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Bad split during bilateral sagittal split osteotomy of the mandible with separators: a retrospective study of 427 patients

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Abstract

An unfavourable fracture, known as a bad split, is a common operative complication in bilateral sagittal split ramus osteotomy (BSSO). The reported incidence of this complication ranges from 0.5 to 5.5% per site. Since 1994 we have used sagittal splitters and separators instead of chisels for BSSO in our clinic in an attempt to prevent post-operative hypoesthesia. Theoretically an increased percentage of bad splits could be expected with this technique. In this retrospective study we aimed to find out the incidence of bad splits associated with BSSO performed with splitters and separators. We also assessed different risk factors for bad splits. The study group comprised of 427 consecutive patients among whom the incidence of bad splits in this group was 2.0% per site, which is well within the reported range. The only predictive factor for a bad split was the removal of third molars at the same time as BSSO. There was no significant association between bad splits and age, sex, occlusion class, or the experience of the surgeon.

We think that doing a BSSO, performed with splitters and separators instead of chisels, does not increase the risk of a bad split and is therefore safe with predictable results.

Introduction

Bilateral sagittal split osteotomy (BSSO) is one of the most common used operative techniques to correct mandibular deformities.[1] Since it was first described by Trauner and Obwegeser, efforts to reduce associated complications have led to several modifications.[2] However, the procedure still presents a certain degree of technical difficulty and is associated with several potential complications.

One such intra-operative complication associated with BSSO is an irregular osteotomy pattern or unfavourable fracture, known as a bad split.[3] The reported incidence of bad split at a sagittal split osteotomy (SSO) site ranges from 0.5 to 5.5%.[4-20] This unwanted fracture is normally located in either the distal (lingual plate fracture) or proximal cortical plate (buccal plate fracture) of the mandible and more rarely affects the coronoid process or the condylar neck. When a bad split is adequately treated, the chances of functional success are good, though there may be some limitations,[21] so the number of bad splits should be minimized.

Our clinic abandoned the use of chisels to minimize post-operative hypoesthesia,[22] in favour of sagittal splitters and separators (elevators) are used.[8] Theoretically, this technique could result in more bad splits, so the purpose of this study is to review retrospectively the incidence of bad splits of the mandible associated with BSSO using sagittal split separators, in a single centre over 17 years.

Patients and Methods

We retrospectively analysed the clinical records and radiographs of 427 consecutive patients who underwent BSSO in our clinic between July 1994 and December 2011. In 1994, we introduced sagittal splitters and separators instead of chisels for BSSO. All planned BSSOs, single procedures, and those associated with other procedures were included (Table 1).

The patients' medical files and orthopantomographs were screened for the patient's sex, age at surgery, pre-operative diagnosis, BSSO procedure (unilateral or bilateral), concomitant procedures, and presence of third molars. The state of third molars was classified as follows: absent at first consultation; removed prior to BSSO; removed concomitant with BSSO; or present after surgery. If third molars were left in place, they were in occlusion with maxillary antagonists. We also noted whether the BSSO was performed by a specialist or a resident, whether there was a bad split during the operation and type of bad split, the incidental use of chisels, and the method of postoperative fixation.

Table 1 Distribution of procedures other than BSSO in 427 patients.

Procedure(s)	Patients	%
BSSO	229	53.6
BSSO + Le Fort I	124	29.0
BSSO + genioplasty	31	7.3
BSSO + Le Fort I + genioplasty	43	10.1

Data are number (%).

There were 150 males and 277 females ages at the time of operation ranged from 13.8 to 55.6 years (mean (SD) age, 27.3 (9.8) years). In 363 cases, the mandible was moved ventrally to correct a class II malocclusion. A class III malocclusion was present in 59 patients, which resulted in posterior movement of the mandible. Indications for BSSO are summarized in Table 2. Five patiens had indications other than class II/III malocclusion (such as condylar hyperplasia or cleft lip and palate).

