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Original Research Article

A modified sagittal split osteotomy: description of technique

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Abstract – The mandibular ramus bilateral sagittal split osteotomy (BSSO) is the common approach in orthognathic surgery; however, this design has some limitations to achieve a good definition in the angle of the jaw in Class II patients with a decreased posterior facial height. This paper aims to show a novel modification and its technic description of the conventional BSSO which increases the vertical length of mandibular ramus and angle, in two patients with a similar diagnosis with a one-year follow-up. In conclusion, modified sagittal split osteotomy is the result of the conjunction of two techniques (BSSO and chin wing osteotomy), that is useful in patients who benefit from improvement in the projection of the mandible angle and increase in posterior facial height. Future studies involving long-term follow-up are needed to evaluate the permanence of these results.

Introduction

Orthognathic surgery is a changeful technique, where several designs can be used to achieve specific facial and occlusal targets. The bilateral sagittal split osteotomy has become the standard mandibular surgery for the treatment of those deformities, it is the most common surgical procedure for displacing the jaw in the three planes of the space. The first design was published by Trauner and Obwegeser in 1955 [1–3]. The design has had several modifications such as Dal Pont in 1961, Hunsuck in 1968, Bell in 1977, Epker in 1978, and recently by Wolford in 1995 [4–7]. Besides some researchers that have shown slight modifications to the original design, one such example is high oblique sagittal split osteotomy by Paulus in 2013 [8].

The mandibular ramus sagittal split osteotomy is the most popular procedure for repositioning the mandible in orthognathic surgery. A review of the design was described by Wolford in 2015, A medial mono-cortical osteotomy above the lingula and extending posteriorly to it, A cut down the ascending ramus stopping distal to the second molar followed by a horizontal cut 8–10 mm below the alveolar bone crest, finally a vertical mono-cortical osteotomy from distal of the second molar perpendicular to the inferior border of the mandible, with the cut extending through the lingual cortex and adding an osteotomy of the inferior border [4]. Thus, aiming to increase bone interface between segments, reduce unfavourable fractures, have better control of condylar position in the proximal segment, and also allowing to perform counter-clockwise rotations and advancements with ease.

Due to the versatility of BSSO, surgical planning needs to take into consideration all possible facial manifestations of jaw placement as well as osteotomy design in concordance with presurgical facial and occlusal analysis; amongst these, facial height, posterior and anterior, and the relationship between them, can change significantly the projection of pogonion, mandibular angle and jawline, thus, recent literature suggests orthognathic surgery focused on modification of planes and rotation of maxillomandibular complex can improve aesthetic results in patients [9].

The principal use of this technique is to increase the projection of the angle of the jaw and pogonion, as well as the ramus height. Class II patients with decreased posterior facial height, increased posterior mandibular plane, and hyperdivergent growth pattern take the greatest benefit from this technique. In addition, introducing counter-clockwise rotation of the distal fragment as the key to exert this purpose (Figs. 1–3). Therefore, this article aims to describe a novel modification to conventional BSSO, its indications, limitations, advantages, and disadvantages, as well as present two cases in which the procedure was successfully used.

Methodology

The modification design was performed in two different patients with similar facial and oclusal characteristics, the surgical planning was done using a 3D planning software

