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Two Different Approaches In Three-Dimensional Planning Of Orthognathic Surgery: Surgery First And Traditional Orthognathic Surgery

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Abstract

In individuals with completed growth development and Class III malocclusion, orthognathic surgery is inevitable for achieving ideal occlusion and facial aesthetics. In the treatment of orthognathic surgery, it has been a long-standing approach to plan orthognathic surgery using traditional two-dimensional cephalometric planning and model surgery after fixed orthodontic treatment, which allows for the decompensation of malocclusion to improve skeletal correction and position of the teeth ideally.

However, with advancing techniques, both the elimination of pre-surgical orthodontic treatment, which prolongs the treatment time and negatively affects the patient's psychology, through the Surgery First method, and the possibility of planning more accurate surgeries with three-dimensional virtual surgical planning have become widespread. In this case report, the treatment outcomes of two adult individuals with bimaxillary orthognathic surgery planned for skeletal Class III malocclusion using three-dimensional virtual surgical planning software will be presented, comparing the results achieved with both the traditional method and the Surgery First method.

Keywords: Orthognathic Surgery, Surgery First, Orthodontic Treatment, 3D Planning

Introduction

Class III malocclusions are generally characterized by abnormal projection of the mandible relative to the cranial base within the maxillo-mandibular complex. In addition to unaesthetic facial appearances, individuals with these malocclusions also experience functional and phonatory disorders. Syndromes, genetic factors, respiratory problems, environmental factors, as well as trauma, physical factors, and habits can be considered among the etiology.[1] It is known that Class III malocclusions show different prevalences depending on race, ethnic origin, and geographical regions.[2-4]

Generally, malocclusions classified as Class III can exhibit highly complex forms due to the involvement of vertical and transversal problems, similar to other malocclusions. Even differences in sagittal maxillo-mandibular configurations alone have a significant impact on the character of Class III malocclusions as well as on the method of treatment and stability. Proffit et al. reported that among individuals undergoing orthodontic-surgical treatment for Class III malocclusion, mandibular excess was present in 20%, maxillary deficiency in 17%, and both problems together in 10%.[5]

In individuals with Class III malocclusion during the developmental period, functional and/or orthopedic devices (FR-3, monoblock, face mask, chin cup, etc.) can be used to achieve extremely positive changes in both maxillo-mandibular and craniofacial structures. For adults with mild Class III malocclusion, camouflage treatment with fixed mechanics may be sufficient in only a small percentage of cases. However, in severe Class III malocclusion with both dentoalveolar and skeletal problems, as well as involvement of vertical discrepancies, orthognathic surgical treatment becomes inevitable. These types of malocclusions are often treated with maxillary, mandibular, or bimaxillary orthognathic surgery/orthodontic treatment combinations.[6-8] Additionally, orthognathic surgery can be performed either before orthodontic treatment or after orthodontic treatment. However, these complex cases require detailed diagnosis, careful and precise orthodontic treatment planning, successful orthodontic application, in addition to professional and precise orthognathic surgical planning, and successful surgical operation.

In traditional planning of orthognathic surgery, cephalometric radiographs showing the position of the maxillo-mandibular complex relative to the cranial base in two dimensions are used. Planning treatment based only on sagittal and vertical directions on these radiographs creates significant difficulties in individuals characterized with facial asymmetry and occlusal cant. The precision of impressions taken from individuals ready for surgery, the precision of laboratory procedures, the experience and manipulation ability of the physician performing the face-bow transfer, and the quality of splints significantly affect the success of orthognathic surgical operation.

On the other hand, when working on cone-beam computed tomography (CBCT) with three-dimensional (3D) customized technologies, multiple sections can be obtained, allowing the facial skeleton, soft tissue, and dental arches to be clearly distinguished in all three dimensions and evaluated. In this application, the positions of maxillo-mandibular structures relative to both the cranial base and each other can be planned separately and/or together.[9,10] Thus, error-free surgical planning and the production of perfect osteotomy lines and compatible splints positively affect treatment success.[11]

