Oral and Maxillofacial Surgery
https://doi.org/10.1007/s10006-023-01148-4

RESEARCH

Bilateral sagittal split osteotomy with or without concomitant removal of third molars: a retrospective cohort study of related complications and bone healing

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Received: 20 May 2022 / Accepted: 8 March 2023

Abstract

Purpose To carry out a comparative evaluation of the intra- and postoperative complications, and bone healing, following bilateral sagittal split osteotomy (BSSO) with or without concomitant removal of third molars.

Material and methods A retrospective analysis was performed of two cohorts subjected to BSSO with the intraoperative removal of third molars (test group) versus the removal of third molars at least 6 months prior to BSSO (control group), comprising at least 1 year of clinical and radiographic follow-up. Partially or completely erupted third molars were extracted immediately before completing the osteotomy, whereas impacted third molars were removed after the osteotomy had been performed. Hardware reinforcement was performed in bimaxillary cases where concomitant molar extraction impeded placement of the retromolar bicortical screw of the hybrid technique.

Results A total of 80 surgical sites were included (40 in each group). Concomitant extraction of the molar represented a mean increase in surgery time of 3.7 min ($p < 0.001$). No additional complications occurred in the test group ($p = 0.476$). The gain in bone density was preserved in both groups ($p = 0.002$), and the increase was of the same magnitude in both ($p = 0.342$), despite the fact that the immediate and final postoperative bone densities were significantly higher in the control group ($p = 0.020$).

Conclusion The results obtained support concomitant molar extraction with BSSO as a feasible option.

Keywords Algorithm · Bilateral sagittal split osteotomy · Cone-beam computed tomography · Orthognathic surgery · Third molar · Wisdom teeth

Introduction

Bilateral sagittal split osteotomy (BSSO) is one of the most frequently performed surgical procedures for the correction of dentoskeletal deformities as well as sleep-related breathing problems [1] and articular-musculoskeletal disorders [2]. The technique was originally introduced by Trauner and Obwegeser in 1955 [3–5], and in order to reduce complications [6, 7], it has undergone a number of modifications since then [8].

An unfavorable and unanticipated split pattern (bad split) during fracture of the mandible is one of the most feared complications in BSSO [9, 10]. The risk of a bad split has been related to a number of factors such as the surgical technique employed, incomplete inferior border osteotomy, larger osteotomies, and limited surgical experience, as well as to patient-related issues including the anatomy of the mandible, older age, and the presence of mandibular third molars (M3Ms) [11]. However, a previous study has shown the only predictor of a bad split to be surgical removal of the mandibular third molar (SRM3M) at the same time as BSSO [12].

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Published online: 24 March 2023

The traditional recommendation therefore was to remove the M3M at least 6 months prior to BSSO in order to lessen the risk of a bad split [13]. Moreover, other postoperative drawbacks have been related to extraction concomitant to BSSO, such as soft tissue closure and healing problems, hardware failure, and an increased risk of infection and relapse [11, 13]. However, improvements in surgical techniques and the introduction of rigid fixation methods have reduced such complications. Hence, recent protocols point to benefits of concomitant SRM3M in conjunction with BSSO [14–16] — the most relevant being the avoidance of additional surgery and its respective anesthetic step [17]. Furthermore, the combined procedure is also preferable from the patient perspective, since SRM3M prior to BSSO is associated to additional pain, facial swelling, trismus, sick leave with days off work or study, and postoperatively diminished oral health–related quality of life [18].

To the best of our knowledge, the influence of this procedure upon postoperative bone healing has not been studied before. Furthermore, the incidence of intra- and postoperative complications remains subject to controversy. A previous study suggests that the timing of removal of third molars in the context of BSSO should be decided based on the angulation, relative height and root shape of the M3M, and its morphological relation to the inferior alveolar nerve [13].

The present study was designed to assess the intra- and postoperative complications and bone healing following BSSO in conjunction with SRM3M (test group) compared with SRM3M performed at least 6 months prior to BSSO (control group). In addition, a decision algorithm and a protocol for SRM3M in conjunction with BSSO are described.

