Bilateral sagittal split osteotomy : risk factors for complications and predictability of the splitter-separator technique

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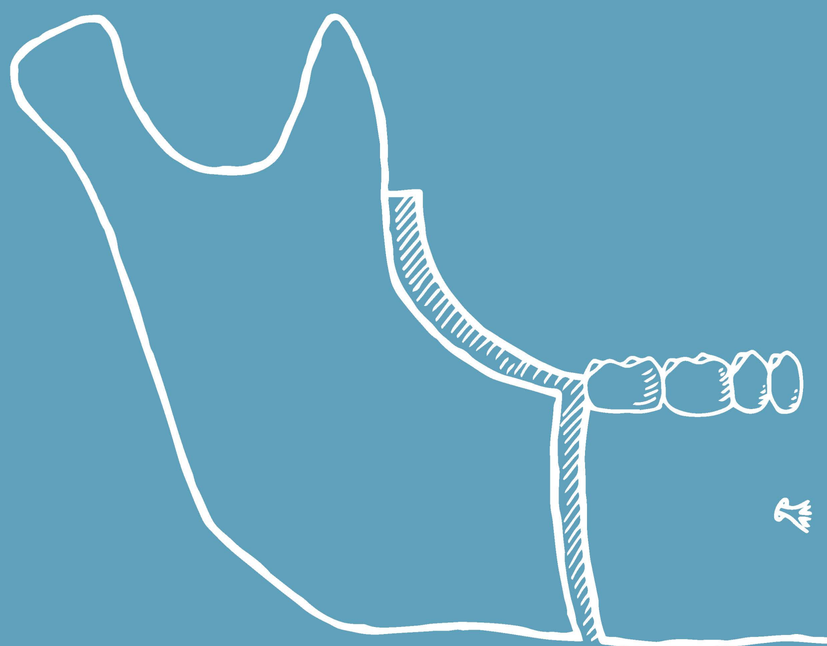

CHAPTER 3

Incidence and recovery of neurosensory disturbances after bilateral sagittal split osteotomy in different age groups: a retrospective study of 263 patients

This chapter is based on the manuscript:

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ABSTRACT

This study aimed to investigate the incidence of neurosensory disturbance (NSD) after bilateral sagittal split osteotomy (BSSO) in different age groups and assess the probability of sensory recovery in patients aged <19 years, 19–30 years and >30 years.

We subjectively and objectively assessed hypoaesthesia in the lower lip immediately, 1 week and 1, 6 and 12 months after BSSO. Hypoaesthesia was considered permanent if it was present one year after BSSO.

In older patients, the frequency of NSD immediately after surgery was significantly higher. The cumulative incidence of recovery at 1 year was lower and mean time to recovery was longer in the older patients, although these differences were not statistically significant. Older age was a significant risk factor for permanent hypoaesthesia with an incidence of 4.8% per patient <19 years; 7.9% per patient 19-30 years; and 15.2% per patient > 30 years.

The findings show that the risk of NSD after BSSO is significantly higher in older patients. These results can aid surgeons in pre-operative patient counselling and deciding the optimal age to perform BSSO.

INTRODUCTION

Neurosensory disturbance (NSD) of the inferior alveolar nerve (IAN) is one of the most frequently occurring complications of bilateral sagittal split osteotomy (BSSO). The most common manifestation is numbness of the lower lip (hypoaesthesia). In many patients, NSD resolves within several months after surgery.[1] However, if it is still present a year after surgery, it is considered permanent. This permanent hypoaesthesia leads to significant morbidity and is therefore an important complication of the elective BSSO procedure that should be explained to the patient before obtaining informed consent.[2]

During mandibular surgery, iatrogenic nerve damage and subsequent NSD can occur because of several factors. For example, IAN bruising can be caused by nerve compression during soft tissue dissection near the mandibular foramen, excessive nerve manipulation during splitting, the use of sharp instruments (chisels) during BSSO or the incorrect placement of screws.[3-5] Large mandibular advancements and increasing age have also been described as risk factors for NSD.[3, 4, 6, 7]

In our clinic, we perform BSSO using a sagittal splitter and separator (without the use of chisels) in an attempt to minimise the risk of hypoaesthesia.[8] This retrospective study analysed the incidence of hypoaesthesia and time to recovery from hypoaesthesia after the use of this BSSO technique in different age groups.

