

# Virtual surgical planning: Balancing esthetics, practicality, and anticipated stability in a complex Class III patient

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The treatment of skeletal Class III malocclusion with anterior open bite is a complex and challenging aspect of orthodontics. Facial esthetic factors, practicality and the anticipated stability of a provisional surgical plan must all be factored into the final decision of the actual orthodontic-orthognathic treatment. This case report presents the multidisciplinary treatment of a 39-year-old female patient with skeletal Class III, severe open bite with first dental contact being on the second molars, lateral crossbite, and crowding in both arches. The nonextraction treatment started with aligning and leveling of the teeth in both arches followed by an initial surgical plan based on the clinical evaluation of the smile esthetics. Precise surgical planning information was imported into the Virtual Surgica (VSP Orthognathics) workflow to visualize the direction and amount of movement necessary. The final plan was adjusted because of anticipated practical limitations of the surgery as well as to insure the stability. LeFort I, bilateral sagittal split osteotomies, and setback genioplasty were thus performed. After the surgery, the treatment concluded with the fine adjustment of the occlusion. In the end, good esthetic and functional outcomes with long-term stability were achieved as a result of this delicate multidisciplinary approach. (*Am J Orthod Dentofacial Orthop* 2019;156:685-93)

The treatment of skeletal Class III malocclusion combined with a vertical growth pattern is one of the most challenging aspects of orthodontics. The incidence of skeletal Class III varies among the different ethnic groups. In people of Caucasian descent it is around 5%, in those of Asian origin it is between 9% and 19%.<sup>1</sup> This can be caused by a maxillary hypoplasia or retrusion, mandibular protrusion, or a combination of both.<sup>2,3</sup> Class III malocclusion is thought to be a polygenic disorder that results from an interaction between susceptibility genes and environmental factors, but at the same time, it might also be a monogenic dominant phenotype showing familial aggregation.<sup>4</sup> Depending on the patient's

age and developmental stage, treatment options may vary. The main goal of orthopedic treatment is to provide a more advantageous environment for growth and to improve the occlusal relationship and facial esthetics.<sup>5</sup> This improvement may also have a favorable effect on the self-esteem and psychosocial development of these young people during puberty.<sup>6</sup> However, there is a lack of evidence for the long-term benefits of early treatment,<sup>7</sup> and the incidence of relapse has been reported to be as high as 50%.<sup>8,9</sup> On the other hand, conventional treatment of anterior open bite, either through molar intrusion, or incisor extrusion shows a rate of relapse between 35% and 42%.<sup>10</sup>

For adults, orthodontic camouflage or orthognathic surgery are the 2 main treatment modalities. According to the traditional approach, orthodontic camouflage should be attempted in mild cases where the patient has favorable vertical facial proportions.<sup>11</sup> With the introduction of miniscrews and miniplates, this indication can be more extended. However, in many cases, the best results are achieved through a combination of orthodontics and orthognathic surgery. Notably, detailed surgical design and management is highly essential in order to achieve an esthetic, functional, and stable outcome. In this case report, the comprehensive and customized treatment for a patient with skeletal

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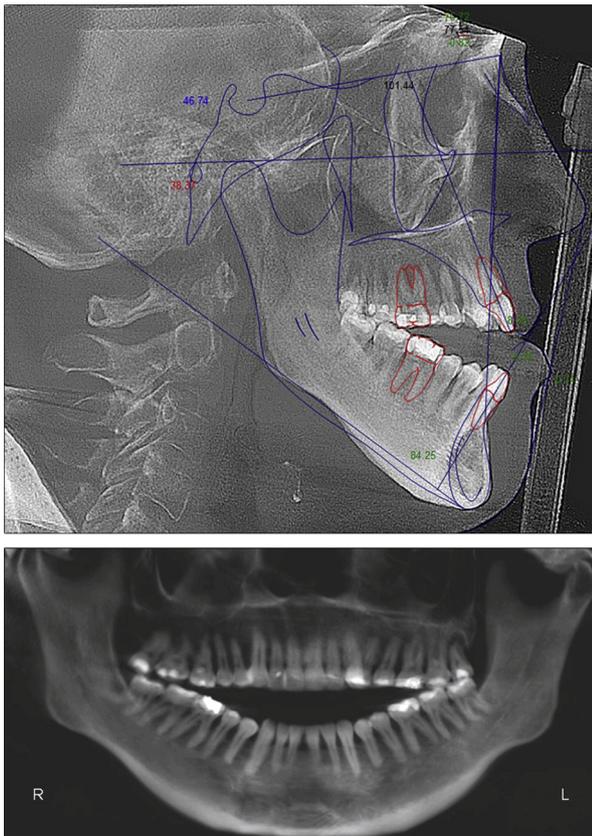
**Fig 1.** Pretreatment extraoral and intraoral photographs.

