Journal of Cranio-Maxillo-Facial Surgery 50 (2022) 393–399

Contents lists available at ScienceDirect

Journal of Cranio-Maxillo-Facial Surgery

journal homepage: www.jcmfs.com

Inferior alveolar nerve preservation during resection and reconstruction of the mandible for benign tumors as a factor improving patient's quality of life

S. Tereshchuk [a, c, *], S. Yu Ivanov [a, b], V. Sukharev [c]

[a] The Peoples' Friendship University of Russia, 6 Miklukho-Maklaya St., Moscow, 117198, Russian Federation
[b] I.M. Sechenov First Moscow State Medical University (Sechenov University), 8/2 Trubetskaya St., 119991, Moscow, Russian Federation
[c] Burdenko Main Military Clinical Hospital, 3 Gospitalnaya Poloschad, Moscow, 105229, Russian Federation

ARTICLE INFO

Article history:
Paper received 27 February 2020
Received in revised form
6 January 2022
Accepted 27 February 2022
Available online 7 March 2022

Keywords:
Inferior alveolar nerve
Numbness
Lip
Mandible
Quality of life
Mental nerve

ABSTRACT

This prospective study aimed to evaluate neurosensory disturbance and quality of life in patients who underwent mandibular resection for benign tumors and whose inferior alveolar nerve (IAN) was either preserved or sacrificed. Mandibular resection was indicated owing to the presence of osteoradionecrosis in 25 patients and ameloblastoma in 15 patients. Resection was unilateral in 24 patients and bilateral in 16 patients.

The authors assessed the inferior alveolar nerve's sensory dysfunction by measuring the electro-excitability of skin receptors using an electro-odontometer. Study participants' quality of life was estimated with the oral health impact profile (OHIP)-14 and short-form (SF)-36 questionnaire. All the patients in whom the inferior alveolar nerve was sacrificed experienced persistent numbness in the area of innervation with mental nerve on the affected side. The average pain threshold reached preoperative levels (point 1–22.7 ± 2.5, p-value = .025; point 2–25.8 ± 2.7, p-value = .023) 6 months after the operation in patients in whom the IAN was preserved (point 1–23.7 ± 2.3, p-value = .022; point 2 –25.4 ± 2.8, p-value = .025). The results of the OHIP-14 and SF-36 showed that patients with preserved IANs had a significantly better quality of life than the patients in whom the IAN was sacrificed. The results of OHIP-14 twelve months after the operation in unilateral resection: control group - 16.0 ± 1.6, p-value = .029; study group - 8.0 ± 0.8, p-value = .029, and in bilateral resection: control group - 26.0 ± 3.2, p-value = .044; study group - 9.0 ± 0.7, p-value = .027. The possibility of sparing the inferior alveolar nerve should not be ignored when planning mandibular resection and reconstruction.

1. Introduction

Mandibular reconstruction is an essential part of head and neck reconstructive surgery evolution. It is crucial for chewing, swallowing, maintaining oral competence, articulation, oral hygiene, and airway protection. Osteocutaneous flaps, which include vascularised fibula, ilium, and scapula, provide the standard solution for reconstructing mandibular and oral cavity defects (Taylor et al., 1975; Swartz et al., 1986; Urken et al., 1991; Mounsey and Boyd, 1994; Anderson et al., 1996; Cordeiro et al., 1999; Bak et al., 2010; Karaaltin et al., 2013; Ferreira et al., 2015; Jehn et al., 2020). Most patients demonstrate cosmetic improvements after reconstruction of the mandible, regardless of what causes the defect.

Ameloblastomas are benign, locally aggressive tumors (recurrence, 25%–35%) of odontogenic epithelium.

The inferior alveolar nerve (IAN) may be preserved during the management of unicystic ameloblastomas (Nowair and Eid, 2020). The IAN was never preserved in cases of recurrent ameloblastoma. However, a more radical approach is necessary to treat multicystic or solid tumors, especially those exhibiting a follicular pattern (Nakamura et al., 2001).

Preoperative planning and 3D modeling ensure accurate tailoring of the inserted bone flap (Zhou et al., 2019; Modabber et al., 2019). Nowadays, advances in reconstructive microvascular

* Corresponding author. Gospitalnaya ploschad 3a, Moscow, 105229, Russian Federation.
E-mail address: tereschuksv@gmail.com (S. Tereshchuk).

https://doi.org/10.1016/j.jcms.2022.02.008
1010-5182/

surgery have overcome the functional limitations which result from misalignment of the mandible and trismus, caused by fibrosis, soft tissue losses, and bony segment failure incapable of holding a denture.

At the same time, during segmental mandibulectomy, the IAN is often sacrificed, thus resulting in lower lip numbness; this can cause drooling, impaired speech, and accidental lip biting (Leung et al., 2013). There have been reports on IAN reconstruction with allografts (Salomon et al., 2016) and autografts (Taraquois et al., 2016; Usami et al., 2016), indicating that surgeons are aware of the issue and are working on a solution. The primary purpose of a health care system is to improve patients' quality of life, which needs consideration of patient judgment while creating a treatment strategy; this ensures that health and medical care are entirely evidence-based.

(Definition, Measures, Applications, & Facts, 2021). The available literature lacks data on the impact that has lost sensation in the lower lip on patients' quality of life after resection of the mandible, as well as a comparison of quality of life of those whose IAN and sensation of the lower lip, as a result, could be preserved. These data might clarify the necessity to sacrifice operation time, sparing the IAN during resection and reconstruction of the mandible due to improving patients' quality of life after the operation.