The purpose of this study was to report the incidence of NSD of the IAN after BSSO in different age groups (<19 years, 19-30 years and >30 years) and further investigate NSD in these different age groups in order to provide information that will aid surgeons in explaining age-specific risks to patients and deciding the optimal age to perform BSSO.

MATERIAL AND METHODS

We conducted a retrospective cohort study, including patients who had undergone BSSO alone or bimaxillary procedures at the Leiden University Medical Center (LUMC). The patients' clinical records were screened for details of sex, age at surgery, pre-operative diagnosis and concomitant procedures. The surgical reports were reviewed to assess the intra-operative status of the IAN, which was classified as follows: not visible in the distal segment, less than half visible in the distal segment, more than half visible in the distal segment, prepared from the proximal segment either blunt or with a burr, and visibly damaged. The patients were divided into three groups on the basis of age: group A (<19 years); group B (19–30 years) and group C (>30 years).

Prospective collection of data regarding NSD after the BSSO procedure had started in our centre in 2004, so we included all consecutive patients undergoing BSSO between January 2004 and January 2014.[3] Exclusion criteria included concomitant genioplasty, previous mandibular surgery and pre-existing hypoaesthesia. A minimum follow-up of six months was necessary for inclusion in this study.

The medical files of 320 patients were retrospectively reviewed. From this series, a total of 57 patients were excluded: 37 who required concomitant genioplasty, one with a previous history of orthognathic surgery, one with pre-existing hypoaesthesia and 18 who could be followed up for less than 6 months. All patients were treated according to the same procedures and the same clinical care was applied for all patients.

BSSO was performed using a sagittal splitter and separator according to the standard protocol in our centre.[3, 8, 9] Fixation of the mandibular segments was performed with three bicortical position screws through the upper border of the buccal cortex into the lingual cortex (superior of the mandibular canal and nerve). BSSO was performed by one of seven maxillofacial surgeons on one side and by a resident under close supervision of the surgeon on the other side. All patients were discharged within a week after surgery and scheduled for clinical and radiographic evaluations at 1, 2 and 3 weeks and 1, 6 and 12 months after surgery. Although principally the last evaluation was performed 1 year after BSSO, not all patients wished to return after the 6 month evaluation moment. If patients experienced any NSD 6 months postoperatively, they were however always evaluated 1 year after surgery.

Neurosensory function was tested preoperatively, immediately after surgery and at clinical evaluation at 1 week and 6 and 12 months after BSSO. Hypoaesthesia was considered permanent if it was present 1 year after surgery. Neurosensory testing was performed in a standardised manner, using sensory testing methods that are most widely used in osteotomy studies.[10] Sensory function was subjectively assessed by questioning the patient about altered sensation in the lower lip and by comparing contralateral sides. Light-touch detection was performed by the maxillofacial surgeon. It consisted of the surgeon softly touching the lower lip with cotton swabs and evaluating if the patient experienced reduced or altered sensation at the lower lip area. NSD was interpreted in as a binary outcome measure (absent/present). If any disturbance or altered sensation was noticed, hypoaesthesia was recorded as present.

This study was performed in accordance with the guidelines of our institution and followed the Declaration of Helsinki on medical protocol and ethics. Because of the retrospective nature of this study, it was granted a written exemption by the institutional review board of Leiden University Medical Center.