Table 2 Indications for BSSO in 427 patients.

Category	Patients	%
Class II malocclusion	363	85.0
Class III malocclusion	59	13.8
Other	5	1.2

Data are number (%).

BSSO was done without the use of chisels, as first described by van Merkesteyn et al.[8,22] Splitting forceps (Smith Ramus Separator 12 mm, Walter Lorentz Surgical, Jacksonville, FL, USA) and elevators were used. The procedures were performed while patients were under general anaesthesia. To reduce bleeding, the surgical area was infiltrated with epinephrine 1:160 000 (Ultracaine D-S, Aventis Pharma, Hoevelaken, The Netherlands). The mandibular ramus was exposed and the mandibular foramen was located. A periosteal elevator was placed subperiosteally just above the mandibular foramen, and the horizontal bone was cut with a Lindeman burr (2.3 × 22 mm) approximately 5 mm above the mandibular foramen. Subsequently, the sagittal and vertical cuts were made with a short Lindeman burr (1.4 × 5 mm). The inferior border was cut perpendicularly through the inferior cortex, just reaching the medial

side. Splitting was done with an elevator positioned in the vertical bone cut and the splitting forceps in the sagittal bone cut. Once the superior aspect of the mandible started to split, the elevator was repositioned at the inferior end of the vertical cut, and splitting was completed. Care was taken to be certain that the inferior alveolar nerve was in the distal segment when the split was completed. A chisel was only used when a small bridge of cortical bone between the buccal and lingual segments remained at the inferior border of the mandible, well below the level of the mandibular canal.

After mobilization, the mandible was placed into the new intermaxillary relationship using a wafer, and intermaxillary wire fixation was applied. When possible, 3 bicortical screws (Martin GmbH, Tuttlingen, Germany; 9, 11, or 13 mm in length; 2.0 mm in diameter) were placed in the upper border of the mandible on both sides. Other fixation methods, such as Champy plates or upper wire fixation, were used if screw fixation was not optimal because of fragile bone, after removal of third molars or after a bad split. The temporary intermaxillary fixation was then removed, and the occlusion was checked. No elastic bands were used. Permanent intermaxillary fixation with upper border wiring was only used after a bad split or intra-oral vertical ramus osteotomy (IVRO).

All patients were discharged from the hospital within a week after the operation and were asked to return for evaluation 1, 6, and 12 months after the discharge.

Statistical methods

All statistical analyses were performed with the help of SPSS 16.0 for Windows (SPSS, Inc.; Chicago, IL, USA). Crosstabs, Pearson's chi-square test, and logistic regression were used, as appropriate, to assess the significance of differences among variables. All statistical associations are reported with odds ratios (ORs) and 95% confidence intervals (CIs). Probability of less than 0.05 accepted as significant.

Results

In 851 sagittal splits (427 patients), there were 17 bad splits (2.0%). All 17 were unilateral, in the form of 11 fractures of buccal plate (64.7%), 5 lingual plate fractures (29.4%) and 1 condylar neck fracture (5.9%) (Figure 1 and 2). Although BSSO was planned in all cases, sagittal split osteotomy was unilateral in 3 (0.7%) patients. One patient eventually had a intraoral vertical ramus osteotomy (IVRO) on both sides, after a large buccal plate fracture occurred during the first initial sagittal split. One patient had a sagittal split on one side and an IVRO on the other side, because of a high mandibular foramen. In the third case, the operation was terminated after the first

