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Effects of low and short medial osteotomy on postoperative neurosensory disturbances after sagittal split ramus osteotomy: a split-mouth randomized study

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Abstract. The aim of this study was to compare postoperative neurosensory disturbances between the Hunsuck–Epker and 'low and short medial osteotomy' (LASMO) modifications of the sagittal split ramus osteotomy. The study included 21 patients aged 18–35 years who presented with dentofacial deformities and sought orthognathic surgery. A split-mouth randomized clinical trial design was employed, with osteotomies performed using the Hunsuck–Epker modification on one side and the LASMO modification on the contralateral side (total 42 osteotomies). Evaluations of neurosensory alterations were conducted in a double-blind manner at 1, 3, and 6 months postoperatively. Various assessments were conducted, including tests for painful stimuli, two-point discrimination, pressure, and brush stroke direction. Additionally, subjective neurosensory recovery was evaluated using visual analogue scale (VAS) scores reported by the patients. The results at 1, 3, and 6 months post-surgery indicated no significant difference between the two techniques for any of the parameters assessed (all $P > 0.05$). Furthermore, the patient-reported VAS scores at 6 months indicated no significant difference in neurosensory recovery between the two techniques ($P = 0.67$). In conclusion, the results of this study showed that there was no significant difference in neurosensory recovery between the LASMO modification and the Hunsuck–Epker modification.

Keywords: Sagittal split ramus osteotomy; Orthognathic surgery; Inferior alveolar nerve injuries; Dentofacial deformities; Postoperative complications.

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The bilateral sagittal split osteotomy (BSSO) is a common surgical procedure used to correct mandibular positional deformities. Patients requiring this treatment frequently have skeletal discrepancies that not only affect their appearance but also lead to functional issues, such as difficulties with chewing and speaking[1]. Many patients with dentofacial deformities experience significant functional and aesthetic improvements from orthognathic surgery.

However, they may also suffer from neurosensory disturbances (NSD) in the lips and facial area post-surgery, which can impact their quality of life considerably[2]. The incidence of NSD ranges from 1.6% to 90%[3].

To minimize the incidence of NSD, various modifications have been made to the original BSSO technique since its introduction by Trauner and Obwegeser[4]. The most notable changes have involved the design of the osteotomy itself, enhancing the effectiveness of the splitting process and promoting better healing. Notable refinements were made by Dalpont and later by Hunsuck[5]. Posnick and Kinard[6] proposed further modifications to minimize the risk of unfavourable osteotomy propagation towards the condyle. This adjustment involves placing the medial horizontal osteotomy lower (close to the mandibular occlusal plane and beneath the lingula) and shortening its length (ending in front of the lingula). This design helps the posterior end of the osteotomy to propagate anteriorly and inferiorly. Although this variation has been shown to reduce the likelihood of a bad split[7], predicting the status of the inferior alveolar nerve (IAN) remains ambiguous. There are concerns regarding the low and short medial osteotomy (LASMO) modification, which can lead to unfavourable outcomes for NSD of the IAN[8,9].

Although there are concerns surrounding the LASMO modification, there is currently no scientific evidence suggesting that LASMO increases the incidence of NSD. The purpose of this study was to compare NSD after Hunsuck–Epker and LASMO modifications applying a split-mouth study design.

Materials and methods

Study design

The study design was a prospective, split-mouth, randomized clinical trial. The study sample was derived from patients who presented for bimaxillary or mandibular orthognathic surgery to treat a dentofacial deformity between January 2023 and January 2024. All patients underwent mandibular BSSO performed by the same senior surgeon. Patients aged between 18 and 35 years were included. Patients with medical conditions that may affect the potential of nerve regeneration, patients who required additional osteotomies such as genioplasty or mandibular subapical segmental osteotomies, patients with a bad split or interrupted IAN, and patients with an expected buccal osseous gap between the proximal and distal segments of more than 5 mm (Fig. 1) were excluded. In order to eliminate the possible effects of the side of surgery on the results, the side on which each osteotomy technique would be performed was determined by randomization. Two columns were created in Excel; the first included patient numbers and the second included the side on which the LASMO modification was to be performed. The RAND formula in Excel was then used for randomization.

