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3

Neurosensory disturbances one year after bilateral sagittal split osteotomy of the mandibula performed with separators: A multicentre prospective study

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Abstract

Bilateral sagittal split osteotomy (BSSO) is an effective and commonly used treatment to correct mandibular hypo- and hyperplasia. Hypoesthesia of the inferior alveolar nerve (IAN) is a common complication of this surgical procedure. This prospective multi-center study aimed to determine the incidence of neurosensory disturbances of the IAN after BSSO procedures performed without the use of chisels. Our study group comprised 172 patients, with a follow-up period of 1 year, who underwent BSSO (with or without Le Fort I) that incorporated the use of sagittal split separators and splitters but no chisels. The percentage of BSSO split procedures that resulted in IAN damage was 5.1%. The percentage of patients (without genioplasty) who experienced IAN damage was 8.9%. The concomitant genioplasty in combination with BSSO was significantly associated with hypoesthesia. Peri-operative removal of the wisdom tooth or a Le Fort I procedure did not influence post-operative hypoesthesia. We believe that the use of splitting forceps and elevators without chisels leads to a lower incidence of persistent postoperative hypoesthesia after 1 year, after BSSO of the mandible, without increasing the risk of a bad split.

Introduction

Bilateral sagittal split osteotomy (BSSO), introduced by Trauner and Obwegeser in 1957,[1] is a successful and common treatment for mandibular hypo- and hyperplasia. Nevertheless, this treatment is known to give rise to various complications; hypoesthesia of the inferior alveolar nerve (IAN) is probably the most common of these.

IAN disturbances are caused by iatrogenic damage to the nerve, including excessive nerve manipulation, nerve laceration (for example, after soft tissue dissection at the medial ramus), fixation of segments by incorrect placement of position screws, large mandibular advancement, bad splits, and incorrect splitting techniques.[2-4]

Multiple studies report postoperative persistent hypoesthesia of the IAN, with the incidence ranging from 8% to 85%. Neurosensory disturbances of the IAN are highly associated with the morbidity rates of patients undergoing BSSO.[3-7] Surgical techniques aimed at minimizing these complications should thus be discussed and developed.

Based on our experience, we believe that the use of separators and splitters, without chisels, to split the mandible is less traumatic to the IAN. Our experience is supported by a retrospective study showing that 8% of the patients investigated experienced unilateral hypoesthesia; in this study[6], BSSO was also performed without chisels, and with splitters and separators. We hypothesize that BSSO performed with splitters and separators will have a lower incidence of IAN hypoesthesia compared to other splitting techniques. The aim of this prospective study is to test our hypothesis by determining the incidence of hypoesthesia of the IAN 1 year postoperatively among 172 patients who underwent BSSO without the use of chisels.

Material and methods

Patients

Of the 172 patients in the study group, 107 were treated at Leiden University Medical Centre and 65 at Helmond Elkerliek Medical Centre in the Netherlands. Treatment took place between 2005 and 2007, and involved BSSO using separators and splitters, without chisels. This method has been used regularly in both clinics for more than 10 years; hence, no approval was obtained from the institutional review board. Further, our study protocol was in accordance with the guidelines of our institution and complied with the Declaration of Helsinki.

We initially evaluated 177 patients, 5 of whom were excluded because of incomplete data. The clinical study group thus comprised 172 patients, 57 of whom were male and 115 female. The mean age was 29 years (range, 14–59 years; SD, 11). BSSO was performed without any other surgical treatment in the case of 123 patients (71.5%). In the case of 35 patients (20.3%), the BSSO was a part of bimaxillary treatment, and in the case of 4 patients (2.3%), the BSSO was combined with genioplasty. Ten patients (5.8%) underwent a bimaxillary procedure combined with genioplasty. No other concomitant surgical procedures were performed (e.g., segmental osteotomy or pre-implant surgery).

Six (3.5%) of the procedures involved setbacks, with a mean setback of 4 mm on the left side and 5.5 mm on the right side. The mean advancement achieved on the right side was 5.22 mm (SD 3.41), and it was 5.23 mm (SD 3.60) on the left side.

In the case of 34 patients (19.8%), one or more wisdom teeth (29 on both sides and 5 on one side) were removed during the operation (Figure 1). All patients were operated on by either experienced senior staff (95 patients, 55.2%) or a resident assisted by a senior staff member (75 patients, 43.6%).

The patients had no neurosensory disturbances before the operation. All patients underwent pre- and postoperative orthodontic treatment for correct dental alignment and adequate occlusion stability.