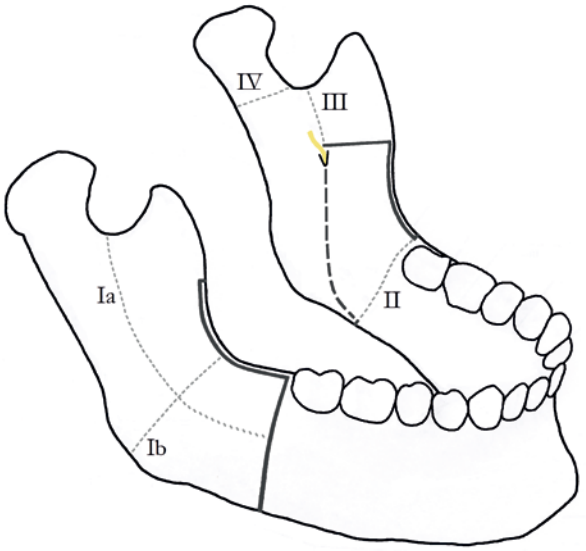

Figure 1 The fracture lines and cuts of a BSSO including the most common unfavourable fractures. Yellow line, mandibular nerve; solid grey line, bone cut made with burr; dashed grey line, favourable fracture line; and dotted grey line, bad split. **I**, fracture of buccal plate; **a**, horizontal and **b**, vertical (n=11; **II**, fracture of lingual plate (n=5); **III**, fracture of coronoid process (n=0); and **IV**, fracture of condylar neck (n=1).

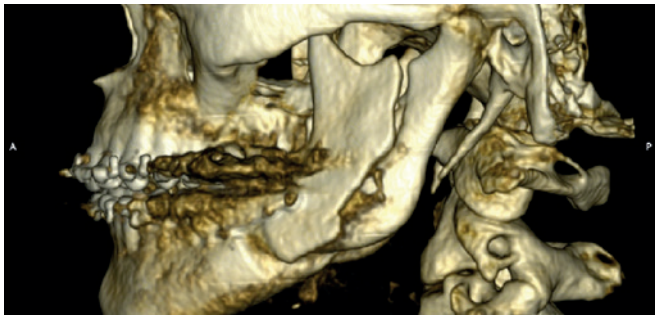

Figure 2 Cone Beam Computed Tomography (CB-CT) scan of a horizontal buccal plate fracture of the left side of the mandible during a BSSO, reaching the incisura semilunaris (figure 1; type Ia). The proximal and distal segment of the mandibula were eventually fixated with two bicortical screws on the lower border of the mandible (in this figure hidden behind the buccal segment), combined with plate fixation to attach the buccal segment.

sagittal split, and fixation was completed without translocation of the mandible because of a large buccal plate fracture. The buccal plate was fixated and both lower third molars were removed. A successful BSSO was performed 6 months after the initial procedure.

The bad splits occurred in 6 males and 11 females (mean age, 29.3 years; range, 14.83–53.89 years). Sex ($p = 0.988$, OR 1.01, 95% CI 0.363–2.711) and older age ($p = 0.399$, OR 0.980, 95% CI 0.935–1.027) were not significantly associated with bad splits during BSSO; however, more bad splits occurred in female than in male patients. Preoperative class of occlusion did not differ significantly either; bad splits occurring in 14 patients with a class II malocclusion and 2 with a class III malocclusion ($p = 0.862$, OR 1.143).

We analysed the duration between preoperative removal of third molars and bad splits. The preoperative status of third molars is summarized in Table 3. In 180 patients (328 sites), one or both third molars were absent at first consultation, making it impossible to determine the time of removal. Third molars were removed preoperatively in 177 patients (301 sites), with time of removal ranging from 1 month to 15 years prior to surgery (mean (SD) 10.4 (16.1) months). Third molars were removed during BSSO in 120 patients (219 sites) and remained present after surgery in 4 patients (6 sites). The time between removal of third molars and bad split was not significanttly associated with the occurrence of a bad split ($p = 0.149$, OR 0.998, 95% CI 0.998–1.001). However, the removal of third molars at the same time as BSSO was significantly associated with bad split ($p = 0.041$, OR 2.637). In 8 of the 17 bad splits, a third molar was present at the site of the split.

All patients were operated on either by experienced senior staff or a resident assisted by a senior staff member. In 165 (38.6%) patients, the sagittal splits on both sides were performed by senior staff; in 252 (59.1%) patients, senior staff performed

Table 3 Status of lower third molars in 427 patients.