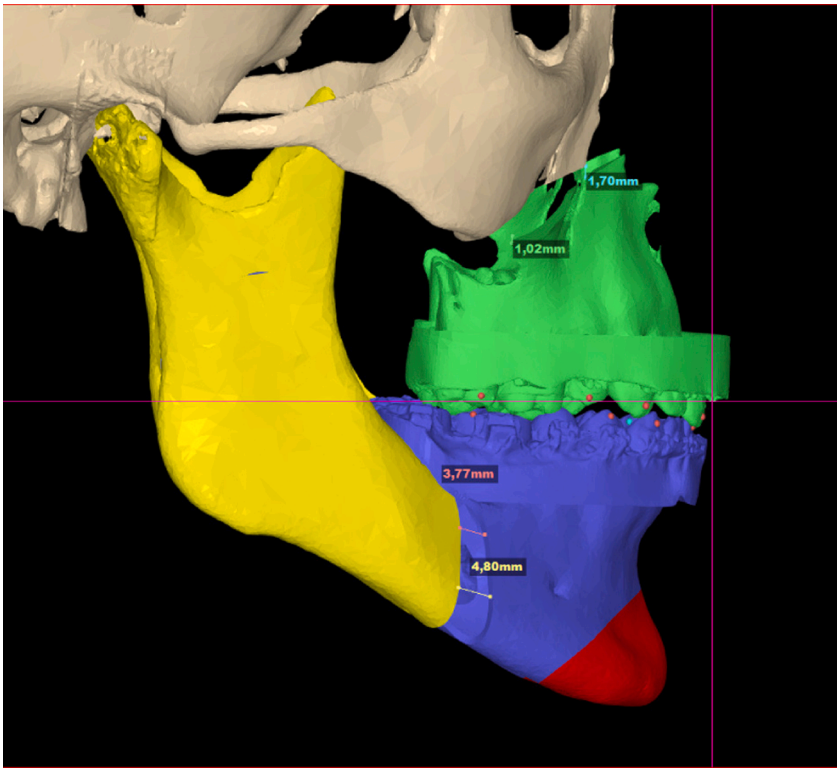

Fig. 1. Evaluation of the estimated buccal osseous gap in the vertical osteotomy area during virtual surgical planning.

Surgical techniques

All surgical procedures were performed by the same surgical team and senior surgeon (N.D.). The researcher who investigated NSD (A.T.S) was not one of the surgical team.

Following nasotracheal intubation, infiltrative local anaesthesia around the surgical area and IAN blocks were performed in both surgical techniques. On the Hunsuck–Epker modification side, the soft tissue dissection was performed on the anterior and medial side of the ramus up to the lingula, and a periosteal elevator was held above the lingula to protect the neurovascular bundle of the IAN. A medial ramus osteotomy was made above the lingula with a Lindeman bur (Fig. 2). All other osteotomies were performed with a piezoelectric device (Piezosurgery; Mectron, Carasco, Italy) and the splits were completed with osteotomes. After the split, the IAN was dissected carefully to keep it within the proximal segment when it was necessary. The mandible was positioned into its preplanned position with the guidance of occlusal wafers, then one four-hole miniplate and four titanium monocortical screws were used for fixation.

