Orthognathic Surgery Combined with Clear Aligner Therapy

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The fundamental concept of clear aligner therapy was introduced in 1945 by Harold Kesling, who proposed that major tooth movements could be accomplished with a series of positioner appliances by manually changing the setup of the dental casts as treatment progressed.[1] Computer-aided design and manufacturing (CAD/CAM) and rapid prototyping technologies have now automated this laborious process and made clear aligners a feasible contemporary treatment option.[2-4] The primary advantages over traditional fixed appliances are esthetics,[5,6] removability,[7,8] and comfort.[9-12]

Among the most difficult movements to achieve with clear aligners are extrusion, rotation, and root control.[13-17] Despite the popularity of clear aligners, the reliability of evidence for the efficacy and predictability of such tooth movements has been limited by methodological issues.[18,19] In particular, the literature supporting the use of clear aligners in conjunction with orthognathic surgery consists only of case reports and expert opinions regarding fixation methods and other techniques.[20-25]

While the adaptation of clear aligner therapy to orthognathic surgery has been slow, recent improvements in preoperative orthodontic prescription design,[18,26] computer-aided surgical simulation and intraoral scanning,[27] and intraoperative techniques for fixation and positioning[20] have facilitated a fluid and easy transition for most orthognathic cases. The challenges in adopting this technology for orthognathic surgery are related primarily to intraoperative control of the occlusion and planning for postoperative elastic guidance. As protocols are further established, procedures as complex as multisegmental Le Fort osteotomies will actually be easier to manipulate and control using clear aligners and full-coverage surgical guides, which can be fabricated with CAD/CAM

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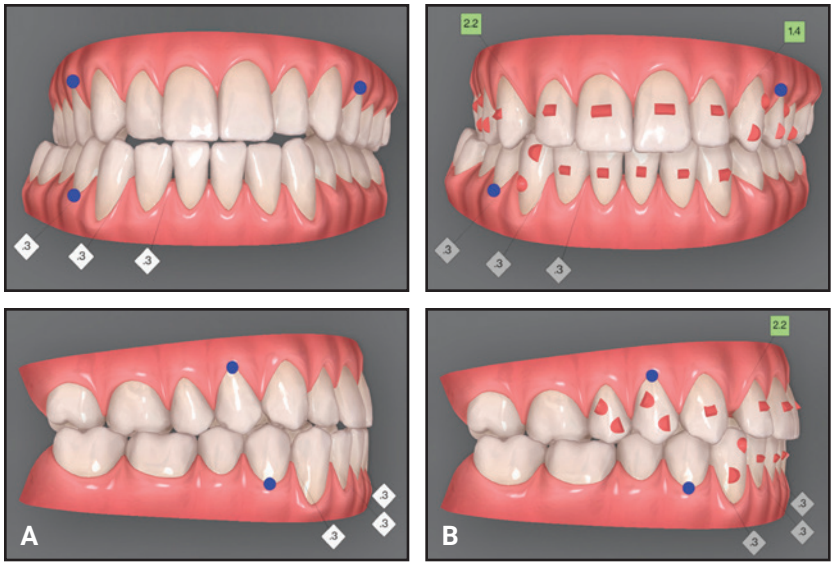

Fig. 1 Setup errors in planning aligner treatment of Class III malocclusion due to maxillary retrognathia and transverse narrowing. A. Initial proposed setup was for nonsurgical correction with inadequate correction of midline and transverse discrepancies. Compromise dentoalveolar compensation involved significant interproximal reduction in lower-incisor region, proclination and protraction of maxillary incisors, retroclination of mandibular incisors, and space creation distal to maxillary lateral incisors. B. Proper presurgical simulation of decompensation, which required three revisions with technician.

techniques to aid in intraoperative positioning.[28]

This article provides recommendations for surgical-orthodontic treatment with clear aligners, including the workflow involved for the orthodontist and surgeon, methods of fixation developed at our surgical center, and the use and management of aligner trays intra- and postoperatively in regard to care, maintenance, and stability.

Diagnosis and Treatment Planning for Skeletal Malocclusions

The initial obstacle faced in presurgical aligner treatment is the need to communicate to the technician that a decompensated occlusion must be created in the treatment-planning setup. The default setup for aligner systems is the achievement of a Class I occlusion using dentoalveolar compensation, with no consideration of the skeletal discrepancy (Fig. 1). Without specific guidance from the orthodontist, the technician will attempt to design a compensated occlusion with the canines in a Class I relationship. The only way to avoid this problem is to provide special instructions to the technician, stating that the diagnosis is of a skeletal malocclusion and deformity requiring surgical decompensation and a higher level of attention.

Although the treatment-planning process for presurgical clear aligner therapy is constantly being refined, the most critical elements are the same ones typically addressed in orthognathic cases involving

TABLE 1
COMPARISON OF NONSURGICAL COMPENSATION AND SURGICAL DECOMPENSATION IN VIRTUAL ORTHODONTIC PLANNING*

	Nonsurgical Compensation	Surgical Decompensation	Comments
Tooth movement restrictions	None	None	Restrictions may apply to teeth that are part of prosthetics or implants.
Aligner attachments	As needed	As needed	No surgical impact; may be removed before surgery.
Anteroposterior relationship	Improve	Maintain or worsen	Goal is Class I canine relationship with ideal overbite and overjet.
Overjet	Improve	Worsen	Increase negative overjet for Class III deformity; increase positive overjet for Class II deformity.
Overbite	Improve	Maintain or worsen	For example, do not correct anterior open bite before surgery.
Bite ramps	As needed	As needed	No surgical impact.
Midline	Correct with IPR**	Maintain	Correct only in dental arches that will not be surgically altered.
Posterior crossbite	Correct	Do not correct	Do not correct if treatment plan or transverse discrepancy warrants segmental maxillary surgery.
Spacing	Maintain or close	Close all spaces	Exceptions include Iowa spaces (if desired) and spaces for prosthetics.
Crowding	Resolve	Resolve	Correct with expansion, IPR, or extractions; goal is to maintain teeth over basal bone.
Special instructions to technician	None	Presurgical decompensation	

*When all teeth in both arches are treated with clear aligners.
**Interproximal reduction.

fixed appliances (Table 1). Among intra-arch issues, leveling and alignment should be accomplished in both arches before surgery. All spaces should be closed except those planned for future prosthetic or implant restorations. Management of crowding—primarily through interproximal reduction (IPR), proclination, or extractions—should be planned prior to the prescription setup. When premolar extractions are warranted, the specific teeth to be removed will depend on the malocclusion. In general, for Class II malocclusions with moderate to severe crowding, the upper second and lower first premolars are suggested for extraction. Conversely, for Class III malocclusions with moderate to severe crowding, the upper first and lower second premolars are recommended for removal.