Material and methods

Study design and sample selection

A retrospective analysis was made of consecutive patients subjected to BSSO either as a single procedure or as part of bimaxillary surgery at the Maxillofacial Institute, Teknon Medical Center (Barcelona, Spain). The study was designed comprising two cohorts defined according to the performance of concomitant extraction of lower molars (test group: uni- or bilateral concomitant SRM3M and BSSO; and control group: BSSO without SRM3M), with a follow-up period of at least 1 year. Data were collected from the medical records of the patients operated upon between January 2018 and December 2019.

The patients were selected on the basis of the following inclusion criteria: age > 18 years in non-growing status, dentofacial deformity in need of mandibular correction involving BSSO, and the obtainment of written informed consent. Patients with an isolated maxillary Le Fort I osteotomy were excluded, in the same way as those presenting any craniofacial syndrome, previous fracture of the mandible, a health-related or disease background that could compromise bone healing, as well as patients with missing follow-up visits (Table 1).

The study was approved by the Ethics Committee of Teknon Medical Center (Barcelona, Spain) (Ref. BSSO-WT) and was conducted in accordance with the ethical standards laid down in the Declaration of Helsinki (1964 and later amendments).

Surgical procedure

The surgical procedure was performed under general anesthesia with nasotracheal intubation, supplemented with local anesthesia. The mandible was operated first in all cases, and BSSO was performed using the Hunsuck-Dal Pont-Obwegeser technique. In addition, when necessary, maxillary Le Fort I osteotomy was carried out using the minimally invasive twist technique [19].

In relation to the timing of M3M removal, partially or completely erupted molars were extracted immediately before BSSO. In contrast, fully impacted M3Ms were removed after BSSO, since separation of the buccal cortical plate allowed direct access to the teeth.

The following mandibular rigid internal fixation methods were used: (a) a single miniplate fixed with four monocortical screws in conventional mono-mandibular cases; (b) the hybrid technique (a miniplate fixed with four monocortical screws and a retromolar bicortical screw) in standard bimaxillary cases [20]; and (c) hardware reinforcement using a doubled miniplate or two miniplates, both fixed with 8 monocortical screws in cases where the retromolar bicortical screw could not be placed, i.e., concomitant SRM3M involving a major bone defect, or the performance of lingual osteotomy of the distal segment [21].

Table 1 Inclusion and exclusion criteria

Inclusion criteria	Exclusion criteria
• Age > 18 years in non-growing status • Dentofacial deformity in need of BSSO • Written informed consent	• Isolated maxillary Le Fort I osteotomy • Craniofacial syndrome • Previous fracture of the mandible • Compromised bone healing • Missing follow-up visits

All patients wore a closed-circuit cold mask (17 ºC) during hospital admission and were discharged 24 h after surgery. Identical postoperative recommendations and antibiotic and analgesic medication were prescribed in both groups. Functional training using light guiding elastics was performed during 1 month, with a soft diet for the same period in both groups.

Data acquisition and evaluation of study variables

All patients followed the standard clinical and radiographic evaluation workflow for orthognathic surgery planning and follow-up at the Maxillofacial Institute, Teknon Medical Center (Barcelona, Spain). The protocol comprises clinical evaluation and a cone-beam computed tomography (CBCT) scan (iCAT, Imaging Sciences International, Hatfield, PA, USA) at three timepoints: preoperatively after orthodontic treatment (T_0) and postoperatively at 1 (T_1) and 12 months of follow-up (T_2).

The following variables were recorded after chart review: patient age and gender, preoperative skeletal class deformity (I, II or III), wisdom tooth classification (Winter's [22] and Pell & Gregory [23]), type of surgery, duration of surgery (from incision to the last suture of the mandible), and the mandibular rigid internal fixation method used. Furthermore, per and postoperative complications such as nerve injury (any degree of nerve dysesthesia) at 1 year of follow-up, bleeding, unfavorable split, prolongation of hospital stay, infection, secondary soft tissue and bone healing problems, and hardware removal problems were documented at the follow-up visits.