Another issue is that the worsening facial profile after decompensation before orthognathic surgery may adversely affect individuals who demand treatment due to aesthetic concerns both psychosocially and in terms of cooperation.[12] Over time, the idea of surgery first was put forward in order to ensure the individual's compliance with the treatment. This application eliminates the pre-surgical orthodontic preparation stage, quickly achieves an ideal aesthetic appearance, and then continues with orthodontic treatment. This increases the individual's co-operation and satisfaction.8 Additionally, it provides a significant advantage in terms of shortening the total treatment duration by eliminating the pre-orthodontic treatment process.[13]

In this case presentation, the treatment outcomes of two separate adult individuals with Class III malocclusion and asymmetry, one undergoing surgery first application (Case 1) followed by orthodontic treatment, and the other undergoing traditional decompensation followed by orthognathic surgery, both planned in 3D virtual surgery, will be presented.

Case 1

A 20-year-old adult male with skeletal Class III malocclusion due to prognathic mandible, facial asymmetry, negative overjet (-3.4 mm), and insufficient overbite (0.5 mm), with a prominent chin tip appearance and concave profile, was identified. Angular and dimensional cephalometric measurements of the individual are provided in Table 1. When the analyses and clinical findings were evaluated together, it was decided to apply bimaxillary orthognathic surgery to the individual to correct maxillo-mandibular disharmony and achieve facial aesthetics and functional occlusion.

Table 1. Cephalometric Measurements of Case 1. T0: Pre-treatment, T1: Post-treatment.

	Cephalometric Analysis	T0	T1
Hard Tissue Analysis	SNA (˚)	82	85
	SNB (˚)	85	85
	ANB (˚)	-3	0
	NA Perp-A (mm)	3	6
	NA-Perp Pog (mm)	11	13
	GoGN-SN (˚)	35	32
Soft Tissue Analysis	Upper Lip -S Line (mm)	0	0
	Lower Lip- S Line (mm)	4	1
	Soft Tissue Convexity (˚)	134	138
	Nasolabial Angle (Col-Sn-UL) (˚)	99	109
Dental Analysis	U1-NA (mm)	4	4
	U1-NA (˚)	27	31
	L1-NB (mm)	4	3
	L1-NB (˚)	24	12
	IMPA (˚)	81	73
	Interincisal Angle (˚)	133	137
	Overjet (mm)	-3	2
	Overbite (mm)	0.5	1

Stone models were taken to assess whether the individual with mild crowding and minimal decompensation requirement was suitable for the surgery first protocol. For surgery first application, there should be minimal dental crowding, straight or mild curve of Spee, minimum transversal directional problems, and at least 3-point contact in occlusion. The dental models of the individual were evaluated, and it was observed that they were suitable for the surgery first protocol, and it was decided to proceed with orthodontic treatment after surgery. Pre-treatment photographs are shown in Figure 1.

Figure 1. Pre-treatment extraoral and intraoral photographs.

For three-dimensional virtual surgical planning of orthognathic surgery, intraoral scanning records (Trios 3Shape□) and CBCT images were obtained from the patient. Both 2D and 3D detailed analyses were performed using the virtual surgical planning program (NemoStudio20□), and based on the clinical examinations, it was decided to apply bimaxillary orthognathic surgery to the individual characterized by midface deficiency and mandibular prognathism.

Using the 3D virtual surgical planning program, the maxilla and mandible were isolated, and virtual surgical osteotomies were created. Because of the absence of gummy smile, 4 mm maxillary advancement along with only 1 mm total impaction and 1 mm rotation (yaw) movement for midline deviation were planned. In the mandible, following spontaneous anterior autorotation according to the new position of the maxilla, 4 degrees of counter-clockwise corpus rotation and 4 mm setback were planned to achieve Class I occlusion and appropriate overjet (Figure 2). Intermediate and final splints were designed based on the existing maxillomandibular positions and produced using FormLabs□ 3D printers (Figure 3.) On the day before the operation, 0.022” Slot Roth brackets and 0.016”x0.022” SS archwires were placed passively in the mouth, and the fit of the splint was checked.