A patient-reported outcome (PRO) measures the experience or view of a participant in a clinical study. It is commonly collected during a patient survey or in an interview. There are many published PRO questionnaires dealing with quality-of-life issues, with some developed for specific conditions or treatments (World Health Organization, 2020).

Several surveys can assess the quality of life-related to dental procedures, the most popular of which is oral health impact profile (OHIP), due to its psychometric properties (Roumani et al., 2010).

This prospective study aimed to compare neurosensory disturbance and quality of life in patients who underwent mandibular resection with inferior alveolar nerve preservation and those with sacrifice of the inferior alveolar nerve.

2. Materials and methods

The Local Ethics Committee approved the experimental protocol of I. M. Sechenov First Moscow State Medical University, Moscow, Russia (Ethics Reference Number 01–20 [01/22/2020]). The procedures were in accordance with the Helsinki Declaration and its later amendments. Informed consent was obtained from all patients before the commencement of the study.

At the center for Maxillofacial Surgery and Dentistry of Burdenko Main Military Clinical Hospital, the authors designed an algorithm for planning and performing resection and primary mandible reconstruction that incorporates preservation of the IAN using state-of-the-art technology (Sukharev and Tereshchuk, 2018).

A 3D model of the mandible was generated via virtual surgical planning; the location of the IAN was determined and, if necessary, underlined in color. A guide to help approach the mandibular canal was then designed. At this stage, a new exit foramen for the IAN was planned. Typically, it is placed 1 cm proximal to the level of mandibular resection (Fig. 1). The upper margin of the guide was set under the mandibular canal, extending from the mental foramen to 1 cm proximal to the planned resection level. The inner surface of the guide was congruent with the outer surface of the mandible. The guide was then fixed to the mandible with one or two screws for stability. The holes for the drilling sleeves were designed to be 0.2-mm wider than the diameter of the sleeves. A burr was used to mark the course of the mandibular canal along the upper margin of the guide (Fig. 2), and the guide was subsequently removed. The dissection continued along the marked groove until the embedded IAN was reached; the IAN was then lifted from the canal. After slightly retracting the mental nerve, the incisive branch of the IAN was cut, and the proximal branch to the lower lip was left intact. This maneuver allowed us to transpose the IAN out of the mandibular canal.

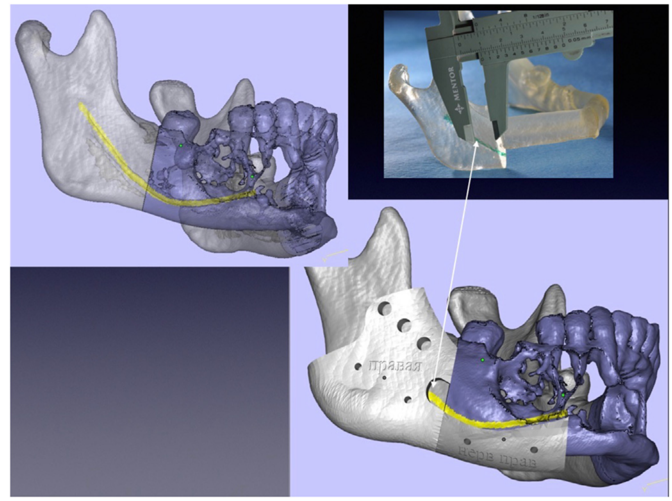

Fig. 1. Designing of the guides and planning of a new exit foramen of the inferior alveolar nerve.

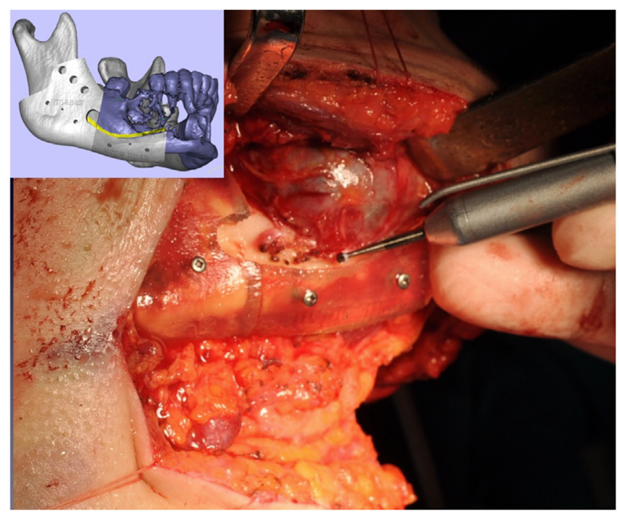

Fig. 2. Marking the course of the inferior alveolar nerve with a burr.

Using typical cutting guides, a transposed IAN can become trapped in the mandibular canal and damaged during the sawing process. A slot (1-cm deep and 5-mm wide) was designed at the anterior margin of the cutting guide in which the transposed IAN would be protected when the mandible is being sawed (Fig. 3). This technique obviated the need to remove the cutting guide during the resection, and the resection was performed according to the planned level and plane (see Fig. 4).

Various methods are used to evaluate the depth of numbness in clinical studies, including soft tissue, lip, and tongue-tip numbness. These signs are further complicated by the subject's interpretation of pain, which is highly variable and depends on their emotional and psychological statuses and previous experiences (Certosimo and Archer, 1996).