Class III open bite is discussed. This case report illustrates that the virtually planned surgical treatment was expected to be practically difficult to accomplish, and that it had to be modified for this reason, as well as to avoid surgical changes that would not only be esthetically undesirable, but would also compromise the airway, and the long-term surgical stability.

#### **DIAGNOSIS AND ETIOLOGY**

A woman aged 39 years 10 months presented in September 2014, at the department of orthodontics at the University of Alabama at Birmingham, with the following chief complaint: "I am ready to be able to smile." Her medical history revealed Ehlers-Danlos syndrome, diagnosed in 2014. She also had vitamin D deficiency, had undergone tonsillectomy and adenoidectomy in 1986, and had a surgery for deviated septum correction. No allergies except a sensitivity to adhesives used during previous surgeries. Regarding her

dental history, the patient also declared a thumb sucking habit sustained until 12 years of age. In addition, she had been under periodontal care for the last 20 years. Clinical examination showed a concave profile, procumbent lower lip and lip incompetence, increased mandibular facial height, and a deviated chin to the left on a skeletal Class III base. She had generalized mild marginal and papillary gingivitis with thin biotype and gingival recession. The smile arc was non-consonant with the lower lip. A slight maxillary occlusal plane cant (right side down) and a mild mandibular jaw asymmetry were also observed. Her malocclusion was complicated by an 8-10 mm open bite from molar to molar, posterior crossbite, 4 mm of negative overjet, and a severe maxillary and mild mandibular arch crowding. The maxillary dental midline coincided with the facial midline and the mandibular midline coincided with the maxillary midline. During physical examination, a deviation to the right side upon opening and a clicking sound on the left side upon closing were observed. However, the patient reported no pain



**Fig 2.** Pretreatment lateral cephalometric radiograph with tracing and panoramic radiograph.

except for an occasional soreness on the left side. During the next visit, extraoral and intraoral photographs and maxillary and mandibular impressions were taken along with the cone beam computerized tomography, from which the cephalometric and panoramic radiographs were subtracted (Fig 1).