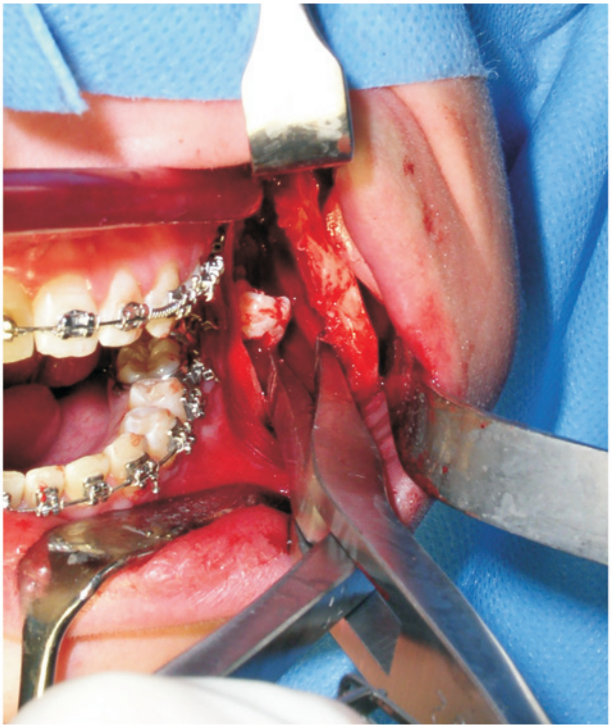

Figure 1 Sagittal split completed with the sagittal splitter (in situ) and separator on the left side. Wisdom tooth is visible in the split and removed during BSSO. Further, note the intact IAN visible just lateral to the wisdom tooth.

Surgical technique

All patients received anti-microbial prophylaxis (penicillin, 1 dose of 1 million units i.v., pre-operatively) and steroids (methylprednisolone i.v.) (for 3 days; day 1: 2 doses of 25 mg i.v., day 2: 2 doses of 12.5 mg i.v., day 3: 1dose of 12.5 mg). After general anesthesia and nasotracheal intubation, articaine and epinephrine in the ratio of 1:160.000 (Ultracaine D-S; Aventis Pharma, Hoevelaken, The Netherlands) were injected submucosally at the surgical site to prevent excessive bleeding during the procedure.

The BSSOs were performed according to the modified method of Hunsuck, except that chisels were not used[6]. Instead of chisels, splitting forceps (curved Smith Ramus separators; Walter Lorenz Surgical, Jacksonville, Florida, USA) and elevators were used. The mandibular ramus was exposed and the mandibular foramen was located. A periostal elevator was placed subperiosteally, just above the mandibular foramen; the horizontal bone cut was performed with a Lindemann bur (2.3 × 22 mm), approximately 5 mm above the mandibular foramen. Subsequently, the sagittal and vertical cuts were made with a short Lindemann bur (1.4 × 5 mm) (Figures 2 and 3). The

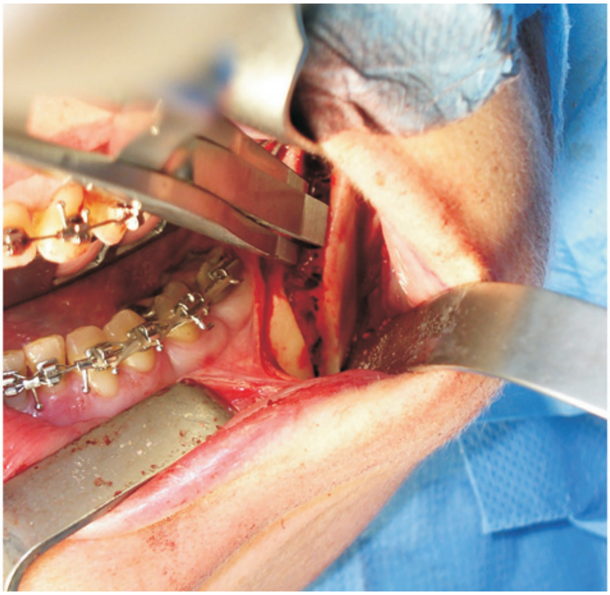

Figure 2 The beginning of the sagittal split is visualized. The sagittal splitter is in the sagittal cut. The sagittal separator is removed to visualize the unfolding of the split, clearly visible in the vertical cut. These sagittal and vertical cuts were made with the short Lindemann bur.

inferior border was cut, with this bur, perpendicularly through the inferior cortex, till it just reached the medial side. Splitting was performed 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 border of the vertical cut, and splitting was completed (Figure 2). Care was taken to ensure that the IAN was in the distal segment when the split was completed. A chisel was used, only if necessary, when a small bridge of cortical bone between the buccal and lingual segments remained at the inferior border of the mandible; this location is well below the level of the mandibular canal. When the IAN remained in the medial segment, it was carefully set free by blunt excavator preparation, or by a bur followed by blunt excavator preparation, to remove the lateral bony segments of the inferior mandibular canal. When necessary, the impacted third molar(s) were removed simultaneously after the mandible split was completed (Figures 1, 2, and 3).

