TOMAC: An Orthognathic Treatment Planning System

Part 3 VTO Construction in the Vertical Dimension

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The first two parts in this series covered the TOMAC facial profile analysis and principles of VTO construction in the horizontal dimension (JCO, June and July 2001). This final part will focus on the vertical dimension, double-jaw scenarios and complex treatment planning, and rotation of the maxillomandibular complex.

Reduction of Lower Anterior Facial Height

The key to planning the correction of maxillary vertical excess, with or without anterior open bite, is that the diagnostic lateral cephalogram must be taken with the lips completely relaxed. The significant soft-tissue measurements are the interlabial gap and the distance from the incisal tip to the upper lip stomion.

On the test VTO, the new maxillary incisor vertical position is represented by a line 2mm below a tangent to the inferior aspect of the relaxed upper lip. The mandible is rotated about condylion until the mandibular central incisor is 1-1.5mm above this horizontal line. When subsequently tracing in the maxilla, it is important that the maxilla not be advanced more than 2mm

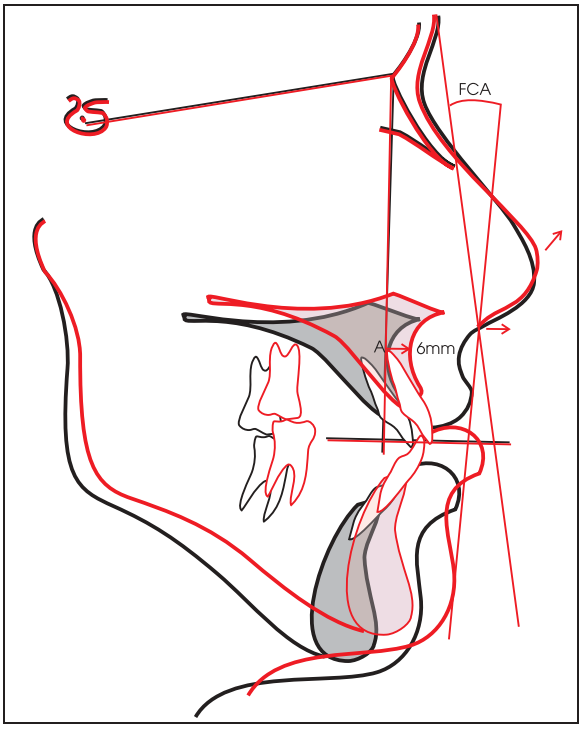

Fig. 14 A point advanced too far (more than 2mm) after autorotation of mandible.

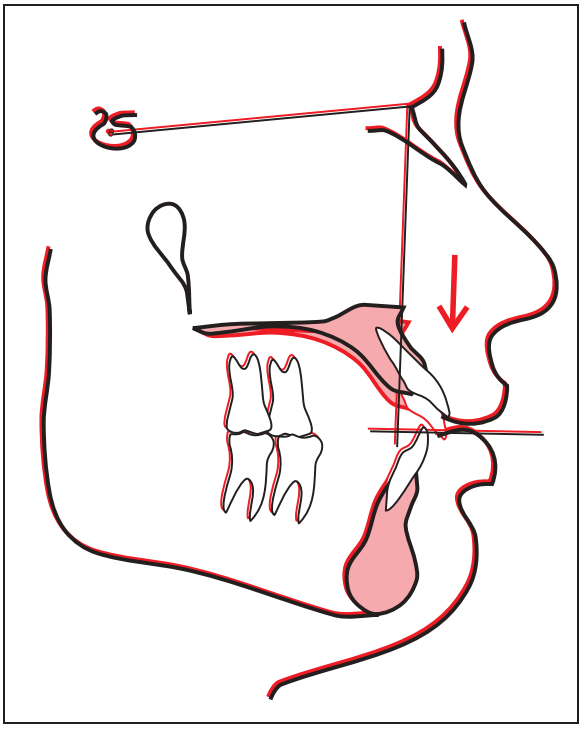

Fig. 15 Incisor relationships reassessed after downgraft of maxilla.

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from the original NA line. Further advancement will cause the mandibular incisors to be too proclined and to require uprighting or retroclination (Fig. 14). Excessive advancement of the maxilla to match the closing rotation of the mandible can also have undesirable soft-tissue effects, such as excessive shortening of the upper lip, deflection of the nasal tip, and flaring of the nostrils. In all cases, the new facial contour angle (FCA) should be measured to determine whether there are profile discrepancies.

Correction of Maxillary Vertical Deficiency

Maxillary vertical deficiency is usually associated with overclosure of the occluding mandible, which increases the freeway space. It is helpful to construct a wax bite at about half the freeway space, depending on the patient's age, and to take the lateral cephalogram with this wax bite in position. To further evaluate the relationship between the maxillary incisors and upper lip stomion, a headfilm can also be taken with the lips just touching.

In maxillary vertical deficiency, the maxillary incisors are usually underexposed relative to the relaxed upper lip. The new maxillary incisor vertical position is represented on the test VTO by a line 2mm below the relaxed upper lip (Fig. 15). An extra 1mm exposure of the maxillary incisor can be budgeted to allow for surgical relapse, since downgrafting of the maxilla can be surgically unstable despite improved fixation techniques. The incisor relationships are then assessed and reconciled with arch length and their physiological positions in the bone.

Treatment of Combined Maxillary and Mandibular Deformities

Double-jaw scenarios involve complex orthodontic and surgical treatment planning. For reasons of stability, the maxilla is seldom advanced more than 6-8mm or the mandible retracted more than 6mm. There are exceptions, of course, but these cases must be thoroughly discussed with the surgeon.