The LASMO modification was performed on the other side of the mandible. The soft tissue dissection on the medial side of the ramus was kept at the level of the occlusal plane. Due to the close proximity of the lingual nerve and artery in the lingual site, a periosteal elevator was kept between the flap and the cutting device, even when the piezoelectric device was used (Fig. 3A). A 10-mm-deep medial osteotomy was made at the level of the occlusal plane, and all of the LASMO side osteotomies were performed with the piezoelectric device (Fig. 2). A through-cut of the lingual cortical plate was made during

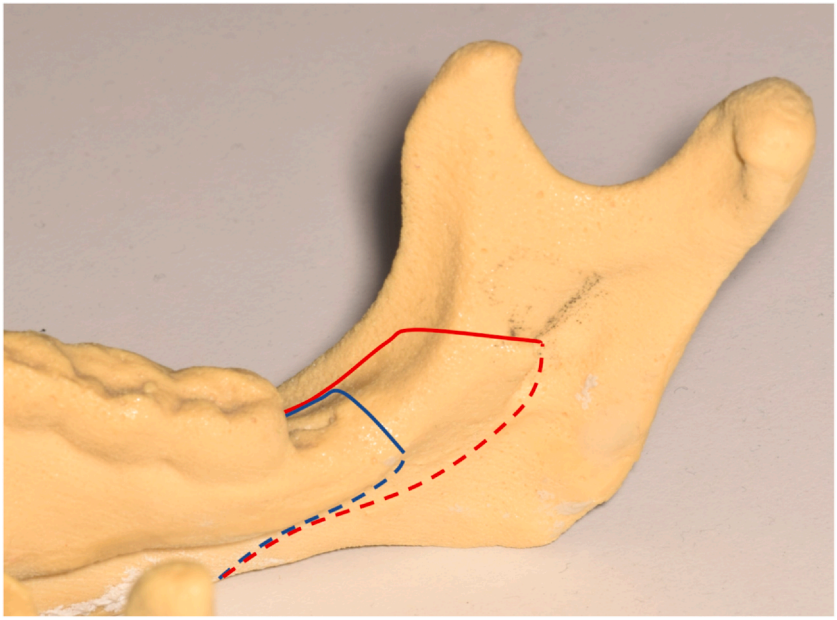

Fig. 2. Locations and depths of the medial osteotomies of the LASMO and Hunsuck–Epker modifications. The red line indicates the osteotomy sites of the Hunsuck–Epker modification, while the red dashed line indicates the expected location of the spontaneous medial split with this technique. The blue line indicates the osteotomy sites of the LASMO modification, while the blue dashed line indicates the expected location of the spontaneous medial split with this technique.

the medial osteotomy to direct the spontaneous split below the mylohyoid process as desired (Fig. 2). In the majority of cases, the IAN passes from the proximal segment to the distal segment (Fig. 3B). Therefore, care was taken not to use osteotomes down to the level of the IAN in the mandible. The rest of the splitting and fixation procedures were the same as used for the Hunsuck–Epker modification.

Neurosensory evaluation protocol

The lip area was divided into left and right sides from the commissure to the midline. Neurosensory tests were performed in this region on the respective sides. A cold test, two-point discrimination test, spatial orientation test, and light touch test were performed on each side of the patient's lips. Each test performed was explained to the patient in detail. During the tests, the patient's eyes were closed. The tests were performed at 1 month, 3 months, and 6 months post-surgery. In addition, the patient's satisfaction with their neurosensory recovery was evaluated using a visual analogue scale (VAS) at 6 months post-surgery. The results were documented using a double-blind method. The researcher who conducted the tests (A.T.S.) was unaware of which side had undergone the LASMO modification.

A cotton pellet was cooled with a refrigerant spray (Roeko Endo-Frost; Coltène, Altstätten, Switzerland) and then applied to one side, to test whether the patient could perceive the cold sensation. Then the same procedure was performed with a new cotton pellet on the other side of the lip and both responses were recorded.

For the evaluation of the light touch response, a cotton pellet was touched to each side of the lip and the responses were recorded as positive or negative.

The two-point discrimination test was performed with a caliper that had a set of paired blunt metallic probes of 0.8 mm in diameter. The caliper was first adjusted to 15 mm between the probes, and if the patient could differentiate the two points, the caliper distance was narrowed by 1 mm at a time until the patient could not distinguish between them. If the patient could not distinguish the two points at 15 mm apart, the caliper distance was increased by 1 mm at a time, up to 20 mm. The smallest interval at which the patient could discern the two probe points was recorded.

