Use of Bone Grafts or Modified Bilateral Sagittal Split Osteotomy Technique in Large Mandibular Advancements Reduces the Risk of Persisting Mandibular Inferior Border Defects

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Purpose: Healing of the inferior border of the mandible can be compromised in large advancements, leaving an unesthetic defect at the inferior border. The objective of this study was to compare different bilateral sagittal split osteotomy (BSSO) techniques to prevent the incidence of lower border mandibular defects.

Materials and Methods: The authors undertook a retrospective multicenter cohort study comparing 3 BSSO techniques for advancements greater than 5 mm: traditional non-grafted BSSO (group A), traditional grafted BSSO (group B), and modified BSSO (group C). The space created by the mandibular advancement was measured. The presence or absence of a defect was determined 1 year after surgery by clinical and radiographic assessment. The bone defect outcome was associated with potential risk predictors (age, gender, side of SSO, and magnitude of mandibular advancement) by logistic regression analysis.

Results: A total of 1,002 operative sites in 501 patients were included in the study. Age (mean, 26.8 yr; standard deviation, 11 yr), gender (310 female, 191 male), and mandibular advancement (right, 9.3 mm; left, 10 mm) were similar among groups ($P > .05$). The proportions of postsurgical lower border mandibular defects were 54.5% in group A, 1.3% in group B, and 10.6% in group C. The traditional grafted and modified BSSO techniques were significantly more effective in preventing the incidence of mandibular lower border defects compared with the traditional non-grafted BSSO technique ($P < .05$).

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Conclusion: Surgeons are advised that the traditional non-grafted BSSO technique produces a large proportion of mandibular lower border defects. Use of bone grafts or the modified BSSO technique in mandibular advancements greater than 10 mm markedly decreases the risk of persisting mandibular inferior border defects.

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The bilateral sagittal split osteotomy (BSSO) is the most widely used technique in mandibular orthognathic surgery. It allows mandibular movements in the sagittal, vertical, and transverse directions, obtaining good results with limited complications.[1-3] In a BSSO, the mandibular body is separated from the proximal fragment and moved to the planned position, creating a gap between segments. The size of this space is proportional to the advancement or mandibular rotation movements required by the patient's maxillomandibular discrepancy. Healing of these surgeries usually proceeds without complications, but in some cases a persistent defect occurs in the osteotomy site at the inferior border.[4] Although not widely described, this complication can be a visible or palpable defect along the inferior border of the mandible, commonly leading to patient complaints. The prevention of mandibular lower border defects is an important issue in planning a BSSO.

Agbaje et al[5] described a modified BSSO technique that lowers the incidence of mandibular lower border defects. Others use the traditional BSSO technique in grafting the advancement gap, but there is no evidence of a decreased incidence of mandibular lower border defects.

The purpose of this study was to compare different BSSO techniques to decrease the incidence of lower border mandibular defects. The authors hypothesized that the use of bone grafts or the modified BSSO technique in mandibular advancements would decrease the risk of persisting mandibular inferior border defects. The specific aims of the study were to estimate and compare the incidence of lower mandibular defects in 3 different groups: traditional non-grafted BSSO, traditional grafted BSSO, and modified BSSO.

Materials and Methods

STUDY DESIGN AND SAMPLE

To address the research purpose, the authors designed and implemented a retrospective multicenter cohort study comparing the 3 different BSSO techniques: traditional non-grafted BSSO (group A), traditional grafted BSSO (group B), and modified BSSO (group C).

The study population was composed of all patients who underwent BSSO advancements at *1)* the Clínica Alemana de Santiago (Santiago, Chile) from January 2009 through August 2014; *2)* St John's Hospital (Genk, Belgium) from July 2012 through March 2013; and *3)* the University Hospital of Leuven (UZ Leuven, Leuven, Belgium) from January 2013 through September 2014. There was no determining factor and no randomization in choosing the BSSO technique in each case. The study protocol was previously approved by the respective ethics committees.

