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## Original research

# Alveolar nerve impairment following bilateral sagittal split ramus osteotomy and genioplasty

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## ABSTRACT

**Objective:** Permanent sensory changes after sagittal split osteotomy have been estimated by various methods of measure. The incidence after sagittal split osteotomy vary considerably. The purpose of this study was to evaluate sensory alterations in patients treated either with sagittal mandibular osteotomy and genioplasty or only with sagittal mandibular osteotomy. The type of sensory alteration and the times of recovery of lower lip sensitivity was also checked in the different groups.

**Methods:** 106 patients who underwent BSSRO w/o genioplasty, during a 4-year period, were included. Qualitative and quantitative tests were applied to investigate tactile sensitivity, providing objectively measurable data involving the ability to feel the stimulus and to discriminate a two points static stimulus. Thermal sensitivity, sharp/blunt discrimination were also evaluated, as well the quality of subjective sensory symptoms.

**Results and conclusion:** Eighteen months after surgery, almost all of the patients had satisfactory recovery of their initial skin and mucosal sensory deficits, but the intensity of more fine discriminative sensitivity was reduced in those who had simultaneously undergone genioplasty associated with BSSRO.

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## 1. Introduction

Surgical repositioning of the skeletal components of the facial structure can be used to improve function and aesthetics. An extensive number of osteotomies are performed within the maxillofacial region to fulfil these purposes. The most commonly used are the Le Fort I osteotomy of the maxilla, the bilateral sagittal split ramus osteotomy (BSSRO) and genioplasty of the chin area [1]. A proliferation of such treatments has occurred, owing to the increasing need to improve facial appearance and resolve functional deficits, such as difficulties in mastication and speech. Various benefits have been reported, including improved masticatory func-

tion, reduced temporomandibular joint pain and improved facial aesthetics [2]. However, as the number of surgical performances increases, numerous complications, such as vascular problems, temporomandibular joint problems, nerve injuries and infections, have also been reported more frequently [3].

Neurosensory deficits are reported to be the most common problem following orthognathic surgery [4]. Sagittal split osteotomy and intraoral vertical ramus osteotomy are the most commonly used osteotomies to correct mandibular deformities. Altered function of the inferior alveolar nerve sometimes complicates mandibular osteotomy and is indicated by sensory changes in the distribution of the mental nerve (the lower lip and the chin). The incidence of permanent sensory changes after sagittal split osteotomy has been estimated by various subjective and objective measures, which vary considerably in their ability to detect and quantify any deficit. In some studies, the incidence after sagittal split osteotomy ranged from 0% to 82%. [5]

Injuries to the inferior alveolar nerve during the osteotomies operation may result from stretching of the nerve during medial retraction, adherence of the nerve to the proximal segment after

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splitting, direct manipulation of the nerve, bony roughness on the medial side of the proximal segment or mobilisation of the segment. The relation of the mandibular canal to the lateral cortex of the mandibular ramus can affect the incidence of nerve damage. In addition, osteosynthesis tools may cause injuries via compression of the inferior alveolar nerve during fixation or direct injury to the nerve [1,6,7].

Virtually all patients have altered sensation in the immediate post-operative period, but even in the long term, more than one-third of patients report subjective sensory disturbances [8–10]. The extent and course of nerve recovery vary greatly in studies in which the subjective sensation has been followed at several time points up to 1 year, but little attention has been paid to factors that could explain the variance.

Persisting sensory alterations can cause problems in the daily lives of patients and decreased satisfaction with the treatment results. Detailed knowledge of the recovery pattern and extent of the sensory alterations would be of great importance for patient communication, as well as for determining the need for possible further diagnostic tests and treatments during the recovery phase [11]. Therefore, one must carefully evaluate the degree of neurosensory disturbance (NSD) and its treatment and prognosis at an early stage after surgery. Such evaluation would be very helpful for clinicians and their patient.

For evaluating the NSD of the chin, many types of neurosensory status examinations are used [5–7,11–14], which can be classified into three groups: measurements of touch, pain and thermal sensation. Physiologically, touch sensation is transmitted by A-beta fibres, thermal sensations by C fibres and pain and cold sensations by A-delta and C fibres, respectively [13]. Therefore, to increase the diagnostic accuracy of the testing and to detect different types of damage, various tests should be combined, such as combination of touch sensory in objective and subjective manners.