In large Class III discrepancies, the optimum facial profile is obtained by preparatory decompensation of the maxillary and mandibular incisors. The amount of decompensation depends on the anatomy of the alveolar bone, crowding, and spacing, any of which may prevent ideal decompensation and result in a compromised profile.

On the test VTO, the vertical discrepancies are corrected first by autorotating the mandible to the desired vertical position, which is determined by elevating the anterior maxilla and maxillary incisors along the NA line. The anteroposterior variations of the soft-tissue profile, facial skeleton, and teeth are then reassessed. The test profile is measured from the FCA. Three possibilities may occur:

1. The FCA is within normal limits. If so, the necessary compensation is assessed by reconciling it with arch-length discrepancies and bony anatomy. If the ideal incisor positions cannot be obtained, the facial contour will be compromised. This is important to know before treatment begins.
2. The FCA is too acute. This indicates either that the mandible is too protrusive or the maxilla is retrusive, making it important to reexamine the original diagnosis. If there are signs of maxillary anteroposterior deficiency, then subnasale can be advanced. Remember that soft-tissue subnasale advances at a ratio of 50% of the maxillary surgical movement. Incisor decompensations can be made, taking into account arch-length discrepancies, bony anatomy, and gingival condition. If there is a mandibular excess, then a mandibular setback is required. If the FCA is still too acute

Fig. 16 Case 3. 16-year-old female skeletal Class II patient before treatment.

or the reverse overjet is 8mm or more, then anteroposterior surgery of both jaws is required in combination with vertical movement. Reduction genioplasties are also useful in obtaining a good profile, but should be balanced with lip structure. The labiomental angle should not be too obtuse, and nasal esthetics must also be considered.

3. The FCA is too obtuse. Consideration should be given to mandibular advancement and/or advancement genioplasty, provided the genioplasty is in harmony with the lip positions. Appropriate incisor decompensations will be required. It is seldom necessary to surgically set back the maxilla except in cases of severe bidental protrusion, and this is usually done in the first premolar area.

In some cases where the upper lip is procumbent and the nasolabial angle is acute, it will be necessary to plan for posterior movement of the upper lip. On the test VTO, the upper lip is retracted first, taking into account lip strain, widening of the nasolabial angle, and protrusion relative to the lower facial contour plane. The maxillary incisors will need to be retracted, and decisions made regarding anchorage and extractions. The new overjet is measured, and the ideal FCA is drawn. Any convexity or concavity is then addressed by advancement or setback of the mandible and/or the chin.

Case 3: Maxillary Impaction and Mandibular Advancement

A 16-year-old female presented with the chief complaints that she could not close her lips properly, that her mouth was consistently open, and that her bite was uncomfortable (Fig. 16). The diagnosis was a severe Class II jaw relationship, recessive mandible, and severely increased lower anterior facial height. She had 6mm of mandibular crowding, 4mm of maxillary crowding, an excessive overjet, an open bite, severely proclined mandibular incisors, and retroclined maxillary incisors. Her soft-tissue profile was severely convex, with deficient chin length, an acute nasolabial angle, a protrusive lip position, a large interlabial gap, excessive nasofacial and columella angles, and a relatively normal exposure of the maxillary incisors beneath the relaxed upper lip.

Test VTO

1. Superimpose a new sheet of acetate over the original cephalometric tracing, trace in all the structures that will not change with surgery—anterior cranial base, the forehead, glabella, and the upper half of the nose—and draw in the SN and NA lines (Fig. 17A).
2. Draw a line 2mm below a tangent to the inferior margin of the relaxed upper lip, intersecting with NA, to represent the new level of normal maxillary incisor exposure (Fig. 17B). By laying this tracing over the original tracing, the distance between the old and new vertical incisor positions can now be measured. The upper lip will shorten by 40% of the distance of impaction, although VY soft-tissue suturing techniques can reduce this to 20% or less. In some open-bite cases, the maxillary incisors are already in a normal relationship to the relaxed upper lip, and this elevation will not be required.
3. Rotate the tracing clockwise about condylion so that the mandibular incisor is 1mm above the new maxillary incisor level (Fig. 17C). This represents the new overbite. Draw in the outline of the mandible, including the soft-tissue chin, lower lip, incisor, and molar. Since the mandible has been autorotated to a new vertical position, the chin will be more anterior. Trace the maxilla in its new position by sliding the tracing along NA so that the molars are in contact with the mandibular molars and the maxillary incisor tip is in contact with the horizontal line of the new maxillary incisor vertical position.

In cases where the posterior aspect of the maxilla is elevated more than the anterior region, A point will advance beyond NA. It should not be advanced more than 2mm, however, to avoid flaring of the nostrils and excessive elevation of the nasal tip. Alar-base cinch techniques can help counter this tendency. The exception to the 2mm limit is a case where the maxilla is deficient in length.

