Bilateral sagittal split osteotomy by the splitter-separator technique: technical aspects, safety, and predictability

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Influence of BSSO surgical technique on postoperative inferior alveolar nerve hypoesthesia: a systematic review of the literature

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Abstract

Objective: The aim of this study was to evaluate the influence of different splitting techniques, namely, “mallet and chisel” versus “spreading and prying”, used during bilateral sagittal split osteotomy (BSSO) on postoperative hypoesthesia outcomes.
Study design: We systematically searched the PubMed and Cochrane databases (from January 1957 to November 2012) for studies that examined postoperative neurosensory disturbance (NSD) of the inferior alveolar nerve (IAN) after BSSO.
Results: Our initial PubMed search identified 673 studies, of which, 14 met our inclusion criteria. From these 14 studies, 3 groups were defined: (1) no chisel use (4.1% NSD/site), (2) undefined chisel use (18.4% NSD/site), and (3) explicit chisel use along the buccal cortex (37.3% NSD/site).
Conclusion: Study heterogeneity and a frequent lack of surgical detail impeded our ability to make precise comparisons between studies. However, the group of studies explicitly describing chisel use along the buccal cortex, showed the highest incidence of NSD. Moreover, comparison of the study that did not use chisels with the 2 studies that explicitly described chisel use, revealed a possible disadvantage of the “mallet and chisel” group (4.1% versus 37.3% NSD/site). These results suggest that chisel use increases NSD risk after BSSO.

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Introduction

Bilateral sagittal split osteotomy (BSSO) is a successful and common treatment for mandibular hypo- and hyperplasia. The intraoral osteotomy was first described by Schuchart[1], later by Mathis[2] , and became a regular procedure after modifications developed by Trauner and Obwegeser were introduced in 1957.[3] The BSSO technique was further modified by Dal Pont in 1959[4,5], Hunsuck[6] in 1968, and Epker[7] in 1977. Despite being routinely performed, BSSO is known to give rise to various complications. The most commonly observed complications include inferior alveolar nerve (IAN) impairment and unfavorable splitting of the mandible, also known as a bad split. IAN impairment leading to permanent anesthesia of the lower lip is probably the most frequently observed complication of BSSO having the most serious impact on the patient's daily life.[8]

Multiple studies have reported persistent hypoesthesia of the IAN after BSSO, with incidences ranging from 0% to 82% with the use of various tests.[9] Neurosensory disturbance (NSD) of the IAN is a considerable morbidity for patients, especially given the elective nature of this surgery. IAN disturbance is caused by iatrogenic damage, especially from incorrect splitting techniques or osteotomies. Nerve damage may also result from excessive nerve manipulation (after soft tissue dissection at the medial aspect of the mandibular ramus), nerve laceration, incorrect placement of position or lag screws during segment fixation, large mandibular advancement, impingement by bony spiculae, or bad splits.[10-14] Iatrogenic damage of the nerve may also be a secondary consequence of surgery-induced hypoxia and edema, which frequently results in a combination of neurapraxia and partial axonotmesis.[10,15] Thus, surgical techniques should be discussed and critically evaluated to minimize potential complications of BSSO.

The type of BSSO splitting technique used may also be a factor affecting the incidence of postoperative hypoesthesia; however, such a correlation has yet to be shown. Even early on, surgeons worried about the potential for chisels to cause IAN injury during BSSO. Therefore, these surgeons used a thin cement spatula instead of a chisel, which seemed to reduce the incidence of postoperative.[16-18] More recently, a number of studies have described the use of chisels to split the mandible; specifically, the chisel is driven along the inner surface of the buccal cortex (Figures 2a and b). These studies, in which chisels were employed, report rather high incidences of postoperative NSD, ranging from 31% to 60% per patient[19-21] and 17% per side.[22] In contrast, other studies emphasize that techniques involving prying and spreading are safer for splitting the mandible compared with "mallet and chisel" methods.[23-26]

The aim of this systematic review was to assess the influence of the type of BSSO splitting technique utilized, namely, "mallet and chisel" or "spreading and prying," on postoperative hypoesthesia outcomes.