The anteroposterior relationship and overjet should be worsened or, at a minimum, left unchanged prior to surgery. A Class III skeletal base will require decompensatory mechanics such as proclination of the lower incisors to increase the negative overjet. A Class II case will require an

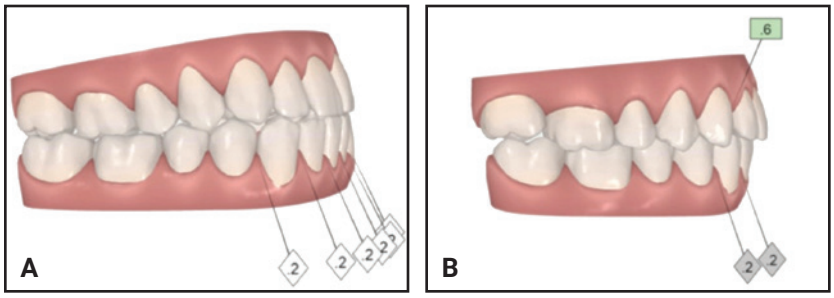

Fig. 2. A. Presurgical setup for decompensation of case shown in Figure 1, using eight trays. Surgical plan involved two-piece Le Fort expansion and advancement. B. Immediate postoperative setup, with surgical guides prepared from scanned models.

increase in positive overjet, often through proclination of the maxillary incisors or uprighting of the mandibular incisors, to optimize the effectiveness of the surgery.

With regard to the vertical dimension and overbite, it is important to avoid presurgical overextrusion or overintrusion of teeth, which can lead to postsurgical orthodontic relapse. For example, orthodontic closure of an anterior open bite will result in a deceptive occlusal position at the time of surgery, and the bite will tend to reopen after orthodontic appliances are removed.[29,30] Bite ramps (surface projections built directly into the aligner trays) are often prescribed in deep-bite cases.[15] Unlike traditional bonded bite turbos, these removable bite ramps will not interfere with the surgical setup when they are used before surgery.

In the transverse dimension, a posterior crossbite should not be corrected if the transverse discrepancy is significant enough to warrant segmental maxillary surgery. Likewise, a midline discrepancy should be left uncorrected in the presurgical phase. The exception is that in a case calling for a single-jaw osteotomy, a traditional midline correction can be performed in the unaffected arch.

Any bonded attachments used to optimize force delivery with aligners[31-33] can easily be removed before surgery, and new ones can be placed for the refinement aligners after surgery.

Proper creation of a decompensated occlusion results in a more ideal environment for surgical correction (Fig. 2). Facial esthetic improvements will be more pronounced, and the final occlusion will be more stable with the teeth in their proper positions. Midline and transverse discrepancies are also better treated.

The following presurgical protocol will provide a smooth, error-free workflow:

1. Five weeks before surgery, all attachments are removed and new scans are taken to make four sets of passive aligners (two for before surgery and two for after surgery).
2. Four weeks before surgery, the oral surgeon performs a digital workup, usually involving panoramic and cephalometric radiographs, a complete set of photos, intraoral scans, a record of centric relation, computed or cone-beam computed tomography, and a thorough clinical exam, followed by treatment presentation and consent. The patient should bring the passive aligners to this appointment.
3. Two weeks before surgery, a virtual meeting is held with the digital technician to design the orthognathic splint and set up the occlusion.
4. At the surgical appointment, the patient should remove the passive aligners and check the fit of the splint.

Intraoperative Management of Osteotomies

Perhaps the most obvious reason why clear aligner therapy and orthognathic surgery have been considered incompatible is the difficulty of localizing, mobilizing, positioning, and fixating the dentoalveolar complex and dental arches during surgery. In the absence of orthodontic brackets with surgical lugs, temporary maxillomandibular fixation is hard to achieve.[20] Erich arch bars or fixation screws are not recommended because of the potential for gingival damage and interference with oral hygiene. Other fixation options not used in our center include screw-retained

Fig. 3 Full-coverage clear-aligner orthognathic splint for temporary maxillomandibular fixation.

arch bars, prefabricated bonded buttons, and modified fixed orthodontic appliances.

In conjunction with virtual planning companies, we developed a CAD/CAM-designed acrylic splint, essentially two clear aligners luted together, to aid in final positioning of the osteotomized segments and fixation of the maxilla without brackets or wires (Fig. 3). The clear-aligner orthognathic splint fits the full crowns of all teeth in both arches and engages the undercuts, so that each arch "snaps" into place. The material needs to be clear enough to allow visual confirmation of cusp seating. In addition, we recommend that any presurgical aligner attachments be removed to permit full seating of the splint. One disadvantage is that because this splint fits much more tightly than a conventional surgical splint, it can be difficult to remove. Depending on the tongue size, posterior traction may be needed to keep the tongue out of the way.

Another useful approach involves the insertion of at least eight orthodontic temporary anchorage devices (TADs), distributed evenly on both sides of both arches (Fig. 4). In our experience, the larger maxillomandibular fixation screws tend to cause traumatic mucosal irritation for the first two or three weeks and are bulky and uncomfortable for patients over the long term. The smaller TADs have a lower profile, are easier to clean, and rarely cause mucosal irritation. In addition, if the TADs fail or loosen during surgery, they are easy to replace under local anesthetic. These TADs not only aid in temporary fixation, but can also function postoperatively for elastic attachment.

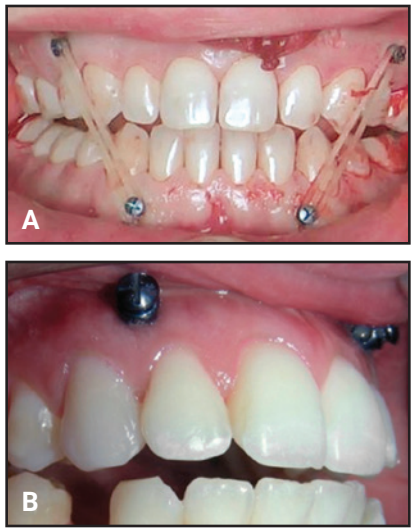

Fig. 4 A. Temporary anchorage devices used for temporary maxillomandibular fixation and subsequent elastic attachment. B. Maxillomandibular fixation screws.

