The Use of Sensory Action Potential to Evaluate Inferior Alveolar Nerve Damage After Orthognathic Surgery

Francesca Calabria, MD, Lucy Sellek, MD,* Fabio Gugole, MD,† Lorenzo Trevisol, MD,† Laura Bertolasi, MD,* and Antonio D'Agostino, MD**

Abstract: To assess and monitor the common event of neurosensory disturbance to the inferior alveolar nerve (IAN) after bilateral sagittal split osteotomy, we used clinical sensory tests and neurophysiologic test sensory action potentials. The diagnostic value of these tests was evaluated by comparing them with the degree of nerve damage reported by patients. Fourteen patients undergoing bilateral sagittal split osteotomy were analyzed preoperatively and 2 years postoperatively. Patients were evaluated bilaterally for positive and negative symptoms: light touch sensation, paraesthesia, hyperesthesia, and dysaesthesia; a "sensation score" was then calculated for each patient. Patients were also asked if they would be willing to repeat the procedure knowing the sensation loss they had now. Next, the right and left IAN were evaluated using sensory action potential and correlated with the other results. Before surgery, the medium latency difference between left and right was lower compared with postsurgery, with all patients having some deficit. The reduction in medium amplitude of 67% after the intervention was statistically significant. The frequency of abnormal findings in the electrophysiologic tests indicating IAN injury correlated with subjective sensory alteration. All patients said that they would repeat the surgery. Electrophysiologic testing is recommended for the evaluation of nerve dysfunction and seems a sensitive method for accurately assessing postsurgical nerve conduction.

Key Words: Inferior alveolar nerve, bilateral sagittal split osteotomies, sensory action potential

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Sagittal osteotomy of the mandibular ramus is increasingly used in the correction of various dentoskeletal deformities. Persistent neurosensory disturbance of the inferior alveolar nerve (IAN) is a common postoperative complication of bilateral sagittal split osteotomies (BSSOs).[1–3] This technique corrects mandibular skeletal defects such as microagnathia and hyperagnathia, which can affect a person's chewing, breathing, and cosmetic appearance.

From the Departments of *Neurological, Neuropsychological, Morphological and Movement Sciences, and †Surgery, Section of Maxillo-Facial Surgery, University of Verona, Verona, Italy.
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Address correspondence and reprint requests to Laura Bertolasi, MD, Department of Neurological, Neuropsychological, Morphological and Movement Sciences, University of Verona-Italy, Clinica Neurologica Policlinico GB Rossi, Piazzale LA Scuro 10, 37134 Verona, Italy; E-mail: laura.bertolasi@ospedaleuniverona.it
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Preoperative and intraoperative risk factors include age, degree of nerve manipulation, and anatomical variation so that patients must be carefully selected before considering surgery. Generally, patients more likely to benefit from the surgery in comparison with the risks involved are considered.

The surgery was first described by Schuchardt in 1942. Since then, different techniques have been proposed: one of the most worldwide used follows descriptions by Hunsuck in 1968 and modifications by Epker in 1977.[1,4] The corrective surgery involves displacement of the mandible fragments and modifies the mandibular angle. Care is taken during surgery to prevent the well-known complication of neurosensory disturbance, although the nerve can be damaged even when visualized. Inferior alveolar nerve damage is thought to occur through mechanical damage to the sensory fibers, although only a low correlation between direct manipulation of the IAN and increased functional impairment of the nerve has been reported.[3] Perhaps stretching of the IAN during surgery causes the postoperative symptoms of hypoesthesia, paraesthesia, and hyperaesthesia along the alveolar nerve distribution (chin, lower lip, teeth, and gingiva).[2,5] The percentage of people affected postoperatively can range from 1% to 95%.[6] Most symptoms resolve within 12 months; however, some persist 2 years or more.[2,3,7,8] The variation in postoperative symptomatology may be due to the differences in subjective methods used to evaluate the disorder.[8,9]

Few studies have investigated the degree of IAN dysfunction using objective measures such as nerve conduction techniques, with most relying on subjective clinical neurosensory evaluations such as surveys, tactile discrimination, and heat and pain testing. Quantitative and objective measures are valuable both preoperatively and postoperatively to assess the degree of iatrogenic impairment, prognosis of recovery, and the need for microsurgery, which may have implications ethically and legally.[7,10–12]