Materials and methods

A search of PubMed (including the Cochrane database) was performed, limited to the time interval from January 1957 to November 2012, using the following search strategy: ((“orthognathic surgical procedures”[Mesh] OR “orthognathic surgical procedures”[tiab]) OR (“bsso” OR “bilateral sagittal split osteotomy” OR “mandibular osteotomy” OR “mandibular advancement” OR “mandibular setback”)) AND nerve* with an English language restriction. A second search was performed using the following strategy: ((bsso) OR (bilateral sagittal split osteotomy) OR (mandibular osteotomy) OR (bssro) OR (mandibular advancement) OR (mandibular setback) OR (orthognathic surgery)) AND ((nerve injury) OR (nerve damage) OR (inferior alveolar nerve) OR (trigeminal nerve)) AND (English [lang]). To expand our search, we also evaluated studies identified through the “related citations” option in PubMed and through manual searches of the references of selected studies.

Studies were selected for inclusion based on the criteria listed in Table 1. When the title and abstract either fulfilled the inclusion criteria or did not provide sufficient information to determine whether the study was eligible for inclusion, the full-text article was retrieved. Subsequently, the Materials and Methods and Results sections were read and scored. The main outcome extracted was the frequency of NSD of the IAN in BSSO patients as assessed through both clinical and subjective methods after 1 year. Additionally, studies were categorized according to the BSSO splitting technique employed.

Results

Study inclusion

From the initial PubMed search, 77 studies were found to be eligible for evaluation in their full-text form (Figure 1). The different parameters required in order for a study to be included in our analysis are shown in Table 1. After strict application of these inclusion criteria, 14 studies were selected for analysis in our systematic review. Most reports identified in our PubMed searches were excluded due to either insufficient description of the exact splitting technique utilized (n= 22) or to an insufficient number of patients included in the study (n = 28). Additional reasons for exclusion included a follow-up period of less than 1 year (n = 5), failure to properly report the incidence of NSD (n = 6), absence of rigid fixation (n = 5), measurement of NSD by electrophysiologic tests (n = 2), and use of nonhuman subjects (n = 1). One study was excluded as it evaluated the same patient population as another report, and several articles did not meet multiple inclusion criteria.

Table 1 Inclusion criteria.

Postoperative outcome of hypoesthesia tested by subjective methods and clinical tests (e.g., mechanoceptive and nociceptive tests)
Rigid fixation (e.g., plates or screws, no IMF)
Only retrospective or prospective (case-control, cohort, or randomized) studies
Human subjects
Description of surgical technique used during BSSO
Follow-up period of at least 1 year
Inclusion of at least 50 patients

Abbreviations: BSSO, bilateral sagittal split osteotomy; IMF, intermaxillary fixation.

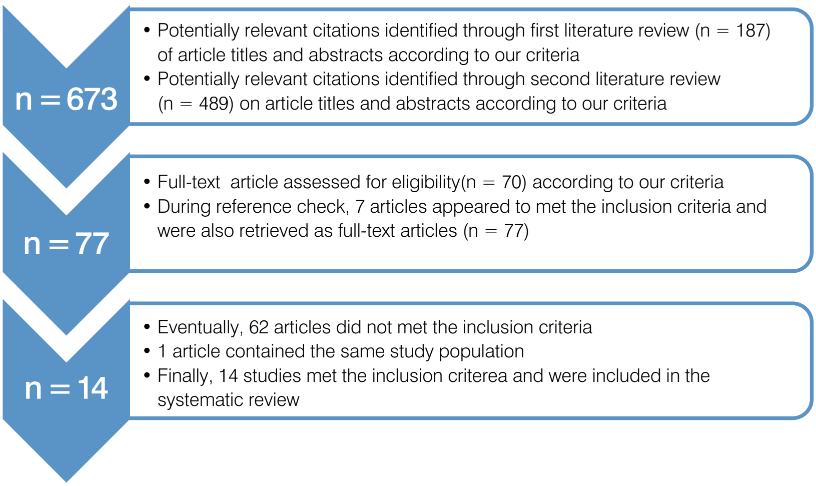

Figure 1 Flow chart summarizing the literature search for the systematic review.