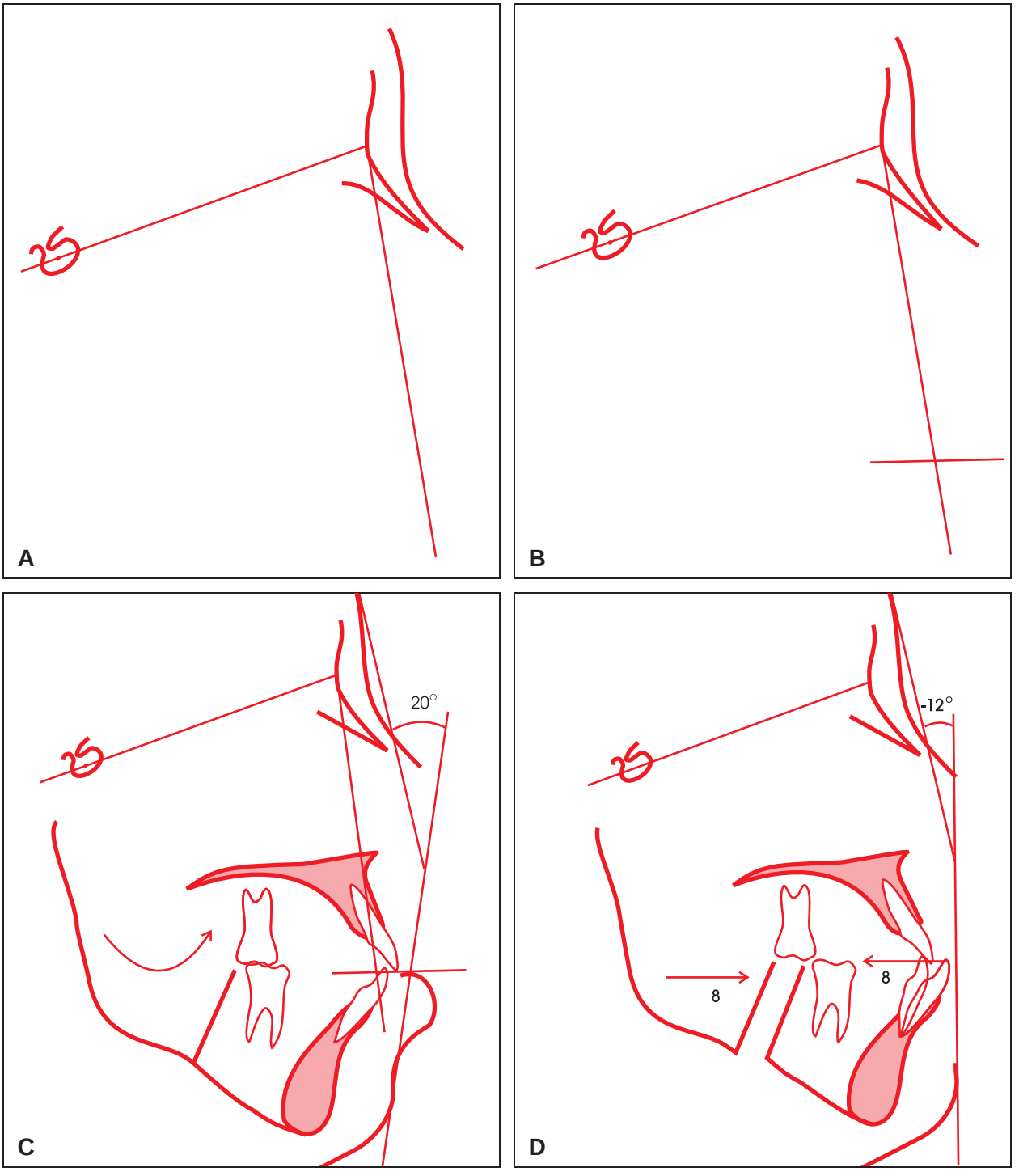

Fig. 17 Case 3. Test VTO. A. Hard and soft tissues that will not change with surgery. B. New vertical incisor position. C. Autorotation of mandible. D. Incisor decompensation needed to achieve ideal profile.

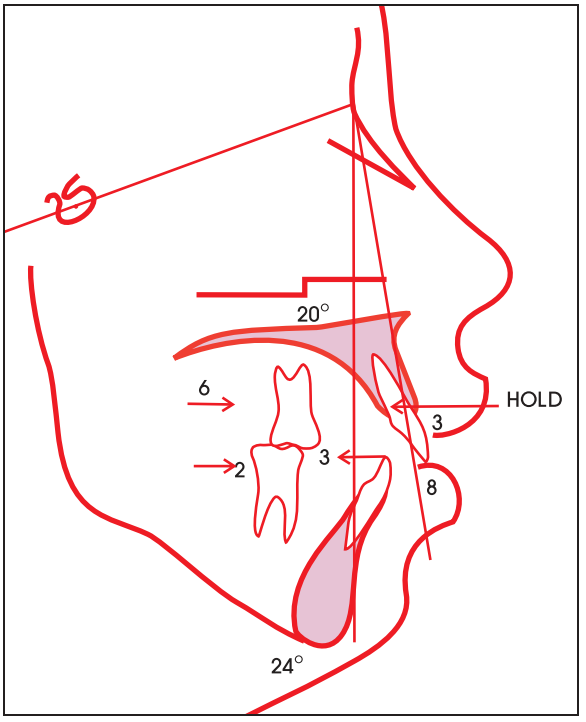

Fig. 18 Case 3. Presurgical-orthodontic VTO.

Reevaluate the anteroposterior positions of the basic profile components by measuring the FCA. The positions of the teeth should also be assessed.

4. With the test tracing superimposed on the original, draw in the upper facial contour plane from glabella to subnasale, which changes very little if the maxilla is kept on the old NA line, and draw the lower facial contour plane at the ideal angle (Fig. 17D). Indicate the surgical cut on the mandible in the second molar area, and slide the tracing along the occlusal plane so that the chin is now tangent to the ideal lower facial contour plane. The incisors must be decompensated to obtain the ideal profile, but an 8mm retraction of the mandibular incisors, as indicated in this patient, is unrealistic. At this point, it is important to evaluate arch-length discrepancies and make the extraction and anchorage decisions needed to obtain optimum incisor positions. It may not be possible in some cases to obtain the ideal anteroposterior mandibular position or ideal FCA because of the limitations of incisor movements. The potential of advancement or retraction genioplasties to help achieve the ideal profile can be assessed from the surgical VTO.