Category	Left Side	%	Right side	%
Absent at first consultation	169	39.6	159	37.2
Removed prior to BSSRO	148	34.7	153	35.8
Removed concomitant with BSSRO	107	25.1	112	26.2
Present after surgery	3	0.7	3	0.7

Data are number (%).

the sagittal split on one side and a resident on the other side; and in 10 (2.3%) patients, a resident, supervised by senior staff, operated on both sides. The occurrence of bad splits was not associated with the surgeons' level of experience (resident vs staff member) ($p = 0.472$, OR 1.514, CI 95% 0.489–4.687).

Of the 17 patients with a bad split, 2 had persistent neurosensory disturbances after at least 1 year.

In 403 (94.4%) patients, BSSO was done with only spreaders and separators. A chisel was necessary in only 24 (5.6%) patients, because of a small bridge of cortical bone that remained at the inferior border of the mandible.

Postoperative mandibular fixation was by bilateral screws in 414 (97.4%) patients. In this group, 4 (0.9%) involved combined fixation with mini-plates, and 2 (0.4%) patients had screw fixation in combination with intermaxillary fixation (IMF). Five (1.2%) patients, unilateral plate fixation on 1 side and screw fixation on the other; bilateral plate fixation was used in 1 patient (0.2%). Plate fixation was used because of a bad split in 4 (0.9%) patients and fragile cortical bone in the other 6 (1.4%). Intermaxillary fixation was used on 9 (2.1%) patients, 7 times after a bad split and twice after the IVRO.

All patients eventually recovered with good functional and aesthetic results.

Discussion

The exact combination of factors that result in bad split is unknown. Reported predictors are the presence of third molars and age at operation. Older patients have been reported to have an increased risk of bad split.[6] In our patients, age was not a complicating factor, as we found no relationship between age and bad split.

No association between bad split and patient's sex or surgeon's experience has been reported, and our findings are consistent with others in this regard.[10,11,12]

The removal of third molars before BSSO is controversial. Some have suggested that if third molars need to be removed, it should be done at least 6 months before orthognathic surgery.[11,13,23] Other have authors advised removal of third molars at the same time as orthognathic surgery and they describe fewer postoperative complications, such as hypoesthesia, with this method.[4,15,24] In our patients, there were significantly more bad splits during BSSO among those who had simultaneous removal of the third molars.

Although one could expect that more healing time would reduce the risk of a bad split, our retrospective study did not allow us to infer an optimal time for removal of third molars before BSSO. In our clinic, most third molars that were present during the last 5 years preoperatively were removed at the time of BSSO. This is because separate third molar removal is estimated to increase the risk of inferior alveolar nerve damage, and separate operation was also more inconvenient for the patient who would have to undergo several procedures instead of just 1 combined procedure.

One would expect bad splits to occur more often with less experienced surgeons, such as residents. However, no such differences were found between senior staff members and residents, probably because the latter were closely supervised during BSSO and corrected when necessary.

In our study sample, a bad split occurred in 17 of 851 sagittal splits, which is consistent with the average reported in the literature (Table 4). The use of splitters and separators

Table 4 Reported incidences of bad split during BSSO.

	Year of publication	Number of bad splits	SSO's (n)	Patients (n)	Incidence per site (%)	Incidence per patient (%)
Doucet[4]	2011	21	677	339	3.1	6.2
Falter[5]	2010	14	2005	1008	0.7	1.4
Kriwalsky[6]	2007	12	220	110	5.5	10.9
Kim and Park[7]	2007	11	-	214	-	5.1
Van Merkesteyn[8]	2007	2	222	111	0.9	1.8
Teltzrow[9]	2005	12	2528	1264	0.5	0.9
Borstlap[10]	2004	20	444	222	4.5	9.0
Reyneke[11]	2002	4	139	70	2.9	5.7
Panula[12]	2001	12	-	515	-	2.3
Mehra[13]	2001	11	500	262	2.2	4.2
Acebal-Bianco[14]	2000	8	-	802	-	1.0
Precious[15]	1998	24	1256	633	1.9	3.8
Van de Perre[16]	1996	97	2466	1233	3.9	7.9
Turvey[17]	1985	9	256	128	3.5	7.0
Martis[18]	1984	5	-	258	-	1.9
Macintosh[19]	1981	16	-	236	-	6.8
Behrmann[20]	1972	10	-	600	-	1.7