Bone healing was monitored radiographically in terms of bone density in Hounsfield units (HU) at the site of crown M3M for the test group and 5 mm distal to the second molar for the control group, at two different time intervals: T_0 to T_1 (ΔT_1, indicating immediate postoperative changes) and T_1 to T_2 (ΔT_2, indicating long-term postoperative changes) (Fig. 1). Two calibrated examiners (AVO and ÖK) independently obtained two consecutive measurements of the radiographic variables, on two separate occasions spaced 2 weeks apart, to ensure accuracy and reproducibility. For this purpose, three-dimensional (3D) superimposition techniques following a landmark-based method were used. Three-dimensional voxel-based superimposition was chosen because it enables unbiased analysis based on software precision, avoiding time-consuming measurements and ensuring that all three virtual images (T_0, T_1, and T_2) were in the exact identical position [24].

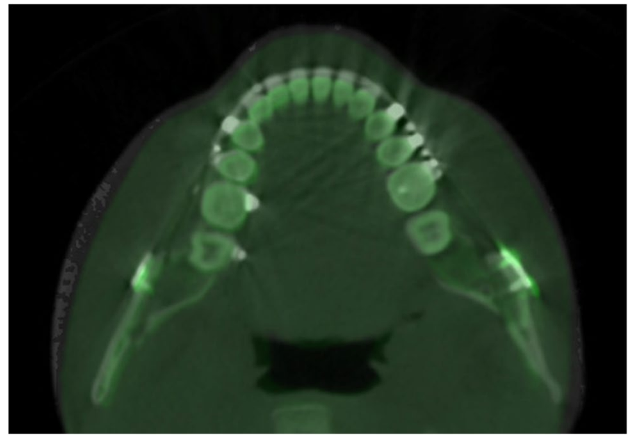

Fig. 1 Measurement of bone density in Hounsfield Units (HU) 5 mm distal to the second molar (control group)

Statistical analysis

A descriptive analysis was made of the study variables, with calculation of the mean, standard deviation (SD), minimum and maximum values, and median for continuous variables. Absolute and relative frequencies (percentages) were reported for qualitative variables.

Regarding the inferential analysis, simple binary logistic regression models were estimated using generalized estimation equations (GEEs) to explain the probability of complication as a function of the group and variables of the demographic and clinical profile of the patient and characteristics of the intervention. Subsequently, the estimation of a multiple model adjusted for potential confounders (age, gender, class) was performed. The GEE method was used to control intra-subject correlation, due to the duplication of sides per patient. For the study of the dependent variable bone healing, general linear models of repeated measures were estimated (also under the GEE approach), with the within-subject factor being the time of CBCT and the between-subjects factors being the same previous independent variables. The analysis was completed with a fully fitted multiple model. Chi-square testing, Fisher's exact test, the student *t* test for independent samples, and the nonparametric Mann–Whitney *U* test and Kruskal–Wallis test were applied to assess homogeneity of the two groups at patient level or for specific comparisons of surgery time. The level of statistical significance was set at 5% ($p = 0.05$).

A logistic regression model such as that described for the association between a binary outcome (complications) and an independent factor of two levels (group) affords a statistical power of 80% in detecting an odds ratio (OR) = 4 as significant in a hypothetical sample of 80 totally independent laterals, assuming a confidence level of 95%. Due to the multi-level design of the data (two sides per patient), the power had to be corrected, assuming a moderate intra-subject correlation ($\rho = 0.5$), yielding a power of 62.1% under the same previous conditions.

Results

A total of 41 patients (two with unilateral SRM3M, 19 with bilateral SRM3M, and 20 without SRM3M) and 80 surgery sites (40 in the test group and 40 in the control group) were included in the study (Table 2). The types of M3M impaction according to Winter's and the Pell and Gregory classifications are summarized in Table 2. There were 22 females (53.7%) and 19 males (46.3%), with a mean age of 30.8 ± 9.9 years (range: 18–54).

Most patients were operated upon under the surgery late protocol (80.5%), followed by the surgery first (17.1%) and surgery early (2.4%) protocols. Regarding surgery, 85.4% of the subjects underwent maxillary osteotomy, whereas 39% underwent genioplasty and 29.3% rhinoplasty/septoplasty.

The homogeneity analysis showed both groups to exhibit a fairly acceptable degree of homogeneity (Table 3) except for age, where a statistically significant difference of 8 years was observed between the two groups (test group 26.8 ± 9.1 years versus control group 34.9 ± 9.2 years; $p = 0.007$).