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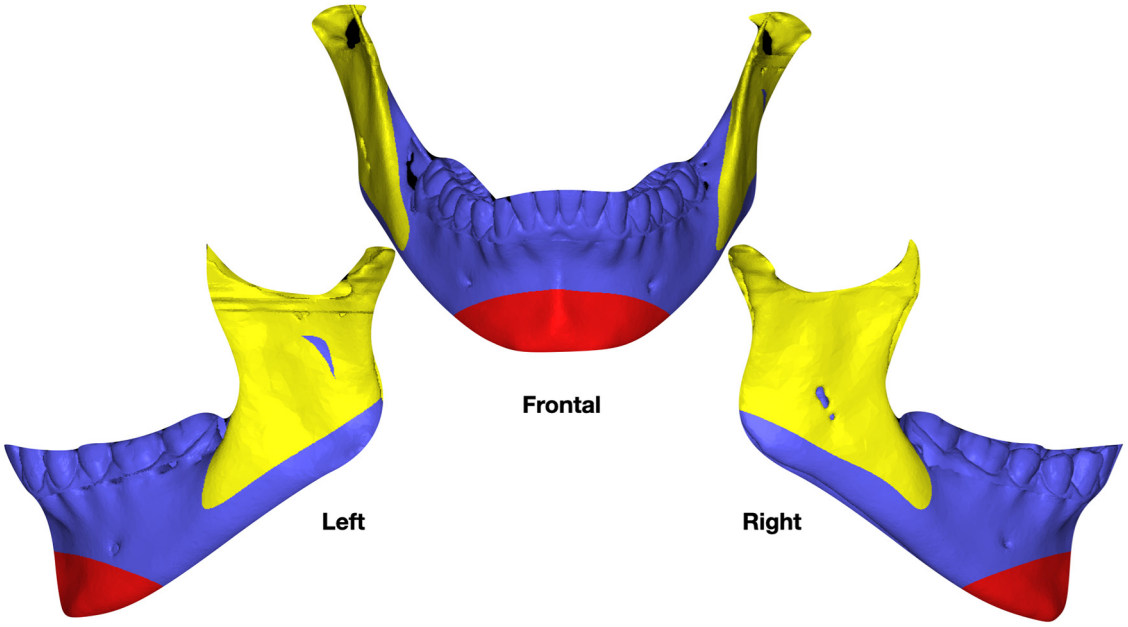

Fig. 1. Design of bilateral osteotomy sagittal split modified (Frontal view, Left view, Right view).
*Digital Images have been taken in NemoStudio, NemoFAB, Version 2019.