The purpose of this study was to verify if substantial differences exist in terms of sensory alterations between patients treated either with sagittal mandibular osteotomy and genioplasty or only with sagittal mandibular osteotomy. It was also our intention to identify the types of sensory alteration and the times of recovery of lower lip sensitivity in the different groups.

## 2. Patients and methods

The clinical records of the patients who underwent BSSRO alone or combined bimaxillary osteotomies at the Maxillofacial Surgery Unit of the Sassari University Hospital, Italy, during a 4-year period between 2009 and 2013, were examined.

Patients who had conditions with greater propensity to alter recovery patterns or complicated systemic conditions, such as a persisting orofacial sensory impairment, diabetes, a history of facial trauma or operation or significant psychiatric disorders was excluded from the study group. Prior to surgery, nerve function was tested bilaterally to document any deficits due to the presence of concomitant disease; no such deficits were encountered. All patients followed an ordinary recovery course after surgery and none showed severe post-operative complications, such as persistent oedema or infection. The study was approved by the ethical committee of the University of Sassari.

The same surgeon, who was experienced in orthognathic surgery, performed all surgeries. All patients were treated with sagittal mandibular ramus osteotomy (Epker's variant), associated or not with genioplasty (at the lower border from the first premolar area of one side to the same area on the opposite). Both osteotomies were performed with a reciprocating saw and then splitted with sagittal splitter and separators. Ostheosintesis was done with titanium plates and screws.



**Fig. 1.** Cutaneous areas tested. V: vermillion. M: median region. P: paramedian region. F: foramen.

The subjects included (106 patients, 66 men and 40 women; mean age: 26.1 years, range: 21–37 years) were divided into the following groups:

Group 1: class III, mandibular retrusion without genioplasty (28 patients)

Group 2: class III, mandibular retrusion plus genioplasty (28 patients)

Group 3: class II, mandibular advancement without genioplasty (26 patients)

Group 4: class II, mandibular advancement plus genioplasty (24 patients)

To obtain a precise map of the sensitivity of the region pertaining to the inferior alveolar nerve (and particularly the mental nerve), the region itself was divided into the following areas (Fig. 1):

- the median region of the chin and lip: 1 cm bilaterally from the symphysis mandibulae, both the cutaneous and mucosal sides;
- the paramedian region: 2 cm bilaterally from the symphysis, both cutaneous and mucosal sides;
- the area of the mental foramen: 3 cm bilaterally from the symphysis (a few millimetres below the roots of the 4th and 5th teeth), on both the cutaneous and mucosal sides;
- the vermillion border of the lower lip.

The function of the inferior alveolar and mental nerves was tested for 18 months after surgeries.

All the tests were carried out by an independent medical doctor in a room free of any acoustic or visual disturbances capable of affecting the tests, with the patients having their eyes closed. The results were recorded on a standard form.

Qualitative and quantitative tests were applied to investigate tactile sensitivity, providing objectively measurable data involving the ability to feel the stimulus and to discriminate a two points static stimulus. Thermal sensitivity, and sharp/blunt discrimination were also evaluated, as well as the quality of subjective sensory symptoms.

### 2.1. Tactile sensitivity

Objective and quantitative evaluations were performed using the Semmes–Weinstein pressure aesthesiometer. The facial skin sites were tested bilaterally while the patients kept their eyes closed. The points of stimulation were selected in random order.

The test started with the thinner filament, followed by filaments with progressively increasing thickness. The patient was asked to answer yes when the touch of the monofilament was felt. Then, a filament immediately thicker was tested, but only in the areas without positive response to the previous filament. Each stimulus

was maintained for approximately 1.5 s, and articulate movements were avoided during use of the monofilaments. For each tested monofilament, the stimuli were applied 4 times in each area of interest. The stimulus response was considered positive when there were at least 3 (75%) correct answers (3 of 4 correct stimuli). The Semmes–Weinstein monofilaments 2.83 and 3.22 were selected as the upper limit of normality for the detection thresholds for the lower lip and chin, respectively.

## 2.2. Two-points discriminative sensitivity

assessment was made using Weber's aesthesiometer, an instrument similar to a pair of dividers that makes it possible to visualize the distance between the two points at the time it is being used. Both points were positioned simultaneously in the area of the skin under investigation, and the patients were asked whether they perceived only one or two distinct stimuli. Beginning with a minimum distance of 5 mm, the points were gradually separated until the patients perceived them as separate; the results were considered negative if the patients failed to perceive two separate stimuli when the distance between the points was 15 mm or more.