Table 2 Data on the number of surgical sites (one or two) per patient and group (control and test), studied side or extracted molar, and its position according to Winter's and the Pell and Gregory classifications

	Group			
	Control		Test	
	n	%	*n*	%
Surgical sites per patient				
total	20	100	21	100
1	0	0	2	9.5
2	20	100	19	90.5
Studied side (control)/extracted molar (test)				
Left/38	20	50	21	52.5
Right/48	20	50	19	47.5
Winter's classification (vertical, horizontal, mesioangular, distoangular, buccolingual, others)				
Vertical	–	–	22	55
Horizontal	–	–	3	7.5
Mesioangular	–	–	15	37.5
Pell and Gregory classification				
A1	–	–	11	27.5
A2	–	–	2	5
A3	–	–	2	5
B1	–	–	2	5
B2	–	–	4	10
B3	–	–	6	15
C1	–	–	0	0
C2	–	–	3	7.5
C3	–	–	10	25

Concomitant extraction of the molar resulted in an average increase in surgery time of 3.7 min (+21.1%) ($p < 0.001$, *t* test) (Fig. 2). Furthermore, neither the side nor the degree of difficulty associated with the position of the molar had a significant effect upon the total increase in time (Table 4). However, additional rigid fixation hardware was placed in 15 sides of the test group, in the form of a doubled miniplate or two miniplates, both fixed with 8 monocortical screws, compared with none in the control group.

A total of 7 patients presented complications: three in the test group (14.3%) and four in the control group (20%) ($p = 0.628$). Specifically, the following complications were recorded: two patients with some degree of dysesthesia on one side; two patients requiring removal of one loosening screw; two patients requiring bony sequestrum and screw removal; and one patient requiring removal of exposed plates on both sides. Thus, 8 sides presented complications: three in the test group (7.5%) (1 dysesthesia on one side, 1 removal of one loosening screw, and 1 bony sequestrum and screw removal) and 5 in the control group (12.5%) (1 dysesthesia on one side, 1 removal of one loosening screw, 1 bony sequestrum and screw removal, and 1 removal of exposed plates on both sides) ($p = 0.476$) (Table 5). The differences in results (analyzing both patient and side complications) remained nonsignificant after adjusting for group effect, gender, age, extracted impacted teeth (left or right), third molar Winter's [22] and Pell and Gregory [23] classifications, dental class, type of orthognathic surgery and complementary genioplasty or rhinoplasty/septoplasty, or the surgical timing approach. All patients were discharged the day after surgery; no differences regarding the length of hospital stay were therefore recorded.

Regarding bone healing, bone density increased significantly from T_1 to T_2 (ΔT_2) ($p = 0.002$), and the increase was of the same magnitude in both groups ($p = 0.342$) — though bone density was significantly higher in the control group than in the test group at both T_1 and T_2 ($p = 0.020$) (Fig. 3). On adjusting the evolution of bone density to the studied variables, its postoperative gain (ΔT_2) was found to be similar in both groups. However, bone density was significantly higher in class III compared to class II patients ($p = 0.028$), though the HU gain was similar in class III and II subjects ($p = 0.989$). On the other hand, mesioangular impacted molars according to Winter's classification [22] showed substantially increased bone density in ΔT_2 (mean + 130.2 HU) compared with other molar positions ($p = 0.001$) (Table 6).

Discussion

Although there is controversy regarding the appropriate timing of SRM3M in the context of BSSO, our results suggest that both procedures can be carried out safely in a

Table 3 Homogeneity of the groups according to demographic and clinical data: Chi^2 test results, Fisher's exact test and independent *t* test (*t*)