Electro-odontometry offers a valuable means to measure local numbness. By applying the electro-odontometer onto the skin, the

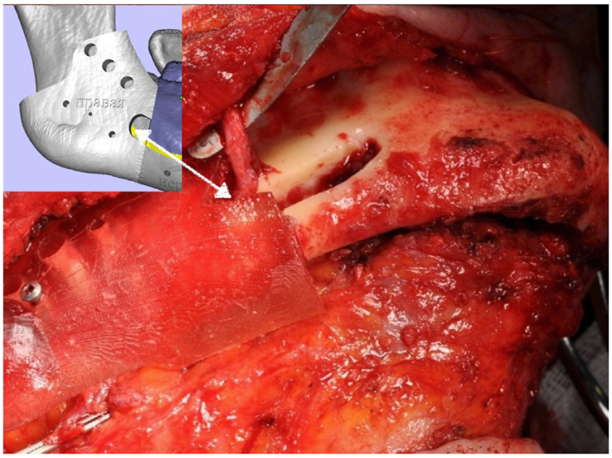

Fig. 3. Inferior alveolar nerve is protected in the slot of the cutting guide during sawing.

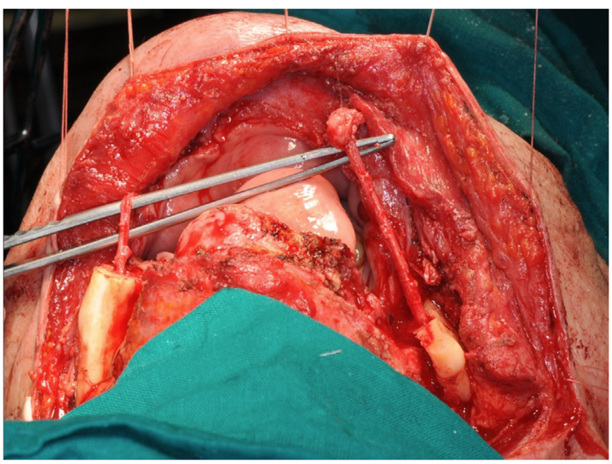

Fig. 4. Transposed and preserved inferior alveolar nerves on both sides.

pain threshold of skin sensory nerves can be determined as well as the conductivity of IAN fibers, that is, the IAN integrity (Dreven et al., 1987; Modaresi et al., 2005). Electro-odontometric examination reveals the threshold of tooth pulp electroexcitability. Pulp testing may involve thermal and electric pulp testing (EPT) in endodontics. These tests are also defined as sensibility tests since they reveal any response to a stimulus. EPT involves stimulation of sensory nerves, and interpretation of the results requires and relies on subjective assessments and comments from the patient. EPT remains a vital aid, and when properly used, it is a safe clinical test that can provide helpful information regarding health and disease (Seltzer et al., 1963; Mumford, 1967; Dummer et al., 1980). The use of electricity in dentistry is attributed to Magitot, and it has been described in his book *Treatise on Dental Caries,* published in France in 1867 (Prinz, 1919). Traumatic injuries to teeth cause problems with tooth vitality. Teeth that temporarily or permanently lose their sensory function do not respond to EPT and are described as 'concussed' (Kaletsky, 1944; Bhaskar and Rappaport, 1973; Pileggi et al., 1996; Waikakul et al., 2002). A positive response only confirms that Aδ fibers in the pulp chamber are responsive. The EPT offers a valuable means to measure local numbness. Results of studies have also suggested that EPT is an accurate means of evaluating local numbness in teeth with non-inflamed and inflamed pulps (Dreven et al., 1987; Modaresi et al., 2005).

To assess the technique's effectiveness for IAN preservation, an electro-odontometer (OSP 2.0; Averon, Yekaterinburg, Russian Federation) was used. The accuracy of this device is within 1 mA, and its error rate is <5%. Using a testing current of 1–100 mA, the patient's pain threshold was determined based on verbal responses. The passive electrode of the electro-odontometer was held in the patient's hand or fixed to the wrist. The active electrode was placed at two points on the area of skin innervated by the mental nerve on the affected side, with one point situated at the midline of the vermilion border of the lower lip and the other located at the labiodental fold. The patient could not view either the equipment or the operator. Measurements were performed before surgery and at 7, 14, and 21 days and 3, 6, and 12 months after surgery. Three measurements were performed with a 10-min interval between each measurement, and the results were averaged. The study's main goal was to assess the conductivity of the IAN and patients' quality of life after preserving or sacrificing the IAN. This is why evaluation of the different neurosensory disturbances of the IAN wasn't attempted.

Study participants' quality of life was assessed using OHIP-14 and short-form (SF)-36 questionnaires. Patients were asked to fill the OHIP-14 questionnaire at 1, 3, 6, and 12 months after surgery. The SF-36 questionnaire was filled at 6 and 12 months after surgery.

The OHIP-14 is a 14-item questionnaire (Slade, 1997) shortened from a 49-item questionnaire (Slade and Spencer, 1994). It was designed to rate the frequency of a patient's problem associated with the mouth, teeth, or denture across seven topics (two questions per topic). Responses were rated on a five-point Likert scale: 0 (never), 1 (hardly ever), 2 (occasionally), 3 (fairly often), and 4 (very usually/every day) (Slade and Spencer, 1994). The OHIP-14 outcome scores ranged from 0 to 56. The higher the total score, the worse the negative impact on Oral Health-Related Quality of Life.