Presurgical-Orthodontic VTO

Using the information from the test VTO, plan the incisor and molar positions (Fig. 18). The mandibular axis (condylion to gnathion) can close slightly, by 1°, if an extraction decision is made and substantial space closure is required. In some nonextraction cases, it can open 1° as the curve of Spee is corrected, but this opening and closing of the mandible is not always predictable.

Surgical VTO

1. Construct the surgical VTO over the presurgical-orthodontic tracing, beginning with the diagrammatic and maxillary osteotomy cuts and the NA line (Fig. 19A). Trace in the soft-tissue profile from glabella to the upper half of the nose. The new vertical position of the maxillary incisor is represented by a horizontal line, 2mm below a tangent to the relaxed upper lip. Rotate the mandible so that the mandibular incisor tip is 1mm above this horizontal line. Draw in the outline of the mandible, the soft-tissue chin, and the incisor, thus establishing a new occlusal plane. Trace the maxilla in its new position, dictated by the horizontal line of the maxillary incisor and by the mandibular molar.
2. Simulate the surgical advancement of the mandible along the new occlusal plane (Fig. 19B). Trace in the soft tissues of the nose and lips, based on established soft-to-hard-tissue movement ratios (see Part 1). Measure the FCA and lip protrusion to evaluate the need for a genioplasty.

Results

The treatment goals were met, with a

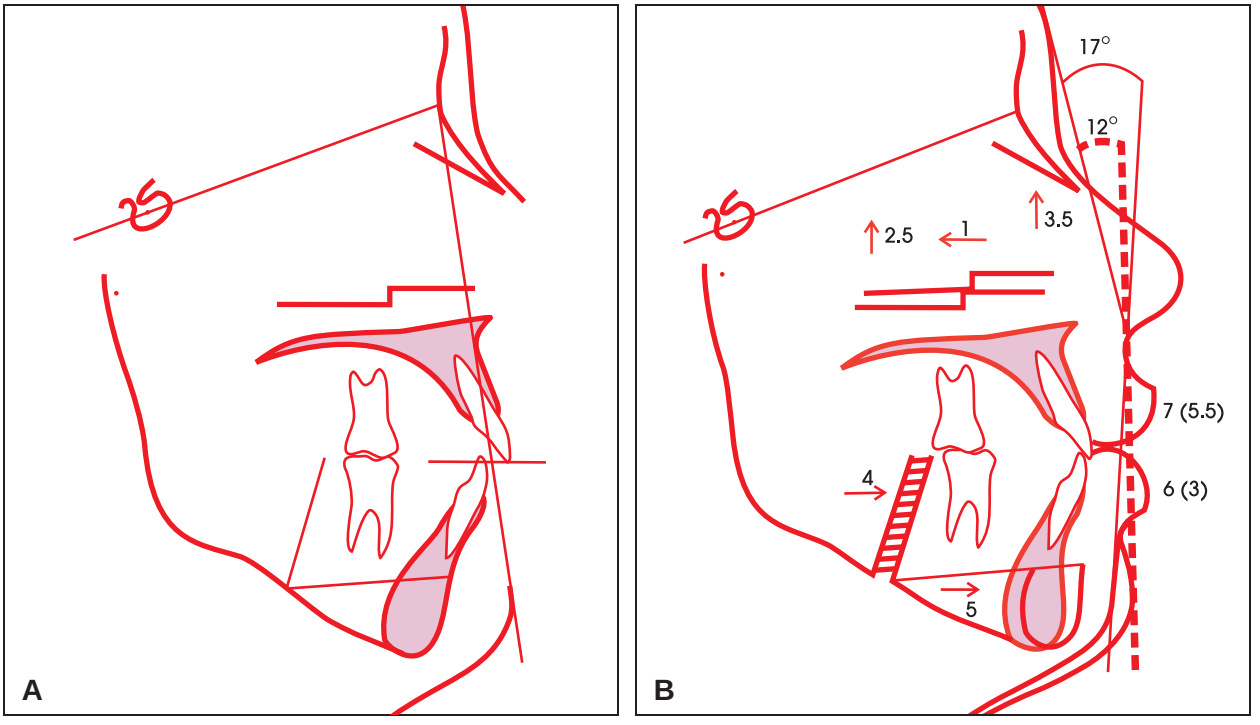

Fig. 19 Case 3. Surgical VTO. A. Vertical positioning of incisors. B. Autorotation of mandible.

much-improved facial profile, an FCA of 13°, and the lips within a standard deviation of normal (Fig. 20). Lip strain was relieved, and a good occlusion was obtained.