Findings

Of the 14 studies included, only 2 explicitly described using the "mallet and chisel" method along the inside of the buccal cortex (Figures 2a and b). The incidences of postoperative NSD in these studies were 40% per side[27,28] and 30.1% per patient.[29]

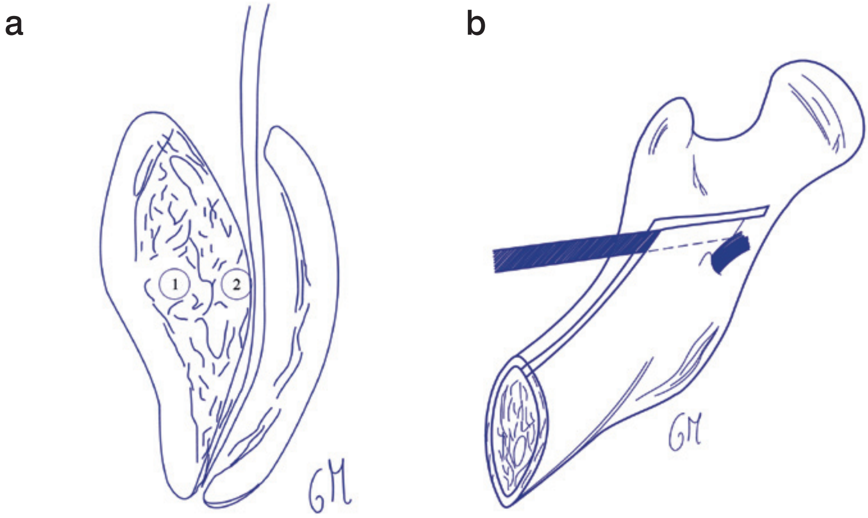

Figure 2a Coronal section of the mandible.

Chisels used to split the mandible along the inner buccal cortex. (1) Normally, the inferior alveolar nerve is positioned more lingually. (2) However, sometimes it is located more buccally. In the latter position, there is a greater risk of nerve damage. Also, compressing the spongious bone lingually while inserting the chisels may lead to damage of the nerve.

Figure 2b Medial view of the mandible.

The superior part of the entrance of the mandibular foramen with the lingula is shown. A curved chisel is used to force a Hunsuck fracture behind the mandibular foramen, which may result in damage due to the presence of a sharp instrument along the inferior alveolar nerve (IAN). There also may be traction on the IAN, and possibly on its vascular supply, at the entrance of the mandibular foramen, which may result in a temporary ischemic event.

Only 1 study explicitly stated that chisels were not used to split the mandible; instead, prying and spreading was accomplished using separators and splitters, with an NSD incidence of 8.9% per patient.[25]

Most studies described the splitting technique used by referring to a technique characterized in an earlier publication, or by reporting additional personal modifications at the same time. Of the earlier techniques described, only Epker reported not driving chisels into the mandible for more than 10 mm.[7] The other studies describe modifications in which chisels are used along the nerve to the inferior border.[3,5-7,17,30,31] In Table 2, the mean NSD incidences of these modifications are shown to range from 12.8% to 32%, which are higher than that in the study explicitly not using chisels.

Table 2 Description of BSSO modification with incidence of postoperative NSD.

Modification*	No. of studies	NSD incidence per side, %	Mean NSD incidence per side, %	Studies
Obwegeser	1	32	32	Nesari et al.[47]
Dal Pont	2	0-30.7	21.3	Fujioka et al.[48]; Jokić et al.[35];
Epker	5	1.6**-50	19.5	Scheerlinck et al.[49] ; Bothur and Blomqvist[50]; Al-Bishri et al.[14]; D'Agostino et al.[51]; Hanzelka et al.[52]
Hunsuck	1	12.8	12.8	Borstlap et al.[10]

* When a study referred to multiple modifications, it was categorized by the modification published last (eg, an Obwegeser-Dal Pont modification was categorized as a Dal Pont modification).