Previous reports of objective testing methods, such as sensory action potentials (SAP), have been shown not to correlate with subjective methods, with participants overestimating the degree of neurosensory loss compared with sensory nerve action potential assessment. This objective and subjective variation tends to lessen as time goes on, suggesting that patients adapt and become accustomed to the dysfunction.[2,10]

Sensory action potential investigations are noninvasive, highly objective, extremely reliable, and can be used to investigate trigeminal sensory hypoesthesia of the lower lip after BSSO.[6,12] This method involves measuring the integrity of the nerve by measuring the latencies to the onset of the SAP and amplitudes from baseline to the negative peak of the recordings. Past reports on trigeminal somatosensory cortical-evoked potentials in healthy subjects are remarkably divergent with regard to both polarity and latency of the response and thus need further examination.[9]

Therefore, the purpose of this study was to determine the degree of IAN impairment 2 years postoperatively using objective methods such as SAP and compare these with clinical subjective methods for detecting neurosensory disturbance. Furthermore, we aimed to investigate whether patients would repeat the procedure despite known neurosensory impairment.

MATERIALS AND METHODS

Patients Selection

Fourteen patients, 9 women and 5 men, with ages ranging from 18 to 50 years (median age, 25 years) who attended the Maxillofacial Surgery Department at the Polyclinic Hospital in Verona as candidates for BSSO of the mandibular ramus were selected.

Surgical Technique

The surgeon decided to perform a sagittal osteotomy of the mandibular ramus according to Epker-Hunsuk technique. In this technique, the proximal portion of the ascending ramus is maintained in its normal anatomical position, with almost/near-complete detachment of the related soft tissue, to allow undisturbed movements of the distal segment. The incision and detachment of the soft tissue and the osteotomic lines are performed to avoid lesions of the inferior alveolar neurovascular pedicle. The mandibular ramus and part of the mandibular body are skeletalized; the entrance of the IAN at the level of the Spix spine is then identified and protected. The osteotomic lines are performed, and the greenstick fracture of the segment is completed. At this time, the IAN is localized and preserved. The procedure concludes with the repositioning of the distal osteotomized segment of the jaw.

Clinical Evaluation

Patients were tested before and 2 years after surgical intervention. Negative and positive symptoms were taken into account: soft touch sensitivity level and the presence of paraesthesia, dysaesthesia, and hypaeresthesia. Four areas were considered: right and left upper mandibular (lips) and right and left lower mandibular (chin). Patients were asked to give a sensation score of 0 to 10, (0, complete anaesthesia; 10, perfect sensation) for their ability to feel soft touch in each area. A "deficit score" was calculated for each area: (10-sensation score)/10. Finally, patients were asked to report the presence or not of paraesthesia, dysaesthesia, and hyperaesthesia. A *sided score* was considered for each side, adding 1 point for each positive symptom to the "deficit score." A *global score* was considered by adding the score of both side.

Neurophysiologic Evaluation

Neurophysiologic evaluation was performed as described by Nocini et al.[7] Briefly, SAP was recorded through a steel, Teflon-coated flexible needle serving as negative electrode, positioned near the foramen of the jaw (near the Spix spine) by the maxillofacial specialist. The reference positive electrode (steel needle) was positioned through the skin in the inferior part of the ear lobe. Stimulation of the IAN was made at the foramen using a low-current stimulator (50 μs square wave pulses, 1 Hz frequency). Signal was recorded by conventional electromyography; tracings were obtained from an average of 10 to 50 stimuli. Latency was measured from the beginning of the stimulus to the first positive peak of the triphasic wave. Amplitude was measured from the first positive peak to the following negative peak.

RESULTS

Before the intervention, none of the 14 patients had neurologic symptoms in the considered areas. Two years after the intervention, 0 patients were free of symptoms, 4 patients displayed symptoms only on 1 side, and 10 patients had symptoms on both sides. No patients referred only to positive symptoms (paraesthesia, hyperaesthesia, dysaesthesia), whereas 5 patients referred to positive symptoms accompanying negative ones. Partial and total scores are shown in Table 1. The intervention was successful in 13 patients; 1 patient needed reintervention after few months to properly correct the dentoskeletal defect.

Neurophysiologic conduction studies were performed on 56 IAN (14 right, 14 left, before and after, results shown in Table 2). The average latency before surgery was 1.39 ms (confidence interval: 1.13–1.65), the medium amplitude of the potential 78.07 μV (confidence interval: 34.04–122.11). The average latency after surgery was 1.58 ms (confidence interval: 1.35–1.82), with the medium amplitude of the 25.25 μV (confidence interval: 12.87–37.63). The 67% reduction in amplitude after the intervention is statistically significant ($P < 0.01$, Student *t* test).