Statistical analysis

Statistical analyses were performed using SPSS version 20.0 for Windows (SPSS Inc., Chicago, IL, USA) and R version 18 (The R Foundation, Vienna, Austria). Descriptive statistics were performed. Chi-squared tests and Student's t-tests were used when appropriate. Mixed models (GLMM) were used to study the effect of age group on the status of the nerve and the status of the third molar. The same model has been applied to investigate the effect of third molar status and nerve status on permanent hypoaesthesia. These models are required since the status of the nerve and the status of the third molar were assessed per side and mixed models are necessary to account for the correlated nature of the left and right side measurement within each patient.[11]

The three age groups were retrospectively compared in this study, no control group was present. NSD was assessed at the patient level and therefore a univariate logistic regression model was employed to assess the effect of the three age groups on NSD after BSSO.

To study the effects of sex, type of malocclusion and concomitant Le Fort I osteotomy on the occurrence of NSD at the patient level, univariate logistic regression models are estimated.

To investigate the effects of age (age groups) on the time to recovery of nerve function, a Cox regression proportional hazards model was used. Recovery was defined as the absence of any sensory dysfunction. Therefore, the outcome was analysed on the patient level (NSD per patient). There was thus no correlated nature of the data (left and right side within one patient) in this analysis.

RESULTS

The study group comprised 263 patients (104 men and 159 women) who underwent 526 sagittal split osteotomies (SSOs/sites). Orthognathic surgery was performed to correct class II malocclusion in 226 patients (85.9%) and class III malocclusion in 37 patients (14.1%). In 86 patients (32.7%), BSSO was combined with Le Fort I osteotomy (bimaxillary procedure). Mandibular third molars were present at 196 sites (37.2%). The mean follow-up duration was 427.9 days (SD, 159.4; range, 188–1465 days).

	Group A (< 19 years)	**Group B (19 – 30 years)**	**Group C (> 30 years)**
Total number of patients	63 (24.0)	101 (38.4)	99 (37.6)
Mean (SD) age, age range (years)	17.1 (1.3), 13.8-18.9	22.7 (3.1), 19.0-29.8	40.6 (6.5), 30.1-55.6
Gender			
Male	19 (30.2)	50 (49.5)	35 (35.4)
Female	44 (69.8)	51 (50.5)	64 (64.6)
Malocclusion class			
II	54 (85.7)	78 (77.2)	94 (94.9)
III	9 (14.3)	23 (22.7)	5 (5.1)
Third molars			
Present (%/site)	94 (74.6)	69 (34.2)	33 (16.7)
Absent (%/site)	32 (25.4)	133 (65.8)	165 (83.3)
Bimaxillary procedure	19 (30.2)	40 (39.6)	27 (27.3)
Mean (SD) follow-up time, range (days)	418.5 (136.2), 188-856	434.1 (194.9), 188-1465	427.6 (131.5), 212-904

Table 1: Groups' characteristics. Data represent the number of patients (%) unless otherwise indicated.

	Group A (< 19 years)	**Group B (19-30 years)**	**Group C (> 30 years)**
Total number of sites	126	202	198
IAN not visible in the distal segment	21 (16.7)	36 (17.8)	24 (12.1)
Less than half of the IAN visible in the distal segment	30 (23.8)	35 (17.3)	27 (13.6)
More than half of the IAN visible in the distal segment	52 (41.2)	98 (48.5)	93 (47.0)
IAN prepared blunt from the proximal segment	11 (8.7)	15 (7.4)	31 (15.7)
IAN prepared with burr from the proximal segment	10 (7.9)	18 (8.9)	20 (10.1)
IAN visibly damaged	2 (1.6)	0 (0.0)	3 (1.5)

Table 2: Status of the nerve during BSSO for the different groupsData represent the number of surgical sites (%).

The characteristics of the patients in groups A, B and C are presented in Table 1. The status of the nerve during BSSO in each group is represented in Table 2. There was a significant statistical association between the three age groups with regard to the presence of mandibular third molars ($p < 0.01$) and status of the nerve ($p = 0.035$). There was no significant effect of third molar status ($p = 0.433$) on hypoaesthesia. If the nerve was prepared from the proximal segment (either blunt or with a burr) or was visibly damaged during surgery, the risk of permanent NSD was significantly higher ($p = 0.01$).