After mobilization, the mandible was placed into the new intermaxillary relationship by using a wafer, and the intermaxillary wires were affixed. A stab incision was made through the skin; using a trans-buccal retractor, three 2-mm bicortical titanium screws, 9, 11, 13, and 15 mm in length (Martin GmbH, Tuttlingen, Germany), were placed in the upper border of the mandible on both sides. The temporary intermaxillary fixation was then removed, and the occlusion was checked. Elastic bands were not used immediately postoperatively; they were occasionally used 1 to 2 days postoperatively to attend to the occlusion when necessary.

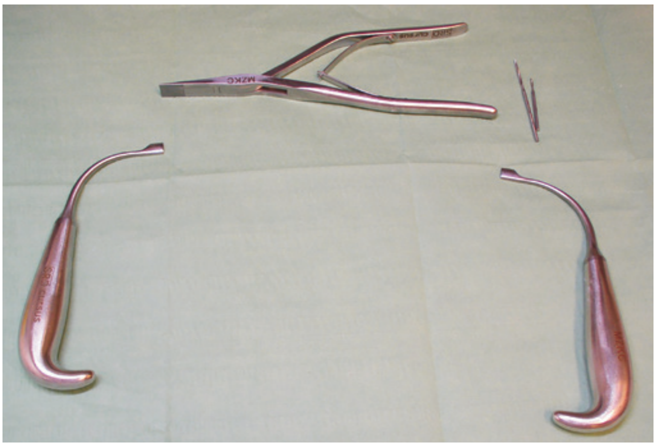

Figure 3 Instruments used during BSSO. Left and right sagittal splitters are shown in the left and right of the figure, respectively. The top shows the sagittal split separator. The top-right corner shows the long and short Lindemann bur used for the horizontal and sagittal/vertical cuts, respectively.

Evaluation

A standardized form was provided in both clinics to gather information before and after operation. Name, gender, date of birth, and operation date were collected and combined with surgical information (all divided into the left and right operation sites), including extent of mandibular advancement or setback of segments, presence of wisdom teeth, presence of a bad split, type of fixation, the use of a chisel, diameter of the screws used, concomitant surgical procedures, and whether the procedure was done by senior staff or a resident.

The peri-operative locations and conditions of the IAN can be listed as follows available: (1) IAN was not visible, and was located in the distal segment; (2) IAN was less than half visible, and was located in the distal segment; (3) IAN was more than half visible, and was located in the distal segment; (4) IAN was freed with a blunt instrument out of the proximal segment; (5) IAN was freed with the help of a bur, which was used to open the bony canal; (6) IAN was visibly damaged.

The neurosensory function of the IAN was tested before the operation; immediately after the operation (within 1 or 2 days); and 1, 6, and 12 months after the operation. IAN function was tested subjectively by asking whether the feeling of the lower lip was changed or different compared to the contra-lateral side or upper lip (or cheek or forehead in the case of bi-maxillary surgery). The postoperative function of the IAN was tested by the light touch detection method (mechanoceptive) and pinprick discrimination (nociceptive). The light touch detection method included gentle striking with a cotton tip (compared to an uncompromised site such as the lip, cheek, or forehead) and pinprick discrimination with the sharp end of a broken wooden stick. Thus, objective and subjective measurements were used to detect neurosensory disturbances; if any disturbance was noticed, the score was recorded as positive.

Statistical methods

All statistical analyses were performed using SPSS 16.0 for Windows (SPSS Inc., Chicago, USA). Crosstabs, the Pearson chi-square tests, and logistic regression were used to determine differences between parameters. Values of $p < 0.05$ were considered statistically significant.