** Hanzelka et al.[52] reported an NSD incidence of 3.1% per patient (9/290 patients); however, based on the figure shown in their study, this should be 9/580 patients, or 1.6% per side.

Abbreviations: BSSO, bilateral sagittal split osteotomy; NSD, neurosensory disturbance.

Note: Becelli et al.[53] and Raveh et al.[54] mentioned the use of chisels in their studies, but the techniques used could not be classified as one of the "classic" modifications; these studies had an NSD incidence of 13% and 6.7%, respectively. Studies with explicit or absent chisel use are not in this table (n = 3; Westermark et al.[27,28]; van Merkesteyn et al.[25]; Bruckmoser et al.[29]).

In order to show the potential influence of chisel use on NSD outcomes, the studies were divided into 3 groups depending on whether or not chisels were used and the type of technique used: (1) no chisel use during BSSO (4.1% NSD per site), (2) undefined use of chisels (18.4% NSD per site), and (3) explicit use of chisels along the buccal cortex (37.3% NSD per site). The mean NSD incidences according to BSSO technique are provided in Table 3 and Figure 3.

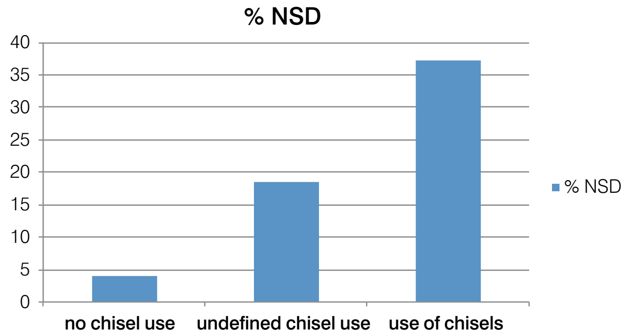

Figure 3 Incidence of postoperative neurosensory disturbance according to method of splitting the mandible.

Table 3 Incidence of postoperative NSD according to method of mandible splitting.

Method	No. of studies	Referral to a modification, if mentioned	NSD incidence per side, mean (range), %	Studies
No chisel use	1		4.1	Merkesteyn et al.[25] (9/218, 4.1%)
Undefined chisel use	11	Epker Obwegeser Dal Pont Hunsuck Bell and Schendel	18.4 (1.6*-50)	Raveh et al.[54] (27/206, 13%); Scheerlinck et al.[49] (36/206, 17.3%); Fujioka et al.[48] (70/228, 30.7%); Becelli et al.[53](6/120, 5%); Bothur and Blomqvist[50] (80/160, 50%); Borstlap et al.[10] (right NSD, 22/199; left NSD, 29/198; 12.8%); Al-Bishri et al.[14],(68/150, 37%); Nesari et al.[47] (43/136, 32%); D'Agostino et al.[51](48/100, 48%); Hanzelka et al.[52] (9/580, 1.6%); Jokić et al.[35] (0/100, 0%)
Explicit chisel use along the buccal cortex	2		37.3 (30.1-40)	Westermark et al.[27,28] (219/548, 40%); Bruckmoser et al.[29] (62/206, 30.1%)

Abbreviation: NSD, neurosensory disturbance.

* Hanzelka et al.[52] reported an NSD incidence of 3.1% per patient (9/290 patients); however, based on the figure shown in their study, this should be 9/580 patients, or 1.6% per side.