Rotation of the Maxillomandibular Complex

Surgical rotation of the maxillomandibular complex offers a new treatment planning option for the management of euryprosopic Class II cases.[61-63] The selection criteria include:

- Proclined maxillary incisors
- Retroclined mandibular incisors
- Deep overbite with a deep curve of Spee
- Deficient lower anterior facial height
- Class I or borderline Class II jaw relationship

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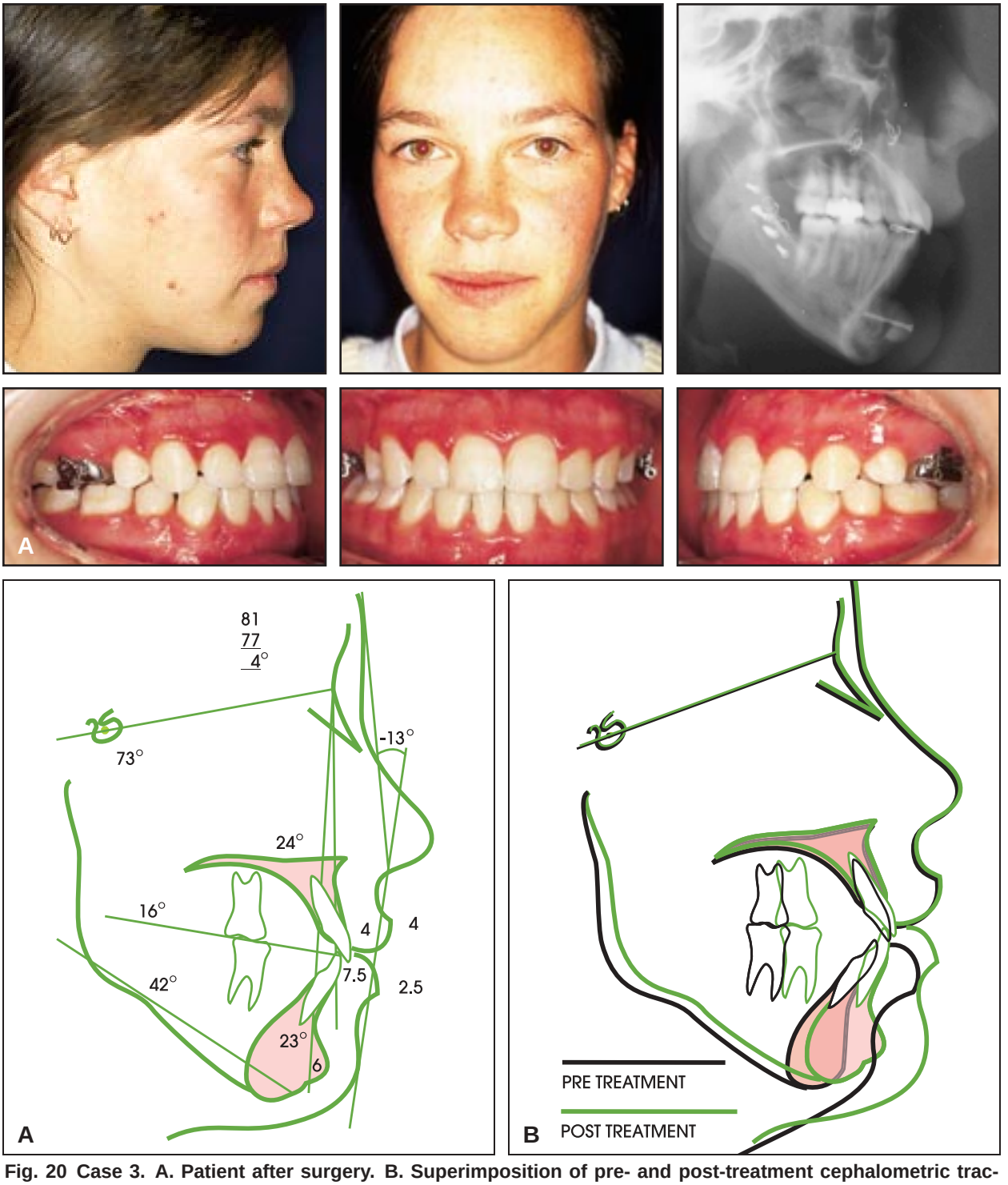

Fig. 20 Case 3. A. Patient after surgery. B. Superimposition of pre- and post-treatment cephalometric tracings.

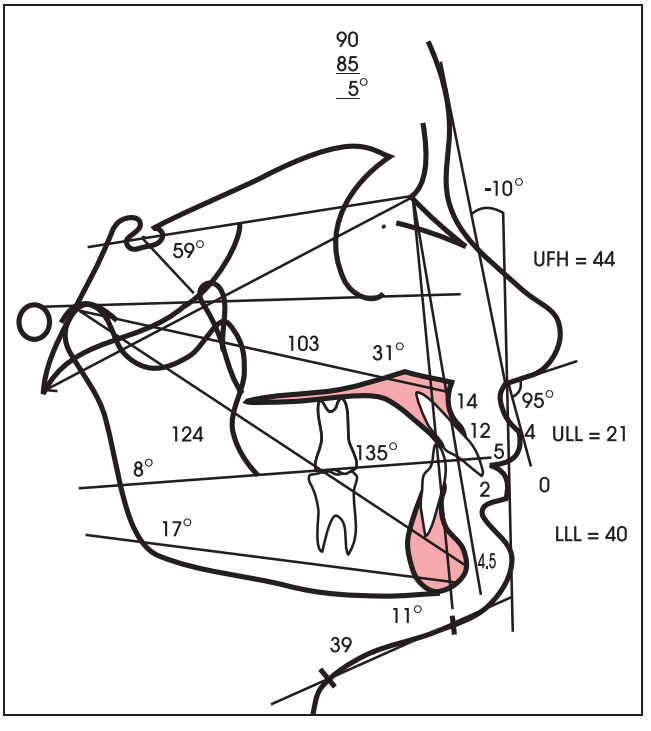

Fig. 21 Case 4. 26-year-old female euryprosopic patient before treatment.