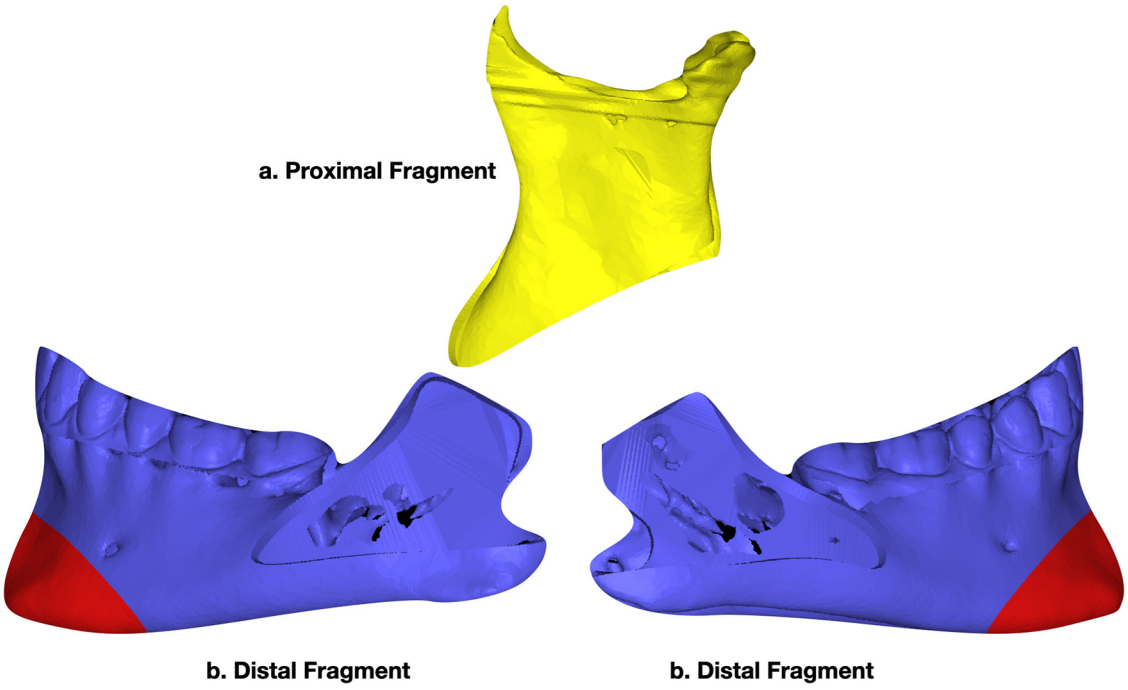

Fig. 2. (a) Proximal fragment (yellow), (b) Distal fragments (purple).
*Digital Images have been taken in NemoStudio, NemoFAB, Version 2019.

(NemoStudio, NemoFAB, Version 2019); two measures were taken in three different moments in time, first one from the Deepest point on the sigmoid notch (R3) to the lowest border of jaw angle (LM), and the second one measured from R3 to the highest point of the antegonial notch. These were measured in the preoperative, in the virtual planning, and at one year postoperative to compare.

Technical note

Preoperative assessment

Clinical examination that carries on with diagnose of lacking mandibular angle projection and the usual clinical checklist for orthognathic surgery is necessary, also facial photographs or facial scanning are needed to run a good diagnosis, besides,

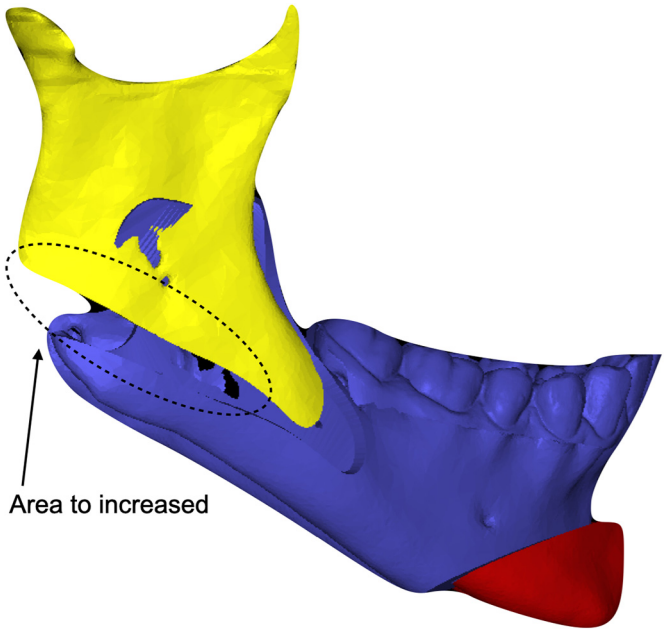

Fig. 3. Area to increase ramus, and projection of angle mandible.
*Digital Images have been taken in NemoStudio, NemoFAB, Version 2019.

Table I. Indications and limitations of modified bilateral sagittal split osteotomy (BSSOM).

Indications	Limitations
Class II patients with hyperdivergent growth pattern	Distance between basal mandible to IAN
Patients with decreased mandibular ramus height	Thin ramus
Loss of jawline definition	No contact points in canine and incisors
Heaviness in the lower third of the face	
Round face	–
Patients with non-active idiopathic condylar resorption	

Medical axial tomography or Cone-beam completes radiological assessment to design this osteotomy and estimate the position of the inferior alveolar nerve (IAN). Indications and limitations to this technique are listed in Table I.

Surgical procedure and technique description

This technique is performed under general anaesthesia. The patient, placed in supine position, is intubated with a nasotracheal tube. Incision for conventional sagittal split is performed over the anterior mandibular border. The mucosa, submucosa and muscle incisions are made by a surgical scalpel and electric scalpel. Subperiosteal dissection is proceeded basally to the mandibles angle, the first molar, and the lingual cortex of the ramus until the lingula is properly visualized.