Thresholds of two-point discrimination was assessed using a "staircase limits method" [15]. This method included four test series with alternating descending and ascending stimulus magnitudes. A threshold was based on the mean of eight stimulus magnitudes corresponding to the reversals from positive to negative responses or vice versa in these four series.

## 2.3. Sharp/blunt discrimination

this tests the ability to distinguish the stimulus caused by the tip of the needle of the aesthesiometer, or of a small paint brush, to evaluate the patient's capacity to differentiate between blunt and sharp stimulation. Each area was randomly touched by one of the instruments while the patients were required to keep their eyes closed to prevent any visual interference.

## 2.4. Thermal sensitivity

This two-part test evaluated sensitivity to cold and heat. A glass test tube with a 4-mm base was filled with water heated to a temperature of 40–45 °C. After its base had been placed against the skin, the patients were asked whether they felt any sensation of heat while they were simultaneously warned not to give an affirmative reply only because they felt the contact with the test tube. The same operation was also carried out using ice.

## 2.5. Subjective sensory symptoms

The subject indicate the different qualities of sensory changes on a schematic figure of the face by marking the regions with different colours, classifying them in 4 categories: normal (nerve with no subjective alterations), negative symptoms (hypoesthesia), positive symptoms with or without hypoesthesia (paresthesia, dysesthesia and/or pain) and total loss of sensibility.

## 2.6. Data analysis

The results of the qualitative tests (numerically unquantifiable) were classified as follows: A: prompt perception of the stimulus; B: less intense perception of the stimulus; C: little perception of the stimulus; D: no perception of the stimulus.

The Mann-Whitney *U* test was used to compare differences between the groups (only in quantitative test). Statistical significance was defined as  $P < 0.05$ . The two points-discrimination

threshold was determined for each site and whether these thresholds differed between groups depending on surgery, with or without genioplasty, using an analysis of variance (ANOVA) for repeated measures.

## 3. Results

Results of the tests seem indicate that patients who underwent mandibular retraction presented a better perception of all types of stimuli. Mentoplasty associated with BSSRO (both advancement and retrusion) worsen the ability to promptly perceive the stimulation. In all the patient groups, the worse quality of the sensitive perception was in vermillion area.

### 3.1. Semmes-Weinstein monofilament test

Data were collected before and 1, 3, 6, 12 and 18 months after surgery and are expressed as percentage rate of patients of each group feeling correctly or abnormally the tactile stimulus in the investigated regions (Table 1). Before the surgery all the patients detected the stimulus of 2.83 and 3.22 monofilament on the lower lip and chin, respectively.

Statistical analysis for the Semmes-Weinstein test was carried out and is summarised below:

Until the sixth months control, significant differences were observed ( $P < 0.05$ ) between groups 1 and 2 and groups 3 and 4 for all regions. Class II patients reported generally worst results, but these data resulted no significant.

At 12 and 18 months, even though the foramen and especially the vermillion area showed less sensitivity, no significant differences were observed ( $P > 0.05$ ) between the groups.

### 3.2. Two-point discrimination test

For the two-point discrimination test, values were collected before and 3, 6 and 12 months after surgery and are expressed as rate of patients that discriminated between two separate points. Both points were positioned simultaneously in the area of the skin under investigation and the patients were asked whether they perceived only one or two distinct stimuli. Beginning with a minimum distance of 5 mm, the points were gradually separated until the patients perceived them as separate. The results were considered negative if the patients failed to perceive two separate stimuli when the distance between the two points was 15 mm or more. Table 2 reports a framework summary of this evaluation.

Statistical analysis for the two-point discrimination test was carried out and can be summarised as follows: at 3, 6 and 12 months, significant differences were observed ( $P < 0.05$ ) between groups 1 and 3 (no genioplasty) and groups 2 and 4 (genioplasty) for almost all regions. (for value  $<5$  mm, i.e. excellent sense of discrimination)

### 3.3. Sharp-blunt discrimination

In group 1, the stimulus was promptly discriminated in 79–90% of patients depending from the areas. In the group of patients who carried out mentoplasty in addition to mandibular retraction (group 2) these rates drop to 75–81%. Likewise, patients subjected to isolated mandibular advancement (group 3) present a prompt perception of the stimulus in 80–86% of the cases, while these data drop to 79–82% when genioplasty was performed (group 4). The difference between the groups was not significant.