Discussion

NSD of the IAN is a major complication of orthognathic surgery that lowers the satisfaction level of patients,[32] especially because of the elective character of the surgery.[32] The purpose of using chisels is to force a fracture line along the mandible in order to create a correct sagittal split, thereby preventing a bad split; however, chisel use is associated with substantial risk of significant complications. Previous studies have shown that splitting the mandible by spreading and prying techniques, using instruments made for this purpose (e.g., splitters and separators), results in good clinical outcomes, with a “low to normal” bad split incidence (1.8% per patient) and low postoperative NSD incidence (8.3% per patient).[25,33]

Our objective in this systematic review was to reveal the importance of the actual splitting technique used on postoperative hypoesthesia. However, most of the full-text articles identified in our PubMed searches that were eligible for further research were eventually excluded because of their failure to describe the splitting technique used in sufficient detail. Many studies only characterized the BSSO splitting method used by referencing a technique described in previous studies, e.g., BSSO with Hunsuck modification. Only a few studies carefully described the actual splitting process employed, including which instruments were used. As stated in other studies, these details are likely to be important for determining the risk factors for NSD caused by BSSO.[34]

Only 14 studies met our inclusion criteria. When the selected articles were divided into 3 groups (no chisel use, undefined chisel use, and explicit chisel use), a tendency to a higher incidence of NSD in the chisel group was observed (Table 3 and Figure 3), showing a 4.1%, 18.4%, and 37.3% NSD incidence after BSSO, respectively. In addition, the modifications with the use of chisels, based on their original description in the literature, mentioned in Table 2 show rather high mean incidences (12.8%-32%) after BSSO.

One unexpected result, is a study that had a postoperative NSD incidence of 0% using a Dal Pont method not otherwise specified.[35] This NSD incidence is very low, and, as also stated by the authors, this result must be interpreted with caution because of several factors. First, all patients had hypoesthesia postoperatively, which is not in-line with the literature. Second, the 2 oldest patients showed recovery of sensation that was faster than average in this group of patients, which is also not in-line with the literature. Third, in all patients, hypoesthesia eventually resolved, which, thus far, has not been. Fourth, the study contained relatively young patients, only mandibular setbacks, and only 2 experienced surgeons.

The causes of IAN damage during surgery are likely multifactorial. In our opinion, the intraoperative technique is likely to play an important role, especially when chisels are used along the IAN—a contention supported by other authors during intraoperative measuring.[36] Medial dissection has also been described as a factor causing impairment of the IAN. A few intraoperative studies have reported a decrease in nerve function during medial dissection identifying the lingula/mandibular foramen. In these cases, however, total recovery was achieved either during surgery or within a short period following surgery. In addition, one study indicated that a decrease in intraoperative nerve function may result from additional damage to the IAN by sharp instruments, such as chisels.[37] Panula et al. [12] demonstrated the importance of minimal distraction of the soft tissue in the ramus during medial dissection, though this was not the sole cause of all IAN disturbances.

Other authors have described the potential influence of the splitting technique on postoperative NSD. Nakagawa et al.[34] stated that the mandibular split should be restricted to within the upper border of the cortical surface in order to avoid neural injury, and advised that this aspect of surgical assessment should be investigated further. This idea is in-line with our hypothesis that the technique used to split the distal and proximal mandibular segments is likely to be an important factor in postoperative NSD outcomes. We suggest that spreading and prying the mandible poses less risk for NSD of the IAN than does the classic “mallet and chisel” method, in which the chisel is forced along the medial site of the buccal cortex to separate the cortical and spongious bones lateral to the IAN and to fracture the inferior border of the mandible (Figures 2a and b). Nakagawa et al.[34] also found, by intraoperative measuring with trigeminal somatosensory-evoked potential (TSEP) spectra, that the onset of sensory deficit occurred after medial periosteal dissection and that the change in the shape of the spectra suggested that dissection was not the only inducer of postoperative NSD. Thus, subsequent surgical processes or changes in anatomic positions contribute to the change in the TSEP spectra. Furthermore, Jääskeläinen[37] stated in 2004 that the saw and chisels used during splitting of the mandible may lacerate the IAN. They demonstrated that the total disappearance of sensory action potential of the IAN that occurred during splitting of the mandible with sharp instruments was compatible with an axonal lesion of the IAN. This is especially important when the nerve is positioned more buccally, as described by Wittwer et al.[38], who mentioned an anatomically neurosensory-compromising proximity of the mandibular canal when it is in contact with or less than 1 mm from the external cortex. This results in more postoperative NSD, as shown by Yoshioka et al.[39], especially when you use chisels along the medial site of the buccal cortex to the inferior border (Figure 2a).