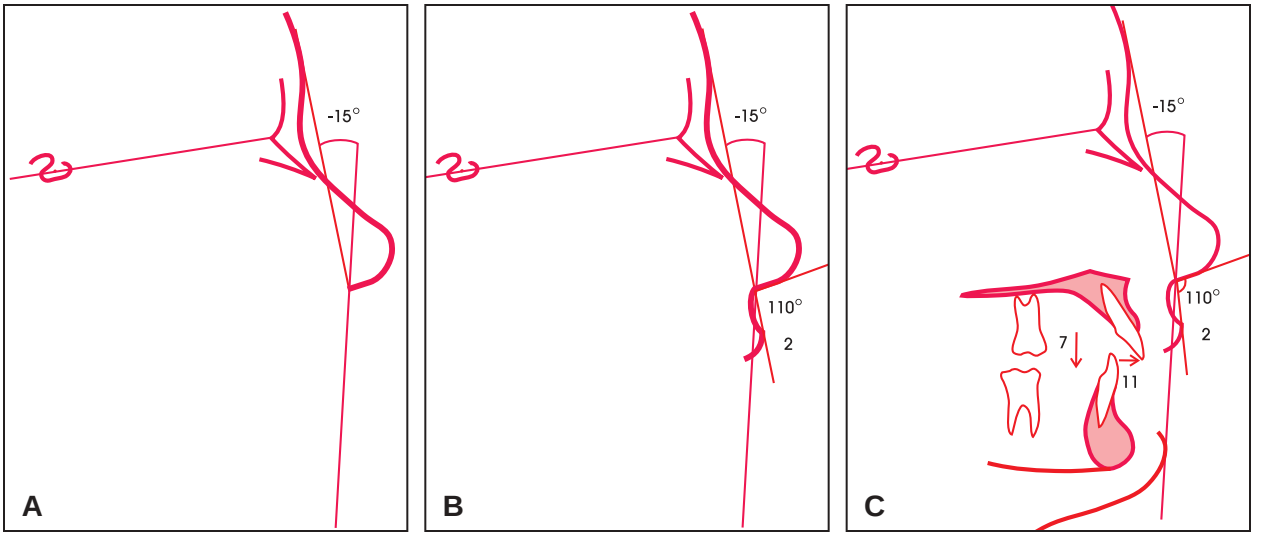

Fig. 22 Case 4. Test VTO. A. Ideal angulation of upper and lower facial contour planes. B. Ideal nasolabial angle. C. Rotation of maxilla about A point.

Case 4: Rotation of the Maxillomandibular Complex

A 26-year-old female presented with the chief complaint of palatal pain from biting (Fig. 21). She had had two years of orthodontic treatment as an adolescent. The patient's skeletal pattern was diagnosed as euryprosopic, with severely deficient lower anterior facial height and a mild Class II relationship. She had a large overjet, a severe overbite, proclined maxillary incisors, retroclined mandibular incisors, a deep curve of Spee, maxillary anterior spacing, and no mandibular crowding. The profile was straight to flat, with deficient lower anterior facial height, an acute nasolabial angle, a protrusive upper lip, a retrusive lower lip, and a deep labiomental fold.

Test VTO

1. Place a new sheet of acetate over the original tracing. Trace in the anterior cranial base from sella to nasion and the soft tissue from glabella to subnasale (Fig. 22A). Draw the upper and lower facial contour planes at the ideal angulation (in this case, –15°).
2. Trace in the upper lip at the ideal nasolabial angle of 110°, 2mm anterior to the lower facial contour plane (Fig. 22B). In this patient, the maxillary incisors can be orthodontically retracted no more than 1.5-2mm due to the space available in the maxillary arch. Further retraction can only be done surgically.
3. Slide the tracing paper upward so that the overbite is corrected and the soft-tissue chin is tangent to the new, ideal facial contour plane. There is still a large overjet and a posterior open bite. The only way to resolve this situation is to rotate the maxilla about a point on the anterior maxilla (the center of rotation), which can be A point, ANS, or the incisal tip. If the ANS area needs to be advanced to satisfy nasal esthetics or reduce paranasal flattening, then the center of rotation can be the incisal tip. In most of these cases, however, it is desirable to further retract the maxillary incisors, which can be done in this patient by selecting A point or ANS as the center of rotation (Fig. 22C). With 2mm of maxillary incisor retraction, the upper lip is also retracted by 2mm, improving the nasolabial angle and reducing lip protrusion.