### 3.4. Sensitivity to heat

In group 1, the hot stimulus was promptly discriminated in 88–89% of patients, depending from the areas. In the group of

**Table 1**

Results of Semmes-Weinstein quantitative test (% of patients).

	Median				Paramedian				Foramen				Vermilion			
1 month	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Normal	13	2	15	5	13	2	15	5	13	0	15	5	9	0	12	3
Abnormal	87	98	85	95	87	98	85	95	87	100	85	95	91	100	88	97
3 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Normal	25	12	25	12	25	12	26	13	22	15	22	13	22	13	20	13
Abnormal	75	88	75	88	75	88	74	87	78	85	78	87	78	87	80	97
6 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Normal	58	47	60	50	60	45	60	48	60	48	58	44	56	45	52	40
Abnormal	42	53	40	50	40	55	40	52	40	52	42	56	44	55	48	60
12 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Normal	81	77	82	77	79	74	82	76	80	73	81	74	77	70	78	71
Abnormal	19	23	18	23	21	26	18	24	20	27	19	26	23	30	22	29
18 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Normal	95	95	98	97	95	94	97	95	87	90	93	92	92	90	92	92
Abnormal	5	5	2	3	5	6	3	5	13	10	7	8	8	10	8	8

**Table 2**

Results of Two-points discrimination quantitative test (% of patients).

	Median				Paramedian				Foramen				Vermilion			
Before surgery	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
>10 mm poor discrimination	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
5–10 mm good sense of discrimination	35	36	39	30	31	31	38	30	31	33	38	30	25	26	26	24
<5 mm excellent sense of discrimination	65	64	61	70	69	69	62	70	69	67	62	70	75	74	74	76
3 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
>10 mm poor discrimination	27	37	38	46	28	38	43	27	39	39	45	30	46	42	45	
5–10 mm good sense of discrimination	52	52	51	44	49	55	50	47	53	50	51	47	52	50	44	55
<5 mm excellent sense of discrimination	21	11	11	10	23	7	12	10	20	11	10	8	18	4	14	0
6 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
>10 mm poor discrimination	24	33	31	44	27	33	32	40	20	35	36	43	28	40	39	40
5–10 mm good sense of discrimination	48	48	48	40	45	50	43	46	50	54	45	42	48	45	43	46
<5 mm excellent sense of discrimination	28	19	21	16	28	17	25	14	30	11	19	15	24	15	18	14
12 months	1	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
>10 mm poor discrimination	18	28	22	27	18	28	24	35	17	30	23	34	12	28	18	28
5–10 mm good sense of discrimination	46	45	44	44	50	53	45	46	53	55	48	48	38	38	35	40
<5 mm excellent sense of discrimination	36	27	34	29	32	19	31	19	30	15	29	18	50	34	47	32

patients who carried out genioplasty in addition to mandibular retrusion (group 2) this rate drops to 77–80%. Likewise, patients subjected to isolated mandibular advancement (group 3) present a prompt perception of the stimulus in 78–86% of the cases, while this rate drops to 77–83% when genioplasty was performed (group 4). The difference between the groups was not significant.

### 3.5. Sensitivity to cold

In group 1, the cold stimulus was promptly discriminated in 85–88% of patients, depending from the areas. In the group of patients who carried out genioplasty in addition to mandibular retrusion (group 2) this rate drops to 77–80%. Likewise, patients subjected to isolated mandibular advancement (group 3) present a prompt perception of the stimulus in 77–86% of the cases; this rate drops to 75–83% in cases that genioplasty was performed (group 4). The difference between the groups was not significant.

All these data are summarized on Table 3.

### 3.6. Subjective sensory symptoms

Results of the subjective sensory symptoms were recorded at 7 days and 1, 3, 6, 12 and 18 months. At 7 days all patients had a total loss of sensibility in every region of the chin and the lip.

The data recorded subsequently are resumed in Table 4. No patients complained complete anaesthesia at 18 months follow up.

