

Microneurosurgery with Allograft Leads to Improved Post-Operative Patient Satisfaction

Original Article

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ABSTRACT

Objective:-The aim of this study was to evaluate the relationship between objective change in neurosensory status after lingual nerve (LN) and inferior alveolar nerve (IAN) repair with a cadaveric nerve allograft and patient satisfaction. **Methods:**-The study design was a retrospective cohort review of patients who received an allograft (Avance; AxoGen, Alachua, FL). Neurosensory testing, criteria of the Medical Research Council, and the Oral Health Impact Profile questionnaire were performed at preoperative and postoperative visits. **Results:**-The sample was composed of 18 patients. Functional sensory recovery was achieved by 65% of the repaired nerve sites. Postoperative satisfaction was significantly greater than preoperative satisfaction for LN repair ($P < 0.003$) and IAN repair ($P < 0.005$). **Conclusion:**-These results suggest patients suffering from LN or IAN injury may benefit from surgical repair with allografts. Improvement in pain, anesthesia, patient satisfaction, and oral function can be expected with this type of repair.

Key Words :lingual nerve injury, inferior alveolar nerve injury, micro-neurosurgery, Nerve allograft

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Background

Trigeminal nerve injuries can be extremely disruptive, causing intermittent or constant pain, speech difficulties, and other functional issues that may result in a lower quality of life. The branches of the trigeminal nerve most often subject to injury during dental procedures—primarily because of their location and variable anatomic positioning—are the lingual nerves (LNs) and inferior alveolar nerves (IANs).^[1] Most trigeminal nerve injuries result from mandibular third molar extractions, implant placements, root canal therapy, or resection, but the most frequent cause is the removal of third molars (M3).^[2] Patients with trigeminal nerve injuries can experience profound oral dysfunction and a neurosensory deficiency. Common sensations experienced after injury are paresthesia, dysesthesia, allodynia, anesthesia, and neuropathic pain.^[3] For many patients with

trigeminal nerve injury, micro-neurosurgery may be beneficial.^[4] If the nerve is transected, surgical intervention for functional recovery is probably required. Without surgical repair, the patient may experience lifelong dysesthesia, anesthesia, and a lower quality of life.^[5] One of the first and most used techniques to reconstruct a peripheral nerve is direct neurorrhaphy.^[6] If the transected nerve can be coapted without tension, direct neurorrhaphy is indicated. However, in cases in which tension, which negatively affects nerve regeneration, is present on the injured nerve,^[6,7] an autologous nerve graft (i.e., autograft) may be used. This type of graft allows tension-free repair when a relatively large distance (greater than 5 mm) exists between the injured nerve endings. An alternative option for tension-free repairs is the use of hollow tube conduits or processed nerve allografts, which were developed to avoid a second surgical procedure

to remove healthy donor nerve tissue.^[8,9] Hollow tube conduits provide a protective environment that serves as a physical barrier to isolate the nerve and contain the nerve fluid that bleeds from the severed nerve ends. Use of these conduits results in disorganized regeneration and is limited to short-gap nerve defects.^[9,10] Repairs within a nerve defect rely on the formation of a fibrin bridge. When the nerve defect within a hollow tube conduit is greater than 5 mm, there are limitations of regenerating axonal growth and cellular migration. Allografts provide an organized and continuous scaffold across the full length of the gap.^[6] Processed nerve allografts are derived from human donor nerve tissue. The nerve allografts are cleaned, and cellular debris is removed, which makes way for axon and Schwann cell migration. The significance of the removal of allogeneic Schwann cells means that the patient does not require immunosuppression. These grafts maintain the microarchitecture inherent to nerve tissue and provide a microenvironment conducive to axonal regeneration. The allografts are implanted by the same microsurgical technique used to implant nerve autografts.^[6–8] Neurosensory assessment tends to reveal minimal information for the functional or pain evaluation of the patient. Therefore, various methods of indirect clinical measurements of sensation, e.g., light touch and 2-point discrimination, have been evaluated as a representation of neurosensory function. Although patient satisfaction appears to be high, few studies have explored the relationship between postoperative patient satisfaction and the objective and subjective changes in neurosensory status after nerve repair. To grade the patient's current nerve injury recovery level, a 4-level nerve injury recovery scale is described by Mackinnon and Dellon (1988).^[1,11] This scale is based on the modified Medical Research Council Scale (MRCS), which places emphasis on measured sensory losses. The MRCS provides a global assessment of neurosensory function, with scores ranging from S0 (no sensation) to S4 (complete sensory recovery). For peripheral nerve injuries, a score S3 or greater indicates functional sensory recovery (FSR). The advantages of this scoring system are its objective criteria for the classification of results and its ability to enable comparison of data from various published studies, even when the scale was not used in the original studies.^[3,12] A