	Control	Test	*p*-value
Gender	9 males + 11 females	10 males + 11 females	0.867 (Chi^2)
Age	26.8 ± 9.1 years (18–54)	34.9 ± 9.2 years (18–50)	0.007** (*t*)
Dental class	I: 1; II: 9; III: 10	I: 0; II: 11; III: 10	0.752 (Chi^2)
Mandible			
Rotation	No: 7; CW:0; CCW: 13	No: 7; CW:1; CCW: 13	1.000 (Chi^2)
Sagittal	No: 4; Fw: 16; Bkw: 0	No: 5; Fw: 15; Bkw: 1	1.000 (Fis)
Centering	No: 11; yes: 9	No: 10; yes: 11	0.636 (Chi^2)
Maxillary			
LeFort I	No: 3; yes: 17	No: 3; yes: 18	1.000 (Fis)
Segmentation	No: 15; yes: 5	No: 15; yes: 6	0.796 (Chi^2)
Rotation	No: 13; CW:0; CCW: 7	No: 17; CW: 0; CCW: 4	0.249 (Chi^2)
Sagittal	No: 5; Fw: 15; Bkw:0	No: 9; Fw: 12; Bkw:0	0.228 (Chi^2)
Vertical	No: 11; up: 2; down:7	No: 11; up: 4; down:6	0.698 (Chi^2)
Centering	No: 16; yes: 4	No: 16; yes: 5	1.000 (Fis)
Expansion	No: 19; yes: 1	No: 18; yes: 3	0.606 (Fis)
Genioplasty	No: 13; yes: 7	No: 12; yes: 9	0.606 (Chi^2)
Rhino/septoplasty	No: 13; yes: 7	No: 13; yes: 8	0.750 (Fis)
APPROACH	First: 4; early: 0; late: 16	First: 2; early: 2; late: 17	1.000 (Fis)

CW clockwise, *CCW* counterclockwise, *Fw* forwards, *Bkw* backwards

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

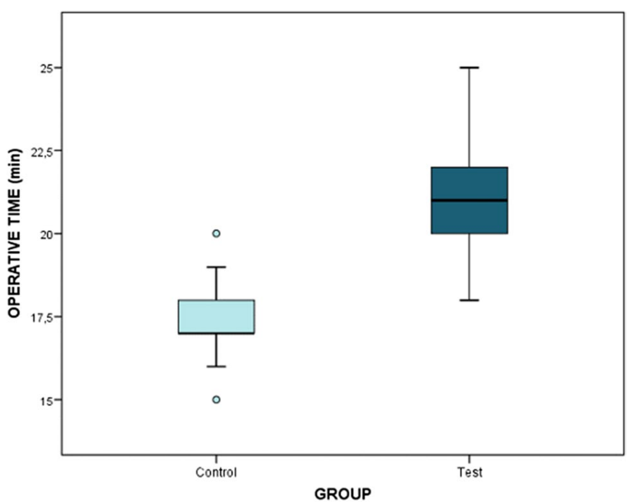

Fig. 2 Mean surgery time (*y*-axis) per side (unilateral sagittal split) in the control and test groups

Table 4 Surgery time according to the side and classification of the impacted third molar (Mann–Whitney *U* test and Kruskal–Wallis test results)

	p-value
Side (38/48)	0.196 (MW)
Winter's	0.127 (MW)
Pell and Gregory (A1/A2/…)	0.359 (KW)
Pell and Gregory (A/B/C)	0.466 (KW)

*$p < 0.05$; **$p < 0.01$; ***$p < 0.001$

single operation when following an appropriate decision-making algorithm (Fig. 4), since no additional complications occurred, in concordance with a previously published systematic review [11]. Besides, bone density gain was preserved in both groups despite the fact that the reported immediate and final postoperative HU values were significantly higher in the control group than in the test group ($p = 0.020$) (Fig. 3). This was to be expected, since SRM3M adds a bone gap to the osteotomy area. However, considering the final difference in bone density between the groups, we can assume that the bone healing process in the test group was not complete after 1 year of follow-up. This is in concordance with the results published by Precious et al., who documented a greater frequency of unfavorable fractures when M3M extraction was performed 6 months prior to BSSO [16], probably due to insufficient bone healing. Thus, well-designed randomized trials are needed to determine whether preoperative SRM3M truly decreases the incidence of bad split instead of increasing it due to incomplete bone densening [11]. Another interesting finding was that bone density was significantly higher in class III compared to class II patients ($p = 0.028$), though the postoperative gain in density was comparable. Likewise, an increased bone density gain was seen during ΔT_2 of mesioangular impacted molars according to Winter's classification [22] (Table 5). Again, further research