The medium difference between left and right latencies was 0.10 ms (confidence interval: 0.01–0.19) and 0.36 ms (confidence interval: 0.16–0.56) after the surgery. The medium difference between left and right amplitude was 22.59 μV (confidence interval: 9.50–35.68) before the intervention, and after surgery, it was 20.10 μV (confidence interval: 5.44–34.77). The difference in latency is statistically significant ($P < 0.05$), the difference in amplitude, however, is not (Student *t* test).

With regards to the relationship between the neurophysiologic data and clinical assessment, we found that the differences in latency between right and left positively correlate to the differences between right and left in neurologic scores (Pearson's correlation coefficient: 0.47) (Fig. 1).

Finally, when asked whether they would repeat the surgery knowing the outcome, all 14 patients confirmed that they would indeed agree to the surgery despite the risks.

DISCUSSION

Studies of patients after BSSO surgical interventions commonly find neurosensory disturbance. Most research previously assessed this by means of clinical examination or questionnaires, and although purporting to be objective, the majority still rely on the

TABLE 1. Clinical Evaluation Scores

Patient no.°		1	2	3	4	5	6	7	8	9	10	11	12	13	14
R	Lip	0.5	0.5	0.1	0.5	0.0	0.2	0.0	0.0	0.0	0.0	0.2	0.2	0.5	0.0
	Chin	0.5	0.5	0.0	0.0	0.0	0.2	0.5	0.1	0.0	0.0	0.3	0.0	0.0	0.0
	Parhestesya	0.0	0.0	0.0	1.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.0	1.0
L	Lip	0.0	0.5	0.4	0.5	0.3	0.0	0.0	0.0	0.5	0.0	0.2	0.4	0.5	0.0
	Chin	0.0	0.5	0.4	0.0	0.0	0.0	0.3	0.1	0.5	0.2	0.3	0.4	0.0	0.0
	Parhestesya	0.0	0.0	0.0	1.0	1.0	0.0	0.0	0.0	1.0	0.0	0.0	0.0	1.0	1.0
Global Score		1.0	2.0	0.9	3.0	1.3	0.4	0.8	0.2	2.0	0.2	1.0	1.0	3.0	2.0

TABLE 2. Neurophysologycal Study: Shows Latency and Amplitude of Each SAP for Each Patient Before and After Surgery

Patient no.°			1	2	3	4	5	6	7	8	9	10	11	12	13	14
Before	R	Latency, ms	0.72	1.12	0.88	1.00	0.96	1.12	2.08	1.28	1.80	1.44	1.40	2.12	2.08	1.83
		Amplitude, μV	197.00	117.00	30.10	63.50	81.80	270.00	61.80	40.90	35.00	40.00	47.06	14.70	55.30	18.00
	L	Latency, ms	0.72	1.12	0.96	1.00	1.00	1.12	2.00	1.20	1.96	1.44	1.40	2.20	1.80	1.23
		Amplitude, μV	279.00	75.00	20.20	40.00	57.70	270.00	78.30	33.90	42.50	54.00	40.00	3.50	42.8	77.00
After	R	Latency, ms	2.56	2.08	1.12	1.80	1.12	1.56	1.40	1.56	1.20	1.72	1.52	1.36	2.08	1.40
		Amplitude, μV	17.20	11.7	40.50	10.00	119.60	16.30	13.90	31.70	42.10	41.90	12.90	28.40	18.80	13.20
	L	Latency, ms	1.36	1.80	1.40	1.20	0.92	1.24	1.28	1.56	1.52	2.72	1.64	1.44	2.02	1.80
		Amplitude, μV	11.30	7.00	5.80	24.80	15.50	39.00	31.70	36.60	36.00	18.30	24.00	7.06	23.50	8.20

patient to assess whether their sensitivity has changed, therefore leaving us with a subjective realm of testing. Our study used objective measures in conjunction with clinical assessment to evaluate postsurgical impairment. Most of the BSSO patients recover sensation within a year; however, our study has shown that neurologic symptoms can persist even 2 years after surgery, which is longer than what was previously reported.[3,13,14]

All patients undergoing surgery experienced some degree of disturbance to the IAN with most displaying symptoms bilaterally. This is unlike the low bilateral incidences previously reported.[13–15] No patient reported all 3 positive symptoms (paraesthesia, hyperesthesia, dysaesthesia) or indeed only positive symptoms. Most complained only of loss of sensation; however, a quarter had a combination of negative symptoms (reported loss of sensation) and 1 type of positive symptom.