## 4. Discussion

The results of these tests and the analysis of the patients' comments revealed that the residual neurosensory alterations are not disabling. Numerous studies [15–34] have already been published concerning post-surgical sensitivity of the inferior alveolar and mental nerves following mandibular osteotomy. The major complication of this type of procedure was a transient or (more rarely) permanent alteration in the neurosensory function of the lower lip. Because of their anatomical position, the inferior alveolar and mental nerves may suffer various types of trauma during orthognathic surgery. These may be indirect, such as compression due to the formation of a post-operative oedema or haematoma, or direct, including strain and/or compression during separation of the soft tissue, osteotomy, repositioning of the bony segments or during stabilisation.

According to some authors [15], the vascular supply may also be compromised, if the nerve is exposed during surgical procedures. Many experimental studies have been performed with the aim of demonstrating that factors such as age can affect the post-operative recovery of sensitivity. A direct correlation seems to exist between increasing age and the persistence of paraesthesia after sagittal osteotomy of the mandible, particularly in patients older than 40 years of age [21,25]; younger patients have a better chance of recovery [18]. In this study, age did not appear to affect the neurosensory alteration and recovery pattern. This is contradictory to previous studies that indicate older age as a risk factor for

**Table 3**

Results of sharp/blunt and thermic tests (% of patients).

	Median				Paramedian				Foramen				Vermillon			
	A	B	C	D	A	B	C	D	A	B	C	D	A	B	C	D
<b>Group 1</b>																
Sharp/blunt	85	11	4	0	90	10	0	0	91	9	0	0	79	11	10	0
Heat	89	10	1	0	89	9	2	0	89	10	1	0	88	10	2	0
Cold	87	11	2	0	88	11	1	0	88	11	1	0	85	10	5	0
<b>Group 2</b>																
Sharp/blunt	81	7	0	0	81	12	7	0	81	13	6	0	75	14	1	0
Heat	79	21	0	0	80	20	0	0	80	20	0	0	77	20	1	0
Cold	78	21	1	0	80	19	1	0	80	19	1	0	77	19	2	0
<b>Group 3</b>																
Sharp/blunt	85	9	6	0	85	9	6	0	86	8	6	0	80	12	8	0
Heat	86	11	3	0	86	10	4	0	86	10	4	0	78	20	2	0
Cold	86	10	4	0	86	9	5	0	85	11	4	0	77	20	3	0
<b>Group 4</b>																
Sharp/blunt	82	15	3	0	82	14	4	0	80	16	4	0	79	12	9	0
Heat	83	13	4	0	77	12	11	0	79	11	10	0	77	18	5	0
Cold	83	12	5	0	78	11	11	0	79	11	10	0	75	17	8	0

A: prompt perception of the stimulus; B: less intense perception of the stimulus; C: little perception of the stimulus; D: no perception of the stimulus.

**Table 4**

Results of subjective sensory symptoms assessment (% of patients).

	Median				Paramedian				Foramen				Vermillon			
	1 month	2	3	4	1	2	3	4	1	2	3	4	1	2	3	4
Normal	0	0	0	0	9	7	0	0	9	7	0	0	10	7	0	0
Negative symptoms	0	0	0	0	10	14	14	12	10	12	12	12	11	14	12	10
Positive symptoms	22	21	17	19	21	21	11	10	20	23	13	10	22	21	13	14
Anaesthesia	78	79	83	81	60	58	75	78	61	58	75	78	58	58	75	76
<b>3 months</b>																
Normal	7	5	6	2	18	14	8	6	18	14	8	5	16	13	8	6
Negative symptoms	38	15	35	20	61	58	50	44	60	58	48	44	63	58	48	44
Positive symptoms	40	60	39	58	14	21	25	31	15	20	27	32	12	22	25	32
Anaesthesia	15	20	20	20	7	7	17	19	7	8	17	19	9	7	19	18
<b>6 months</b>																
Normal	40	25	35	25	46	44	44	40	45	44	44	40	45	44	45	40
Negative symptoms	35	30	40	28	36	40	31	36	37	39	32	35	36	39	30	35
Positive symptoms	15	25	12	27	12	10	15	11	13	10	16	12	12	11	16	12
Anaesthesia	10	20	12	20	6	6	10	13	5	7	8	13	7	6	9	13
<b>12 months</b>																
Normal	64	57	57	54	64	67	56	57	64	65	56	55	64	65	57	55
Negative symptoms	27	25	31	32	27	33	31	29	26	33	31	31	26	33	32	31
Positive symptoms	9	18	12	14	9	0	13	14	10	2	12	14	10	2	11	14
Anaesthesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
<b>18 months</b>																
Normal	96	95	98	96	96	98	96	97	96	95	95	95	97	96	96	95
Negative symptoms	3	3	2	2	3	2	1	2	2	4	3	3	3	3	2	4
Positive symptoms	1	2	0	2	1	2	1	2	1	1	2	0	1	2	1	1
Anaesthesia	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0

prolonged sensory disturbance. This difference probably resulted because the patient group of this study was mainly composed of adults under 40 years old. To investigate the effect of ageing, future studies based on subjects with an indiscriminate age distribution should be performed.