To evaluate spatial orientation, the tip of a dental probe was lightly placed on each side of the lip area and moved in six different directions. The patient scored between 1 and 6 based on the number of directions they recognized.

Each patient was asked to rate their satisfaction with their neurosensory recovery on a VAS of 0–100. Satisfaction was determined based on numbness, function, discomfort, and the comparison between the pre-surgical and post-surgical sensation. Patients were informed to consider '0' as total numbness and '100' as total recovery of neurosensory function to the preoperative level.

Finally, the patients' functional sensory recovery (FSR) according to the grading system introduced by the British Medical Research Council was determined at 6 months post-surgery[10] (Table 1).

Statistical analysis

An a priori power analysis based on the two-point discrimination test results of a previous study[11] was performed to determine the number of patients required for this study ($N = 20$, effect size 0.78, power 0.90). Categorical data were described as frequencies and percentages. The homogeneity and normality of the VAS scores and spatial orientation scores were evaluated with the Shapiro–Wilk test. The Wilcoxon matched pairs test was used to compare the VAS scores and spatial orientation scores between the LASMO and Hunsuck–Epker groups. The McNemar test was used for the comparisons of dependent qualitative data (cold application, light touch, and FSR grade) between the LASMO and Hunsuck–Epker groups. The data were analysed using IBM SPSS Statistics version 26.0 (IBM Corp., Armonk, NY, USA). A P-value < 0.05 was considered to indicate a significant difference between the experimental groups.

Results

Twenty-one patients were included in this study, with 42 osteotomies made in total. Fourteen patients were female and seven were male. Their mean ± standard deviation age was 23.80 ± 3.44 years. All patients underwent bimaxillary surgery. The integrity of the IAN was preserved during all of the osteotomies included in this study, and no neuropathic pain was noted in any patient during the postoperative observation period. One patient who had