Table 5 Data on the complications per patient and site

	Group			
	Control		Test	
	n	%	*n*	%
Complications per patient				
Total	4	20	3	14.3
Sensory disturbance	1	5	1	4.8
One loosening screw	1	5	1	4.8
Exposed plates	1	5	0	0
Bony sequestrum	1	5	1	4.8
Complications per site				
T otal	5	12.5	3	7.5
Sensory disturbance	1	2.5	1	2.5
One loosening screw	1	2.5	1	2.5
Exposed plates	2	5	0	0
Bony sequestrum	1	2.5	1	2.5

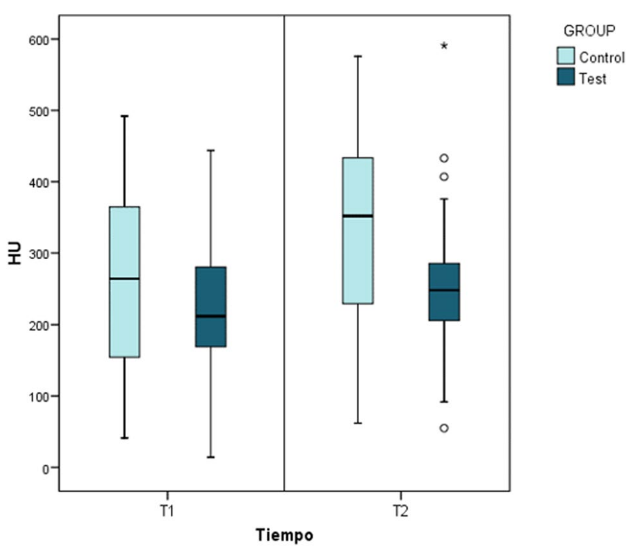

Fig. 3 Comparison of postoperative bone density in Hounsfield Units (HU) between the control and test groups after 1 and 12 months of follow-up

is required in order to be able to draw firm conclusions. In any case, we wish to underscore that to our knowledge, this is the first paper to study postoperative bone healing density in the context of concomitant SRM3M and BSSO.

Apart from the support of the simultaneous performance of both procedures found in the literature [10, 14–17], at present, there is an increasingly widespread use of surgical timing protocols other than conventional orthodontics first, such as surgery only, surgery first, or surgery early [25], due to improved surgical techniques and a widening of orthognathic surgery indications beyond occlusal related problems, such as esthetic purposes or sleep-related breathing disorders [1]. Therefore, delaying surgery due to M3M extraction 6 months prior to surgery would jeopardize the overall treatment timing and patient degree of satisfaction [17, 18].

Regarding patient selection, those subjects who require SRM3M at the time of BSSO tend to be younger, as in our sample, where the test group was seen to be an average of 8 years younger than the control group ($p = 0.007$). This finding was not unexpected, since it is generally advised to remove M3Ms as teenagers or young adults, due to the lower reported risk of complications [26]. Moreover, patient age did not influence the incidence of complications.

We only recommend avoiding simultaneous performance of the two procedures when a mandibular advancement of > 15 mm is required, because a full-thickness bone defect may arise. Moreover, the simultaneous strategy should be avoided when impacted molars occupy the whole thickness of the buccolingual mandibular ramus (mainly molars with a buccolingual inclination according to Winter's classification [22]), since they could favor a bad split and a torpid bone healing process (Fig. 4). Otherwise, if concomitant SRM3M is considered in such cases, the surgeon should take care to prevent the presence of the 3M3 from deviating the saw during the sagittal osteotomy.

The literature also suggests considering the root shape of the M3M and its morphological relation to the inferior alveolar nerve [13], though we believe that when the cortical plate of the proximal segment is separated, this relationship is more evident, and the approach is easier — thus reducing the risk of neurovascular bundle damage. Likewise, decreased proximal segment nerve entrapment has been reported when concomitant SRM3M is performed [27].