without chisels, therefore, does not lead to a higher risk of bad splits. The bad splits were localised as 11 (64.7%) buccal plate fractures, 5 (29.4%) lingual plate fractures, and 1 condylar neck fracture (Figure 1 and 2). When a bad split occurred, additional fixation was usually necessary. Fractures of the buccal and lingual plate could be fixated with screws, or plates, or both and sometimes IMF, depending on the fracture lines. The fractured condylar neck resulted from a bad split of the buccal segment, with the condylar neck attached to the distal segment. The condylar process was therefore separated on purpose from the distal segment and we attempted to fix it to the proximal segment. Because this was not possible, we eventually wired the upper border and used IMF. This procedure was almost similar, although accidently, to the recently discussed supraforaminal horizontal oblique osteotomy.[25]

Although BSSO was planned in all patients, the procedure was converted to IVRO in 3 sites in 2 patients. This is only possible during a setback and requires IMF, making it a suboptimal option. However, when a safe sagittal split is not possible, it can be helpful in treating these difficult cases.

Our goal in using splitters and separators was to reduce postoperative neurosensory disturbances after BSSO, so the percentage of neurosensory disturbances after a bad split should not be increased. The incidence of persistent neurosensory disturbances after a bad split was 11.7% per patient in this study. Our reported incidence of neurosensory disturbances in previous studies using this technique was 10.5% per patient, which is slightly less.[22] Bad splits using this technique, therefore, do not introduce significantly more postoperative neurosensory disturbances.

The chances of good functional success after a bad split are high, and as such bad splits are regarded as complications without long-term consequences.[5,21] Nevertheless, the number of bad splits should always be minimized because of adverse short-term consequences, such as longer operation time, loss of concentration of the surgeon, use of intermaxillary fixation, and reoperation or conversion to IVRO with IMF. All patients in our group, including the patients with bad splits, functioned well after the operation(s).