Univariate logistic regression models for NSD at the patient level have been estimated. Risk factors used were sex (OR, 1.06; CI, 0.58–1.89; $p = 0.87$), type of malocclusion (OR, 1.12; CI, 0.51–2.49; $p = 0.77$), concomitant Le Fort I osteotomy (OR, 0.91; CI, 0.49–1.68; $p = 0.76$). The risk factors showed no significant association with permanent NSD.

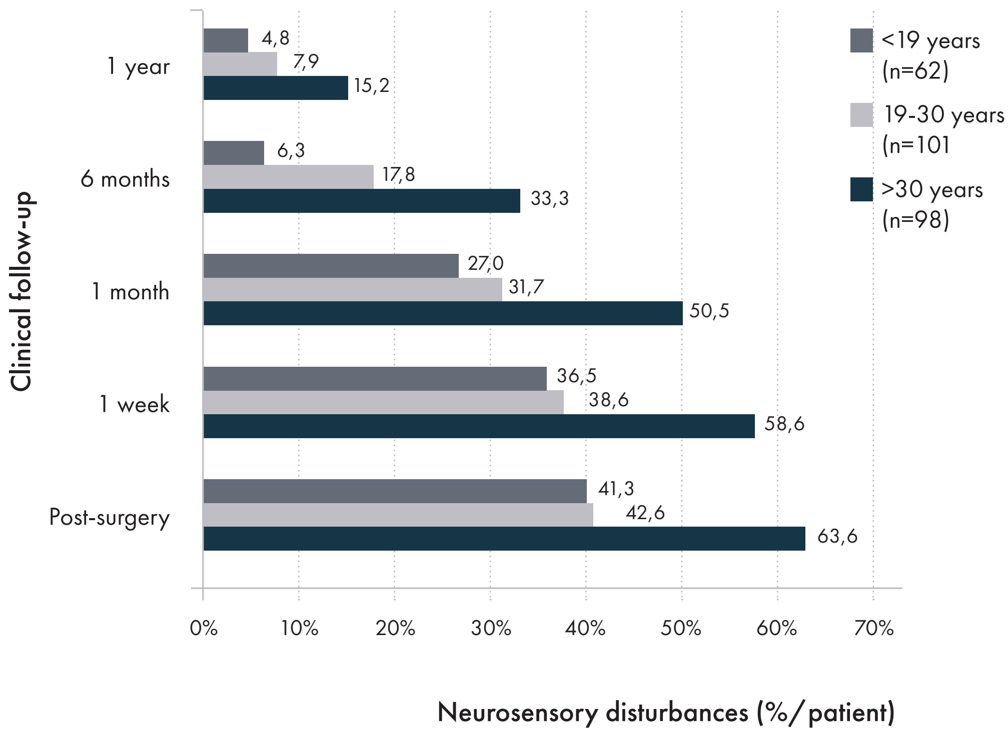

Figure 1: Bar chart showing the incidence of neurosensory disturbance in different age groups directly after BSSO and during clinical follow-up at 1 week, 1 month, 6 months and 1 year postoperatively.

The incidence of NSD in the three age groups during the clinical follow-up is represented in Figure 1. Immediately after BSSO, NSD was present in 132 patients (50.2%): 26 in group A (13 left side, eight right side, five bilateral), 43 in group B (12 left side, 15 right side, 16 bilateral) and 63 in group C (19 left side, 24 right side, 20 bilateral). Accordingly, the incidence of immediate post-operative NSD was 41.3% per patient in group A, 42.6% per patient in group B and 63.6% per patient in group C.