Results

Mandibular advancement or setback was successful in all patients. At 12 months after surgery, 11 of the 172 patients (6.4%) experienced hypoesthesia on the right side; 9 patients (5.2%) experienced hypoesthesia on the left side, among these patients 2 had bilateral hypoesthesia. Thus, a total of 18 patients (10.5%; 16 unilateral and 2 bilateral) had hypoesthesia after 1 year (Table 1). No hyper-sensation was mentioned by any of the patients.

Table 1 Number of patients/sites and incidence of hypoesthesia after BSSO surgery.

Hypoesthesia after 12 months	Patients/sites	Incidence (%)
Total group (172 patients)	18	10.5%
Right site (172 sites)	11	6.4%
Left site (172 sites)	9	5.2%
Total sites (344 sites)	20	5.8%
Sub-group without genioplasty (p = 0.018) (158 patients)	14	8.9%
Right site (158 sites)	8	5,1%
Left site (158 sites)	8	5,1%

No influence of gender on hypoesthesia was found (OR = 0.99; p = 0.985). There was a significant positive association between age and hypoesthesia; the frequency of hypoesthesia increased in older patients (OR = 1.07 per year of increase in age; p = 0.006) (Table 2).

In 34 patients (19.8%), one or more wisdom teeth were present (29 on both sides and 5 on one side). With regard to unilateral BSSO split procedures (e.g., 172 left sites and 172 right sites in a total of 344 sites) with and without peri-operative removal of the wisdom teeth, no influence was found on post-operative hypoesthesia 12 months after surgery (p = 0.841). When the effect of patient variables was considered, no significant difference was found (Generalized Estimating Equations (GEE); OR = 1.1; 95% CI: 0.37–3.32; p = 0.864). The frequency of hypoesthesia in unilateral split procedures was 5.8% (Table 2). The Le Fort procedure (35 patients; 20.3%) also had no significant influence on the occurrence of hypoesthesia (14.3%) after 12 months (p = 0.209) (Table 2).

In 14 patients (8.1%), BSSO was combined with genioplasty (with or without a Le Fort I procedure); of these patients, 28.6% experienced hypoesthesia. The association of genioplasty with hypoesthesia was statistically significant (p = 0.018) (Table 2).

Table 2 Possible concomitant influence on hypoesthesia after BSSO surgery and significance (p-value), odds ratio (OR), and 95% confidence interval (95% CI).

Concomitant influence on hypoesthesia after BSSO treatment	p-value	OR	95% CI	Risk of hypoesthesia after BSSO
Gender	p = 0.985			No difference in risk
Age	p = 0.006			More risk with increasing age
Peri-operative removal of wisdom teeth	p = 0.841	1.123	0.36–3.481	No extra risk
Le Fort I procedure	p = 0.209	2.111	0.659–6.767	No extra risk
Genioplasty	p = 0.018	5.067	1.32–19.42	Increased risk
Freeing IAN by instruments (by bur or blunt instruments)	p = 0,003 (right side) p = 0,000 (left side)			Increased risk

The BSSO procedure without the concomitant genioplasty showed a hypoesthesia frequency of 8.9%, and the frequency of hypoesthesia in unilateral split procedures without the concomitant genioplasty was 5.1% (Table 1). Because genioplasty showed an association with hypoesthesia, we analyzed the remaining parameters without the 14 patients from the genioplasty group, and thus 158 patients remained in the study group.

In the remaining 158 patients (316 surgical sites), 2 direct injuries to the IAN occurred during the procedure. One resulted in hypoesthesia of the IAN that was still present 12 months after surgery; the other led to hypoesthesia that lasted 1 month, after which normal sensation was regained. In 72 surgical sites (22.8%), no nerve was visible during the split. In 51 sites (16.2%), the IAN was less than half visible, and in 183 sites (57.9%) more than half of the IAN was visible in the distal segment.

The IAN had to be released from the buccal segment with a bur for 30 surgical sites; in 45 sites, it had to be released in a blunt manner; thus, 75 sites (23.7%) required instrumentation. A (unilateral) “bad split” occurred in 7 patients (4.5%); 3 resulted in permanent hypoesthesia that persisted 12 months after surgery. The bad splits were all buccal or lingual plate fractures. Because of these bad splits, 2 IAN’s had to be freed by means of a bur, resulting in postoperative hypoesthesia after 12 months. A plate fixation was used in 4 sites, 2 of which were required because of a bad split. A chisel was used in 2 surgical sites, one of which was required because of a bad split. No hypoesthesia was found after the use of chisels. Hypoesthesia was not observed after any of the setback procedures. No significant correlations were found between any of these parameters.