Intraoperatively, in relation to the timing of molar removal, the authors advocate extraction of the M3M before BSSO in the case of partially or completely erupted teeth that do not require bone removal, while the removal of impacted molars should be made after the osteotomy. This is because anatomical studies have firmly demonstrated that the thickness of the buccal mandibular ramus bone decreases significantly from the second molar area [6, 28]. Thus, profuse bone removal for SRM3M may predispose to an irregular fracture during the sagittal splitting procedure, apart from hindering postoperative bone regeneration. Moreover, the separation of the buccal cortical plate in the proximal segment allows direct visualization and access to the teeth.

As previously mentioned, the most feared complication of BSSO related to concomitant SRM3M is an unanticipated and unfavorable split pattern of the proximal or distal segments [9–11, 29]. Accordingly, several technical modifications have been proposed to avoid unfavorable splits during

Table 6 Evolution of bone density in Hounsfield Units (HU) according to group (control and test) and studied variables

	p-value	*p*-value (excluding time × group as interaction term)	*B*	95%CI
Time	0.004**	0.005**	47.7	14.4 81.1
Group (test)	0.019*	0.020*	– 58.6	– 108.1 to – 9.13
Time × group	0.522	–	–	–
Gender (female)	0.057	0.059	43.1	– 1.66 87.9
Age	0.284	0.287	– 0.92	– 2.62 0.77
Dental class (III)	0.028*	0.030*	48.2	4.78 91.7
Side (48)	0.627	0.635	7.81	– 24.5 40.1
Winter's (horizontal)	0.955	0.972	0.70	– 38.5 39.9
Winter's (mesiolingual)	0.001**	0.001**	– 40.1	– 63.6 to – 16.6
Pell and Gregory (B)	0.189	0.195	– 21.6	– 77.5 38.4
Pell and Gregory (C)	0.416	0.427	– 37.1	– 94.5 19.3
Pell and Gregory (A3, B3, C2, C3)	0.175	0.192	– 31.3	– 78.1 15.7