Evaluating the situation following multiple surgical procedures is important: genioplasty performed at the same time as a sagittal mandibular osteotomy may lead to nerve lesions at different levels and thus hinder satisfactory recovery of the altered sensation from these procedures [19]. Genioplasty tends to aggravate the nerve damage caused by orthognathic surgery. Genioplasty alone is very rarely associated with neurosensory disturbances compared to orthognathic surgery because incisions are usually made at more peripheral sites of the inferior alveolar nerve (IAN). Few articles [1,13] have evaluated the effect of genioplasty on neurosensory disturbance. These studies report a relatively low incidence

of hypoesthesia after genioplasty. Our results are in accord with others [9] showing that the recovery of the IAN is much slower in patients undergoing mandibular osteotomy combined with genioplasty, which is probably attributable to the double insult caused by the combined procedures. The damaging effect seems to be more severe in the case of class II with genioplasty and could be explained by the stretching of the nerve after the advancement [1].

Recovery of nerve damage was most marked following the first 3 months after surgery, which is in accord with the results reported in previous prospective 1-year follow-up studies on IAN recovery after BSSRO [20]. In the case of BSSRO, most nerve damage occurs during the subperiosteal retraction on the medial side of the mandibular ramus, mainly resulting in demyelinating lesions owing to compression. Demyelinating nerve lesions are generally known to recover during the first 4 months after injury. The results indicate further nerve regeneration even after 6 months and

continuing recovery up to the 1-year follow-up. This corresponds to findings from other studies reporting improvement of sensory alteration up to 1 year after BSSRO [6].

In our study, the mandibular movement was related to the increase in threshold level after the operation because direct stimulation or disturbance to the inferior alveolar nerve seldom occurs during osteotomy surgery and traction of the nerve caused by movement of the bone segments might be one of the causes of post-operative sensory disturbance. In any type of orthognathic surgery, nerve compression can occur due to hooking or inflammatory oedema resulting from movement of the distal bone segments.

At least 1 year is generally necessary to verify resolution of a neurosensory alteration, as patients may report sensory disturbances in the immediate post-operative period, but the majority experience almost total recovery within 18 months post-operation [17,22]. However, the discordant results of the large number of studies designed to test the function of the inferior alveolar and mental nerves often make them difficult to compare. This discord is mainly due to methodological differences: some are exclusively qualitative studies based on subjective tests or on the use of questionnaires [18,23], others report both objective and subjective data obtained using exclusively qualitative techniques [16,21,35–37] and still others have used quantitative tests. Their results, however, are difficult to compare as the tests themselves were different [15,22,24–26,38,39]. Furthermore, the results are sometimes reported in terms of the rate of areas with altered sensitivity and sometimes in terms of the rate of patients examined. An accurate evaluation of neurosensory dysfunction should be based on a standardised methodology capable of investigation and quantification, rather than one based on a simple questionnaire [28].

In our series, one year after surgery, almost all of the patients had satisfactory sensory recovery of their initial skin and mucosal sensory deficits, but the intensity of the sensation was reduced in those who had simultaneously undergone genioplasty (groups 2 and 4) and in the patients undergoing orthognathic surgery for class II.

## 5. Conclusions

In conclusion, this study has extended information on normal values for static light touch and static two-point discrimination for facial sites. We showed that simple hand-operated devices, such as Semmes-Weinstein nylon monofilaments (light touch sensation) and the Weber's aesthesiometer (two-point discrimination) remain useful for studying trigeminal sensory function. The force conditions during testing are such that normal values from different laboratories for a variety of sites are generally applicable to any trained observer. The use of these devices is therefore appropriate, particularly in daily clinical practice in which easy and fast application is advantageous.

Eighteen months after surgery, almost all of the patients reported a satisfactory recovery of their initial skin and mucosal sensory deficits. Patients who had simultaneously undergone genioplasty or surgery for class II presented a worst recover of more fine discriminative sensitivity. In these patients the recovery is generally slower and required not less than 6–12 months.