review of the recent published literature found only a few publications that explored patient satisfaction after repair with a decellularized cadaveric nerve graft. Because of this scarcity of patient satisfaction findings regarding trigeminal nerve repair in the current literature, we offer this report on the outcomes and satisfaction of patients who have undergone trigeminal nerve repair with allografts.^[13] The purpose of this study was to evaluate patient satisfaction with the microsurgical reconstruction of injured LNs and IANs by using processed nerve allografts from a single supplier. We hypothesized that there would be a strong correlation between increased postoperative patient satisfaction and the objective measures of FSR. The specific aims of the study were 1) to compare relationships between patient satisfaction and FSR status; 2) to compare patient satisfaction and improved neurosensory anesthesia; 3) to compare neurosensory pain and improved quality of life

Methodology

To address the research purpose, we designed and implemented a retrospective analysis study of patients that underwent LN or IAN grafting conducted by a single surgeon (L.L.C.) at the University of Kentucky Oral and Maxillofacial Surgery Department at UK Health Care (Lexington, KY). Cadaveric nerve allografts (Avance Nerve Graft; AxoGen®, Inc., Alachua, FL) were used for repair in all patients. The study population was composed of all patients presenting to for evaluation and management of trigeminal nerve damage between April 2009 and August 2016. Surgical procedure: Nerve identification and exposure (either via access through soft tissues for the LN or via an osteotomy for the IAN) dissection of the nerve from the surrounding tissues (fig 1,2)



Fig 1. Lingual nerve identification and exposure

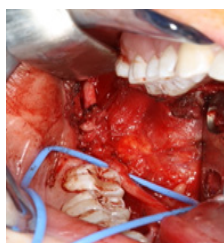


Fig 2. Complete lingual nerve dissection.

assessment of the degree of injury, manipulation of the nerve (neurolysis), which may include neuroma resection (fig 3),



Fig 3. Neuroma resection

debridement of the nerve stumps as required, and repair with the use of a the nerve graft (Axogen® nerve graft) (Fig 4),

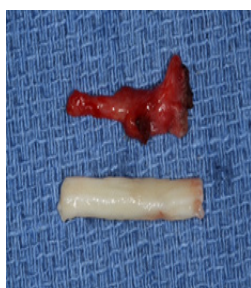


Fig 4. The use of the nerve graft (Axogen® nerve graft)

the graft was sutured to the stumps using 7.0 prolene. Operating microscope ($\times 12$ magnification) was used for higher magnification. To be included in the study sample, patients had to be between the age of 18 and 80 years and had to participate in at least one follow-up examination a minimum of 6 months after their surgery date. The same surgeon performed the preoperative and postoperative neurosensory examinations, and patients were required to complete a standardized Oral Health Impact Profile (OHIP) questionnaire anonymously at preoperative and postoperative visits. This study was reviewed and approved by the University of Kentucky Institutional Review Board.