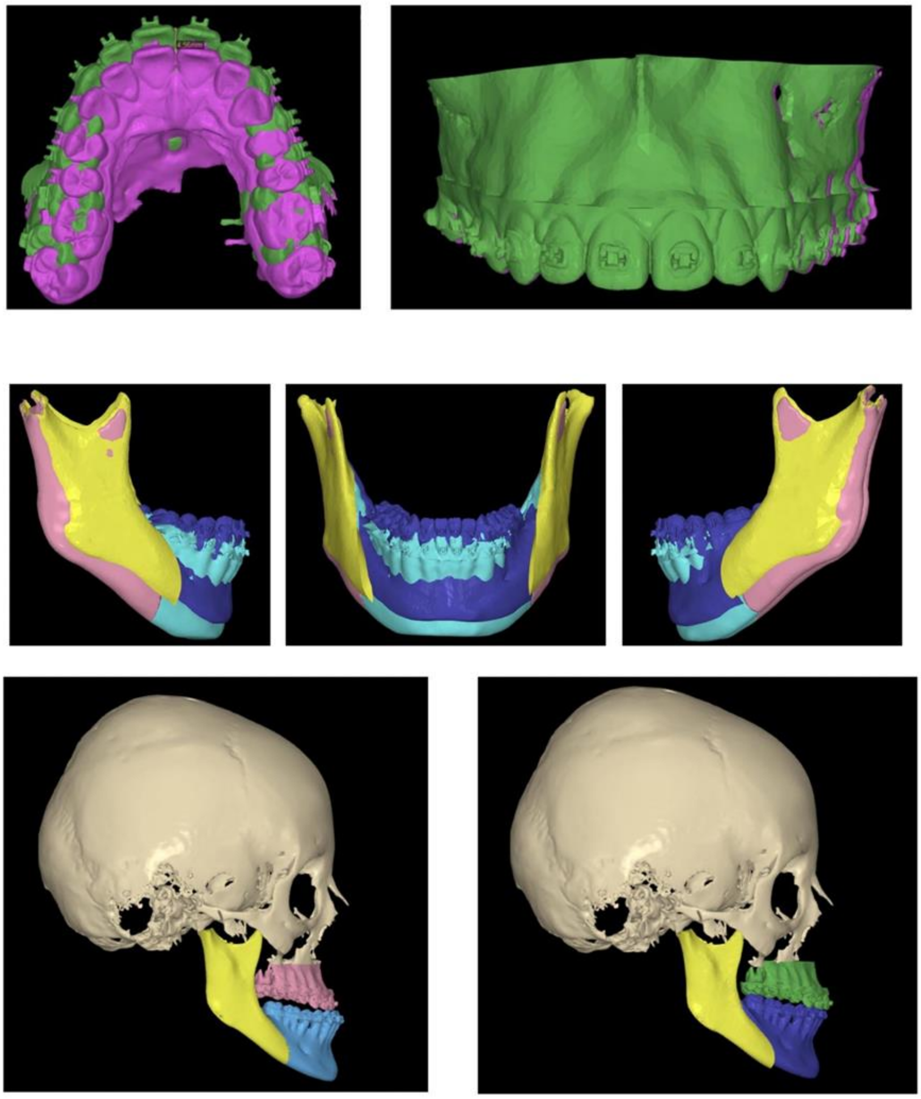

Figure 2. 3D Virtual Surgical Planning of Case 1.

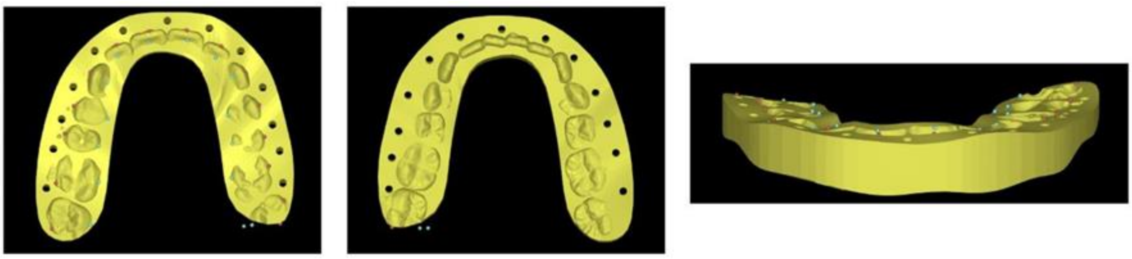

Figure 3. Splint Design of Case 1

Four intermaxillary fixation (IMF) screws were applied to both the maxilla and mandible, both during the operation to place the splints and to ensure stability after the surgery. Following bimaxillary surgery, ¼” - 8 oz vertical and Class III elastics were applied from the

IMF screws. The elastics were changed every other day by the orthodontist for the first ten days. Then, a heavy elastic protocol was applied for 1 month with weekly check-ups.