The SF-36 measures health status and consists of eight scaled scores, which are the weighted sums of questions in their section. Each scale is directly transformed into a 0–100 scale, assuming that each question has equal weight. The lower the score, the more significant incapacity. Likewise, a higher score indicates less disability, i.e., a score of zero is equivalent to a maximum disability, and a score of 100 is equal to no disability (Anderson et al., 1996).

The OHIP-14 and SF-36 total outcome variables and individual topic scores between the study and control groups were evaluated.

2.1. Statistical analysis

Data were analyzed using Statistica version 7.0 software (StatSoft Inc., USA) and performed using a non-parametric measure of rank correlation (Spearman method). The mean values and standard deviations were determined for each parameter in both groups. Statistical significance was set at $P < .05$.

3. Results

The patients who underwent resection and primary mandibular reconstruction with sacrificed IAN and exhibited neurosensory deficiency were sex- and age-matched with patients in the study group. These individuals comprised the study's control group, whereas patients who underwent operations according to this algorithm comprised the study group (Table 1). No recurrence of ameloblastoma was observed neither in patients with sacrificed IAN nor in those whose IAN was preserved.

Mandibular resection was indicated owing to the presence of osteoradionecrosis in 25 patients and ameloblastoma in 15 patients. Resection was unilateral in 24 patients and bilateral in 16 patients (Table 2). Fibula free flap was used to reconstruct the

Table 1
Demographic characteristics of study participants.

	Study group (n = 20)	Control group (n = 20)
	Number	Number
Gender		
Male	16	14
Female	4	6
Age (years)		
<30	3	4
30–41	5	4
41–50	6	5
50+	6	7

Table 2
Nosologic characteristics of study participants.

	Study group (n = 20)	Control group (n = 20)
	Number	Number
Nosology		
Ameloblastoma	12	7
Osteoradionecrosis	8	13
Osteotomy		
Unilateral	12	12
Bilateral	8	8

mandible in 26 patients, the lateral aspect of the scapula in four patients, and the iliac crest bone free flap in 10 patients (Table 3). The type of free flap used for reconstruction did not affect the technique or results of IAN preservation.

No patient in this group had postoperative complications at the donor or recipient sites. Endosteal implants were used in all patients to restore masticatory function at 10–12 months after surgery.

All patients in the control group experienced persistent numbness in the area of innervation with mental nerve on the affected side. No response was achieved at 100 mA of testing current 12 months after surgery.

In the study group, the sensation was significantly impaired up to 10 days after surgery, which could primarily be attributed to traumatic edema. On day 14, patients reported improvements in sensation, and the testing showed a decline in the average pain threshold. Average thresholds at three weeks after surgery were close to the levels before surgery and reached preoperative levels at six months after surgery (Table 4).

The most significant difference in mean score was observed at 6 and 12 months after surgery in patients of both groups with bilateral mandibular resection: 31 ± 4.0 and 14 ± 1.1 at six months after surgery; 26 ± 3.2 and 9.0 ± 0.7 points at 12 months after surgery. Similar results were observed in both groups during the survey with SF-36.

A significant difference was observed between the groups at six months after surgery by the following charts of SF-36: Physical Functioning – 55.4 ± 5.6 (Control Group) to 77.7 ± 8.4 (Study Group) points; Role-Physical – 30.9 ± 3.5 (Control Group) to 54.6 ± 6.4 (Study Group) points; Vitality – 50.0 ± 5.7 (Control Group) to 68.9 ± 7.2 (Study Group) points and Role-Emotional – 32.7 ± 4.3 (Control Group) to 54.2 ± 6.1 (Study Group) points. At month 12, the significant differences were as follows: Physical Functioning – 72.3 ± 5.1 (Control Group) to 90.2 ± 6.7 (Study Group) points; Role-Physical – 45.5 ± 4.9 (Control Group) to 72.5 ± 4.7 (Study Group) points; Social Functioning – 69.2 ± 5.8 (Control Group) to 88.1 ± 6.7 (Study Group) points; Role-Emotional – 37.4 ± 4.1 (Control Group) to 78.4 ± 7.3 (Study Group) points and Mental Health – 63.7 ± 6.4 (Control Group) to 76.2 ± 7.1 (Study Group) points.

The mean OHIP-14 score in patients with bilateral mandibular resection was significantly higher than in patients with unilateral mandibular resection. The most considerable difference in the mean score between patients with bilateral and unilateral mandibular resection was at months 6 and 12: 20.0 ± 1.7 against 31.0 ± 4.0 points and 16.0 ± 1.6 against 26 ± 32 points respectively.

When the OHIP-14 mean score was compared between patients with unilateral and bilateral resection in the study group, the most significant difference appeared at 1 and 3 months after surgery and took 30.0 ± 2.9 and 36.0 ± 3.1 points, 27.0 ± 2.6 and 33.0 ± 2.6 points, accordingly. In patients with unilateral and bilateral mandibular resection whose IAN was preserved according to the developed methodology, the difference in OHIP-14 mean score over six months after surgery was minor: 12.0 ± 1.2 and 14.0 ± 1.1, 8.0 ± 0.8 and 9.0 ± 0.7 points respectively.

Comparison of OHIP-14 and SF-36 showed significantly higher levels of quality of life in those with preserved IAN (Tables 5 and 6).