Forcing a lingual Hunsuck split also could harm the IAN. In this chisel technique, a curved chisel enters through a bur cut just above the mandibular foramen, and is driven along the mandibular foramen in order to start a lingual fracture behind the foramen (Figure 2b), which could potentially damage the IAN. However, this detail of the chisel technique was not included in the selected papers, so no conclusions are possible.

Other causes of IAN damage during surgery could be the length of mandibular advancement and the type of fixation. Like other studies, Bruckmoser et al.[29] showed no significant difference in postoperative hypoesthesia after BSSO between the use of position screws and plates. Therefore, the type of fixation is not considered to be an influencing factor, regardless of the splitting technique employed. This is probably because there is no major difference in the anatomy of the fixation place. Larger advancements are thought to cause more postoperative hypoesthesia, as shown previously.[40] However, because information regarding the exact replacement during surgery was unavailable for some of the studies in this review, this could not be linked to postoperative hypoesthesia. Furthermore, we assume that the amount of replacements is equally distributed and therefore will attribute in the same amount of nerve damage within the different splitting techniques and will not be influenced by the type of splitting technique (i.e., fracture pattern).

The inclusion criteria applied in the present study were chosen carefully. The measurement of postoperative hypoesthesia can be performed by purely objective sensory tests (e.g., TSEP, blink reflex, and orthodromic sensory nerve action potentials), by relatively objective clinical tests, such as mechanoceptive tests (e.g., static light touch, 2-point discrimination, and brush stroke direction) and nociceptive tests (eg, thermal discrimination or pin tactile discrimination), or by subjective tests (eg, visual analog scale and scoring lists). Purely objective tests clearly show a lower frequency of NSD compared with conventional clinical testing modalities and often approximate 0%, whereas subjective tests almost never reach such a low incidence.[37,41,42] Due to this contrast, we excluded the 2 studies that used only the TSEP measuring method. However, the significance of subjective testing versus objective clinical testing is ambiguous; in part, we believe that patients tend to adapt to neural deficit and report normal sensation, whereas clinical tests still show NSD, which also has been noted in previous studies.[9,10,43] Therefore, relatively objective clinical tests combined with subjective tests seem to be the most reliable way of testing NSD.

Although some authors consider the recovery of sensation after an IAN lesion to be stabilized 18 months after iatrogenic trauma, the general consensus is that a 12-month follow-up period is sufficient for nerve regeneration to occur and to enable informative neurologic data monitoring.[9,35,43,44] Most NSD essentially disappears within 1 year.[43] Therefore, we included all studies with a follow-up of at least 1 year. On the basis of similar studies, it was decided that a sample should consist of at least 50 patients.[35] Without a sufficiently large sample size, the absence of a single persistent IAN disturbance could significantly influence statistical inferences. After careful selection, we included all retrospective (n = 6) and prospective (n = 8) studies, even though prospective studies are generally superior to retrospective studies. The included papers were heterogeneous in many of their parameters, so that, although postoperative NSD incidences could be compared, possible confounding variables were present and should be discussed. For example, it is known that both the age of the patient at the time of surgery and the addition of a genioplasty increase the risk of NSD.[40,45] Some authors excluded cases that included genioplasty because of this influence. The experience of the surgeon is also a likely factor affecting the incidence of postoperative NSD, as more experienced surgeons have been reported to cause less damage to the IAN than do less experienced surgeons. However, diligent observation of a less experienced surgeon by one with more experience would likely avoid this problem. Paulus and Steinhauser[46] reported a higher risk of NSD of the IAN associated with rigid fixation. Presently, rigid fixation of the proximal and distal segments is the standard of care. Therefore, we excluded patients with intermaxillary fixation.

