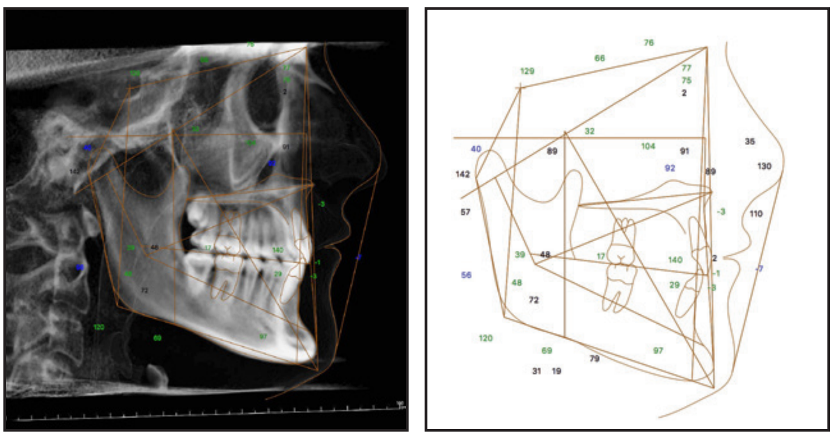
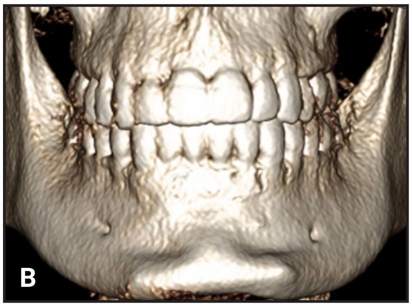


Fig. 10 Case 3. A. Patient after POPA and 21 months of orthodontic treatment (continued on next page).



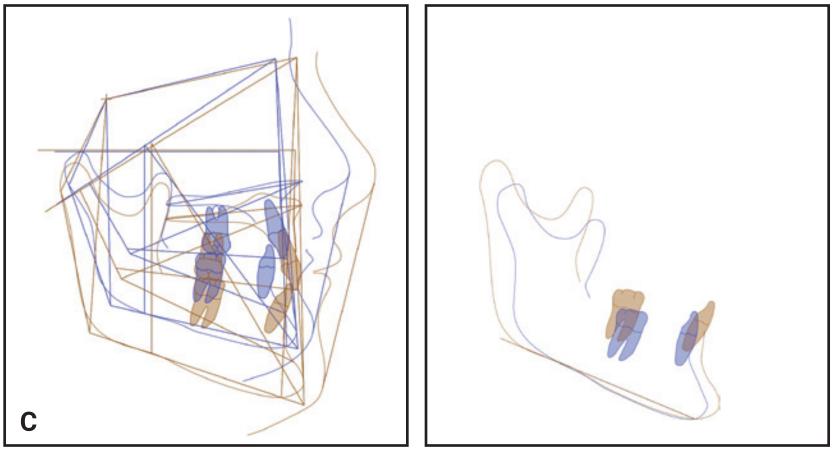


Fig. 10 (cont.) Case 3. B. CBCT image. C. Superimposition of pre- and post-treatment cephalometric tracings.

Discussion

Orthodontic advancement of the lower incisors can be limited biologically by the dentoalveolar process and can sometimes lead to fenestrations and dehiscences. Gingival recession, which occurs because of insufficient alveolar bone, is widely treated during orthodontic treatment by soft-tissue gingival augmentation. As this article shows, POPA is a more proactive, anticipatory means of resolving the discrepancy between alveolar bone and root volume by ameliorating the bone deficiency in the direction of tooth movement.