Patients were included in the study sample if they underwent orthognathic surgery (maxillomandibular surgery or mandibular surgery only) with correction of mandibular retrognathism by symmetrical or asymmetrical mandibular advancements greater than 5 mm. Patients were excluded as study subjects if bad splits were reported during the BSSO or if they presented a medical condition that could affect the surgical results (diabetes, kidney disorders, or an immunocompromised condition).

STUDY VARIABLES

The primary predictor variable was the BSSO technique. Three groups were defined: traditional non-grafted BSSO (group A), traditional grafted BSSO (group B), and modified BSSO (group C).

Group A was composed of all patients who received a traditional BSSO and no grafting of the gap between segments. No modified BSSO technique was performed in this group.

Patients in group B were treated with a traditional BSSO, grafting with a Puros particulate allograft (Zimmer Biomet, Warsaw, IN) plus platelet-rich plasma (PRP) in the gap between fragments, and a collagen membrane (CollaTape; Zimmer Biomet) as graft protection (Figs 1-3).

Patients in group C were treated with a modified BSSO technique as described by Agbaje et al[5] and no grafting of the mandibular gap.

In all 3 groups, 2 straight plates with 4 monocortical screws on each side of the SSO were installed.

The study's primary outcome was the presence of an inferior mandibular border defect. The criteria for diagnosing these defects included 1 of the following: *1)* a visible or palpable defect that caused patients discomfort, *2)* a defect that required correction in a second surgical intervention, or *3)* a conspicuous

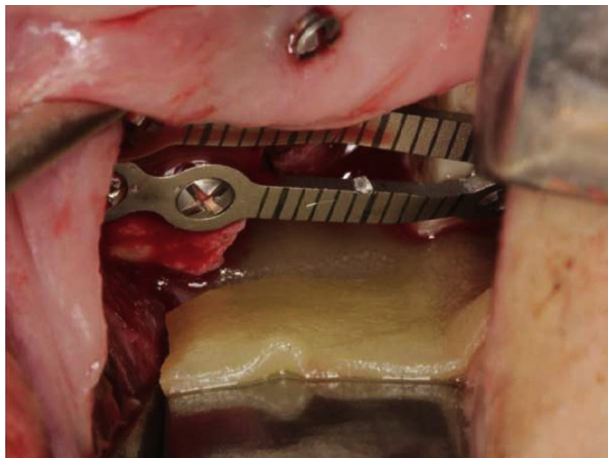

FIGURE 1. Collagen membrane (CollaTape) in the lower border of the jaw to support the graft.

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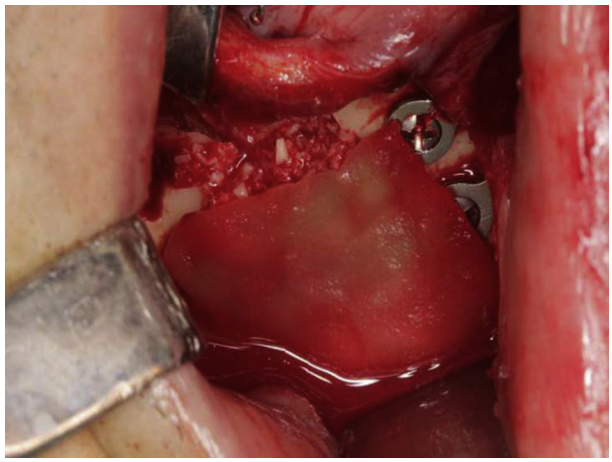

FIGURE 3. Puros particulate allograft plus collagen membrane (CollaTape).

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defect evaluated on the panoramic image 1 year after surgery that was not present on the preoperative image and that presented a clear alteration in the continuity of the inferior border that caused patients discomfort.

Inferior border irregularities or increased radiolucency without cortical discontinuation were not considered pathologic in the absence of subjective complaints. The evaluators were calibrated in each medical center by the observation of clinical images of patients with and without mandibular osseous defects and panoramic radiographs with and without mandibular defects.