One study that is particularly interesting for our hypothesis is that of Westermark et al.[27,28] They commented on 2 types of mandible splitting techniques. In both types, they used chisels along the nerve to split the inferior border. However, in one technique, they specifically used the “cortical shaving” method, and in the other, they used a spreading and prying method to split the segment apart, and eventually used osteotomes to complete the inferior border cut. In their conclusion, they stated that “the 2 split techniques were followed by equal distributions of sensitivity scores (40% NSD per side),” but they did not elaborate further on this point. Having rather high incidences of NSD in both groups, but equally divided, unfortunately precluded our drawing any conclusions from their study.

Conclusion

It is difficult to draw solid conclusions from this systematic review for various reasons. Significant differences in the methods of information collection, heterogeneity across various parameters between studies, and the absence of explicit descriptions of the splitting techniques used made it difficult for exact comparison. However, we did find that studies in which chisels were explicitly used along the inner side of the buccal cortex showed relatively high incidences of NSD. Furthermore, the modifications reported by Epker, Hunsuck, Dal Pont, and Obwegeser (Table 2) with possible use of chisels during BSSO showed higher incidences of postoperative NSD (12.8%–32%). Furthermore, the difference between the 1 study that did not use chisels and the 2 studies that explicitly used chisels in terms of NSD incidence was large (4.1% versus 37.3% per side, respectively). This clearly indicates the disadvantage of the “mallet and chisel” group. Therefore, chiseling your way through the mandible may be considered an increased risk factor for postoperative hypoesthesia, while spreading and prying methods are likely to be safer with regard to the occurrence of bad splits and IAN damage.[23-25,45] Therefore, we strongly recommend spreading and prying the mandible with splitters and separators, or even perhaps with a chisel, over the classic “mallet and chisel” technique.

Future studies on the sequelae of BSSO with the inclusion of more patients should, in our view, precisely describe the splitting technique used. Furthermore, the results of postoperative NSD incidence should be given per side for better comparison between different studies, as suggested by Poort et al.[9] A randomized study to compare the influence of chisels during the splitting of the mandible should be performed to further analyze the advantages of the different techniques.

Supplementary Table Overview with different parameters of all 14 studies included in this systematic review.

Author	Publication year	Number of patients	Number of sides	Retrospective/ prospective research	Obw#	Hun	Dal Pont	Epker	Referral to other technique(8)	Chisel use mentioned in manuscript	"Classic" Mallet & chisel along inside buccal cortex	
Bruckmoser et al.	2012	103	206	retro	N	N	N	N	According to Watzke	Y	Y	
Jokic et al.	2012	50	100	pros	N	N	Y	N	N	NK	NK	
Hanzelka et al.	2011	290	580	pros	N	Y	N	Y	N	Y	NK	
D'Agostino et al.	2010	50	100	retro	N	Y	N	Y	N	Y	NK	
van Merkesteyn et al.	2007	109	218	retro	N	Y	N	N	N	N	N	
Nesari et al.	2005	68	136	retro	Y	N	N	N	N	NK	NK	
Al-Bishri et al.	2005	93	185	retro	N	N	N	Y	N	NK	NK	
Borstlap et al.	2004	199	397	prosp	Y	Y	Y	N	N	NK	NK	
Bothur and Blomqvist	2002	80	160	retro	N	N	N	Y	According to Bell & Schendel	NK	NK	
Becelli et al.	2002	60	120	prosp	N	N	N	N	N	Y	probably	
Westermark et al. 1998a; Westermark et al.	1998		548	prosp	N	N	N	N	According to Bell	Y	Y(5)	
Fujioka et al.	1998	114	228	prosp	Y	N	Y	N	According to Dautrey	NK	NK	