Three weeks after the surgical operation, to accelerate tooth movement, increase treatment speed and effectiveness, thick archwires (0.016”x0.022”) were removed, and leveling stage was initiated with 0.014” Ni-Ti archwires. The patient was continued to use intermaxillary elastics to ensure occlusion, and final occlusion was achieved eight months after the surgical operation, and the treatment was terminated. The treatment lasted a total of 8 months. Extraoral and intraoral photographs (Figure 4), comparative cephalometric radiographs and superimpositions (Figure 5) obtained after treatment are shown.

Figure 4. Post-treatment Photographs of Case 1.

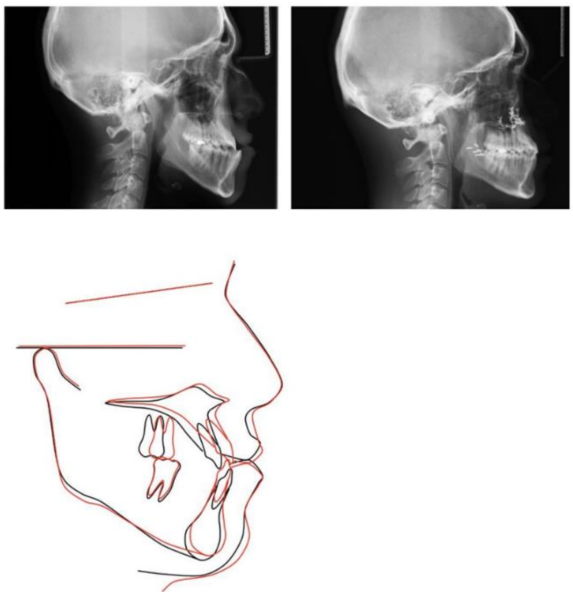

Figure 5. Cephalometric Radiographs and Superimpositions of Case 1.

At the end of the treatment, there was a 3° improvement in the ANB value due to the angular change of the maxilla and mandible relative to the cranial base, a 5° decrease in the GoGN-SN angle due to mandibular counter-clockwise rotation and setback, and a 3 mm improvement in lower lip protrusion, a 10° improvement in nasolabial angle (Col-Sn-UL), 5.5 mm improvement in overjet, and 0.7 mm improvement in overbite (Table 1).

Case 2

An adult female aged 21 presented with a combination of retrognathic maxilla and prognathic mandible, resulting in skeletal Class III malocclusion and asymmetry, negative overjet (-3 mm), and deep bite (4 mm), along with a prominent chin and concave profile (Table 2). Upon evaluation, due to both facial aesthetic issues and severe maxillo-mandibular disharmony, orthognathic surgical treatment was deemed necessary. Pre-treatment photographs of the individual are shown in Figure 6.

Table 2. Cephalometric Measurements of Case 2. T0: Pre-treatment, T1: Post-treatment

Cephalometric Analysis T0T1.

	Cephalometric Analysis	T0	T1
Hard Tissue Analysis	SNA (˚)	78	82.5
	SNB (˚)	86	82.5
	ANB (˚)	-8	0
	NA Perp-A (mm)	0	5
	NA-Perp Pog (mm)	12	11
	GoGN-SN (˚)	34	33
Soft Tissue Analysis	Upper Lip -S Line	-3	-1
	Lower Lip- S Line	4	-1
	Soft Tissue Convexity (˚)	145	140
	Nasolabial Angle (Col-Sn-UL) (˚)	83	85
Dental Analysis	U1-NA (mm)	4	4
	U1-NA (˚)	23	30
	L1-NB (mm)	1	2.5
	L1-NB (˚)	8	21
	IMPA (˚)	66.5	83
	İnterincisal Angle (˚)	157	129
	Overjet (mm)	-3	2
	Overbite (mm)	4	1

Figure 6. Pre-treatment Photographs of Case 2.