Bonded orthodontic brackets can be a quick, simple alternative for temporary maxillomandibular fixation. At least six brackets should be used, involving the central incisors, canines, and first molars in each arch. We recommend bonding at the cementoenamel junctions, because brackets placed in their ideal facial positions are more prone to breakage from shearing and do not have the bond strength to retain a 25-gauge interarch wire. Another advantage is that aligners can be worn immediately after surgery if cutouts are created for the brackets. Elastics can be attached to the small hooks on the brackets.

Ligation of the maxilla is especially difficult during multisegmental Le Fort osteotomies if conventional orthodontic brackets are not present. In such a case, a clear-aligner orthognathic splint is recommended for fixation, since the full-cusp coverage will help seat the maxillary segments by engaging the undercuts of the dentition. A mandible-first approach to double-jaw surgery will avoid the need for a two-in-one splint (Fig. 5). If the case requires additional rigidity or postoperative elastic management, the acrylic splint can be used concomitantly with TADs or maxillomandibular fixation

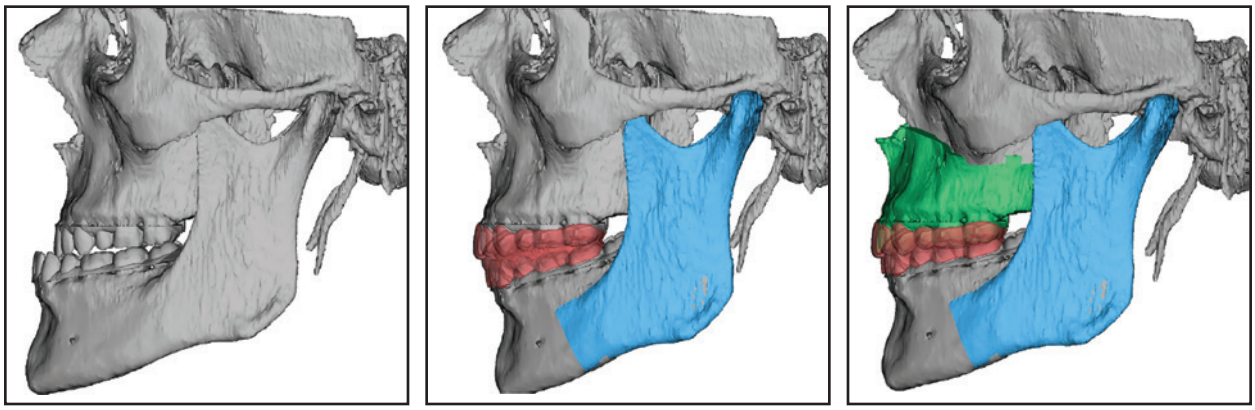

Fig. 5 Digital setup of segmental Le Fort osteotomy using mandible-first approach.

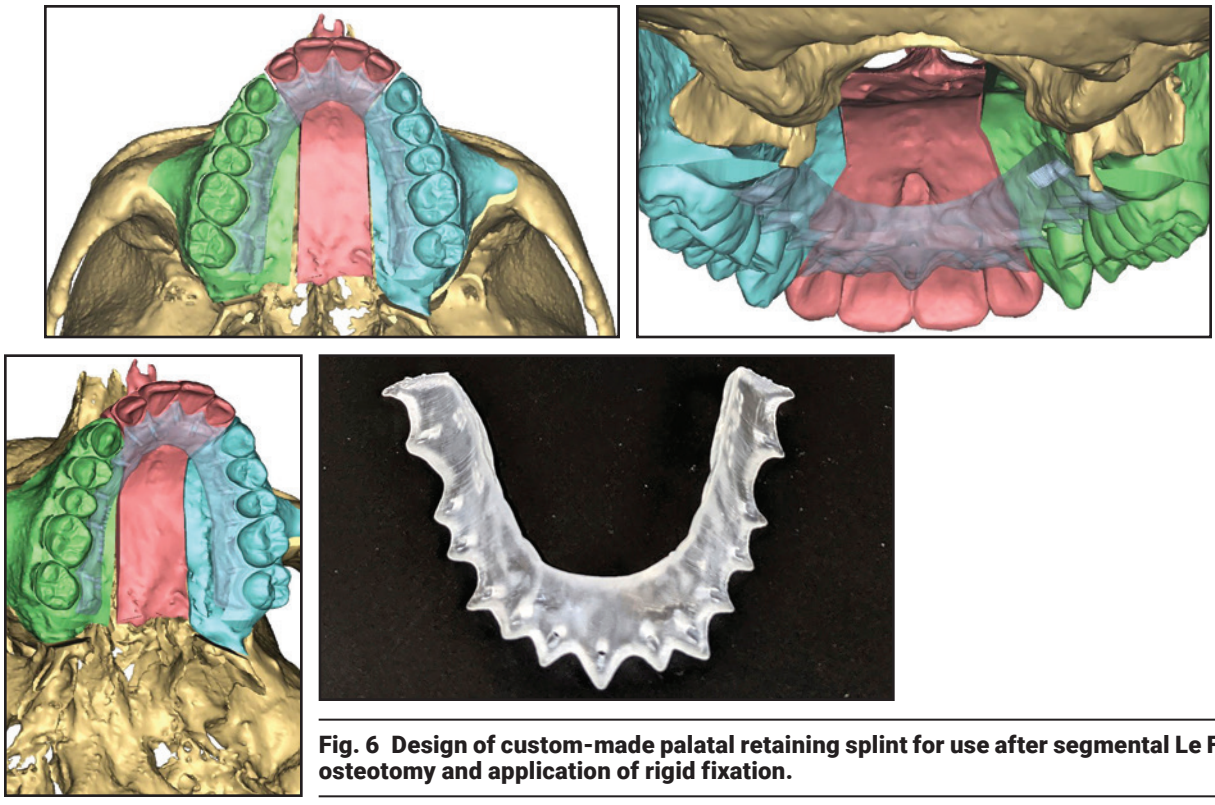

Fig. 6 Design of custom-made palatal retaining splint for use after segmental Le Fort osteotomy and application of rigid fixation.

screws. The simplest approach is to insert two to four rigid fixation screws (about 9mm in length and 1.5-1.85mm in diameter) in the maxilla and two to four in the mandible, leaving them 1-2mm clear of the gingiva so that wires and elastics can be placed.

Regardless of the method employed to attain temporary maxillomandibular fixation, the application of rigid internal fixation remains the same. The key is to ensure stability and prevent movement of the bony segments. The protocol at our

center is to bend four perfectly passive, 2mm-thick L plates, using a total of 16 screws for the maxilla. The mandible is fixed with three-position screws or plates, depending on the amount of advancement required.