In relation to SAP values, all patients had some degree of nerve conduction deficit after surgery, seen as significant reduction in amplitude scores after surgery. Initially, both right and left IAN have similar latency scores as seen in Figure 1, and after surgery, the difference was greater. However, we also see a greater range of values collected before the surgery, with data after the surgery more homogeneous. The dispersion of amplitude values is largest, probably because of the experience in technique gained throughout the years, particularly in approximating the correct site for needle insertion. In fact, if the needle is inserted too proximally to the nerve, the potential is larger and vice versa. Comparisons between left and right at the same time point minimalized this effect; however, reliable usability of this technique will require a minimum number of nerves tested to avoid operator error that is yet to be elucidated.

We found a correlation between neurophysiologic data and clinical evaluation when only considering a total score composed of both positive and negative symptoms. Therefore, it is important to evaluate not only postoperative sensation deficits but all kinds of dyasesthesia and paraesthesias, which can be even more invalidating.

The objective SAP method also showed even greater rates of damage than what patients themselves reported, perhaps because of adaptation effects mentioned by previous studies. Importantly, by comparing both objective and subjective methods of investigation, it appears that those who report deficit symptoms indeed have damage as measured by SAP. In accordance with previous studies, our data show that an objective measure such as SAP correlates with subjective methods of testing neurosensory damage after surgery, with even more sensitivity in detecting greater percentage of people affected by minor peripheral nerve damage.[7] In particular, we are able to identify the side more affected.

There were no indications for microsurgery; however, future experiments may help elucidate the severity and thus prognosis of recovery.

Overall, this study highlights again that, despite good technique by the same surgeon and taking every precaution to preserve the integrity of the nerve, some damage is unavoidable: in most cases, avoiding mandibular osteotomy, so preserving NAI, would compromise the best final result. Whether this is of significance to the patient is evident in the numbers willing to repartake in surgery. Despite damage, all patients agreed that they feel well even with paraesthesia, were pleased with the outcome, and would repeat the surgery, suggesting that sensation loss to the

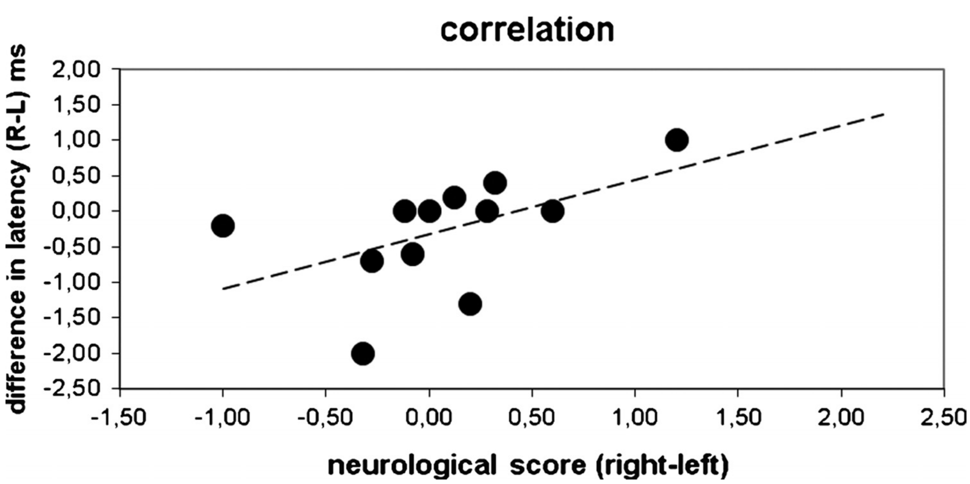

FIGURE 1. Electrophysiologic-clinical correlation: postsurgical correlation between the sided sensation score (right-left difference) and the electrophysiologic study (right-left difference in latency)

chin and lips is of minor consequence in comparison with the more troubling symptoms of malocclusion, apnea, lethargy, and cosmetic appearance.

In conclusion, SAP, in combination with clinical assessment, is an important method for objectively investigating presurgical and postsurgical neurosensory dysfunction, and patients should be fully informed of such outcomes. In our study, all patients having some degree of damage as detected by SAP and self-reported symptoms assessment, however, were still willing to risk sensation loss to experience the benefits of orthognathic surgery.

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