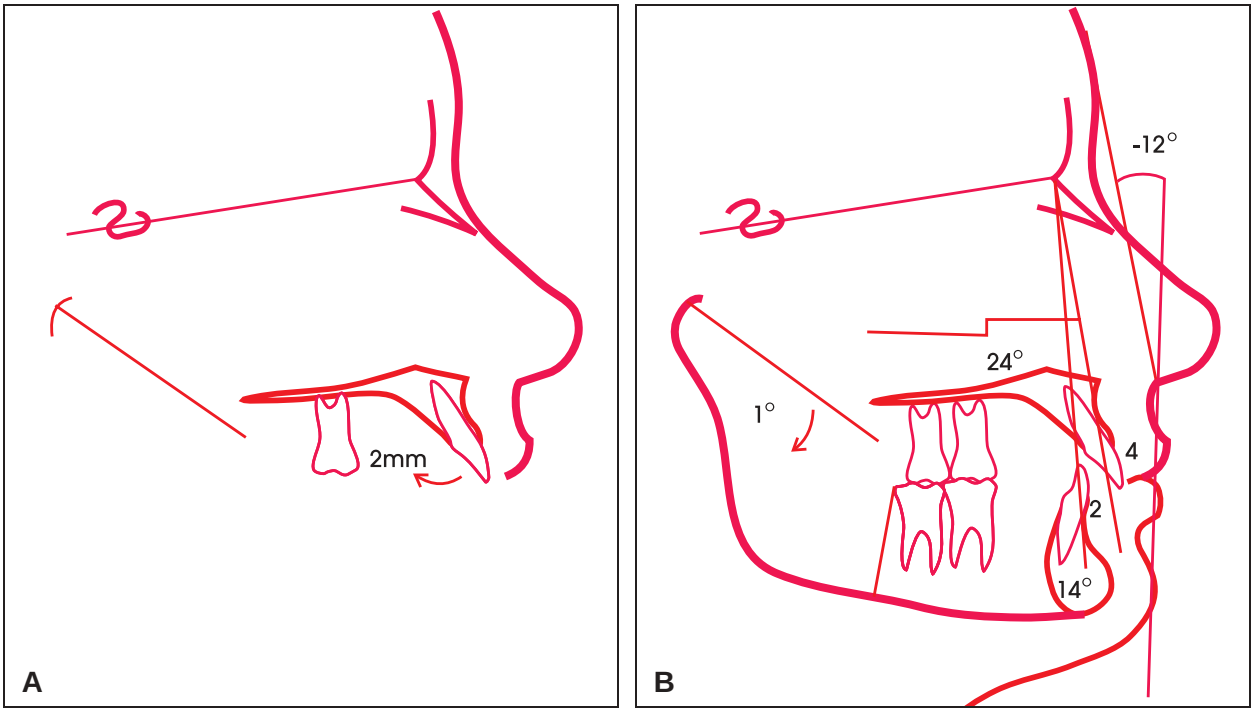

Fig. 23 Case 4. Presurgical-orthodontic VTO. A. Retraction of maxillary incisor. B. Remainder of orthodontic objectives.

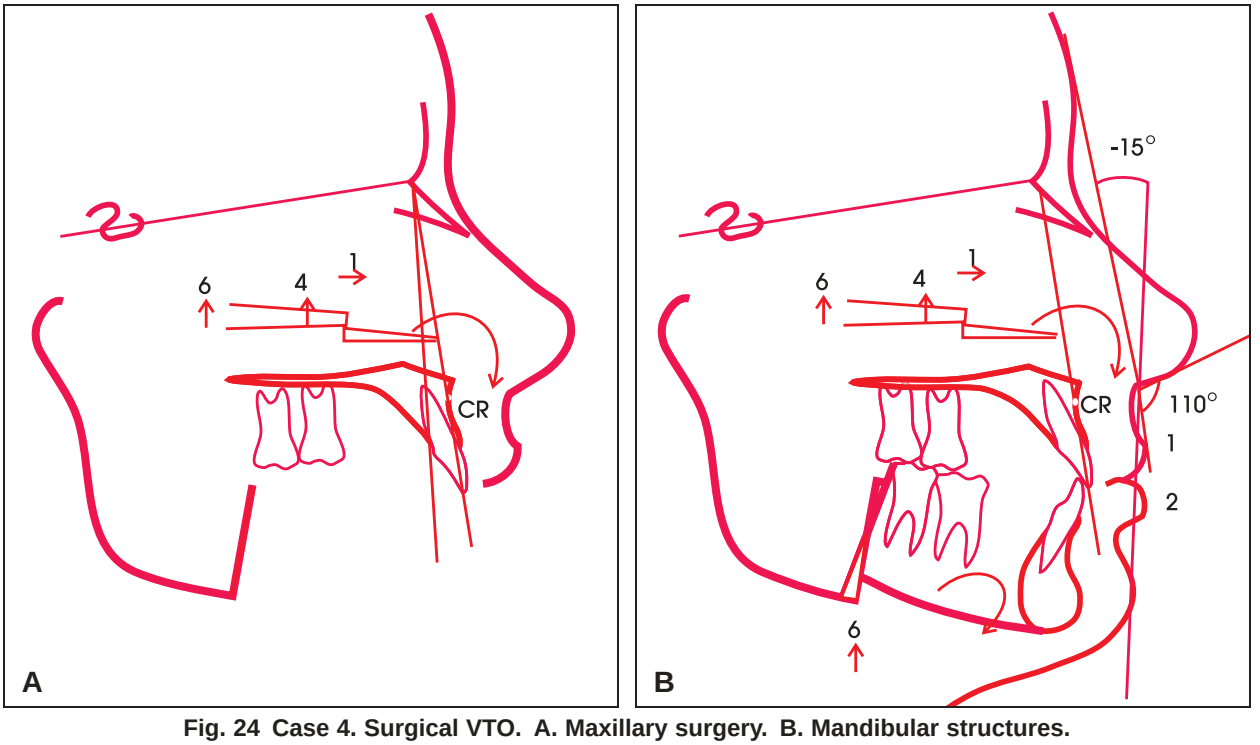

Fig. 24 Case 4. Surgical VTO. A. Maxillary surgery. B. Mandibular structures.