After the application of rigid fixation, when the maxillomandibular complex is placed in its planned position, the clear-aligner orthognathic splint is replaced by a custom-made palatal retaining splint (Fig. 6). This splint contains four small

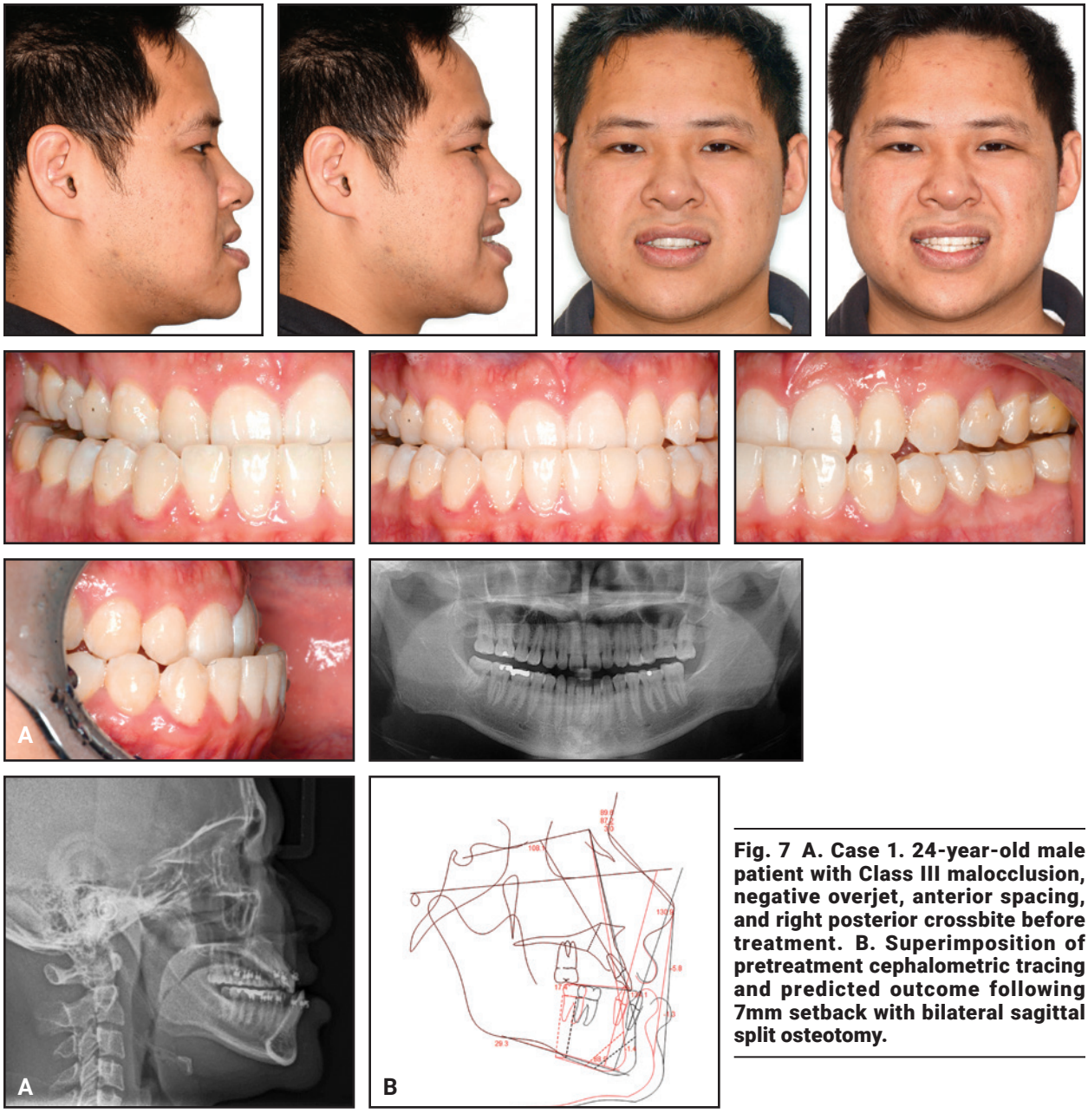

Fig. 7 A. Case 1. 24-year-old male patient with Class III malocclusion, negative overjet, anterior spacing, and right posterior crossbite before treatment. B. Superimposition of pretreatment cephalometric tracing and predicted outcome following 7mm setback with bilateral sagittal split osteotomy.

holes, usually at the lateral incisor and second premolar positions on both sides, through which small stainless steel wires can be threaded to hold it in place. The splint is often not required in cases requiring anterior open-bite closure, or it can be removed as early as two weeks later to allow vertical traction of the anterior segment. If there has been considerable expansion and advancement of the maxilla, the splint can stay in place for six to eight weeks. It may help to add a small amount of no-etch composite to the teeth on either end of the segmented arch to act as a bond and prevent the flaring (and hence spacing) that sometimes occurs with segmental Le Fort surgeries.

Postoperative Management

Oral hygiene can be challenging for the patient to manage immediately after orthognathic surgery, primarily because of the difficulty of removing the aligner trays.

Postsurgical elastics are often required to maintain and support the corrected occlusion. Various configurations may be used, including Class II, Class III, or box elastics, depending on the presurgical malocclusion. The elastics can be attached to orthodontic TADs or bonded buttons or directly to notches in the aligner trays. Bonded buttons, usually placed on the gingival aspects of the clinical crowns, will require relief cutouts in the aligners. Notches made in the trays will necessitate attachments for additional retention. In cases where postsurgical settling of the buccal segments is required, the aligner trays can also be cut posteriorly.

Refinement aligners are recommended during the postoperative phase to accommodate any necessary adjustments, as well as to improve tray fitting. Intraoral scans can be taken four weeks after surgery, with the goal of delivering the refinement aligners by the sixth week. Refinement aligners are mandatory after segmental maxillary surgery due to the accompanying changes in archform. In this case, the intraoral scans may be performed by the surgeon at the four-week follow-up appointment. The virtual planning is then coordinated between the orthodontist and surgeon, and the final aligners are delivered to the orthodontist.

*Registered trademark of Align Technology, Inc., San Jose, CA; www.aligntech.com.