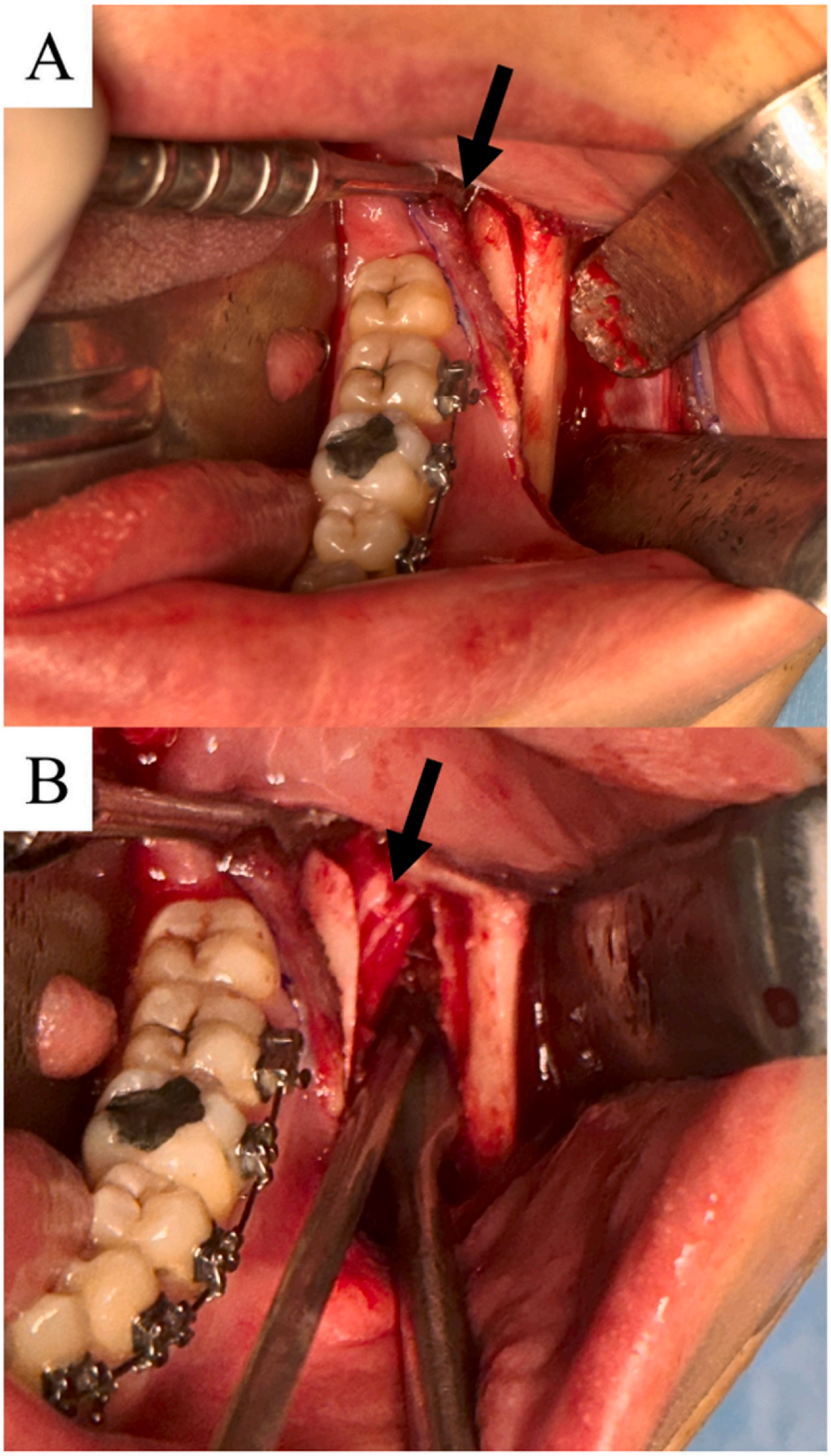

Fig. 3. (A) Surgical field after the osteotomies by LASMO modification. The black arrow indicates the correct location of the periosteal elevator to protect the lingual soft tissue and related anatomical structures. (B) Surgical field after the splitting of the ramus. The black arrow indicates the inferior alveolar neurovascular bundle passing through the proximal segment to the distal segment.

a bad split with a high buccal plate fracture (condyle remained connected to the distal segment) on the Hunsuck–Epker modification side was excluded from the study.

Regarding cold sensation, there was no significant difference in the frequencies of patients with negative and positive responses between the two technique groups at any evaluation time point. For static light touch, no significant difference in the number of positive and negative responses was noted between the two groups across all time points evaluated. The frequencies of positive cold sensation and static light touch responses at the different time points are shown in Table 2.

For the spatial orientation scores, there was no significant difference between the two groups at any evaluation time point. The median and interquartile range (IQR) spatial orientation scores at 1, 3, and 6 months are shown in Table 2.

There was no significant difference in the VAS scores for subjective neurosensory recovery between the LASMO group (median 90, IQR 27.5) and the Hunsuck–Epker modification group (median 85, IQR 30) (P = 0.67; Table 2).

The distribution of FSR grades in the two groups is presented in Table 3. All patients were grade S3 or higher, which is classified as meeting the criteria for FSR after orthognathic surgery[10]. Most of the patients in both groups were scored as S3+. There was no significant difference in the distribution of FSR grades between the two groups (P = 0.82).

Discussion

While orthognathic surgery has functional and aesthetic benefits, post-surgical NSD may significantly affect the patient's quality of life. Paraesthesia of the lower lip after BSSO can lead to saliva leakage, lip chewing, and difficulty during speech[12]. In the present study, the effects of the LASMO introduced by Posnick and Kinard[6] on neurosensory recovery were investigated using a split-mouth study design. In addition to routine neurosensory tests, overall patient satisfaction with their neurosensory recovery was also investigated, using a VAS, and any notable differences in terms of neurosensory recovery and patient satisfaction were recorded. The most important benefit of the split-mouth study design is the ability to compare different methods within the same patient, thus confounding factors such as individual sensory perception and regeneration capacity were minimized.