Logistic regression analysis to investigate the effects of age group on the occurrence of NSD immediately after BSSO was used. A significant association between age and NSD was found ($p < 0.01$). With group A as a reference group, the ORs for groups B and C were 1.06 (CI, 0.56–2.00) and 2.49 (CI, 1.30–4.76), respectively.

One year after BSSO, hypoaesthesia was observed in 26 patients (9.9%): three in group A (two left side, one right side), eight in group B (three left side, four right side, one bilateral) and 15 in group C (six left side, nine right side). Accordingly, the incidence of permanent hypoaesthesia was 4.8% per patient in group A, 7.9% per patient in group B and 15.2% per patient in group C. Logistic regression analysis to study the association between age group and permanent hypoaesthesia was employed. A significant association between age and permanent NSD was found ($p = 0.05$). With group A as a reference group, the ORs for groups B and C were 1.72 (CI, 0.44–6.74) and 3.57 (CI, 1.00–12.89), respectively.

The cumulative incidence of recovery at 1 year after BSSO was 0.833%, 0.702% and 0.593%, respectively, in groups A, B and C. The cumulative incidence of post-operative sensory recovery in each age group is shown in Figure 2. The hazard ratio decreased with increasing age, implying that the older group experienced recovery at a later stage compared with the younger groups. However, the difference among groups was not statistically significant ($p = 0.33$). The hazard ratios and mean time to recovery in each age group are shown in Table 3.

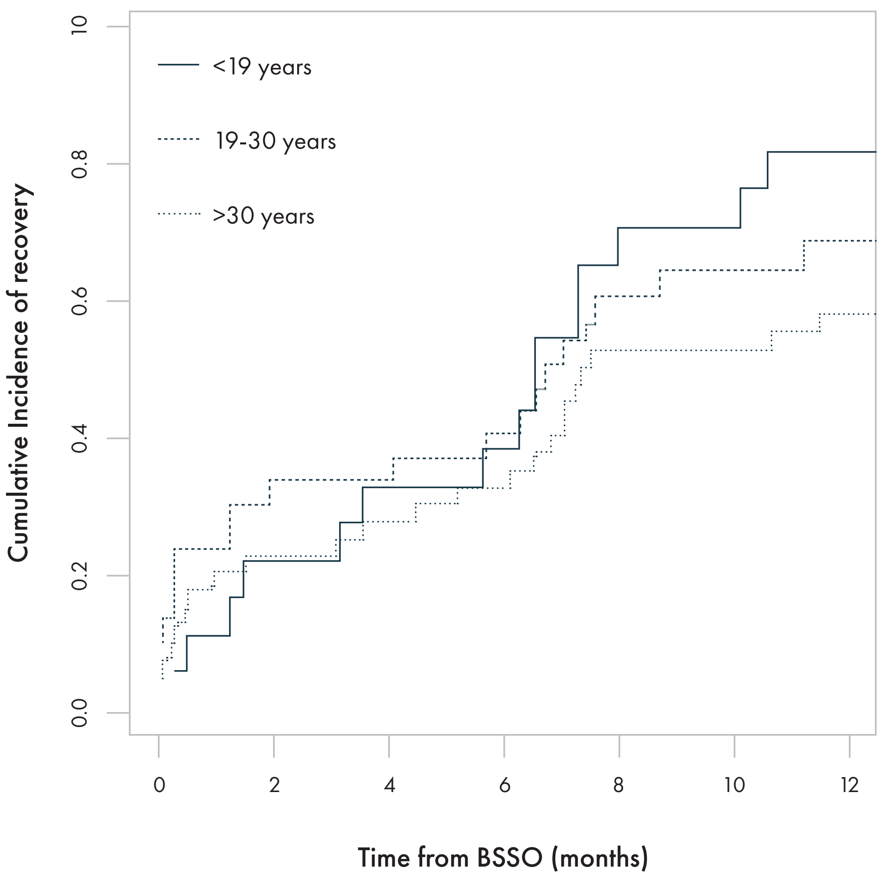

Figure 2: Graph of the cumulative incidence of recovery of nerve function in different age groups, showing a lower cumulative incidence of recovery one year after BSSO in the older groups.