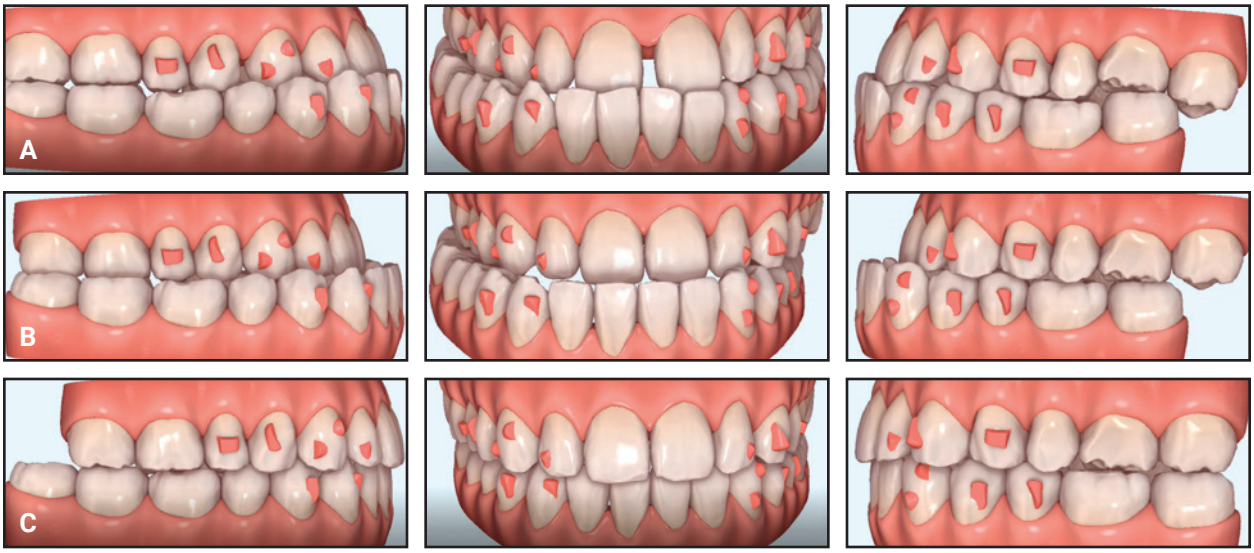

Fig. 8 Case 1. A. Pretreatment ClinCheck.* B. Presurgical ClinCheck after six months of treatment. C. Simulated postsurgical bite jump.

Case 1

A 24-year-old male presented with the chief complaint of a protruding jaw and "spaced-out teeth" (Fig. 7). Clinical examination indicated a prognathic facial type with a concave profile. The patient had a Class III malocclusion with a negative overjet, anterior spacing, and a unilateral right posterior crossbite.

A surgical treatment option was presented to the patient as the means to achieve the most stable occlusal result and address his chief complaint. The only way to fully address the transverse discrepancy was to segmentalize the maxilla. Because the maxillary anteroposterior and vertical positions were excellent, the decision was not to perform a Le Fort osteotomy for expansion purposes, but to plan a 7mm setback with a bilateral sagittal split osteotomy. This choice would have been the same regardless of whether clear aligners or traditional fixed orthodontic appliance were used, but the patient chose clear aligners for the orthodontic phases of treatment.

Presurgical orthodontic therapy involved 26 sets of upper and lower aligners, changed every two weeks (Fig. 8). Dental decompensation required worsening of the overjet, and the midline discrepancies were left uncorrected. We expected that the transverse discrepancy would be improved by the mandibular setback. Two sets of passive aligners were worn immediately before the surgery.

The surgical protocol included computer-aided simulation for the fabrication of surgical guides to set back the mandible with asymmetry correction. Orthodontic brackets were bonded before

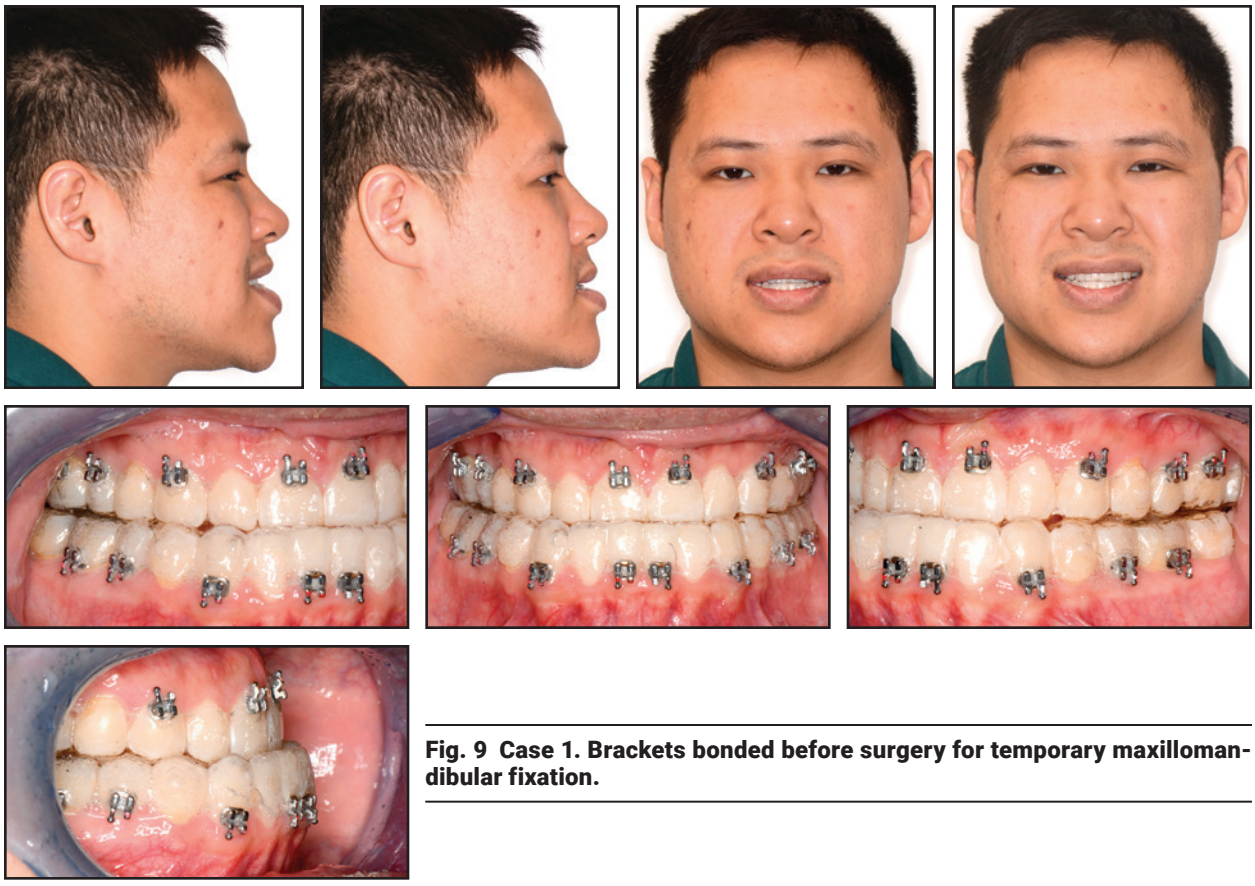

Fig. 9 Case 1. Brackets bonded before surgery for temporary maxillomandibular fixation.