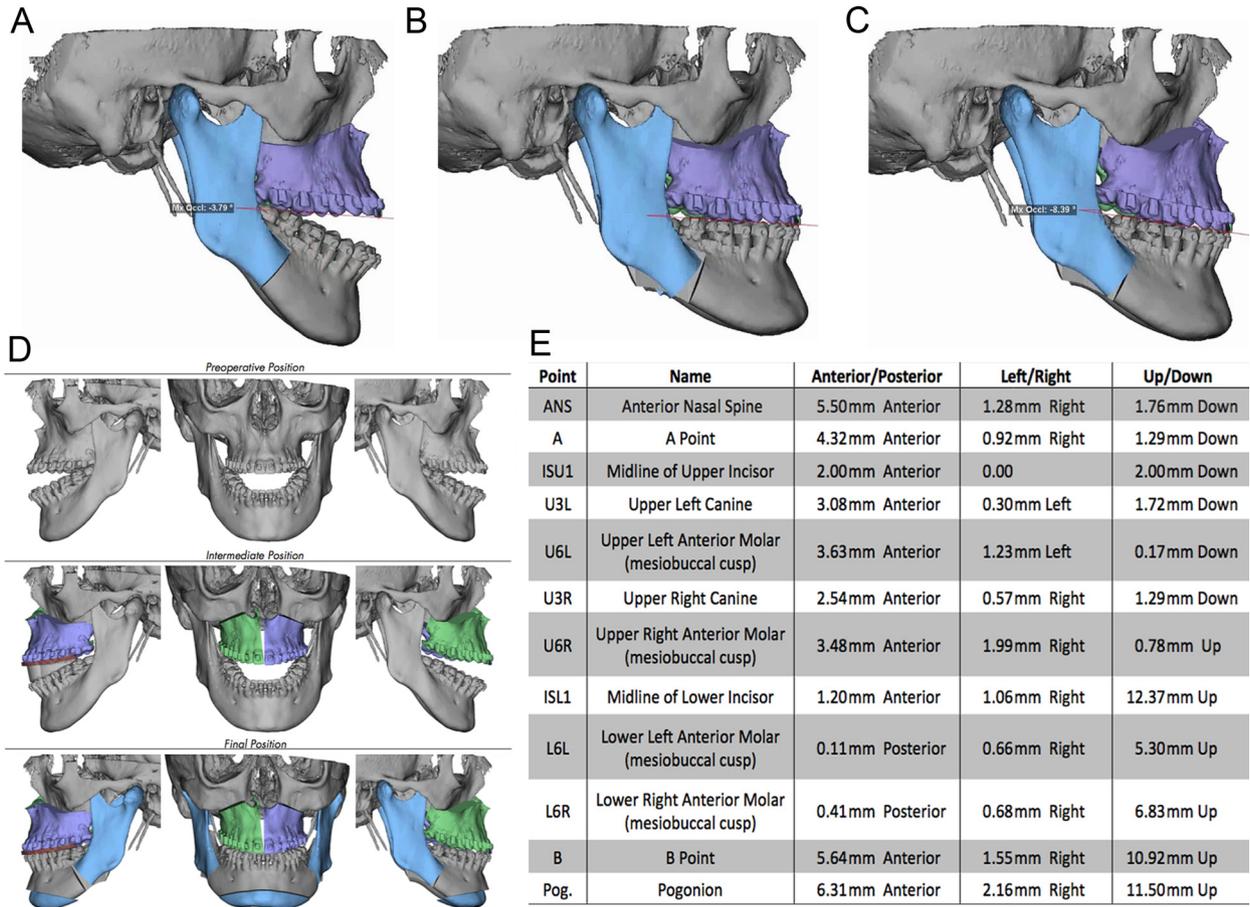
Dental casts showed an open bite with contacts only on the second and third molars. The first molars were in 1/2 Angle Class III on the left side and 3/4 step Class III on the right side. The panoramic radiograph showed that all the teeth were present, and the appearance of the temporomandibular joint was within normal limits. Lateral cephalometric analysis revealed skeletal and occlusal Class III deformity with ANB  $-0.8^\circ$ , Maxillomandibular Bisector (MMB) Wits appraisal  $-12.8$  mm, hyperdivergent growth pattern with increased mandibular plane angle (SN-MP  $45.3^\circ$ ), normal maxillary facial height, and increased mandibular facial height compared with total facial height. The relation of the upper and lower lips to the E-line was  $-7.5$  mm and  $0.7$  mm respectively (Fig 2). Cone beam computerized tomography showed no condylar resorption.

## TREATMENT PLAN

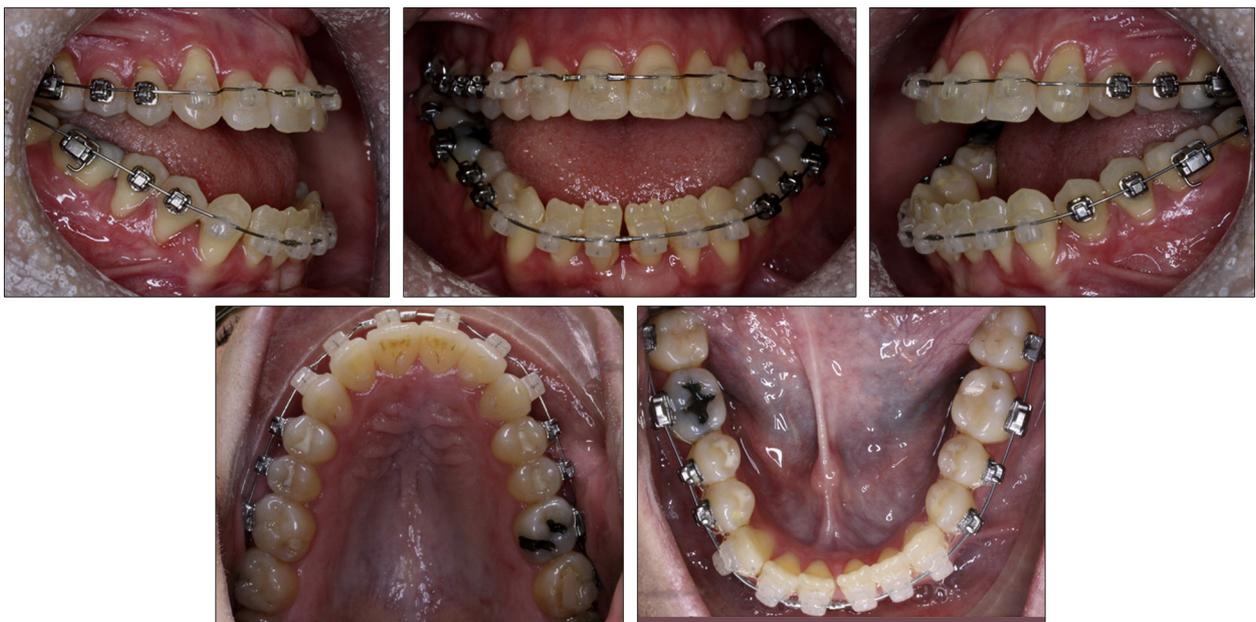
The main dental, skeletal, and soft-tissue treatment objectives for this patient were to (1) resolve the crowding in both jaws and correct the anterior open bite, (2) correct the skeletal base in all 3 planes of space by normalizing ANB, decreasing the mandibular plane angle and by forward movement and expansion of the maxillary jaw, and (3) harmonize the facial profile and thirds. After careful examination of the treatment alternatives, together with the patient, a nonextraction approach with maxillary and mandibular fixed appliances followed by bimaxillary surgery with the option of genioplasty was selected. Third molars were to be extracted at least 3-4 months before surgery.