The osteotomy can be performed using either piezotome tips or surgical reciprocating and oscillating saws, 702 burs are used for the initial cut which is the same to conventional sagittal split, this is made horizontally on the lingual cortex right above the lingula in the anterior two-thirds of the ramus, the osteotomy is continued with an oblique cut down the ascending ramus' anterior cortex stopping distal to the first molar, where a vertical cut is made down the buccal cortex and stopped right below the IAN canal, then a new horizontal monocortical cut is made in the external cortex of the mandible parallel to the basilar border and right below IAN canal towards the posterior border of the ramus, similar to basilar osteotomy described by Triaca in 2010 [10]. The surgical saw is slightly inclined downwards and inwards in order to avoid the IAN, this cut is stopped right at the ante-gonial notch area (Fig. 1–3). Then a bicortical horizontal osteotomy is performed 5 to 8 mm above the basilar border of the mandibles angle, starting at the posterior border of the mandible in a posteroanterior direction to unify the osteotomies at the ante-gonial notch area where the previous cut was left [11]. The split is completed using osteotomes as conventional.

Due to the similar behaviour of the osteotomy with conventional sagittal split and given that they share almost the same contact bone area, the surgeon has several options to provide rigid fixation like plates with monocortical screws, plates with bicortical screws, only bicortical screws, or a combination of plates and additional bicortical screws. To our knowledge, three bicortical screws are enough to achieve a correct rigid fixation.