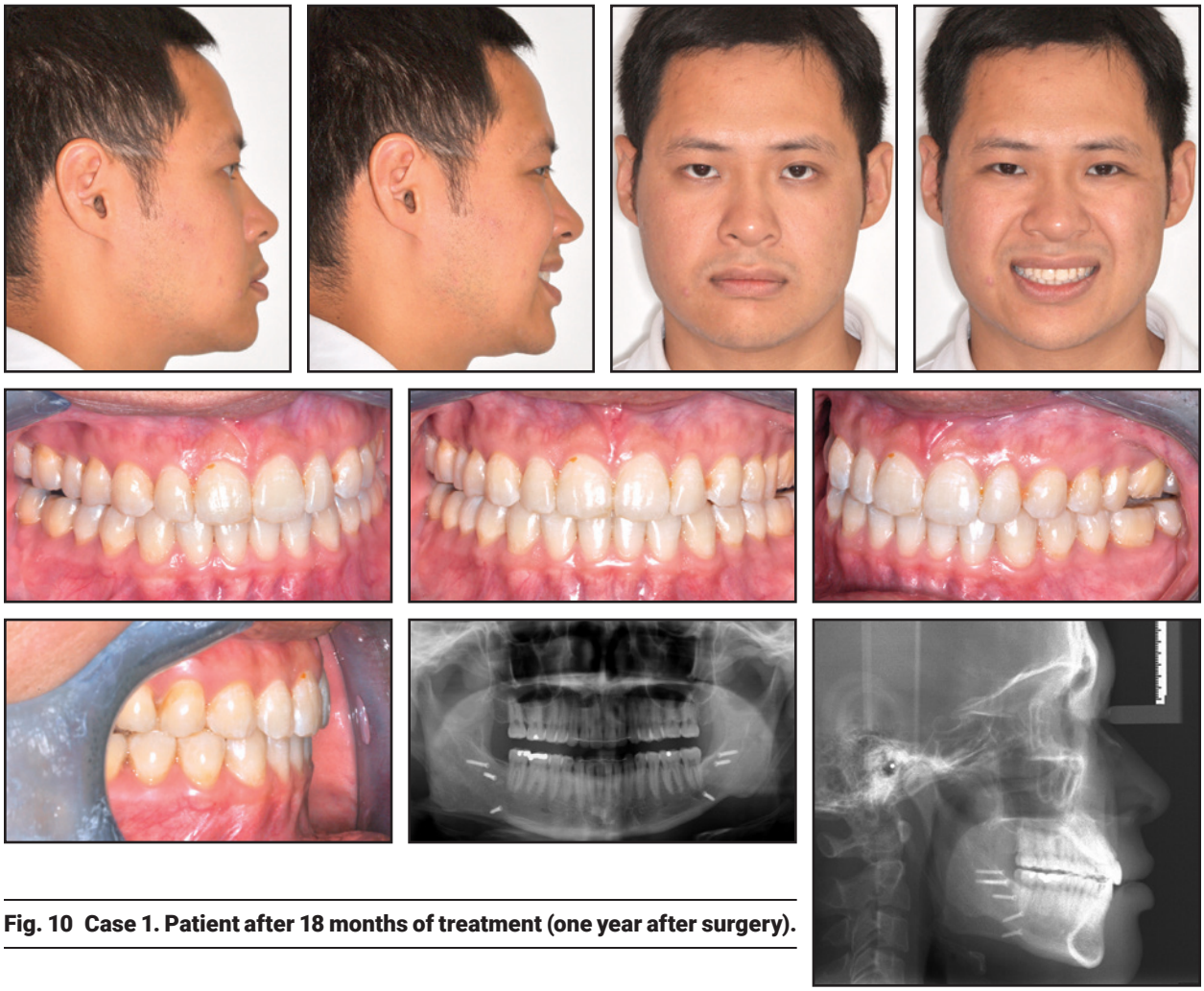

Fig. 10 Case 1. Patient after 18 months of treatment (one year after surgery).

surgery for temporary maxillomandibular fixation as described above, and the final aligner trays were trimmed to fit around the brackets (Fig. 9). The surgery was executed as planned and was uneventful.

Postoperative guidance was provided by 6oz, ¼" elastics attached to TADs that were placed in the alveolus during surgery. Two sets of passive aligners were delivered for postoperative wear. Our patients are instructed to start wearing these aligners as soon as they can open their mouths wide enough—typically five to seven days after surgery.

Two weeks after surgery, the patient was seen in the surgeon's office to reduce the elastic traction and to have scans performed for refinement aligners, which were delivered two weeks later. The refinement trays were changed every two weeks and used for seven months postoperatively. At the end of treatment, an upper Hawley retainer was delivered, and a lower 3-3 lingual retainer was bonded.

One year after surgery, the planned occlusion was unchanged and stable, and the patient reported a high degree of satisfaction (Fig. 10). Although this case was not finished perfectly, as seen in the posterior occlusion, it nonetheless validates the use of clear aligners as a treatment option in surgical-orthodontic patients.

Case 2

A 25-year-old male presented with a skeletal and dentoalveolar Class III malocclusion (Fig. 11). The patient had a prognathic facial type with a concave profile, a slightly constricted maxillary arch with mild crowding, and a moderately crowded mandibular arch with extreme negative overjet.

A nonextraction treatment plan with clear aligners was combined with a "surgery early" approach using orthognathic surgery to advance the maxilla, rotate the occlusal plane, and set back the mandible.

Only 10 sets of aligners were prescribed for the presurgical phase, with upper and lower trays changed every two weeks. Crowding in the lower anterior region was alleviated by proclination of the lower incisors. The presurgical treatment was completed in about three months (Fig. 12).

All aligner attachments were removed one month before surgery. Four sets of passive aligners

Fig. 11 Case 2. 25-year-old male patient with Class III malocclusion before treatment.

were delivered for one month of wear before surgery and one month after surgery.