Other variables described previously as potential risk predictors by Agbaje et al[5] were registered (age, gender, magnitude of mandibular advancement, and side of the SSO). Advancement after the BSSO was determined from standardized linear measurements made on panoramic radiographs taken from week 1 to 3 postoperatively.[4]

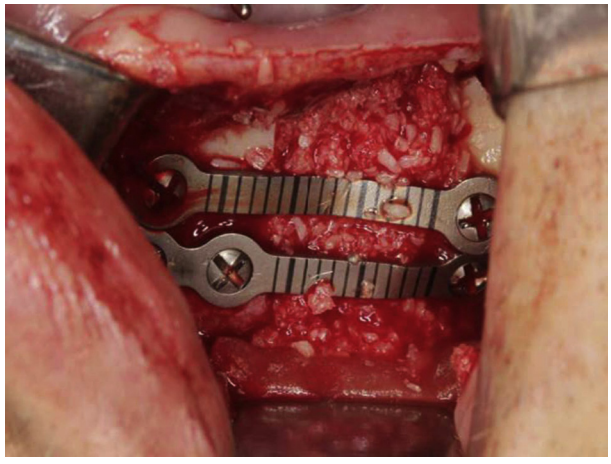

FIGURE 2. Puros particulate allograft plus platelet-rich plasma in the gap between fragments.

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Modified BSSO Technique

The sagittal osteotomy of the inferior border was executed with a standard Mectron piezosurgery insert (OT7; Mectron, Carasco, Italy).[5] After completion of the vertical cut through the outer cortex of the mandible at a level between the first and second molar, a bevel was made—with a round drill—medial to the vertical cut at the inferior border of the mandible to allow placement of the piezosurgery insert as parallel to the inferior border as possible. The piezosurgery insert was placed against the bevel and gently driven into the inferior border to divide the inferior border into a lingual side and a buccal side. Care was taken not to drive the tip too lingually. The tip was inserted until the first black dot disappeared in the bone (approximately 7 to 10 mm deep). This allowed the initiation of an inferior border split in which the lingual border at the gap remained in the tooth-bearing fragment, whereas the buccal side of the inferior border remained part of the buccal fragment (proximal segment), avoiding the emergence of an unfavorable split.

Data Collection Methods

Data were extracted from the clinical records and images of patients who met the selection criteria according to the protocols of anonymization, protection, confidentiality, and information security according to parameters established by the Office of Extra-Institutional Research of the National Institutes

of Health (Bethesda, MD). An anonymous database was created using codes to protect the identity of patients.

Data Analyses

Continuous variables were described by mean and standard deviation, and categorical variables were described using frequency and proportion. The bone defect outcome was associated with risk predictors by logistic regression analysis. A bone defect prognostic model based on logistic regression analysis was obtained by evaluating the capacity of discrimination by the area under the receiver operating characteristic curve. By weighing the value of the variables involved in the model by their respective odds ratios and evaluating sensitivity and specificity, a prognostic score was obtained. A significance level of 5% was considered and all statistical analyses were performed using STATA 14 (StataCorp LP, College Station, TX).

Results

The results are presented in Table 1. A total of 1,002 operative sites in 501 patients were included in the study (age, gender, and mandibular advancement were similar among groups; $P > .05$). The proportions of postsurgical lower border mandibular defects were 54.5% in group A, 1.3% in group B, and 10.6% in group C. All mandibular defects considered in this study produced clinical alterations in the continuity of the inferior border (visible or palpable defect) that caused patients discomfort with a radiographic correlation (see criteria for diagnosing mandibular border defects in the Materials and Methods section). The traditional grafted and modified BSSO techniques were significantly superior in preventing the incidence of mandibular lower border defects compared with the traditional non-grafted BSSO technique ($P < .05$).

The traditional grafted BSSO technique was superior to the modified BSSO technique in preventing mandibular lower border defects. In addition, the length of advancement and age increased the risk of a persisting osseous defect of the inferior border at the osteotomy gap after BSSO ($P < .05$; Tables 2-4).