4. Discussion

IAN injury is considered a severe complication of oral surgery. However, the IAN is often sacrificed during the segmental mandibular resection, resulting in permanent loss of sensation in the lower lip. Bilateral IAN injury is especially traumatic for patients. In 1987, Jensen and Nock described a technique that permitted placement of dental implants in the atrophied mandibular alveolar ridge that lacked sufficient vertical height superior to the mandibular canal (Jensen and Nock, 1987). This technique also facilitated the orthognathic surgery (Kahnberg and Ridell, 1987; Tabrizi et al., 2020). The procedure includes removal of the bone lateral to the mandibular canal and transposition of the IAN. With this, the continuity and function of the IAN are preserved while giving way to a surgeon in achieving a desired result of the surgery. The same approach can be applied before the segmental mandibular resection. Virtual surgical planning based on CT scans allows visualization of the mandibular canal, making access to the IAN fast and safe.

The reasons for mandibular resection can be as follows: osteonecrosis of the mandible, benign and malignant tumors. It was found that in patients with osteonecrosis, the IAN maintains its function even when bone destruction is clinically vivid until the mandibular body fracture occurs. Benign tumors in their growth distort and destroy the mandible while dislocating the IAN and only at the late stages, invading the mandibular canal disrupting the nerve continuity. When planning the operation that implemented the segmental mandibular resection, preservation of the IAN was possible in all these patients.

This approach is also feasible in patients with malignant oral cavity tumors. However, patients with cancer should meet the strict criteria considered for this procedure. An absolute contraindication for IAN preservation is tumor invasion into the mandible or tumors occurring within it. This method was applied in patients with mouth floor cancer when the tumor was intimate to the mandible but had not spread beyond the insertion point of the mouth floor muscle and had not spread onto the periodontal ligament or

Table 3
Flaps used in study participants.

	Study group (n = 20)	Control group (n = 20)
	Number	Number
Fibula Free Flap	12	14
Scapula Free Flap	1	3
Iliac Crest Bone Flap	7	3

Table 4
Average pain thresholds in the study group.

		Current Application Points			
Time of testing		Midline at the vermilion border of the lower lip Point 1 (mA)	p-value	Midline in the labiomental fold Point 2 (mA)	p-value
Before surgery (Day 0)		22.7 ± 2.5	.025	25.8 ± 2.7	.023
After surgery	Day 7	73.6 ± 7.2	.022	82.2 ± 9.1	.025
	Day 14	46.2 ± 4.9	.024	54.3 ± 6.7	.028
	Day 21	26.5 ± 2.9	.024	33.2 ± 3.6	.024
	Month 3	25.4 ± 2.4	.021	34.4 ± 3.7	.024
	Month 6	23.7 ± 2.3	.022	25.4 ± 2.8	.025

Table 5
Comparison of OHIP-14 scores in the control and study groups.

Time	Mean Score								Total Score	
	Unilateral Resection				Bilateral Resection					
	Control Group	p-value	Study Group	p-value	Control Group	p-value	Study Group	p-value	Control Group	Study Group
Month 1	37.0 ± 3.7	.029	30.0 ± 2.9	.028	44.0 ± 3.9	.031	36.0 ± 3.1	.030	864	724
Month 3	34.0 ± 2.8	.024	27.0 ± 2.6	.028	40.0 ± 3.2	.028	33.0 ± 2.6	.028	786	654
Month 6	20.0 ± 1.7	.025	12.0 ± 1.2	.029	31.0 ± 4.0	.046	14.0 ± 1.1	.028	588	268
Month 12	16.0 ± 1.6	.029	8.0 ± 0.8	.029	26.0 ± 3.2	.044	9.0 ± 0.7	.027	480	186

Table 6
Comparison of SF-36 scores in the control and study groups.