Temporary maxillomandibular fixation was achieved using the clear-aligner orthognathic splint and four TADs. The planned surgical movements were a 4.5mm setback of the mandible and slight asymmetry correction, followed by a 4mm advancement and 3mm impaction of the maxilla. During the first two weeks after surgery, the patient wore corrective elastics to maintain the occlusion, using the TADs as points of attachment (Fig. 13).

Following an uneventful postoperative course, the patient returned to our clinic after two weeks and was scanned for refinement aligners. The virtual treatment plan, designed in coordination with the surgeon, called for 20 additional sets of aligners, which were delivered to the patient about two weeks later. With aligners changed every two weeks, the refinement stage lasted 11 months. An upper Hawley retainer was then delivered, and upper and lower 2-2 lingual retainers were bonded.

After a total 16 months of treatment, final

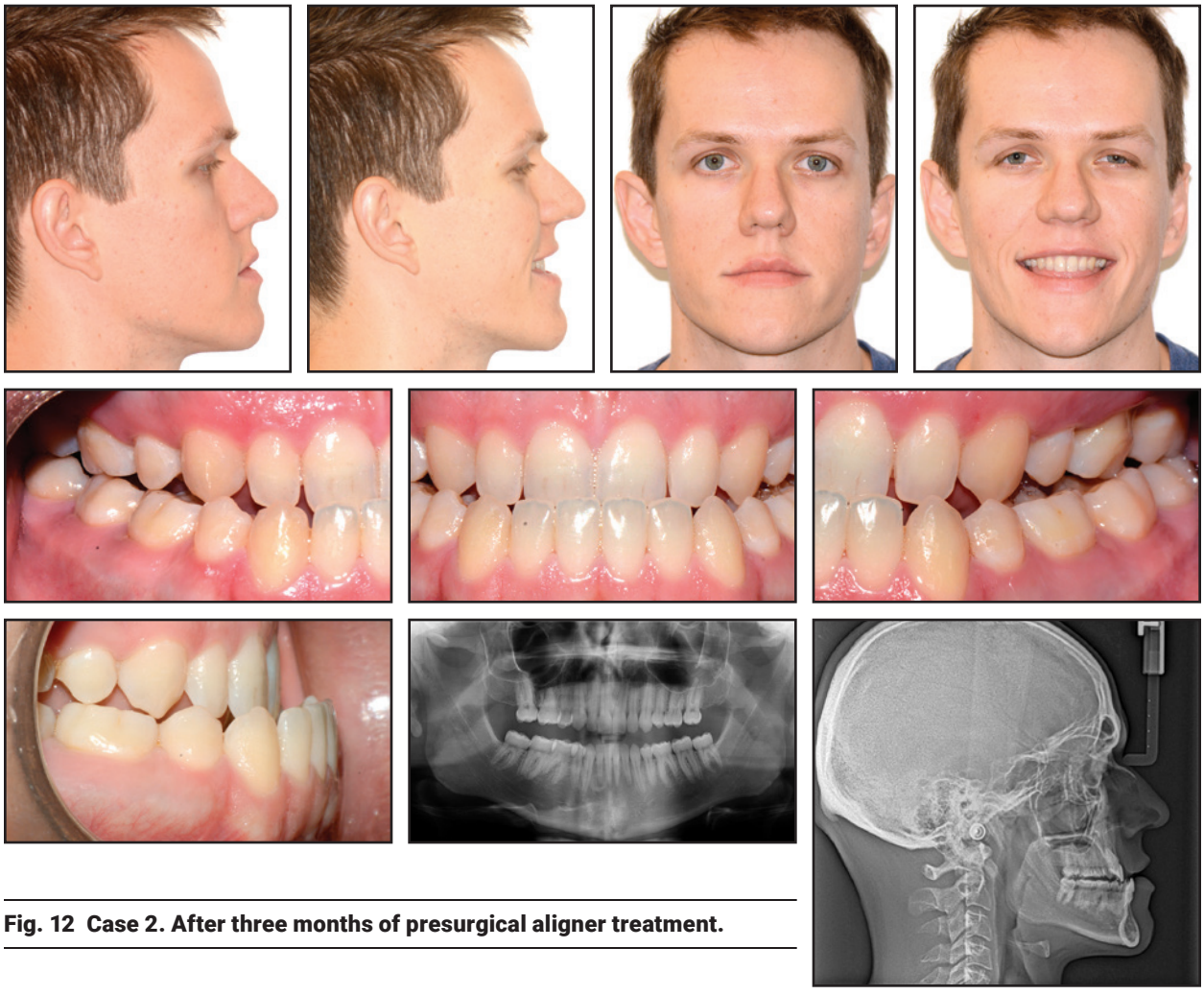

Fig. 12 Case 2. After three months of presurgical aligner treatment.

records confirmed complete correction of the anteroposterior and transverse deficiencies (Fig. 14). The patient was entirely satisfied with the treatment results.

Discussion

Once seen as a difficult strategy for managing patients with skeletal discrepancies, clear aligner treatment now offers certain advantages

TABLE 2
ADVANTAGES AND DISADVANTAGES OF COMBINING CLEAR ALIGNER THERAPY WITH ORTHOGNATHIC SURGERY

Advantages	Disadvantages
Esthetics	Low level of evidence, especially for extraction cases
Removability	Difficulty achieving some tooth movements, such as rotations and extrusions
Comfort	Compliance issues
Ease of oral hygiene	Need for presurgical removal of attachments
Improved multisegmental osteotomy control	Challenges of intraoperative maxillomandibular fixation, including increased surgical time
High level of patient satisfaction	Need for refinement aligners after surgery
	Potential for postsurgical open bite