The rate of infection was 13.7% for the traditional non-grafted BSSO technique, 6.5% for the traditional grafted BSSO technique, and 12.3% for the modified BSSO technique.

Discussion

The main purpose of this study was to identify and compare different BSSO techniques in minimizing inferior mandibular defects. The authors hypothesized that the use of bone grafts or the modified BSSO technique for mandibular advancement would decrease the risk of persisting mandibular inferior border defects. The specific aims of the study were to estimate and compare the incidence of lower mandibular defects in 3 different techniques: traditional non-grafted BSSO, traditional grafted BSSO, and modified BSSO.

The traditional grafted and modified BSSO techniques presented a notably lower incidence of mandibular lower border defects compared with the traditional non-grafted BSSO technique. The magnitude of mandibular advancement and the age of patients statistically increased the risk of mandibular defects. Patient gender and the site of the BSSO were not associated with an increased risk of mandibular defects.

Agbaje et al[4] studied 400 postoperative sites in 200 patients and reported postsurgical defects in more than one third of the sites (traditional BSSO). The risk factors reported were total inclusion of the inferior border in one or the other fragment of the BSSO, the scale of mandibular advancement, and the patient's age. This group also recently reported a new modified BSSO technique (the same modified technique included in the present study) that considerably

Table 1. SUMMARY OF RESULTS

	Group A: Traditional Non-Grafted BSSO Technique	Group B: Traditional Grafted BSSO Technique	Group C: Modified BSSO Technique	Total	*P* Value
Age (yr), mean (SD)	27.6 (10.9)	25.8 (9.4)	26.6 (12.6)	26.8 (11)	>.05
Women/men	124/76	89/61	97/54	310/191	>.05
Advancement (mm), mean					>.05
Right	10.4	8.2	9.3	9.3	
Left	11.6	9.2	9.3	10	
Total patients	200	150	151	501	

Abbreviations: BSSO, bilateral sagittal split osteotomy; SD, standard deviation.

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Table 2. COMPARISON OF BSSO ADVANCEMENT

	No Defect	Defect	Total
Age (yr), mean (SD)	24.9 (10.4)	32 (11.5)	26.8 (11)
Men/women	149/225	42/85	191/310
Advancement (mm), mean	7.6	11.8	9.6
Right BSSO	445	56	501
Left BSSO	388	113	501
Total patients	374	127	501

Abbreviations: BSSO, bilateral sagittal split osteotomy; SD, standard deviation.

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lowered the risk of mandibular lower border defects.[5] Agbaje et al included 408 surgical sites with the modified BSSO technique in 204 patients in which the lingual border at the gap remained in the tooth-bearing fragment, whereas the buccal side of the inferior border remained part of the buccal fragment (proximal segment). The modified technique prevented the full thickness of the lower border from being included in the buccal fragment.[5] The results of that study showed that in cases in which the advancement was more than 10 mm or the patient was older than 30 years, the risk of mandibular defect increased considerably. These results are concordant with the present study using the bone defect prognostic model described in the Study Variables section. They confirmed previous findings that identified the magnitude of the mandibular advancement and the age of patients as risk factors. In fact, only 3 grafted surgical sites (1% of total grafted sites included) in 2 patients showed inferior border defects on their 1-year postoperative panoramic images.

Table 3. COMPARISON OF BSSO TECHNIQUES FOR DEFECTS VERSUS NO DEFECTS

	No Defect	Defect	*P* Value
Group A: traditional non-grafted BSSO technique	91	109	<.05
Group B: traditional grafted BSSO technique	148	2	>.05
Group C: modified BSSO technique	135	16	>.05
Total	374	127	

Note: The traditional grafted and modified BSSO techniques were significantly superior in preventing the incidence of mandibular lower border defects compared with the traditional non-grafted BSSO technique ($P < .05$). Results for the traditional grafted versus modified BSSO technique were not statistically significant ($P > .0.5$).