SF-13	Six months after surgery						12 months after surgery					
	Control Group/Study Group						Control Group/Study Group					
	Mean	p-value	Unilateral	p-value	Bilateral	p-value	Mean	p-value	Unilateral	p-value	Bilateral	p-value
Physical	55.4 ± 5.6/	.023	57.2 ± 6.5/	.025	48.4 ± 5.3/	.024	72.3 ± 5.1/	.016	77.1 ± 6.2/	.018	67.9 ± 6.9/	.023
Functioning	77.7 ± 8.4	.024	86.2 ± 8.3	.022	70.7 ± 7.2	.023	90.2 ± 6.7	.017	97.1 ± 8.1	.019	83.8 ± 7.5	.020
Role-Physical	30.9 ± 3.5/	.025	32.5 ± 3.7/	.025	29.0 ± 3.6/	.028	45.5 ± 4.9/	.024	49.4 ± 4.6/	.021	42.8 ± 4.6/	.024
	54.6 ± 6.4	.026	60.4 ± 6.7	.025	48.8 ± 5.4	.025	72.5 ± 4.7	.014	82.2 ± 9.1	.025	67.3 ± 7.1	.024
Bodily Pain	70.7 ± 7.3/	.023	64.3 ± 7.1/	.025	66.6 ± 6.7/	.022	58.2 ± 4.6/	.018	57.5 ± 5.6/	.022	61.4 ± 6.8/	.025
	48.7 ± 5.2	.024	46.3 ± 4.6	.022	50.0 ± 5.2	.023	42.8 ± 3.8	.020	38.7 ± 3.4	.020	43.1 ± 5.1	.026
General Health	49.2 ± 4.4/	.020	54.1 ± 5.1/	.021	44.4 ± 4.8/	.024	53.6 ± 4.5/	.019	57.5 ± 5.3/	.021	49.6 ± 5.2/	.023
	56.4 ± 6.1	.024	60.2 ± 5.8	.022	51.8 ± 5.1	.022	67.8 ± 6.6	.022	72.5 ± 6.8	.021	63.1 ± 5.8	.021
Vitality	50.0 ± 5.7/	.025	56.8 ± 4.9/	.019	44.0 ± 4.7/	.024	60.1 ± 7.5/	.028	65.4 ± 6.4/	.022	55.0 ± 6.4/	.026
	68.9 ± 7.2	.023	71.7 ± 6.3	.020	64.3 ± 6.4	.022	72.9 ± 7.2	.022	76.3 ± 7.3	.021	66.4 ± 7.2	.024
Social	61.9 ± 7.1/	.026	66.3 ± 5.1/	.017	55.1 ± 4.7/	.019	69.2 ± 5.8/	.019	74.6 ± 8.2/	.025	65.3 ± 6.7/	.023
Functioning	69.8 ± 6.8	.022	76.2 ± 6.3	.018	65.5 ± 5.3	.018	88.1 ± 6.7	.017	94.8 ± 7.7	.018	82.8 ± 8.3	.022
Role-Emotional	32.7 ± 4.3/	.029	34.6 ± 4.4/	.028	29.9 ± 3.1/	.023	37.4 ± 4.1/	.025	44.3 ± 5.8/	.029	31.6 ± 3.7/	.026
	54.2 ± 6.1	.025	58.2 ± 6.1	.023	49.7 ± 5.3	.024	78.4 ± 7.3	.021	89.7 ± 8.8	.022	67.5 ± 7.8	.026
Mental Health	56.9 ± 6.3/	.025	58.5 ± 7.2/	.028	54.9 ± 5.2/	.021	63.7 ± 6.4/	.022	66.2 ± 6.9/	.023	60.8 ± 6.8/	.025
	62.6 ± 5.6	.020	68.4 ± 6.6	.022	56.9 ± 5.5	.022	76.2 ± 7.1	.021	86.3 ± 8.7	.023	72.6 ± 7.3	.022
Physical Health	40.3 ± 3.7/	.021	44.4 ± 3.9/	.020	37.4 ± 3.7/	.022	48.9 ± 4.8/	.022	53.5 ± 6.3/	.026	45.3 ± 5.1/	.025
	49.3 ± 4.2	.019	54.4 ± 5.1	.021	44.7 ± 4.7	.024	50.9 ± 5.3	.023	56.2 ± 7.1	.028	48.6 ± 6.1	.028
Energy and	43.1 ± 3.8/	.020	45.8 ± 4.5/	.022	40.4 ± 4.2/	.023	45.6 ± 4.8/	.024	48.8 ± 5.0/	.023	42.4 ± 4.9/	.026
Emotion	43.7 ± 4.5	.023	47.6 ± 5.3	.025	40.2 ± 4.3	.024	54.6 ± 5.4	.022	64.4 ± 7.1	.025	46.5 ± 5.8	.028

beyond the middle of the alveolar ridge. IAN preservation in these patients remains a pending research focus. Therefore they were not included in this particular study.

There have been reported attempts to restore continuity of the sacrificed IAN during the mandibular IAN resection with allograft (Salomon et al., 2016), autografts from sural nerves (Tanaka et al., 2016), and larger auricular nerves (Taraquois et al., 2016). These efforts support the importance of the idea to recover skin sensation provided with the IAN. IAN reconstruction should be considered when it cannot be spared. Sparing seems to be more reasonable than reconstruction whenever possible.

The findings show permanent sensory dysfunction on the affected side in patients with sacrificed IAN. Some patients of this group partially recovered their mental nerve function, but the effect was negative in those tested with the current. Patients' main complaints were drooling of saliva and liquids, articulation problems, and negatively affected functions such as kissing, make-up application, and shaving. Most of these patients could only eat with a mirror in front of them and avoid eating in public places, negatively impacting their social activity. Some patients lost their jobs because public speaking was required, and they could not perform. Together, these consequences of IAN injury had adverse psychological effects and thus lowered patients' quality of life.

Patients with preserved IAN reported a total recovery of sensation in the area innervated with mental nerve starting three weeks after surgery. In some cases, it took six months to recover the trigeminal nerve branch fully. Patients of this group complained mainly of a deformity resulting from an operation and expressed no concern with dietary restrictions.

The present study has some limitations. Electroexcitability of skin receptors was the only skin sensation measured in this study. It is evident that the pain threshold measured in the study does not represent all the senses of the skin (pressure sensations, temperature, moisture, discrimination sense, etc.). The study aimed to measure pain levels to evaluate the integrity of nociceptive fibers. If the skin receptors were not affected during resection and mandibular reconstruction and because nociceptive fibers were closely interweaved with other receptive fibers, the preservation of the pain sensation indicates that the other senses were also preserved. The relatively small sample size is another study limitation. This study includes those patients whose sensation in the area of IAN innervation was not impaired before surgery.

Moreover, patients with malignant tumors were excluded. The research and data collection are ongoing; however, it is evident that IAN preservation substantially improves patients' quality of life at this stage of the study. Therefore, the article aimed to share the results of the research.