Before Posnick and Kinard[6] published the LASMO technique in 2021, Sant'Ana et al.[13] introduced the technique as 'lingual short split' in 2017,

Table 1. Assessment of functional sensory recovery (FSR).

FSR	Grade	Required parameters
No	S0	No sensation
	S1	Pain sensation—deep
	S1+	Pain sensation—superficial
	S2	Pain and touch sensation
Yes	S2+	Pain and touch sensation with some overreaction
	S3	As S2+, without overreaction and with static 2PD 15–20 mm
	S3+	As S3, with static 2PD 7–15 mm
	S4	As S3+, with static 2PD < 7 mm

2PD, two-point discrimination.

Table 2. Comparisons of the cold sensation, light touch, and spatial orientation test results, and the VAS scores for satisfaction with neurosensory recovery between the two surgical technique groups (21 patients, 42 osteotomies).

	1 month post-surgery *n* (%) or median [IQR]	3 months post-surgery	6 months post-surgery
Cold sensation test, positive			
LASMO	14 (66.6%)	21 (100%)	21 (100%)
Hunsuck–Epker	10 (47.6%)	20 (95.2%)	21 (100%)
P-value	0.12	1.0	-[a]
Light touch test, positive			
LASMO	13 (61.9%)	19 (90.5%)	21 (100%)
Hunsuck–Epker	13 (61.9%)	19 (90.5%)	21 (100%)
P-value	1.0	1.0	-[a]
Spatial orientation test (Number of directions correctly discerned)			
LASMO	4 [4]	5.5 [3]	6 [1]
Hunsuck–Epker	3.5 [4]	6 [2]	6 [1]
P-value	0.54	0.72	0.73
VAS score for satisfaction with neurosensory recovery			
LASMO	-	-	90 [27.5]
Hunsuck–Epker	-	-	85 [30]
P-value	-	-	0.67

IQR, interquartile range; LASMO, low and short medial osteotomy; VAS, visual analogue scale.

[a]Statistical test could not be conducted for the 6 months post-surgery time point due to zero observed value in at least one cell of the table.

Table 3. Distribution of functional sensory recovery (FSR) grades in the two groups at 6 months post-surgery.

FSR grade	S3	S3+	S4
LASMO	1	12	8
Hunsuck–Epker	2	11	8

LASMO, low and short medial osteotomy.

and they proposed this technique to minimize the risk of a bad split particularly in patients with a narrow jaw with thick cortical bone and thin medullar bone. The authors reported no case of bad split with this technique. In addition to the benefits of a reduced incidence of bad split, Posnick and Kinard[6] pointed out that the LASMO limits interferences between the proximal and distal segments. Unfortunately, when the Hunsuck–Epker modification is utilized, the posterior portion of the distal segment may interfere with the proximal segment. This is more evident in cases of mandibular asymmetry, especially those requiring correction of the roll and yaw orientation. Ellis recommended an additional lingual osteotomy behind the terminal molars to passively position the segments in these asymmetry cases[14], and that additional osteotomy can be eliminated with the utilization of the LASMO. John et al.[15] investigated the incidence of segment interferences and bad splits between supralingular and infralingular BSSO, and reported one bad split and two segment interferences that required an additional osteotomy in the supralingular osteotomy group, while neither of these occurred in the infralingular BSSO group.