Our use of POPA in adolescent patients is a logical extension of our previous clinical experience with full-mouth periodontal augmentations in the adult dentition prior to orthodontic treatment. Post-treatment evaluation of each patient shown here indicated a healthy and robust periodontium, with abundant bone support owing to an increase in alveolar bone volume. This suggests

TABLE 3
CASE 3 CEPHALOMETRIC ANALYSIS

	Norm	Pretreatment	Post-Treatment	Difference
SNA	82.0°	78.4°	76.6°	–1.8°
SNB	80.2°	75.3°	74.9°	–0.4°
ANB	2.0°	3.1°	1.7°	–1.4°
Facial axis	90.0°	93.1°	88.6°	–4.5°
GoGnSN	32.0°	26.5°	31.1°	4.6°
U1-NA	4.0mm	1.4mm	2.2mm	0.8mm
L1-APo	0.0mm	–6.3mm	–2.7mm	3.6mm
U1-SN	104.0°	91.9°	91.6°	–0.3°
L1-GoGn	90.0°	84.5°	91.2°	6.7°
Interincisal angle	130.0°	157.2°	140.3°	–16.9°

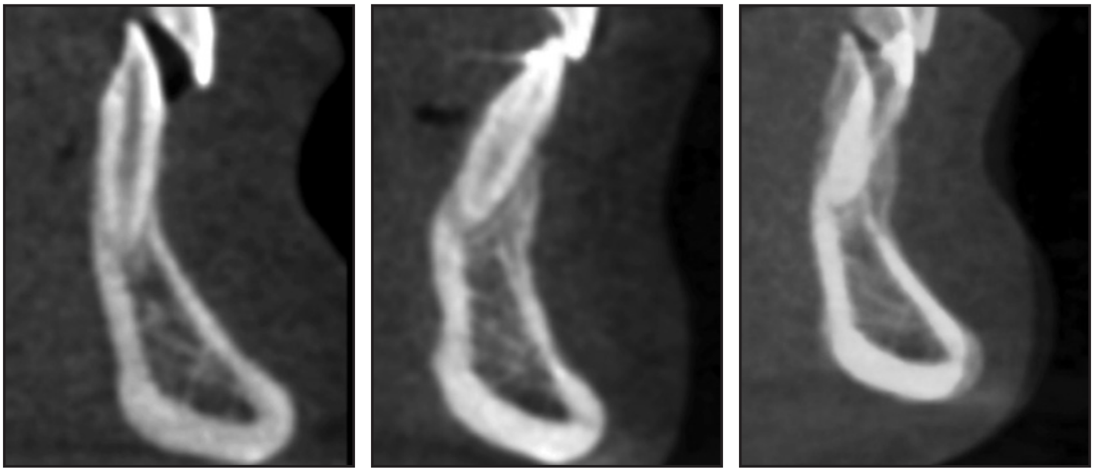


Fig. 11 Case 3. CBCT images taken before and after treatment superimposed on internal cortex of mandibular symphysis, showing bony apposition on facial aspect of lower anterior teeth.

that even more facial root torque of the lower incisors could be achieved with the appropriate orthodontic mechanics to further reduce incisor proclination. The additional benefit of enhanced orthodontic stability has also been reported.[27-31]

The surgical phase of POPA, which was well tolerated by our patients, is similar to other adjunctive surgical procedures commonly used to facilitate orthodontic therapy. The addition of corticotomies and bone grafting to soft-tissue gingival grafting can be effective in enhancing alveolar bone and soft-tissue support for advancement of the lower incisors. The advantages of covering the bone-substitute material with an acellular dermal matrix were suggested by reports that a barrier membrane increases soft-tissue thickness and improves bone regeneration.[34,35]

These case reports demonstrate the integral relationship of orthodontics and periodontics. Effective communication between the orthodontist and periodontist was required to determine the extent of the POPA procedure and to coordinate appointments so we could take advantage of the RAP effect and ensure patient comfort. Alveolar augmentation enabled the use of routine orthodontic mechanics to advance the lower incisors and improve facial appearance, while addressing the fundamental deficiencies that previously prevented those movements. In each case, clinical and radiographic periodontal evaluation confirmed a healthy biology, while pre- and post-treatment imaging comparisons substantiated the orthodontic results.

Conclusion

Although controlled studies are needed for further support, our clinical observation of POPA in more than 50 adolescent patients has been consistent with the cases presented here. POPA warrants consideration as a proactive periodontal procedure that can provide a more substantial periodontal foundation for orthodontic lower incisor advancement, with only the minor risks associated with other adjunctive periodontal procedures.

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