## Conflict of interest

None declared.

## Ethical approval

The study was approved by the ethical committee of the University of Sassari.

## Acknowledgment

None

## References

- [1] Al-Bishri A, Dahlberg G, Barghashc Z, Rosenquista J, Sunzela B. Incidence of neurosensory disturbance after sagittal split osteotomy alone or combined with genioplasty. *Br J Oral Maxillofac Surg* 2004;42:105–11.
- [2] Posnick JC, Wallace JW. Complex orthognathic surgery: assessment of patient satisfaction. *J Oral Maxillofac Surg* 2008;66:934–42.
- [3] Sousa CS, Turrini RNT. Complications in orthognathic surgery: a comprehensive review. *J Oral Maxillofac Surg Med Pathol* 2012;24:67–74.
- [4] Kim SG, Park SS. Incidence of complications and problems related to orthognathic surgery. *J Oral Maxillofac Surg* 2007;65:2438–44.
- [5] Poort IJ, van Neck JW, van der Wal KGH. Sensory testing of inferior alveolar nerve injuries: a review of methods used in prospective studies. *J Oral Maxillofac Surg* 2009;67:292–300.
- [6] Gianni AB, D'Orto O, Biglioli F, Bozzetti A, Brusati R. Neurosensory alterations of the inferior alveolar and mental nerve after genioplasty alone or associated with sagittal osteotomy of the mandibular ramus. *J Cranio-Maxillofac Surg* 2002;30:295–303.
- [7] Kabasawa Y, Harada K, Jinno S, Satoh Y, Maruoka Y, Omura K. New evaluation method for neurosensory disturbance in the chin of patients undergoing mandibular sagittal split ramus osteotomy: an application of the heat flux technique. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2006;102:719–24.
- [8] Panula K, Finne K, Oikarinen K. Incidence of complications and problems related to orthognathic surgery: a review of 655 patients. *J Oral Maxillofac Surg* 2001;59:1128–36.
- [9] Teerijoki-Oksa T, Jääskeläinen S, Forssell K, Forssell H. Recovery of nerve injury after mandibular sagittal split osteotomy: diagnostic value of clinical and electrophysiologic tests in the followup. *Int J Oral Maxillofac Surg* 2004;33:134–40.
- [10] Westermark A, Bystedt H, Von Konow L. Inferior alveolar nerve function after mandibular osteotomies. *Br J Oral Maxillofac Surg* 1998;36:425–8.
- [11] Teerijoki-Oksa T, Jääskeläinen SK, Soukka T, Virtanen A, Forssell H. Subjective sensory symptoms associated with axonal and demyelinating nerve injuries after mandibular sagittal split osteotomy. *J Oral Maxillofac Surg* 2011;69:208–13.
- [12] Park JW, Choung PH, Seop KH, Kim YK, Chung JW. A comparison of neurosensory alteration and recovery pattern among different types of orthognathic surgeries using the current perception threshold. *Oral Surg Oral Med Pathol Oral Radiol Endod* 2011;111:24–33.
- [13] Satoh Y, Kabasawa Y, Jinno S, Omura K. Analysis of clinical usefulness of the heat flux technique: predictability of the recovery from neurosensory disturbances in the chin undergoing mandibular sagittal split ramus osteotomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2008;106:637–43.
- [14] Vriens JPM, van der Glas HW. Extension of normal values on sensory function for facial areas using clinical tests on touch and two-point discrimination. *Int J Oral Maxillofac Surg* 2009;38:1154–8.
- [15] Jones DL, Wolford LM, Hartog JM. Comparison of methods to assess neurosensory alterations following orthognathic surgery. *Int J Adult Orthod Orthognath Surg* 1990;5:35–42.
- [16] Wang JH, Waite DE. Vertical osteotomy vs sagittal osteotomy of the mandibular ramus: comparison of operative and postoperative factors. *J Oral Surg* 1975;33:596–9.
- [17] Hohl TH, Epker BN. Macrogenia: a study of treatment results with surgical recommendations. *Oral Surg Oral Med Oral Pathol* 1976;41:545–8.
- [18] Walter JM, Gregg JM. Analysis of postsurgical neurologic alterations in the trigeminal nerve. *J Oral Surg* 1979;37:410–4.
- [19] Schendel SA, Epker BN. Results after mandibular advancement surgery: an analysis of 87 cases. *J Oral Surg* 1980;38:265–72.
- [20] Brusati R, Fiamminghi L, Sesenna E, Gazzotti A. Functional disturbances of the inferior alveolar nerve after sagittal osteotomy of the mandibular ramus: operative technique for prevention. *J Maxillofac Surg* 1981;9:123–5.
- [21] Macintosh RB. Experience with the sagittal osteotomy of the mandibular ramus: a 13-year review. *J Maxillofac Surg* 1981;9:151–3.
- [22] Nishioka GJ, Zysset MK, Van Sickels JE. Neurosensory disturbance with rigid fixation of the bilateral sagittal split osteotomy. *J Oral Maxillofac Surg* 1987;45:20–6.
- [23] Upton LG, Rajyanakarn M, Hayward JR. Evaluation of the regenerative capacity of the inferior alveolar nerve following surgical trauma. *J Oral Maxillofac Surg* 1987;45:212–6.
- [24] Lindqvist CC, Obeid G. Complication of genioplasty done alone or in combination with sagittal split-ramus osteotomy. *Oral Surg Oral Med Oral Pathol* 1988;66:13–6.
- [25] Karas ND, Boyd SB, Sinn DP. Recovery of neurosensory function following orthognathic surgery. *J Oral Maxillofac Surg* 1990;48:124–7.
- [26] Leira JL, Gilhuus-Moe OT. Sensory impairment following sagittal split osteotomy for correction of mandibular retrognathism. *Int J Adult Orthod Orthognath Surg* 1991;6:161–7.