	Group A (<19 years)	**Group B (19-30 years)**	**Group C (> 30 years)**
Hazard ratio for recovery (95% CI)	reference category	0.95 (0.50-1.80)	0.74 (0.17-3.18)
Mean time to recovery (days) (95% CI)	83.69 (38.47-128.91)	99.30 (68.13-130-46)	203.83 (26.36-152.16)

Table 3: Recovery hazard ratios and mean time to recovery along with 95% CI corresponding to the three age groups.

DISCUSSION

This study aimed to analyse the incidence of NSD after BSSO in different age groups and investigate the time to recovery of nerve function. In the older patients, we found a significantly higher incidence of NSD immediately after surgery and permanent NSD. Although a trend for slower recovery and a lower probability of recovery was observed for the older patients 1 year after BSSO, this difference was not statistically significant.

During the assessment of NSD, both objective and subjective assessments are used to evaluate sensory function and the possibility of hypoaesthesia. In this study, we recorded hypoaesthesia if either objective or subjective tests indicated altered sensation in the lower lip area, in order to avoid underestimation of the incidence of NSD. We found that the overall incidence of permanent hypoaesthesia was 9.9% per patient (5.1% per site). In the literature, the reported incidence of permanent hypoaesthesia after BSSO varies between 0% and 85% patient.[12] Few studies have reported an incidence below 10%.[4, 5, 13, 14] We speculate that the relatively low incidence of NSD in our study was due to our technique, which involved the use of sagittal splitters and separators to perform BSSO without the use of chisels.[3]

The frequency of NSD immediately after surgery was significantly higher in the oldest patient group (>30 years). This indicates that the difference between younger and older patients is already established during surgery. With increasing age, neurons show axonal atrophy and degeneration.[15] Therefore, we believe that the loss of nerve fibres in older patients can play a role in the increased risk of nerve damage, and older patients are inherently more prone to iatrogenic damage during surgery. Furthermore, a lower probability of recovery and a longer time to recovery were observed in the older patients. Although this difference in recovery between age groups was not statistically significant, the trend was apparent. Functional recovery of nerve function depends on the survival of injured neurons and functional re-innervation of target tissue. Older patients have been reported to show decreased nerve regeneration and re-innervation.[15] It may be hypothesised that older patients exhibit not only a higher risk of NSD after surgery but also decreased recovery, even though this study does not prove the latter part of this hypothesis.

The incidence of permanent NSD in specific age groups is rarely reported in the literature. Age-specific incidences are important and clinically relevant for the surgeon, particularly for pre-operative counselling of individual patients about the risk of permanent hypoaesthesia. In our study, the incidence of permanent hypoaesthesia was 4.8% in patients aged <19 years, 7.9% in those aged 19–30 years and 15.2% in those aged >30 years.

Several different authors have reported a significant association between increasing age and an increased risk of permanent NSD. Westermark et al.[16] reported that an older age significantly influenced IAN dysfunction. Ylikontiola et al.[6] showed that hypoaesthesia was significantly associated with age, distance of mandibular movement and manipulation of the nerve. Van Sickels et al.[7] also reported older age as a risk factor for NSD, particularly in patients undergoing large mandibular advancements or genioplasty. Borstlap et al.[4] reported a significant effect of age on nerve recuperation, with the mean age of patients without and with hypoaesthesia being 24 and 31 years, respectively. Mensink et al.[3] showed that the frequency of hypoaesthesia is higher in older patients, with a mean increased risk of 1.07 per year of increasing age. Politis et al.[17] showed an increased risk of self-reported hypoaesthesia by 5% per year in his patients. All these findings are in concordance with the findings of our study. Therefore, we strongly believe that older age is an important risk factor for NSD. This information can also prove important for patients with obstructive sleep apnoea requiring BSSO, considering these patients are generally older.