Freeing the IAN from the proximal segment with a blunt instrument or by using a bur to open the bony canal was significantly associated with hypoesthesia (right side, $p = 0.003$; left side, $p = 0.000$), however there was no significant difference between the use of a bur or a blunt instrument in freeing the IAN comparing these 2 operation techniques (right side, $p = 0.053$; left side, $p = 0.709$).

Discussion

According to the current literature, persistent hypoesthesia of the IAN is the most common complication of BSSO of the mandible. Our hypothesis was that BSSO performed with splitters and separators will have a lower incidence of IAN hypoesthesia compared to other splitting techniques. The percentage of BSSO split procedures that resulted in IAN damage was 5.1% in this study, and 8.9% patients experienced IAN damage. Other studies reported persistent hypoesthesia of the IAN in 8–85% of patients who had undergone BSSO. [3-7]

Nerve fibers can be injured by surgical manipulation, such as stretching or crushing during the operation, or by compression of the nerve bundle within the mandibular canal; nerve damage can also result from the hypoxia and edema caused by these manipulations. The type of nerve injury that results is most likely a combination of neurapraxia (bruising that damages the myelin sheath) and partial axonotmesis (nerve fibre damage caused by sectioning of the axon).[3,4,8] The lower incidence of partial axonotmesis and neurapraxia in our study may be attributed to the fact that we did not use a chisel.

Our study showed no association between the persistence of hypoesthesia at post-surgery 12 months and peri-operative wisdom teeth removal or Le Fort I osteotomy (Figure 1). This observation is consistent with that of Reyneke et al., who reported that although IAN recovery was slower in patients who had un-erupted wisdom teeth at the time of surgery, the recovery rates at 1 year were equal to those who did not have un-erupted wisdom teeth.[9]

To test for neurosensory disturbances in our patients, we used both objective and subjective measurements. Variations reported in the literature on the prevalence of hypoesthesia of the IAN depend on whether objective measurements or subjective self-reports are used.[10] As Bothur and Blomqvist reported in their study, these objective and subjective measurements do not always correspond.[11,12] We therefore used both modalities; if a disturbance was noted using either test method, the score was recorded as positive. This methodology avoided underestimation of hypoesthesia.

Among the 158 patients in our study group, 8,9% experienced hypoesthesia (without the concomitant genioplasty). When the unilateral surgical sites were considered, the incidence was 5.1% (Table 1). Few authors have reported the rates of hypoesthesia to be under 10%.[2,7,8,13,14] The lower rates of hypoesthesia seen in our study suggest that the use of a splitter and separator, without the use of a chisel, could lead to fewer injuries to the IAN.

The reported incidence of a bad split at a BSSO site ranges from 0.5% to 5.4%, which is comparable to the incidence (4.5%) with our splitting technique; therefore, this technique does not lead to the development of more bad splits. Furthermore, bad splits do not seem to result in more damage to the IAN.[15,16]

As mentioned previously, genioplasty is significantly associated with hypoesthesia of the IAN. In our study, 14 patients underwent BSSO combined with genioplasty. This group of patients had a higher incidence of hypoesthesia at 12 months after surgery ($p = 0.046$) than did those without genioplasty. This observation is consistent with another study that showed an 11.1% increase in neurosensory disturbances associated with BSSO when genioplasty was used as a concomitant procedure.[13]

The type of fixation used also influences the occurrence of IAN-associated hypoesthesia. The low incidence of hypoesthesia seen in our study indicates that positional screw fixation is reliable.[2,4,17]

Another factor that may affect the occurrence of hypoesthesia as a complication of BSSO is the method of handling soft tissues during the procedure. One study showed a weak association between reduced hypoesthesia and gentle handling of soft tissues, especially the medial part of the ramus.[5] In our BSSO procedures, we never use the larger channel retractor for retraction of these medial soft tissues. Because we use a small bur instead of a saw, the retraction can be less wide, requiring only the use of a periostal elevator. Furthermore, the foramen can be identified only by lifting the periostium and not probing with, for example, a blunt ball-pointed amalgam condenser.

Most patients are satisfied with their BSSO treatment despite mildly altered sensation (87–100% satisfaction).[3,7] Nonetheless, other treatment modalities should be discussed and perfected to minimize these common complications.

Conclusion

Our findings here indicate that the use of splitting forceps and elevators leads to a lower incidence of persistent post-operative hypoesthesia after BSSO of the mandible, without increasing the risk of a bad split. Further prospective investigations to compare these different techniques and their outcomes are underway.

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