Previous studies have described mechanoreceptive and nociceptive testing methods of assessing IAN function. Mechanoreceptive testing can be divided into two types based on two-point discrimination: static light touch and brush directional stroke. Nociceptive testing can be subdivided into pinprick and thermal discrimination. Some authors recommend using the light touch test with Semmes–Weinstein monofilaments for grading IAN injury using a visual analog scale-based questionnaire to evaluate subjective sensibility (Poort et al., 2009; Schenkel et al., 2016).

The current perception threshold test is not a widely applicable testing method for nerve injury and is mentioned in only one study (Seo et al., 2005). Individual sensitivity to the current and mechanical stimuli is the main obstacle to establishing a standard method. By applying a current of 1–100 mA, a researcher obtains objective data according to this 100-point scale, which ensures that the changes and the dynamics of the responses of a subject are tracked accurately. Further research on how the extension of resection of the mandible influences IAN function is needed. In this study, was assessed the viability of the method. Electroodontometry was chosen to test the continuity of the nerve after its reposition and preservation. No attempt to explore the level of sensory disturbances other than electroexcitability of skin receptors after the procedure was taken. In addition, the effect of IAN preservation on patients' quality of life was examined.

5. Conclusion

The possibility of sparing the IAN should not be ignored when planning mandibular resection and reconstruction. This study has shown that lower lip numbness due to the IAN sacrifice is a primary factor that reduces patients' quality of life who have had mandibular resection and reconstruction. Preserved sensation of the lower lip dramatically improves patients' quality of life. Bilateral injury to the IAN results in even more debilitation. Computed tomography scanning, 3D imaging for virtual operation planning allows for the production of surgical templates to spare the IAN during the mandibular resection and reconstruction.

Acknowledgments

The authors would like to thank Enago (www.enago.com) for the English language review.

References

Anderson, R.T., Aaronson, N.K., Bullinger, M., McBee, W.L., 1996. A review of the progress towards developing health-related quality-of-life instruments for international clinical studies and outcomes research. Pharmacoeconomics 10, 336–355.
Bak, M., Jacobson, A.S., Buchbinder, D., Urken, M.L., 2010. Contemporary reconstruction of the mandible. Oral Oncol. 46, 71–76.
Bhaskar, S.N., Rappaport, H.M., 1973. Dental vitality tests and pulp status. J. Am. Dent. Assoc. 86, 409–411.
Certosimo, A.J., Archer, R.D., 1996. A clinical evaluation of the electric pulp tester as an indicator of local anaesthesia. Operat. Dent. 21 (30), 25.
Cordeiro, P.G., Disa, J.J., Hidalgo, D.A., Hu, Q.Y., 1999. Reconstruction of the mandible with osseous free flaps: a 10-year experience with 10 consecutive patients. Plast. Reconstr. Surg. 104, 1314–1320.
Dreven, L.J., Reader, A., Beck, M., Meyers, W.J., Weaver, J., 1987. An evaluation of an electric pulp tester as a measure of analgesia in human vital teeth. J. Endod. 13, 233–238.
Dummer, P.M.H., Hicks, R., Huws, D., 1980. Clinical signs and symptoms in pulp disease. Int. Endod. J. 13, 27–35.
Ferreira, J.J., Zagalo, C.M., Oliveira, M.L., Correia, A.M., Reis, A.R., 2015. Mandible reconstruction: history, state of the art and persistent problems. Prosthet. Orthot. Int. 39, 182–189.
Jehn, P., Spalthoff, S., Korn, P., Zeller, A.-N., Dittmann, J., Zimmerer, R., Tavassol, F., Gellrich, N.-C., 2020. Patient-specific implant modification for alloplastic bridging of mandibular segmental defects in head and neck surgery. J. Cranio-Maxillofacial Surg. 48 (3), 315–322.
Jensen, O., Nock, D., 1987. Inferior alveolar nerve repositioning in conjunction with placement of osseointegrated implants: a case report. Oral Surg. Oral Med. Oral Pathol. 63, 263–268.
Kahnberg, K.E., Ridell, A., 1987. Transposition of the mental nerve in orthognathic surgery. J. Oral Maxillofac. Surg. 45, 315–318.
Kaletsky, T., 1944. The management of traumatized pulps. Am. J. Orthod. Oral Surg. 30, 93–97.
Karaaltin, M.V., Canter, H.I., Batioğlu-Karaaltin, A., Yoğun, F.N., Güneren, E., Sönmez, T.T., 2013. The multiple osteotomized free iliac osteocutaneous flap for reconstructions of complex maxillofacial and oromandibular defects. J. Craniofac. Surg. 24, 1586–1592.
Leung, Y.Y., Lee, T.C., Ho, S.M., Cheung, L.K., 2013. Trigeminal neurosensory deficit and patient reported outcome measures: the effect on life satisfaction and depression symptoms. PLoS One 8, e72891.
Modabber, A., Rauen, A., Ayoub, N., Möhlhenrich, S.C., Peters, F., Kniha, K., Hölzle, F., Raith, S., 2019. Evaluation of a novel algorithm for automating virtual surgical planning in mandibular reconstruction using fibula flaps. J. Cranio-Maxillofacial Surg. 47 (9), 1378–1386.
Modaresi, J., Mozayeni, M.A., Dianat, O., 2005. Comparing the quality of anaesthesia in normal and inflamed teeth by pulp testing. Aust. Endod. J. 31, 120–122.
Mounsey, R.A., Boyd, J.B., 1994. Mandibular reconstruction with osseointegrated implants into the free vascularized radius. Plast. Reconstr. Surg. 94, 457–464.
Mumford, J.M., 1967. Pain perception threshold on stimulating human teeth and the histological condition of the pulp. Br. Dent. J. 123, 427–433.
Nakamura, N, Mitsuyasu, T, Higuchi, Y, Sandra, F, Ohishi, M, 2001 May. Growth characteristics of ameloblastoma involving the inferior alveolar nerve: a clinical and histopathologic study. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 91 (5), 557–562. https://doi.org/10.1067/moe.2001.113110.
Nowair, I., Eid, M., 2020. A modified surgical approach for the treatment of mandibular unicystic ameloblastoma in young patients. J. Cranio-Maxillofacial Surg. 48 (2), 148–155.
Pileggi, R., Dumsha, T.C., Myslinksi, N.R., 1996. The reliability of electric pulp test after concussion injury. Endod. Dent. Traumatol. 12, 16–19.
Psoort, L.J., van Neck, J.W., van der Wal, K.G., 2009. Sensory testing of inferior alveolar nerve injuries: a review of methods used in prospective studies. J. Oral Maxillofac. Surg. 67, 292–300.
Prinz, H., 1919. Diseases of the dental pulp. Dental Cosmos 61, 308–316.
Roumani, T., Oulis, C.J., Papagiannopoulou, V., Yfantopoulos, J., 2010. Validation of a Greek version of the oral health impact profile (OHIP-14) in adolescents. Eur. Arch. Paediatr. Dent. 11, 247–252.
Salomon, D., Miloro, M., Kolokythas, A., 2016. Outcomes of immediate allograft reconstruction of long-span defects of the inferior alveolar nerve. J. Oral Maxillofac. Surg. 74, 2507–2514.
Schenkel, J.S., Jacobsen, C., Rostetter, C., Grätz, K.W., Rücker, M., Gander, T., 2016. Inferior alveolar nerve function after open reduction and internal fixation of mandibular fractures. J. Cranio-Maxillo-Fac. Surg. 44, 743–748.
Seltzer, S., Bender, I.B., Ziontz, M., 1963. The dynamics of pulp inflammation: correlations between diagnostic data and actual histologic findings in the pulp. Oral Surg. Oral Med. Oral Pathol. 16, 969–977.
Seo, K., Tanaka, Y., Terumitsu, M., Someya, G., 2005. Characterization of different paresthesias following orthognathic surgery of the mandible. J. Oral Maxillofac. Surg. 63, 298–303.
Slade, G.D., 1997. Derivation and validation of a short-form oral health impact profile. Community Dent. Oral Epidemiol. 25, 284–290.
Slade, G.D., Spencer, A.J., 1994. Development and evaluation of the oral health impact profile. Community Dent. Health 11, 3–11.
Sukharev, V., Tereshchuk, S., 2018. Refined approach to preservation of the inferior alveolar nerve during resection and primary reconstruction of the mandible. Craniomaxillofacial Trauma Reconstr. 12, 34–38.
Swartz, W.M., Banis, J.C., Newton, E.D., Ramasastry, S.S., Jones, N.F., Acland, R., 1986. The osteocutaneous scapular flap for mandibular and maxillary reconstruction. Plast. Reconstr. Surg. 77, 530–545.