Severe maxillary crowding was observed in the individual, and there was no space for the left canine, but tooth extraction was not anticipated to avoid maxillary collapse. Instead, leveling was initiated with 0.022” slot Roth brackets and 0.014” Ni-Ti archwires, and initially, space was created for the canine tooth using open coil springs to maintain arch integrity. Occlusion was periodically checked by taking plaster models. Class II elastics were used for decompensation of malocclusion. Post-decompensation photographs of the individual are presented in Figure 7.

Figure 7. Photographs After Decompensation Treatment of Case 2.

To enable orthognathic surgery planning using a 3D virtual surgical planning program (NemoStudio20), intraoral scanning records (3Shape-Trios 3) and CBCT images were obtained from the patient. Both 2D and 3D detailed analyses were performed in the program, and based on the clinical examinations, it was decided to perform bimaxillary surgery in the individual characterized by midface deficiency and mandibular prognathism. Through the 3D virtual surgical planning program, maxilla and mandible were isolated, and virtual surgical osteotomies were created. In the maxilla, 6 mm advancement, slight yaw rotation with 0.5 mm shift to the right at midline, and 2 mm anterior maxillary impaction were planned to eliminate the existing gummy smile when the maxilla was advanced. In the mandible, following anterior otorotation based on the final position of the maxilla, 3 mm setback on the right side and 6 mm setback on the left side were planned to correct asymmetry. Intermediate and final splints were designed based on the existing maxillomandibular positions and produced using FormLabs® 3D printers. The surgical planning is presented in Figure 8.

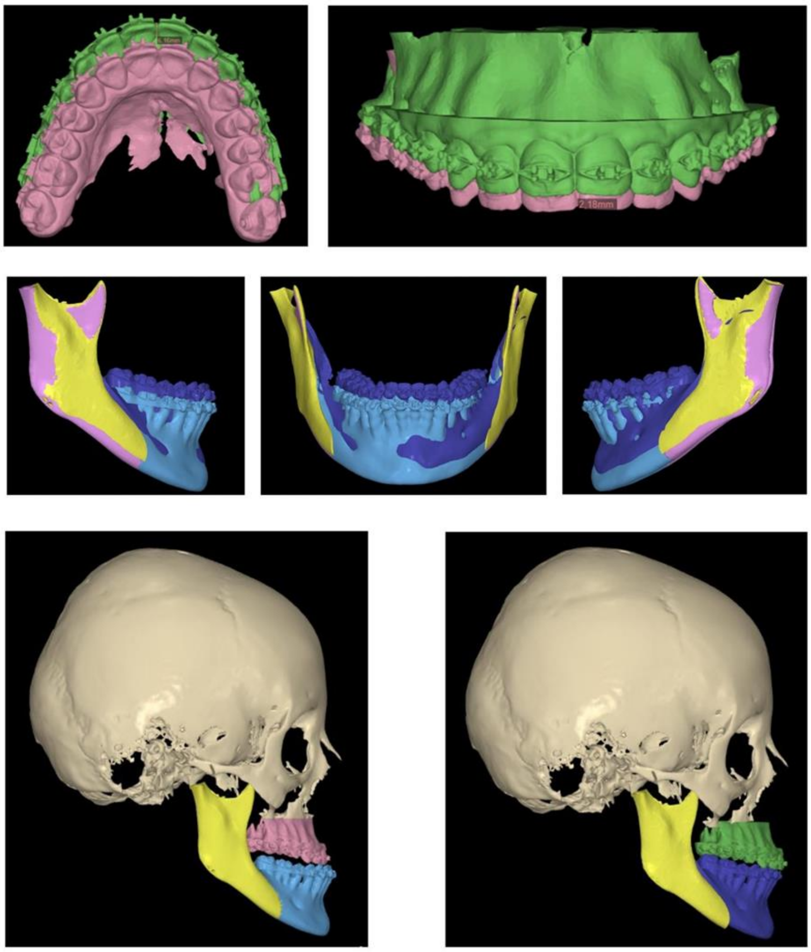

Figure 8. 3-D Surgical Planning of Case 2.