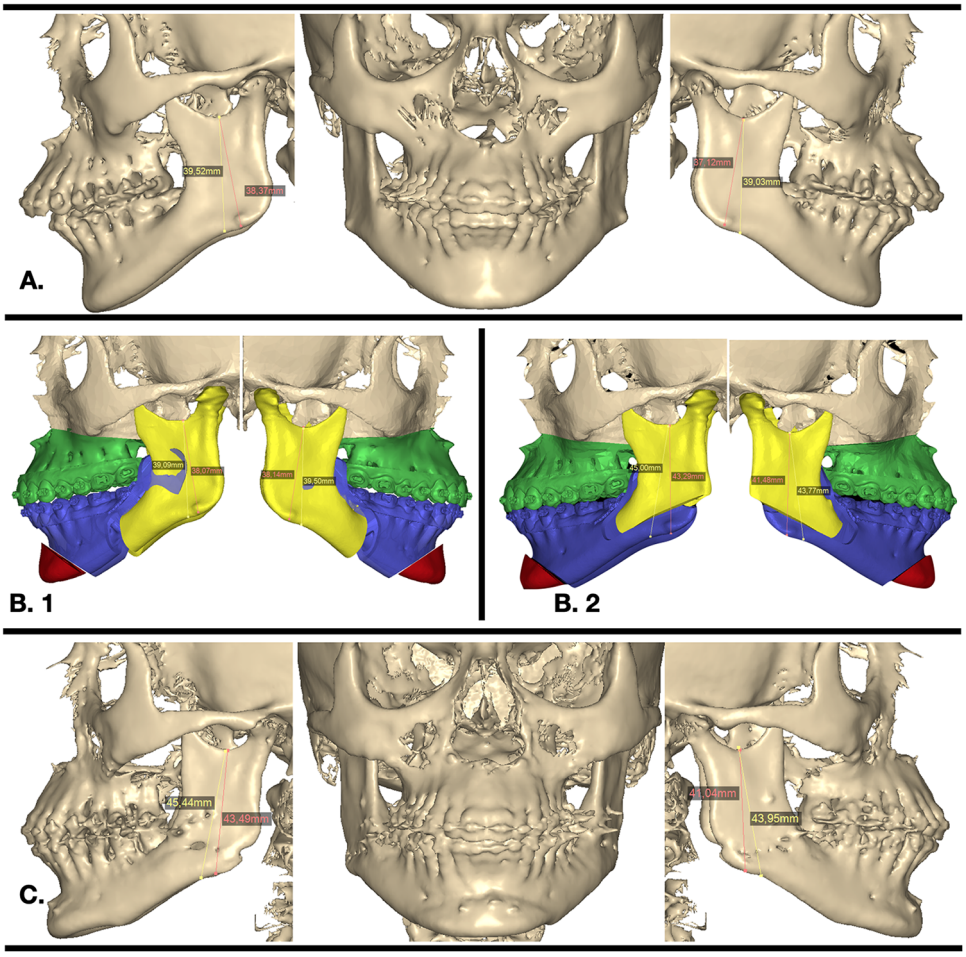

Fig. 4. 3D reconstruction; A. Before surgery, measure (R3 to the lowest border of jaw angle "red", R3 to antegonial notch "yellow"), B1. Surgical Planning without osteotomy modification (NemoStudio, NemoFAB, Version 2019), B2. Surgical Planning with BSSOM, C. Follow-up 1 Year.

The pillars of this osteotomy are counter-clockwise rotation of distal fragment creating a gap that increases the posterior ramus height; therefore, posterior open bite should be present after surgery to enhance a better expression in the mandibular angle. Occlusal contact points on canine and incisors, and in some cases also on firsts premolars, will provide the support of the new temporary occlusion. The patients must start orthodontic therapy with vertical elastics immediately after surgery using 3/16″ 3 Ounces to promote posterior teeth extrusion, to achieve this, the patients must have a light orthodontic arch wire to allow it, ideally not greater than a stainless steel 0.016″ – 0.016″ wire.

Case presentation

In 2018, two female patients, patient 1 being 22 years-old and patient 2 being 39 years-old, were treated with the same protocol. They both presented with skeletal and dental Class II, hyperdivergent growth pattern, with clinical temporomandibular joint (TMJ) crepitus but no articular pain and no functional limitations, in the radiological analysis they showed flattening and erosion of both condyles but had no progression of their malocclusion within the last two year which is why they were diagnosed with inactive bilateral condylar resorption. Patient 1 presented with a preoperative oral aperture of 35 mm, an overjet of 5 mm and an overbite of 0%, while patient 2 presented with a preoperative oral aperture of 38 mm, an overjet of 4 mm and an overbite of 10%.

The protocol included a presurgical orthodontic treatment of twelve months for levelling and alignment, followed by the modified bilateral sagittal split osteotomy BSSOM previously described (to achieve advancement and counter-clockwise rotation of the mandible), advancement and vertical impaction LeFort I osteotomy, advancement chin osteotomy, and bilateral TMJ meniscopexy (following Wolfords protocol for Class II patients with inactive bilateral condylar resorption) [12]; they were left with posterior open bite to be corrected after surgery. Surgical 3D planning was done in NemoStudio, NemoFAB, 2019 Version. In both patients, the downward movement of the jaw angle was more than 4 mm on each side. However, it depends on the amount of open-bite left after surgery (Fig. 4). The facial characteristics and the occlusion pre- and post-surgery of

Fig. 5. Patient one: A, C. Presurgical (Front and right profile view) and occlusion (Left, Front and right view), B, D. Postsurgical (Front and right profile view) and occlusion (Left, Front and right view) 1 year postsurgical.
*Osteotomy Lefort I, BSSOM, osteotomy chin, and meniscopexy TMJ.

patients are shown in Figures 5 and 6. In both patients, an oral aperture of 42 mm, an overjet of 1.5 mm and an overbite of 15% was achieved after surgery.

A follow-up cone-beam one year after surgery was performed, the results of the measurements taken in the pre-operative, the surgical planning and the one-year post-operative are shown in Table II. And the differences between these measures are shown in Table III, making evident the average increase in posterior facial height of 4.45 millimetres as planned for each patient, also reflected in the better gonial projection they show in the control photographs. Neither one of the patients reported sensitivity disturbances after the one-year follow up.