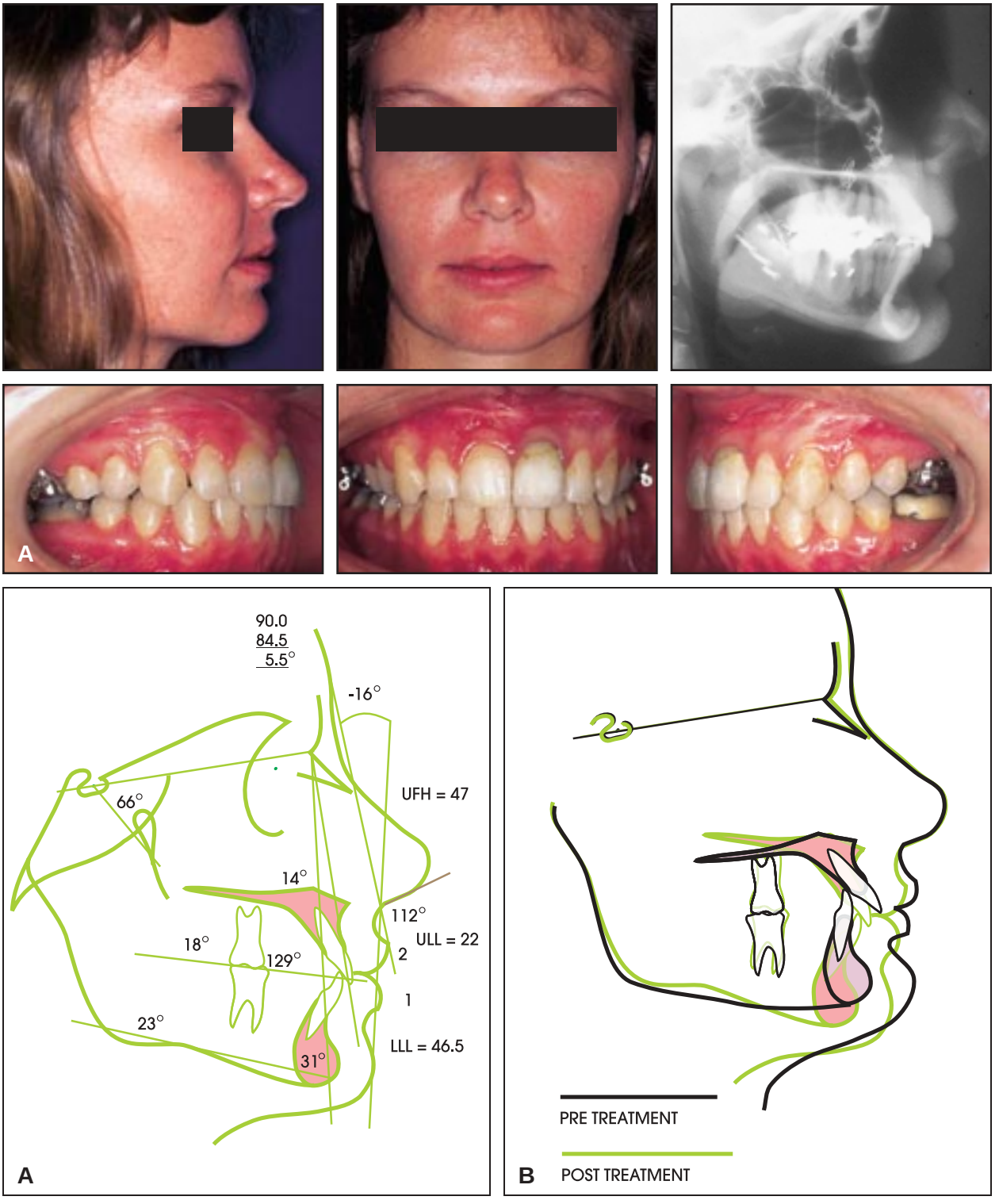

Fig. 25 Case 4. A. Patient after surgery. B. Superimposition of pre- and post-treatment cephalometric tracings.

Presurgical-Orthodontic VTO

1. Trace in the anterior cranial base, palate, mandibular axis from condylion to gnathion, and soft-tissue profile from glabella to subnasale (Fig. 23A). The maxillary incisor is retracted by 2mm to close the anterior spaces, and the upper lip follows by 1-2mm, taking into account minimal lip strain.
2. The mandibular incisor is held in its current position (Fig. 23B). The condylar axis is opened 1° due to leveling of the mandibular teeth, but the curve of Spee is only about half-corrected. It is important not to intrude the mandibular incisors, because the deep overbite allows surgical correction of the lower anterior facial height. Draw in the osteotomy lines.

Surgical VTO

1. Place a new sheet of acetate over the presurgical-orthodontic tracing. Trace in the cranial base, the NA line, the proximal segment of the mandible, and the profile from glabella to the upper lip (Fig. 24A). Rotate the maxilla clockwise about the center of rotation at A point. The maxilla is then elevated by 6mm at PNS. The maxillary incisors further retract by about 1mm, considering residual lip strain.
2. Trace in the mandible to follow the rotation of the maxilla, so that the incisors are positioned in a normal overbite and overjet relationship (Fig. 24B). The molars will be in contact in a Class I relationship. The step in the lower border of the mandible could be surgically contoured, but it will continue to remodel and is actually advantageous because it defines the lower border of the mandible. Measure the distances between surgical cuts for the model operation and later surgery. Draw the profile according to normal soft-tissue reactions to skeletal movements (Part 1). In this case, the mandibular advancement creates the major soft-tissue change. The maxillary rotation allows the upper lip to retract.

Results

The post-treatment results showed profound soft-tissue, dental, and skeletal changes (Fig. 25).

Conclusion

The TOMAC system offers the opportunity to identify treatment goals in the vertical and anteroposterior planes, allowing the clinician to be more confident in making the difficult decision of whether a case can be treated by orthodontics alone or requires orthognathic surgery.

In the future, computerized tracing and video imaging techniques in three dimensions may be faster and more efficient than conventional tracing methods. With soft-tissue responses to hard-tissue movements better understood than in the past, these and other influential factors could be incorporated into computerized technology, using multiple-regression equations, to provide extremely accurate treatment planning information.

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