- [27] Posnick JC, Al-Qattan MM, Stepner NM. Alteration in facial sensibility in adolescents following sagittal split and chin osteotomies of the mandible. *Plast Reconstr Surg* 1996;97:920–7.
- [28] Frydman WL. Nerve injuries. *Oral Maxillofac Surg Clin N Am* 1997;9:207–18.
- [29] Newman L. Beware the inferior alveolar nerve in ramus osteotomy. *Br J Oral Maxillofac Surg* 1997;35:297–302.
- [30] August M, Marchena J, Donady J, Kaban L. Neurosensory deficit and functional impairment after sagittal ramus osteotomy: a long term follow-up study. *J Oral Maxillofac Surg* 1998;56:1231–5.
- [31] Blomqvist JE, Alberius P, Isaksson S. Sensibility following split osteotomy in the mandible: a prospective clinical study. *Plast Reconstr Surg* 1998;102:325–33.
- [32] Takasaki Y, Noma H, Masaki H, Fujikawa M, Alberdas JL, Tamura H, et al. A clinical analysis of the recovery from sensory disturbance after sagittal splitting ramus osteotomy using a Semmes-Weinstein pressure aesthesiometer. *Bull Tokyo Dent Coll* 1998;39:189–97.
- [33] Ylikontiola L, Kinnunen J, Laukkonen P, Oikarinen K. Prediction of recovery from neurosensory deficit after bilateral sagittal split osteotomy. *Oral Surg Oral Med Oral Pathol Oral Radiol Endod* 2000;90:275–81.
- [34] Westermark A, Bystedt H, Von Konow L. Patient's evaluation of the final result of sagittal split osteotomy: is it influenced by impaired sensitivity of the lower lip and chin? *Int J Adult Orthodon Orthognath Surg* 1999;14:135–9.
- [35] Bailey PH, Bays RA. Evaluation of long-term sensory changes following mandibular augmentation procedures. *J Oral Maxillofac Surg* 1984;42:722–5.
- [36] Martis CS. Complications after sagittal split osteotomy. *J Oral Maxillofac Surg* 1984;42:101–7.
- [37] Coghlan KM, Irvine GH. Neurological damage after sagittal split osteotomy. *Int J Oral Maxillofac Surg* 1986;15:369–72.
- [38] Campbell RL, Shamaskin RG, Harkins SW. Assessment of recovery from injury to inferior alveolar and mental nerves. *Oral Surg* 1989;64:519–22.
- [39] Yoshida T, Nagamine T, Kobayashi T, Michimi T, Nakajima T, Sasakura H, et al. Impairment of the inferior alveolar nerve after sagittal split osteotomy. *J Cranio-Maxillofac Surg* 1989;17:271–6.