On the day before the operation, 0.017”x 0.025” SS arch wires were applied. To ensure both the placement of splints during surgery and postoperative stability, 4 intermaxillary fixation (IMF) screws were applied in both maxilla and mandible. Following the operation, ¼”- 8 oz vertical and Class III elastics were applied. The elastics were changed every other day by the orthodontist for the first ten days. Then, a heavy elastic protocol was applied for 1 month with weekly check-ups. After 8 months of the operation, dental occlusion was stabilized and settled into ideal occlusion, and orthodontic treatment was completed. The treatment lasted a total of 26 months.

Post-treatment extraoral and intraoral photographs are provided in Figure 9; comparative cephalometric radiographs and superimpositions are presented in Figure 10.

Figure 9. Post-treatment Photographs of Case 2.

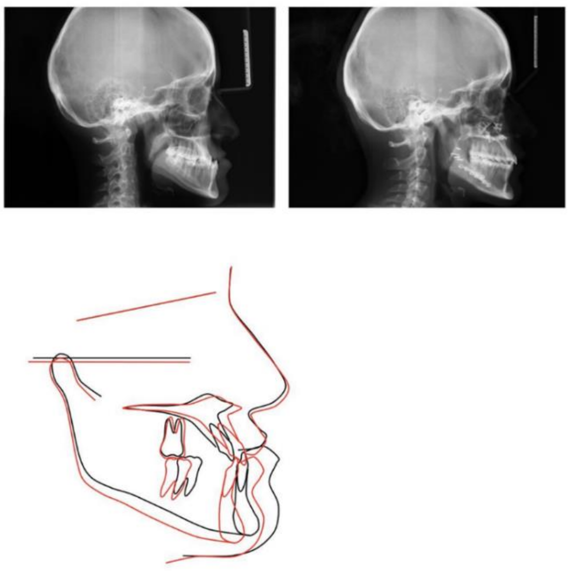

Figure 10. Cephalometric Radiographs and Superimpositions of Case 2.

At the end of treatment, there was an 8° improvement in ANB value due to the new position of the maxillo-mandibular complex. A decrease of 1° in GoGN-Sn angle, 1 mm retrusion in the lower lip, and a 2° increase in nasolabial angle were observed. Dentally, there was a 15° improvement in IMPA, 28° increase in interincisal angle, 5.5 mm improvement in overjet, and 3 mm improvement in overbite. (Table 2).

Discussion

Poulton et al. observed cases operated without any orthodontic treatment, noting that the amount of overjet restricts mandibular movements during surgical operation, emphasizing the importance of proper alignment of upper and lower incisors with the maxillo-mandibular base for achieving an ideal surgery and sufficient mandibular set-back.[14] The idea of orthodontics first followed by orthognathic surgery became popular in the 1970s; however, the disadvantages of this approach include worsening of facial aesthetics and quality of life during and after decompensation.[15]

Nagasaka et al1[6] recommended Surgery First approach, which became preferable due to factors such as early aesthetic improvement, increased cooperation of individuals whose physical appearance improved, and accelerated dental movements.[9,10,11,16] The surgery-first approach requires minimal dental crowding, straight or mildly curved Spee's curve, minimal transverse problems, at least 3-point contact in occlusion, and minimal decompensation, but traditional methods are applied when this is not possible.

The main disadvantages of the traditional method include worsening of facial aesthetics following exacerbation of existing skeletal problems, deterioration of cooperation, decreased desire for treatment, the uncertainty of pre-surgical orthodontic treatment duration, and the length of total treatment time.[16,17] Hernandez-Alfaro et al[18] reported in their study that individuals who underwent surgery first showed complete aesthetic and functional recovery 9 months after surgery, along with a significant increase in their self-confidence.

Yu et al[19] reported in their study that the total treatment duration was approximately 14-19 months when surgery first was performed, and dental movements accelerated after surgery compared to individuals who underwent orthodontics first. Regional Acceleratory Phenomenon

(RAP) increases periodontal movements for 3-4 months after surgery, accelerating dental movements. However, Yang et al[20] stated that when comparing stability, effectiveness, and aesthetic results between surgery first and traditional methods, the results were similar.