The initial surgical plan was created from clinical evaluation of the smile esthetics.<sup>12,13</sup> The incisor shown at rest is a function of age and sex. For a youthful smile and in females, the incisor display should be increased.<sup>14</sup> For this patient, the maxillary incisors were designed to show 4 mm on lip rest for the best esthetic result. The vertical position of the posterior part of the maxilla was planned according to the first molar on smile. The smile arc concept involves not only the incisors and canines, but also the premolars and molars, the edge of which should follow the curvature of the lower lip.<sup>15</sup> For this, the slot of the molar bracket should be approximately at the middle of the buccal corridor to achieve a consonant smile arc. This information was input into and visualized in VSPOrthognathics (3D Systems) (Fig 3, A). Due to the notably obtuse gonial angle and the increased mandibular plane angle, the mere counterclockwise rotation of the mandible was deemed insufficient to close down the anterior open bite. The reason being that, the extensive rotational movement will lead to the overstretching of the major muscle ligament structures, resulting in a greater risk of relapse (Fig 3, B). Thus, although we originally designed to maintain the vertical position of the maxillary posterior segment; from an esthetics point of view, a compromise had to be made to reduce the difficulty of the orthognathic surgery and to ensure the stability of the results. Therefore, apart from the expansion and forward movement of the maxillary jaw, the inclination of the maxillary occlusal plane also needed to be adjusted by selective posterior impaction and anterior extrusion, in order to facilitate an initial autorotation of the mandibular jaw, augmented by bilateral sagittal split osteotomy and counterclockwise rotation (Fig 3, C-E).

The procedure would also bring the chin more forward, but this concern would be addressed by the setback genioplasty. Postsurgical orthodontic treatment was also planned to correct minor discrepancies. The



**Fig 3.** A, Preoperative position; B, Original virtual surgical plan; C, Adjusted virtual surgical plan; D, Adjusted virtual surgical planning workflow; E, Occlusal and bony anatomical landmarks and their summarized movements from preoperative position to simulated postoperative position.



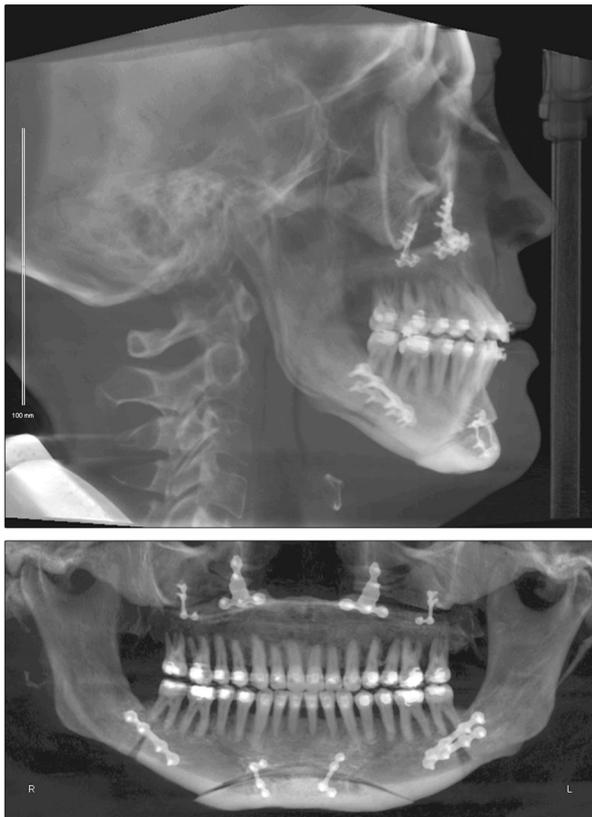
**Fig 4.** Initial appliance placement.