Tabrizi, R., Behnia, H., Behnia, P., Ozkan, B.T., 2020. What factors affect the attachment of the inferior alveolar nerve to the buccal plate following sagittal split osteotomy? J. Cranio-Maxillofacial Surg. 48 (5), 483–487.

Taraquois, R., Joly, A., Sallot, A., Kün Darbois, J.D., Laure, B., Paré, A., 2016. Réhabilitation sensitive du nerf alvéolaire inférieur après mandibulectomie interruptrice. Rev Stomatol Chir Maxillofac Chir Orale 117, 438–441.

Taylor, G.I., Miller, G.D., Ham, F.J., 1975. The free vascularized bone graft. A clinical extension of microvascular techniques. Plast. Reconstr. Surg. 55, 533–544.

Urken, M.L., Weinberg, H., Vickery, C., Buchbinder, D., Lawson, W., Biller, H.F., 1991. Oromandibular reconstruction using microvascular composite free flaps. Report of 71 cases and a new classification scheme for bony, soft-tissue, and neurologic defects. Arch. Otolaryngol. Head Neck Surg. 117, 733–744.

Usami, S., Tanaka, K., Ohkubo, A., Okazaki, M., 2016. Vascularized nerve bypass graft: a case report of an additional treatment for poor sensory recovery. Plast Reconstr Surg Glob Open 4, e686.

Waikakul, A., Kasetsuwan, J., Punwutikorn, J., 2002. Response of autotransplanted teeth to electric pulp testing. Oral Surg. Oral Med. Oral Pathol. Oral Radiol. Endod. 94, 249–255.

World Health Organization, 2020. WHOQOL: measuring quality of life [online]. Available from: http://www.who.int/healthinfo/survey/whoqol-qualityoflife/en/. (Accessed 5 February 2020).

Zhou, Z., Zhao, H., Zhang, S., Zheng, J., Yang, C., 2019. Evaluation of accuracy and sensory outcomes of mandibular reconstruction using computer-assisted surgical simulation. J. Cranio-Maxillofacial Surg. 47 (1), 6–14.