For the surgery-first approach, the clinician's experience must be excellent, and the condition of the case must be thoroughly evaluated. Individuals suitable for the "surgery first" technique are those characterized by mild to moderate crowding without significant deep or open bite, a straight-to-mildly curved Spee's curve, coordinated upper and lower intercanine widths, and upper and lower incisors positioned with appropriate inclination to the basal bone.[18,21,22] However, individuals with severe facial deformities or asymmetries, advanced maxillomandibular discrepancies, disruption of centric relation and occlusion due to abnormal eruption of second molar teeth, or risk of compromising the stability of postoperative incisor positions are not suitable cases for the Surgery First approach.[18,23,24]

The first advantage of the surgery-first approach is that the individual achieves a good aesthetic appearance without waiting for the decompensation process. The second advantage is that tissues adapt to the regenerative process more quickly due to RAP, leading to accelerated dental movement.[25]

Bimaxillary osteotomy is a widespread but complex surgical procedure requiring proper planning and operation. Factors such as correct intervention, timing, and cost are crucial considerations in bimaxillary surgery.[26,27] Firstly, in the 1980s, an anatomical replica of the skull was created using computerized tomography, and this technology has evolved into modern 3D printing techniques over time.[28] It has been observed that splints made with virtual simulation and 3D printing facilitate treatment planning and implementation compared to splints made with standard two-dimensional films and attached to an articulator, resulting in better outcomes.[29,30]

Findik et al. reported in their prospective study that both orthognathic surgical approaches positively affected patients' psychosocial and quality of life aspects due to their contributions to facial and profile appearance. However, they found that the surgery-first approach, by addressing the patient's main complaint of non-aesthetic facial and profile appearance in the early stages of treatment, led to progressive improvement in psychosocial and quality of life aspects, as well as a greater decrease in the level of depression.[31]

The cases presented in this study were planned in a three-dimensional virtual environment using CBCT and NemoStudio20 software to achieve the most compatible position of the maxilla and mandible with the cranial base. To correct dentofacial discrepancies: in the first case, surgery first was performed followed by orthodontic treatment, effortlessly resolving the existing asymmetry with the support of 3D planning. Although cephalometric analysis findings suggested only mandibular excess, hence according to McNamara analysis and clinical evaluation the midface depression was noticeable, maxillary advancement was deemed appropriate along with mandibular counter-clockwise rotation and mandibular set-back to avoid potentially narrowing the airway and exerting pressure on the carotid sheath. Initially, esthetics and profile improved, increasing the individual's desire for treatment and cooperation, while dental movements accelerated due to the Regional Acceleratory Phenomenon (RAP) following Surgery First, leading to faster attainment of the final outcome. However, due to surgery being performed first, movements of the maxilla and mandible were restricted. The fixed orthodontic treatment process concluded in a shorter time than expected, achieving not only a functional occlusion but also a successful esthetic profile and facial appearance. In the second case, orthodontic treatment was initially applied followed by decompensation, then double-jaw surgery was performed. It was observed that cooperation and compliance decreased during the treatment course, and concurrently, aesthetic concerns increased due to the exacerbation of the anomaly with decompensation.

Conclusion

The existing asymmetry was easily manipulated with 3D planning support. Additionally, it was observed that in individuals who underwent surgery traditionally, the maxilla and mandible could be more easily manipulated during the operation because of the proper decompensation of the dental arches, resulting in achieving an optimized functional occlusion and successful esthetic profile and facial appearance in an optimal timeframe.

The cases presented in this study were planned in a three-dimensional virtual environment using CBCT and NemoStudio20 software, achieving the most compatible position of the maxilla and mandible with the cranial base. To correct dentofacial discrepancies: in the first case, surgery first was performed followed by orthodontic treatment, while in the second case, orthodontic treatment was initially applied followed by decompensation and then double-jaw surgery. It is highlighted at the literature that the patient treated with Surgery First completed the total treatment duration in a short period of 8 months, due to both the rapid treatment process and the rapid improvement in profile, treatment was maintained with extremely high motivation. In both patients, orthognathic surgery was successfully applied with high accuracy thanks to three-dimensional virtual surgical planning, but Surgery First provided a significant advantage in terms of shortening the treatment duration.

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