Prying & spreading the mandible	% genioplasty	Fixation method	Mean age in years	Resident performing surgery	subj/obj	Objective measurements	% NSD after 1-y follow-up
Y	43.8%	pos screws/ plates	26.4	N	subj	NA	30.1% per side(1)
NK	0%	pos screws	22.1	N	obj	SW	0%
NK	0%	plates	27	N	subj	NA	3.1% per pat/ 1.6% per side
NK	NK	plates	27	NK	obj	LTS/PPS/S2/ M2D	48% per side
Splitters and separators	25.7%	pos screws	26.9	Y	obj+subj	LTS/PPS	8.3%per pat/ 4.1% per side
NK	0%	wires/ lag screws/ plates	28	Y	obj+subj	LTS/PPS	32% per side(2)
NK	29.2%	pos screws	35	Y	subj	NA	37% per side
NK	0%	plates	25.2	Y	subj+obj	NK	21% per pat (3)/ 12.8% per side
NK	13.8%	plates/ pos screws	27	NK	subj	NA	50% per side (4)
NK	8.3%	pos screws	25.8	NK	obj	S2D/TD/PSS	6.7% per pat/ 5% per side
NK	0%	according to Bell	25.5	Y	subj+obj	PPD/LTS	40% (per side)(5)
NK	NK	lag screws (LS)/ plates(P)	20.4	N	obj+subj	SW	Obj: 29% LS/9% P Subj: 48% LS/10% P mean 19.7% per side(7)

Supplementary Table Continued.

Author	Publication year	Number of patients	Number of sides	Retrospective/ prospective research	Obw#	Hun	Dal Pont	Epker	Referral to other technique(8)	Chisel use mentioned in manuscript	"Classic" Mallet & chisel along inside buccal cortex
Scheerlinck et al.	1994	103	206	prosp	N	N	N	Y	N	NK	NK
Raveh et al.	1988	103	206	prosp	N	N	N	N	N	Y	probably

When a study mentioned a Epker/Hunsuck modification, only these methods (Epker and Hunsuck) were marked as Y (yes). When only a standardized Dalpont method was mentioned, this was marked as Y (yes); the other parameters were marked as N (not) K (known).

Abbreviations in table: Obw: Obwegeser; Hun: Hunsuck; NSD: neurosensory disturbance; NA: not applicable Y/N: Yes/No; NK: not known; SW: Semmes Weinstein monofilament; LTS: light-touch sensation; PPS: pinprick sensation; S2D: static 2-point discrimination; M2D: moving 2-point discrimination; TSEP: trigeminal somatosensory evoked potential; TD: thermal discrimination; pos screws: positioning screws; obj: Objective measurement; subj: Subjective measurement

(1) All patients were classified on the basis of 4 regions (lip left/right; chin left/right). Subjectively 69.9% and objectively 71.8% (lowest incidence number in this study) of the patients experienced no NSD after 1 year in all regions. However 2 patients were excluded from the dataset because of transectioned IAN during the BSSO; thus the incidence of NSD should be higher.
(2) The incidence of NSD was measured at 2, 6, 18, and 30 months. To have at least 1-year follow–up, the 18-month incidence is mentioned.

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Prying & spreading the mandible	% genioplasty	Fixation method	Mean age in years	Resident performing surgery	subj/obj	Objective measurements	% NSD after 1-y follow-up
NK	0%	plates	25.2	NK	subj+obj	PPS/TD/S2D	17.3% (per side)
NK	NK	lag screws	NK(6)	NK	obj	S2D/PPD/LTS	13% (per side) (6)

(3) The incidence of NSD was measured at 3, 6, and 24 months. To compare with the regular 1-year follow-up, the 24 months incidence is mentioned. Total amount of patients at the 24-month follow-up period.
(4) The subjective evaluation was performed between 6 months and 4 years postoperatively. No exact distinction could be made.
(5) Same study group. Only measured in sides, not in amount of patients, with a follow-up of 2 years. Two types of splitting were used: traditional split (not further specified) and cortical shaving (thin chisels along the inner surface of the lateral cortex).
(6) Follow-up 1-4 years, not otherwise specified. Age parameters not mentioned.
(7) Subjective and objective methods were compared; a combination as in other studies would be most reliable. Because some patients did not report subjective numbness, but did test positive on objective tests, NSD incidence would be higher than both results. Therefore, the highest (subjective) NSD incidence was taken.
(8) Reference in a study to another technique besides an Obwegeser/Dal Pont /Epker/Hunsuck modification was mentioned (according to Watzke). We then analysed these publications/book chapters on exact technique description.

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