No patient with asymmetry was included in the present study due to the possible confounding effects of different movements on the two sides. Therefore, it was not feasible to investigate segmental interferences in this study. However, one bad split happened at a Hunsuck–Epker modification site and this patient was excluded from the study. A potential disadvantage of the Hunsuck–Epker modification is the proximity of the medial osteotomy to the condyle and the sigmoid notch. Thus, the medial osteotomy may propagate towards the sigmoid notch instead of the inferior ramus, as in the bad split case mentioned above. The inferiorly positioned medial osteotomy in the LASMO almost eliminates the possible propagation towards the superior ramus, thus preventing a bad split[6].

One of the main concerns among surgeons using the LASMO technique is the potential for postoperative NSD. In BSSO techniques involving supralingual horizontal cuts, the surgeon aims to keep the IAN within the distal segment to avoid nerve exposure during the procedure. Abotaleb et al.[16] investigated the effects of IAN exposure during BSSO, reporting an increased risk of NSD and longer sensory recovery times when the nerve was exposed. Of note, they found that the IAN was exposed in half of the patients, indicating that nerve exposure is not uncommon even in supralingual osteotomy cases. Hopper et al.[17] reported that the IAN was contained within the proximal segment in 45.2% of cases when the LASMO was performed, concluding that the distance between the mandibular occlusal plane and the mandibular foramen is the main predictor of the IAN position after LASMO. However, in the current study, the IAN passed from the proximal segment to the distal segment in all LASMO cases. Moreover, infralingual osteotomies can potentially compromise the IAN during the operation itself. Ettinger et al.[18] examined the safe depth for infralingual osteotomy, hypothesizing that the IAN would be

located at least 5 mm away from the medial cortex of the ramus at the occlusal plane. They reported that an osteotomy depth of less than 15 mm is safe for the IAN. In this study, the length of the infralingual osteotomy was limited to 10 mm, and the integrity of all nerves was preserved at the LASMO sites. Based on the current authors' experience, this depth is adequate for progressing the medial osteotomy towards the base of the mandible.

In the study by John et al.[15], in which BSSO patients were randomly allocated to either infralingual medial osteotomy or supralingual medial osteotomy, NSD were investigated up to 3 months postoperatively. It was found that the supralingular osteotomy group showed better neurosensory recovery in the first week. However, during the first month and at the 3-month follow-up, there were no significant difference between the two groups. Susarla et al.[19] evaluated NSD in 25 patients who underwent BSSO with a low medial horizontal osteotomy. They observed that all patients had achieved a full sensory recovery by 1 year postoperatively, with a mean interval to FSR of 116 days. Suzen et al.[20] examined NSD in patients who unintentionally underwent a supralingular osteotomy, specifically between the base and apex of the lingula, and below the mandibular foramen. They concluded that there was no significant difference in subjective neurosensory recovery among the patients, and all achieved FSR by 6 months postoperatively. Based on the research discussed, the current study found no significant difference in any of the NSD parameters investigated, including FSR, subjective patient evaluation scores, and spatial orientation scores.

While there is a strong belief that nerve exposure and possible traction of the nerve between the proximal and distal segments may hinder neurosensory recovery, larger dissection areas within the ramus and efforts to locate the lingula while protecting the nerve during osteotomies can also be detrimental to the IAN. Teerijoki-Oksa et al.[21] demonstrated that the most significant changes in the physiological parameters of the IAN, such as amplitude, latency, and nerve conduction velocity, occurred during surgical procedures on the medial side of the mandibular ramus.

In conclusion, the use of the LASMO technique during bilateral sagittal split osteotomy had no negative impact on postoperative neurosensory recovery. Although the sample size of the study was determined based on the results of a previous study, the effect size of the power analysis (0.78) was relatively high and the number of participants was relatively low. Therefore, further studies with larger sample sizes are required. Furthermore, future studies are needed to explore additional outcomes associated with the LASMO technique beyond neurosensory deficits.

Ethical approval

This study was approved by the Ethics Committee of Bezmialem Vakif University (Decision number: 22/3).

Patient consent

Not required.

Trial registration

Clinical Trials NCT06662331.

Funding

None.

Competing Interests

None.

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