$p < 0.05$; $^{**}p < 0.01$; $^{***}p < 0.001$

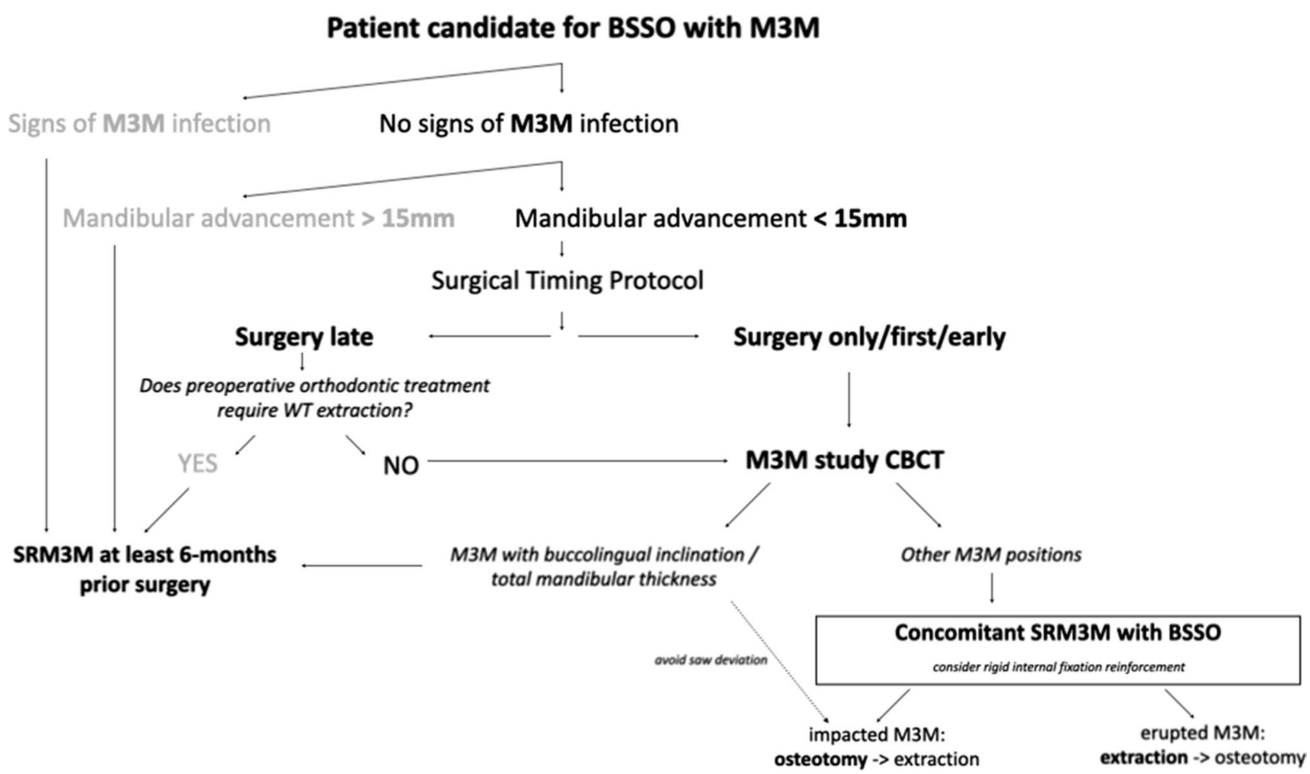

Fig. 4 Decision-making algorithm for concomitant mandibular third molar surgical removal with bilateral sagittal split osteotomy

sagittal osteotomy, particularly when M3Ms are removed concomitantly: using an inferior border osteotomy [30] and prying proximal and distal cortical layers apart with spreaders instead of the traditional "mallet and chisel" technique [16]. In any case, when a bad split occurs, it can be managed through different salvage strategies depending on the localization of the irregular fracture, with no impact upon the final outcome [31]. The most frequent pattern — buccal plate fracture of the proximal segment — can be easily solved by placing an additional miniplate fixing both segments.

As the bone defect is increased in cases of concomitant SRM3M, some protocols advise additional rigid fixation hardware [30]. However, we prefer to keep using the hybrid technique for rigid fixation [20], except when the retromolar bicortical screw cannot be placed due to a considerable bone defect secondary to SRM3M. Instead, an additional miniplate or a doubled miniplate fixed with 8 monocortical screws is advised in this situation. In our sample, this occurred mostly in impacted molars with a mesioangular inclination.

The surgery time was slightly increased by + 3.7 min per side (Fig. 2; Table 4), which is negligible compared to the time required by extra surgery for M3M extraction. On the other hand, no differences regarding the length of stay were reported, which indicates considerable social and financial benefits and lesser patient morbidity in comparison to two-step surgery [17, 18]. Hence, concomitant SRM3M includes several patient-related advantages provided the risk of complications, bad split and bone healing following BSSO are comparable.

Lastly, the present study has some limitations, such as its retrospective and single-center design, with the inherent biases involved.

Nevertheless, the results are consistent with those found in the literature, showing concomitant SRM3M and BSSO to be feasible when the abovementioned recommendations are followed (Fig. 4), since it does not result in increased intra- or postoperative complications or in lessened bone density gain during the healing process. Likewise, an additional previous surgical procedure and its respective anesthetic and recovery period are avoided by adopting the concomitant approach.

Acknowledgements The authors wish to especially thank all the staff members at the Institute of Maxillofacial Surgery, Teknon Medical Center (Barcelona, Spain), for their administrative and clinical support.

Author contribution • Conception and design of the study: Valls-Ontañón A, Kesmez Ö, Hernández-Alfaro F.

• Data acquisition: Valls-Ontañón A, Kesmez Ö.

• Data analysis: Valls-Ontañón A, Kesmez Ö.

• Drafting and/or critical review of the article: Valls-Ontañón A, Kesmez Ö, Starch-Jensen T, Triginer-Roig S, Neagu-Vladut D, Hernández-Alfaro F.

• Final approval of the manuscript: Valls-Ontañón A, Kesmez Ö, Starch-Jensen T, Triginer-Roig S, Neagu-Vladut D, Hernández-Alfaro F.

Data availability The datasets generated and/or analyzed during the current study are available from the corresponding author upon reasonable request.

Declarations

Ethical approval Ethical approval was obtained from the Ethics Committee of Teknon Medical Center (Barcelona, Spain).

Consent to participate Patient written consent was obtained to access the CBCT database.

Consent for publication Not applicable.

Competing interests The authors declare no competing interests.

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