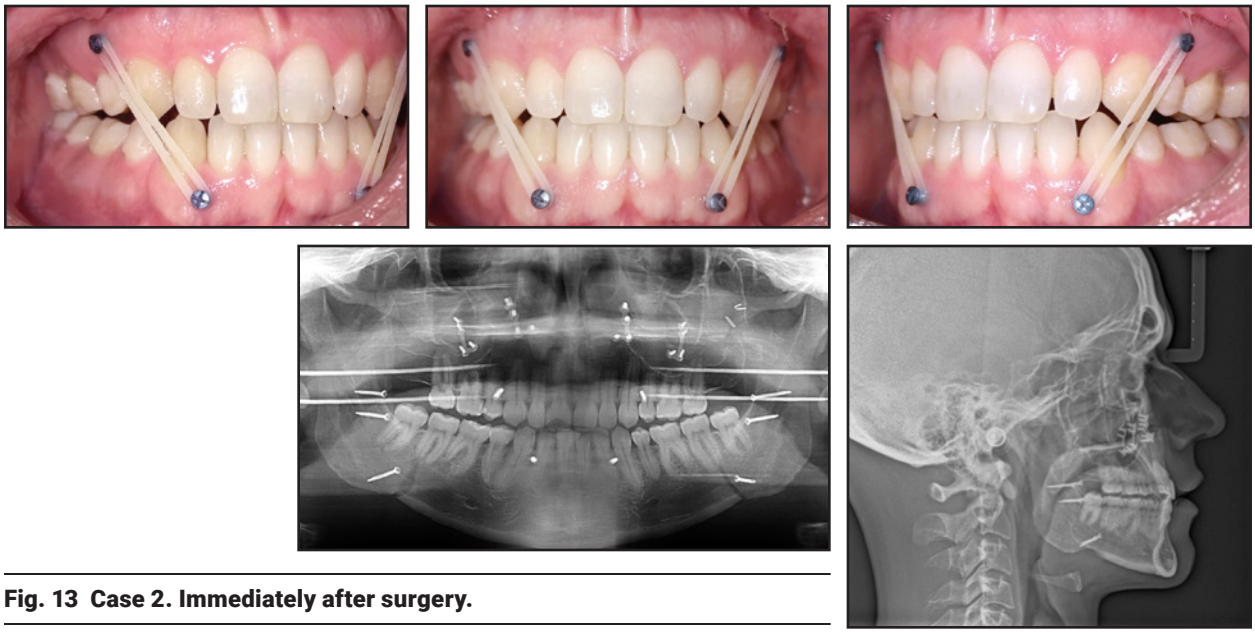

Fig. 13 Case 2. Immediately after surgery.

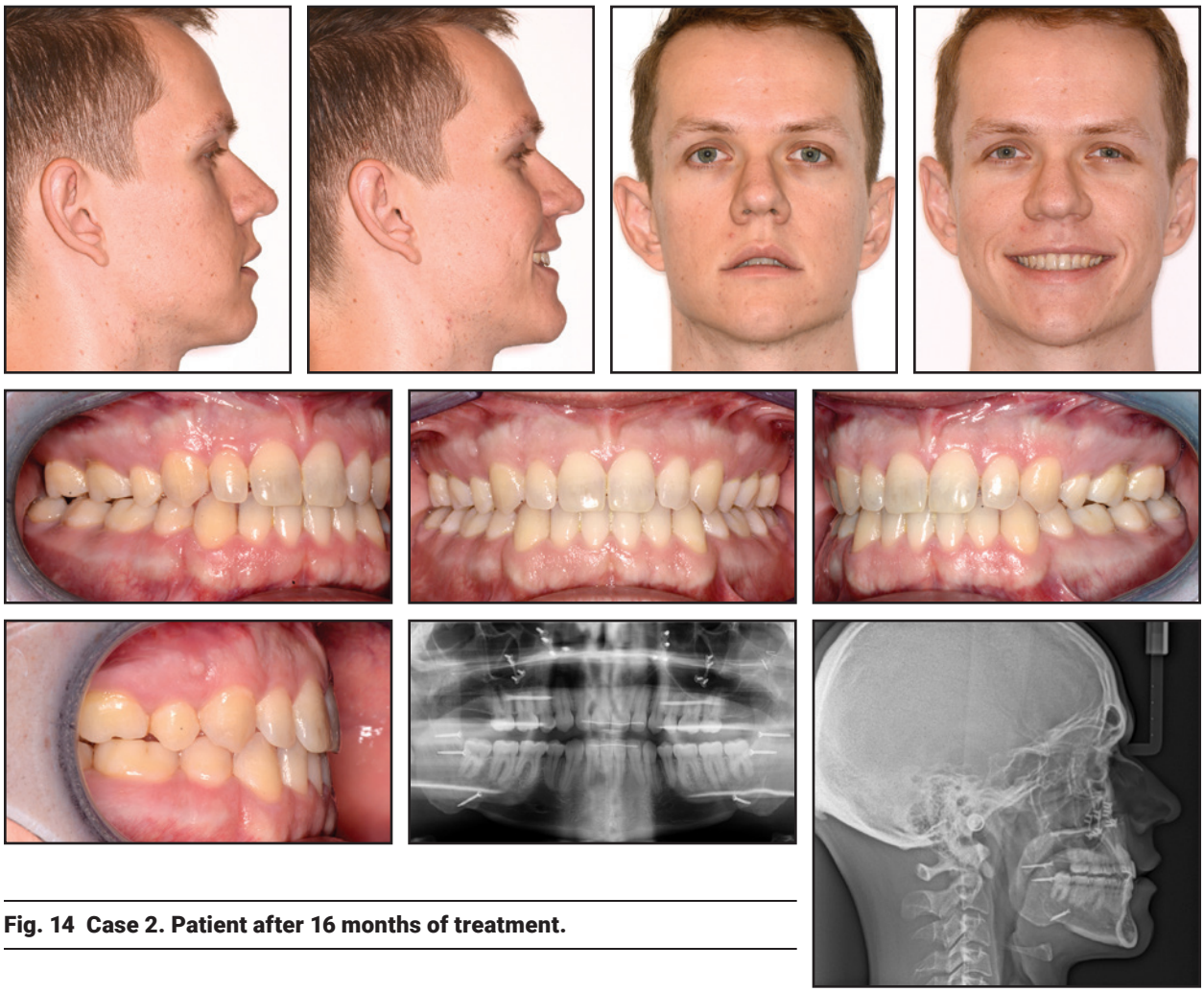

Fig. 14 Case 2. Patient after 16 months of treatment.

when combined with orthognathic surgery (Table 2). The challenges involved should not deter practitioners from using aligners in such cases. Preoperatively, it is critical that the virtual setup be designed with proper decompensation. Intraoperatively, an effective method of maxillomandibular fixation must be selected. Postoperatively, refinement scans are needed to finish the case.

The clear-aligner orthognathic splint described here is not only useful in a conventional surgical-orthodontic treatment protocol, but could potentially improve the diagnosis and treatment planning of "surgery first" cases,[34] minimizing the errors often encountered with traditional laboratory-fabricated splints.[35] A "surgery first" approach requires the orthodontist and oral surgeon to plan the occlusion and the osteotomies simultaneously. By combining digital scanning for clear aligners with computer-aided surgical simulation, the clear-aligner orthognathic splint simplifies the process. Indeed, recent studies have demonstrated that 3D-printed surgical splints can accurately transfer the desired virtual treatment plan to the final surgical outcome.[36]

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