References

1. Wyatt WM. Sagittal ramus split osteotomy: literature review and suggested modification of technique. *Br J Oral Maxillofac Surg* 1997;35(2):137-141.
2. Trauner R, Obewegeser H. The surgical correction of mandibular prognathism and retrognathia with consideration of genioplasty. I. Surgical procedures to correct mandibular prognathism and reshaping of the chin. *Oral Surg Oral Med Oral Pathol* 1957;10(7):677-689.
3. van Merkesteyn JP, Groot RH, van LR, Kroon FH. Intra-operative complications in sagittal and vertical ramus osteotomies. *Int J Oral Maxillofac Surg* 1987;16(6):665-670.
4. Doucet JC, Morrison AD, Davis BR, Gregoire CE, Goodday R, Precious DS. The presence of mandibular third molars during sagittal split osteotomies does not increase the risk of complications. *J Oral Maxillofac Surg* 2012;70(8):1935-1943.
5. Falter B, Schepers S, Vrielinck L, Lambrichts I, Thijs H, Politis C. Occurrence of bad splits during sagittal split osteotomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2010;110(4):430-435.
6. Kriwalsky MS, Maurer P, Veras RB, Eckert AW, Schubert J. Risk factors for a bad split during sagittal split osteotomy. *Br J Oral Maxillofac Surg* 2008;46(3):177-179.
7. Kim SG, Park SS. Incidence of complications and problems related to orthognathic surgery. *J Oral Maxillofac Surg* 2007;65(12):2438-2444.
8. van Merkesteyn JP, Zweers A, Corputty JE. Neurosensory disturbances one year after bilateral sagittal split mandibular ramus osteotomy performed with separators. *J Craniomaxillofac Surg* 2007;35(4-5):222-226.
9. Teltzrow T, Kramer FJ, Schulze A, Baethge C, Brachvogel P. Perioperative complications following sagittal split osteotomy of the mandible. *J Craniomaxillofac Surg* 2005;33(5):307-313.
10. Borstlap WA, Stoelinga PJ, Hoppenreijs TJ, van't Hof MA. Stabilisation of sagittal split advancement osteotomies with miniplates: a prospective, multicentre study with two-year follow-up. Part I. Clinical parameters. *Int J Oral Maxillofac Surg* 2004;33(5):433-441.
11. Reyneke JP, Tsakiris P, Becker P. Age as a factor in the complication rate after removal of unerupted/impacted third molars at the time of mandibular sagittal split osteotomy. *J Oral Maxillofac Surg* 2002;60(6):654-659.
12. Panula K, Finne K, Oikarinen K. Incidence of complications and problems related to orthognathic surgery: a review of 655 patients. *J Oral Maxillofac Surg* 2001;59(10):1128-1136.
13. Mehra P, Castro V, Freitas RZ, Wolford LM. Complications of the mandibular sagittal split ramus osteotomy associated with the presence or absence of third molars. *J Oral Maxillofac Surg* 2001;59(8):854-858.
14. Acebal-Bianco F, Vuylsteke PL, Mommaerts MY, De Clercq CA. Perioperative complications in corrective facial orthopedic surgery: a 5-year retrospective study. *J Oral Maxillofac Surg* 2000;58(7):754-760.
15. Precious DS, Lung KE, Pynn BR, Goodday RH. Presence of impacted teeth as a determining factor of unfavorable splits in 1256 sagittal-split osteotomies. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 1998;85(4):362-365.
16. Van de Perre JP, Stoelinga PJ, Blijdorp PA, Brouns JJ, Hoppenreijs TJ. Perioperative morbidity in maxillofacial orthopaedic surgery: a retrospective study. *J Craniomaxillofac Surg* 1996;24(5):263-270.
17. Turvey TA. Intraoperative complications of sagittal osteotomy of the mandibular ramus: incidence and management. *J Oral Maxillofac Surg* 1985;43(7):504-509.
18. Martis CS. Complications after mandibular sagittal split osteotomy. *J Oral Maxillofac Surg* 1984;42(2):101-107.
19. MacIntosh RB. Experience with the sagittal osteotomy of the mandibular ramus: a 13-year review. *J Maxillofac Surg* 1981;9(3):151-165.
20. Behrman SJ. Complications of sagittal osteotomy of the mandibular ramus. *J Oral Surg* 1972;30(8):554-561.
21. Veras RB, Kriwalsky MS, Hoffmann S, Maurer P, Schubert J. Functional and radiographic long-term results after bad split in orthognathic surgery. *Int J Oral Maxillofac Surg* 2008;37(7):606-611.
22. Mensink G, Zweers A, Wolterbeek R, Dicker GG, Groot RH, van Merkesteyn RJ. Neurosensory disturbances one year after bilateral sagittal split osteotomy of the mandibula performed with separators: A multi-centre prospective study. *J Craniomaxillofac Surg* 2012.
23. Schwartz HC. Simultaneous removal of third molars during sagittal split osteotomies: the case against. *J Oral Maxillofac Surg* 2004;62(9):1147-1149.

24. Precious DS. Removal of third molars with sagittal split osteotomies: the case for. *J Oral Maxillofac Surg* 2004;62(9):1144-1146.
25. Kaduk WM, Podmelle F, Louis PJ. Revisiting the supraforaminal horizontal oblique osteotomy of the mandible. *J Oral Maxillofac Surg* 2012;70(2):421-428.