**Fig 5.** Extraoral and intraoral photographs before surgery.



**Fig 6.** (Top row) Intraoral photographs 2 weeks postsurgery. (Bottom row) Intraoral photographs after splint removal.



**Fig 7.** Postsurgical lateral cephalometric tracing and panoramic radiograph.

patient was supplied with all the information necessary to decide, she understood the benefits and risks of the treatment and signed an informed consent before the treatment was initiated. Furthermore, the patient was given the option of combining esthetic brackets in the front and metallic brackets in the lateral segments. Thus, self-ligating brackets were used (Damon system, Ormco, Calif): Damon Clear from canine to canine and Damon Q from first premolar to second molar in both arches. Postsurgical interarch settling was done with the aid of intermaxillary elastics.

### TREATMENT PROGRESS

Due to the periodontal issue, the patient was first referred to the periodontal department for evaluation and treatment. In the meantime, the patient was also diagnosed with hypothyroidism and a mild sleep apnea, but she was still determined to go through with the proposed treatment. Once the general and periodontal problems were under control, the maxillary arch was bonded and leveling was started with 0.018 CuNiTi (Fig 4). After 5 months, the mandibular jaw was also bonded and a 0.013 CuNiTi was placed. At the same

time, the wire sequence in the maxillary jaw was advanced to 0.014 × 0.025 CuNiTi. The open bite and the different occlusal planes were maintained to facilitate the surgical procedure. Before surgery, 0.019 × 0.025-in stainless steel archwires were placed in both arches. One year after the initial bonding, orthognathic surgery planning was discussed with the oral surgeon and the surgical splint was fabricated accordingly.

To facilitate the osteotomies, the final maxillary archwire was cut between the central incisors, and hooks were placed for interarch rubber band settling (Fig 5). It was planned to place a continuous archwire at the beginning of the postsurgical period to get better control for the final occlusal adjustment. Thirteen months after initiation of the orthodontic treatment, the orthognathic surgery was performed with the patient under general anesthesia. LeFort I osteotomy was performed from the posterior maxilla through the piriform rim. Interdental osteotomy was implemented between central incisors. Hence, the pterygoid planes were separated, and the maxilla was down fractured. A 3.5-mm expansion, 5-mm forward movement, and clockwise rotation by posterior impaction and anterior downward movement were done in the maxilla. The splint was then placed and the maxillomandibular fixation was performed. Four L-shaped plates were incorporated in the maxilla, one on either side on the nasomaxillary buttress and one on either side along the pterygomaxillary buttress. Sagittal split osteotomies were performed in the mandibular jaw on both sides and 11 mm of counterclockwise rotation of the mandibular body was achieved. The mandible was fixed using mono-cortical screws and plates. When the final occlusion was verified and found satisfactory, light elastics were placed. Toward the end of the surgery, setback genioplasty was performed, the chin was moved 4 mm backward and its position fixed with 2 plates, after which the patient was extubated without any complication. The patient was transferred to postoperative care unit and subsequently discharged after 2 days of post-op observation and care. She was given Norco elixir, Zofran, Robaxin, and guaifenesin as required for a standard orthognathic surgery (Fig 6, A).

Five weeks after the successful surgery, the splint was removed. Maxillary alignment along with the minor occlusal adjustments were started on 0.016 × 0.016 NiTi supplemented with a 0.36 stainless steel overlay arch to keep the expansion (Fig 6, B). Post settling was performed on rectangular TMA wires using rubber bands.

### TREATMENT RESULTS

Nineteen months after the initiation of orthodontic treatment, debonding was carried out. A mandibular



**Fig 8.** Posttreatment extraoral and intraoral photographs.

fixed retainer was placed from canine to canine and maxillary and mandibular Essix retainers were delivered to the patient upon removal. Facial, intraoral, and extraoral photographs, panoramic and lateral cephalogram, and dental impressions were taken for final records (Fig 7).