Some authors also reported older age to be associated with an increased risk of other clinical complications after BSSO, such as bad splits, infection and non-union.[18-20] These reports are, however, not always in concordance with other findings.[4, 21] Therefore, the effects of age on clinical complications other than NSD remain unclear.

When investigating the influence of age on complications, it is important to consider any possible confounding factors that can hinder accurate interpretation of the observations, particularly when dealing with a complication that is difficult to assess, such as NSD. We decided to exclude patients who underwent additional genioplasty, because several authors have reported an increased risk of permanent hypoaesthesia due to genioplasty.[3, 17] Some authors even reported associations among genioplasty, age and sensory deficits, confirming that genioplasty can be a confounding factor in the relationship between age and NSD.[7]

The status of the nerve during BSSO is another important factor for the development of permanent hypoaesthesia.[3, 14, 21] This can also be associated with the surgical technique and osteotomy design. Therefore, BSSO was performed using the same technique in all patients.[22] In this study, preparation of the nerve from the proximal segment was significantly associated with an increased risk of permanent NSD and the age groups were different with regard to the status of the IAN during BSSO. Increased manipulation of the nerve could therefore partially explain increased NSD in older patients. The anatomical position of the IAN in the ramus and body area was not assessed in this study, because earlier findings had shown no significant association between the position of the nerve in the ramus and body area and NSD.[23] Other surgical factors, such as duration of the procedure and experience of the surgeon have shown to not significantly influence NSD and were therefore not included in this study.[21]

Different authors have reported contradicting findings regarding the association between the presence of third molars and hypoaesthesia.[24, 25] However, most authors reported no correlation between the presence of third molars and NSD.[4, 21, 24] In our study group, the three age groups differed significantly with regard to the pre-operative presence of third molars. It is understandable that third molars are more often present in younger patients.[21] Nevertheless, there was no significant association between the presence of third molars and the status of the nerve or NSD. We therefore believe that the presence of third molars did not significantly influence the incidence of hypoaesthesia in the different age groups. Other possible risk factors, such as sex, type of malocclusion and additional Le Fort I osteotomy showed no significant association with permanent hypoaesthesia in this study and were not considered influential in the development of NSD. Note that other confounding factors such as comorbidities or the use of medication could have influenced the outcomes in the different age groups; however, this was not investigated.

Permanent hypoaesthesia after BSSO negatively affects the patient's perceived quality of life and results in decreased patient satisfaction.[2, 14] Therefore, it is one of the most important complications of BSSO. Older patients are considered more likely to experience interferences in daily life activities due to altered sensations after BSSO and are also at an increased risk of neuropathic pain, which is again responsible for patient dissatisfaction after BSSO.[14,26]

Although the results of this study advocate the performance of BSSO at a younger age, the risk of relapse should also be considered. Borstlap et al.[4] performed a prospective study and reported that a younger age (mean, 20.7 years) was a strong risk factor for the relapse of malocclusion. However, Den Besten et al.[27] reported no significant differences in skeletal stability after BSSO in patients under 18 years of age. In their literature review, Joss et al.[28] concluded that skeletal relapse after BSSO is multi-factorial and dependant on factors such as the amount of advancement, mandibular plane angle, soft tissue and muscles, future growth and pre-operative age. Therefore, BSSO can be performed in younger patients under certain circumstances; for example, when the amount of mandibular advancement required is less than 6 mm and/or when patients exhibit a low mandibular plane angle. Further research is necessary to investigate important considerations such as the possibility of relapse in specific (younger) patients and the risk of (permanent) hypoaesthesia after BSSO.

In conclusion, the results of this study suggest that the incidence of NSD immediately after surgery and permanent NSD is lower in younger patients than in older patients. Furthermore, younger patients tend to exhibit a shorter recovery time and a higher hazard ratio for recovery. This information can aid surgeons in pre-operative counselling about the risk of hypoaesthesia and deciding the optimal age for BSSO.

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