Discussion

Bilateral sagittal split osteotomy is probably the most adaptable osteotomy in the mandible for several cases of dentofacial anomalies, the conventional design applies for almost all cases of orthognathic surgery; however, this type of osteotomy has some limitations, among them, the impossibility to increase the projection of the gonial area and the length of the ramus; that being said, the described modification of sagittal split osteotomy can be used in specific cases such as forward movement, or counter-clockwise rotation of distal mandible segment in Class II and Class I patients that require changes in the gonial area. On the other hand, changes in the TMJ and condylar position may depend solely on the osteotomy technique, however, the current literature has not reached a consensus about how to control the proximal fragment position during its fixation, therefore, this position is still pending on the surgeons expertise [13–15].

The vertical ramus osteotomy (VRO) and BSSO can provide slight changes in the gonial angle, this angle is an important part of harmonious facial contour, therefore when both techniques are used to get a mandibular setback, theres a reduction in the gonial angle, although the VRO technique can have a significantly greater decrease in gonial angles after setback [16]. Singer and Gomes in their researches concluded that the gonial angle increases with mandibular advancement with VRO [17,18]. However, the researches included in this review described that the changes depended on the amount of rotation that was applied to the proximal fragment, yet in this novel modification design these changes depend on the distal fragment, therefore it could be more stable and predictable, and depends on the amount of counter-clockwise rotation of said fragment. Thus, any design of mandibular osteotomy that includes the whole gonial angle in the distal fragment could get the same results.

Mont'Alverne *et al.* in 2019 described an osteotomy similar to the design shown in this paper, however, specific indications, advantages and disadvantages for its use are not clarified [11]. The obtained preliminary results of this report can elucidate advantages of using this design such as the preservation of contact area for fixation between both segments, the protection of the vascular facial bundle in the ante-gonial notch by avoiding a cut on the lower border of the mandible, the preservation of the masseteric cinch insertion that cant be achieved by the angular osteotomy reported by Verweij *et al.* [19], it reduces the need for

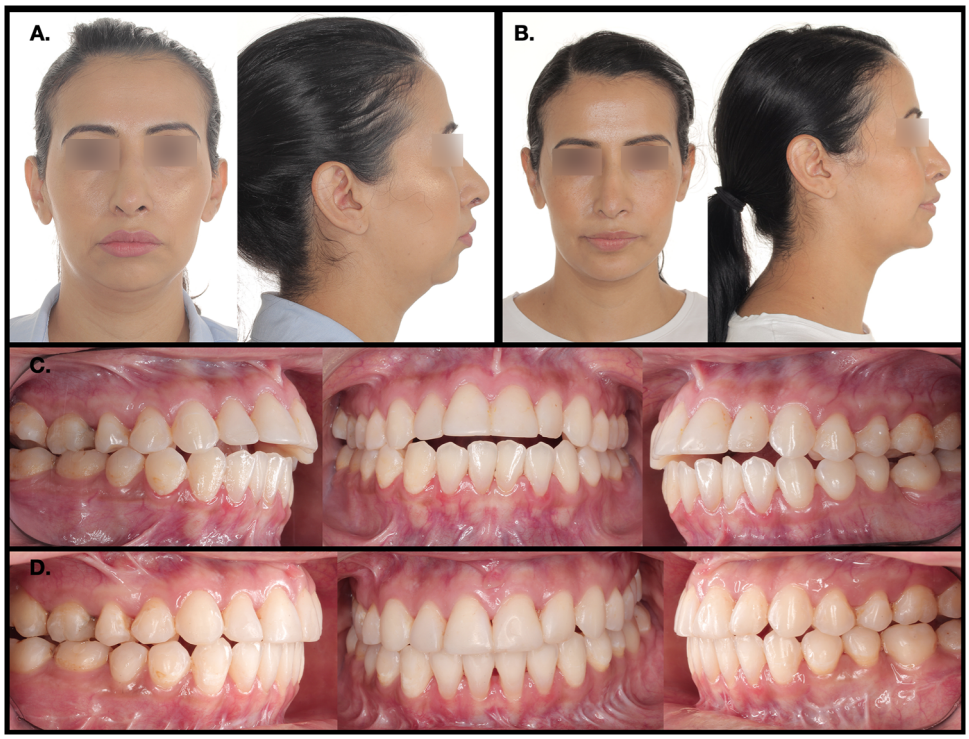

Fig. 6. Patient two: A, C. Presurgical (Front and right profile view) and occlusion (Left, Front and right view), B, D. Postsurgical (Front and right profile view) and occlusion (Left, Front and right view) 1 year postsurgical.
*Osteotomy Lefort I, BSSOM, osteotomy chin, and meniscopexy TMJ.