Abbreviations: BSSO, bilateral sagittal split osteotomy; SD, standard deviation.

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Table 4. COMPARISON OF BSSO TECHNIQUES

	Odds Ratio	95% CI	*P* Value
Group A: traditional non-grafted BSSO technique	53	11.6-237.8	<.05
Group B: traditional grafted BSSO technique	ref	—	—
Group C: modified BSSO technique	5	0.96-21.6	>.05
Age	1.1	1.04-1.10	<.05
Length advancement (mm)			
Right	1.14	1.03-1.25	<.05
Left	1.1	1-1.2	<.05

Abbreviations: BSSO, bilateral sagittal split osteotomy; CI, confidence interval; ref, reference group.

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The first patient was a 30-year-old man who presented with a left inferior border defect from a Class II skeletal deformity. The postsurgical bone gap at the inferior border on the right and left sides was 11.5 mm with a counterclockwise rotation of 6.7°. The second patient, a 39-year-old woman with a Class II skeletal deformity, presented with bilateral defects (Fig 4). The inferior border postsurgical bone gap was 7.3 mm on the right side and 11.6 mm on the left side, with a counterclockwise rotation of 11.2°. These 2 patients presented all 3 risk factors: *1)* age, *2)* magnitude of advancement, and *3)* full thickness of the lower border included in the buccal fragment.

Until the present article, there was no evidence or report that compared the use of the grafted BSSO technique with the non-grafted BSSO or modified BSSO technique. The present results showed that the

FIGURE 4. Panoramic view of a 39-year-old woman with bilateral lower mandibular border defects 1 year after surgery.

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traditional grafted and modified BSSO techniques were markedly superior in preventing the incidence of mandibular lower border defects compared with the traditional non-grafted BSSO technique. The grafted BSSO technique presented the smallest proportion of mandibular notching complications. This technique is not technically complex, but the main disadvantages of grafting the mandibular osteotomies are increased surgical time and costs. The modified BSSO technique is another excellent alternative that showed good results, but one might need more surgical training to perform the technique properly, and the incidence of mandibular defects is higher than in the grafted BSSO technique. In their protocol, the authors used particulate allograft bone, PRP, and collagen membranes in the grafted BSSO group. The authors find it straightforward to manipulate, with predictable results when it is properly applied. In addition, it avoids taking a graft from a donor site, thereby decreasing morbidity while still obtaining successful results. The dental and maxillofacial literature reports widely on the use of the collagen membrane as a protective barrier for bone grafts,[6,7] showing that the use of membranes is associated with lower resorption rates for particulate grafts, because the membrane acts as a barrier to keep the graft in place during the healing process.[8,9]

The literature has reported a 7% infection rate after orthognathic surgery. Studies have shown that risk factors that might be associated with a higher incidence of infection after orthognathic surgery include longer surgery; short-term antibiotic prophylaxis; extraction of a third molar during surgery; larger number of osteotomies performed; older age; smoking; poor oral hygiene; and a compromised immune system.[10] In this study, the grafted group showed a similar rate of infection as those described in the literature (6.5%). The others groups were associated with a higher incidence of infection, probably due differences in the antibiotic protocol and in the determination of surgical site infection.

The weaknesses of this study are those associated with any observational multicenter study. In addition, other variables that could play an important role in choosing which BSSO technique to perform were not analyzed in this study (general complications, surgery duration, bad splits, and costs). It would be desirable to perform a randomized clinical trial incorporating these variables to confirm the results and recommendations and to decrease the risk of bias. Nevertheless, the authors believe, based on previous findings and the considerable sample size studied, that relevant variations in future results are unlikely.

In conclusion, the use of bone grafts or the modified BSSO technique in mandibular advancement markedly lowers the risk of persisting mandibular inferior border defects. The traditional grafted and modified BSSO techniques are appropriate to decrease the complications of lower mandibular healing.

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