The posttreatment records show a more harmonious facial profile and balanced occlusion (Fig 8). The open bite was corrected, Class I molar and canine relationship, normal overjet, and overbite were achieved, the teeth were properly leveled and aligned, the maxillary and mandibular midlines were coincident with the facial midline. The soft-tissue profile of the patient was straight, and an esthetically pleasant smile arc was attained with lip competency and adequate gingival display. Although the maxillary posterior molar position was compromised for the purpose of the surgery, it was still within normal range and did not compromise the esthetics of the smile based on the posttreatment records.

Skeletally, ANB did not change significantly, MMB Wits appraisal increased (-9.5 mm), and SN-MP was

reduced to 37.4°. Furthermore, the soft-tissue concavity was decreased, and lip profile and facial height ratio were improved (Fig 9). The final outcome of the comprehensive treatment approach satisfied both functional and esthetic demands and at the same time the chief complaint of the patient was also addressed.

## DISCUSSION

Skeletal Class III treatment in itself is a challenging aspect of orthodontics but when combined with an open bite, it becomes even more so, since the majority of the treatment options for the latter involve a certain amount of mandibular counterclockwise rotation, which further worsens the sagittal component. While ANB is the most generally used cephalometric indicator of the severity of sagittal discrepancy between the maxillary and mandibular jaw, in open bite cases when the mandible is posteriorly rotated, along with the B point, this measurement by itself can be misleading. The validity of this measurement has already been questioned early on in the literature.<sup>16</sup> Thus, for this significant



**Fig 9.** Superimposition of initial and final lateral cephalometric radiographs.

open bite case, we used the MMB Wits appraisal to make a more precise determination of the sagittal jaw relationship.

One of the key factors in a successful combined orthodontic-orthognathic treatment is the accurate surgical planning. In this case, this was carried out by Three-dimension (3D) planning in the virtual surgical planning (VSP Orthognathics) workflow. This allows a better visualization of the process, more accurate measurements, and an easier communication between the orthodontist and surgeon. There were 2 types of mandibular rotation that occurred in correcting the anterior open bite of this patient: mandibular autorotation and counterclockwise mandibular osteotomy rotation. Autorotation occurs when there is impaction of the posterior maxilla that allows the mandible to automatically rotate around a rotation center that is the same as that in the mouth opening. In mild cases of anterior open bite, counterclockwise osteotomy can help to correct the open bite if the maxilla is in a good position. However, in the present case with a severe open bite, the degree of the counterclockwise mandibular osteotomy rotation required was deemed excessive based on the original surgical design. Thus, the maxillary plane angle had to be

adjusted to accommodate a more predictable surgical plan. This movement may be termed altering the pitch of the occlusal plane.

Surgical treatment of Class III often involves mandibular setback,<sup>17-19</sup> however, this patient was diagnosed with sleep apnea and such an intervention could lead to the worsening of this preexisting condition. Tselnik and Pogrel reported that, the airway narrows when mandibular setback surgery is performed.<sup>20</sup> Although the etiology of sleep apnea is still not clear, it is believed to be multifactorial, and this may very well be a contributing factor.<sup>21</sup> For this reason, no mandibular setback was planned for this patient and the esthetic correction of the chin prominence was solely achieved by the setback genioplasty.

After a two-piece maxilla, splinting is recommended to keep the transversal expansion. The recommended duration varies. In this case, the splint was left in place for 5 weeks. However, because of the postoperatively accelerated orthodontic tooth movement, which was attributed to the regional acceleratory phenomenon,<sup>22</sup> minor movement of the dentition might occur during this period. This should be kept in mind and, if necessary, light intermaxillary elastics can be used for a better retention.

In addition, orthodontists should also pay attention to the effect of using self-ligating brackets in the finishing stage. One of the drawbacks of this type of bracket is that, when used in combination with elastic chains, the rotation of the teeth tends to happen easily, which can result in difficulties in the final detailing of the occlusion and finishing. Avoiding or reducing the use of elastic chains during the postoperative period may help to prevent the undesired tooth movements.

## CONCLUSION

This case demonstrates the importance of multidisciplinary treatment planning and execution for patients having a complex malocclusion of skeletal origin. Close cooperation between the orthodontist and the oral surgeon is extremely important. We can make plans in the virtual surgical realm, based upon what we think is sound clinical and radiographic data, but in the operating room we might decide to do something else, for a number of defensible reasons. Factors such as esthetic design, occlusion, practicability, and long-term stability should all be taken into consideration when determining the actual surgical plan. Importantly, 3D virtual surgical planning can help us to understand the potential mistakes and allow us to make adjustments before we actually commit them.

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