Table II. Posterior facial height measures (in millimeters).

	T1				T2				T3			
	R3–LM		R3–Ag		R3–LM		R3–Ag		R3–LM		R3–Ag	
	L	R	L	R	L	R	L	R	L	R	L	R
Patient 1	38.37	37.12	39.52	39.03	43.29	41.48	45.00	43.77	43.49	41.04	45.44	43.95
Patient 2	38.73	39.46	39.62	40.01	41.81	43.63	42.46	44.77	42.27	43.54	43.51	44.28

*T1: pre-surgical, T2: virtual planning, T3: one-year post-operative.
*L (left) R (Right).

implants or grafts in the gonial area for rounded faced patients, also eliminates the palpable step in the basilar and gonial outlines [11]. In addition, the step permits a better control of the position of the proximal segment limiting its auto-rotation. On the other hand, it has some disadvantages and limitations too, these being the need for surgical precision and skill, there may be a higher risk of injury to IAN, therefore a broad analysis is required before surgery, technique demands the use of angled oscillating and reciprocating saw, or angle tips of piezo surgery devices, there can be a slightly higher risk of complications such as fracture of the proximal segment or the gonial area in the distal segment specially in patients with thinner mandibular ramus or when the osteotomy is incomplete.

This surgery runs against one of the principles of orthognathic surgery, "occlusal stability". However, this paradigm was eliminated with the first surgery protocols, where the stability of the surgery did not depend on the immediate postoperative occlusion, given that teeth begin to move once the surgery ends, besides, an accelerated movement can be seen during the first 4 months due to the regional acceleratory phenomenon (RAP) described by Frost [20,21]. On the other hand, the forces of the bite are decreased during the first 6 months after surgery [22–24], therefore, the canine or anterior teeth would not have a problem supporting temporary occlusion while attain molars extrusion.

In conclusion, this BSSOM is an option when the patient benefits from increasing the gonial angle height with a downward posterior displacement of the distal fragment and its counter-clockwise rotation, it is important to note that with this technique, the amount of vertical change in the gonial area will depend on the amount of posterior open bite that is left after surgery and therefore, directly proportional to the

Table III. Differences between given measures (in millimeters).

	T2–T1				T3–T1				T3–T2			
	R3–LM		R3–Ag		R3–LM		R3–Ag		R3–LM		R3–Ag	
	L	R	L	R	L	R	L	R	L	R	L	R
Patient 1	4.92	4.36	5.484.74		5.12	3.92	5.924.92		0.2	-0.44	0.44	0.18
Patient 2	3.08	4.17	2.844.76		3.54	4.08	3.894.27		0.46	-0.09	1.05	-0.49
Average Planned increase in PFH 4.29					Surgical increase in PFH 4.45				Difference between planning and surgery 0.16			

*T1: pre-surgical, T2: virtual planning, T3: one-year post-operative.
*L (left) R (Right).
*PFH: Posterior facial height.

rotation achieved. This technique is another solution in patients with non-active idiopathic condylar resorption where theres no need for condylar prostheses. In addition, this technique could be used in cases of hemifacial microsomia, even after osteogenic distraction where an increase the jaw angle is required. Further Long-term studies and bigger patient samples are required to compare BSSO, VTO, and BSSOM and show the changes in ramus height, increase in gonial angle, and post-surgical bone remodelling.

Conflict of interest

The authors declared no potential conflicts of interest with respect to the research, authorship, and publication of this article.

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Ethical approval and consent to participate

The patients have given their consent to publish their photos in a scientific journal.

Consent for publication

The authors give their consent for its publication.

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