The electronic health records of patients were reviewed for demographic data (age and gender), chief complaint, past medical history, preoperative neurosensory level, type of trigeminal nerve injury, cause of the injury, preoperative pain level, preoperative neurosensory examination findings, time between the occurrence of the injury and its repair, type of graft, and other operative data available concerning the trigeminal nerve injury. The primary predictor variables was the neurosensory tests with objective measures were light touch testing (scale of 0, no sensation to 10, normal sensation), brush stroke direction testing (scale of 0-5) with 5 correctly identifying the 5 brush strokes and normal sensation, 2-point discrimination testing (scale of 0-20, the lower number indicates better tactile sensation), and thermal testing^[13] The lingual nerve was subjected to a taste test (salt and sugar) using a scale of 0 to 2; a score of 2 indicated that the patient felt the application and correctly identified the taste, a score of 1 indicated that the patient felt the application but was unable to identify the taste, and a score of 0 indicated that the patient felt the application and was unable to identify the taste. Objective neurosensory testing was conducted preoperatively and postoperatively all done by the same investigator (M.R.). Increasing positive values in post-operative testing indicated neurosensory improvement. The primary outcome variable was patient satisfaction regarding the nerve repair; satisfaction was assessed based on descriptive data collected preoperatively and postoperatively. Patients were asked to rank their level of postoperative satisfaction as excellent, great, good, fair, and poor. The responses were quantified on a postoperative scale of 0 (excellent) to 4 (poor). Patient satisfaction is defined as the overall satisfaction with nerve repair as "good" or "better." (Renton & Van der Cruyssen, 2020) The secondary subjective variable of patient quality of life was measured with the OHIP survey, which used a scale of 1 (never), 2 (hardly ever), 3 (occasionally), 4 (fairly), and 5 (often). The OHIP questionnaire was designed to assess the level of oral dysfunction along 7 dimensions: functional limitation, physical pain, psychological discomfort, physical disability, psychological disability, social disability, and handicap.(3,8,14) Paired t tests and unpaired t tests were performed. Spearman rank correlation tests between subjective satisfaction and outcome variables were performed. Patients were

classified as having FSR if the following criteria specified by the Medical Research Council were met: (13-16) the patient experienced superficial pain and touch without hyperesthesia and static 2-point discrimination less than 15 mm (Table 1).

Table 1. Modified Medical Research Council Scale used to assess functional sensory recovery.^{4,10,13}

FSR	Grade	Description
No	S0	No sensation
	S1	Deep cutaneous pain
	S2	Some superficial pain and touch
	S2+	Superficial pain and touch plus hyperesthesia
Yes	S3	Superficial pain and touch without hyperesthesia and static 2-point discrimination >15 mm Indicates useful sensory function
	S3+	Same as S3 with good stimulus localization and static 2-point discrimination of 7-15 mm Indicates useful sensory function
	S4	Same as S3 and static 2-point discrimination of 2-6 mm Indicates complete sensory recovery

If a patient could detect sensation 15 mm or less between the 2-points using the two-point discriminator tool, the patient was classified as useful sensory function.

Result

Table 2. Patient Demographic and Clinical Characteristics at Baseline.

DESCRIPTIVE STATISTICS		
Variable	IAN	LN
Demographic		
Gender		
Male	2	2
Female	7	7*
Age (yr)		
Mean	47.11 ±12.39	28 ± 8.52
Time between injury and repair (months)		
Mean	10.55 ±15.19	5.45 ± 1.38
Interval to surgery 6 months or sooner	5	7
Interval to surgery 7 months or after	4	4
Follow-up duration (months)		
Mean	33.2 ±30.73	52.27 ± 33.99
Nerve Injured		
Number of patients	9	9

Number of nerves	9	11
Etiology		
Extraction	5	11
Resection	2	0
Dental implant	1	0
Root canal therapy	1	0
* 2 female subjects had bi-lateral LN		

Eighteen patients with 20 trigeminal nerve injuries (i.e., 11 LN and 9 IAN injuries) were identified. In the group with LN injuries, 2 patients were male and 7 were female. Two patients in this group had undergone bilateral LN reconstruction. In the group with IAN injuries, 2 patients were male, and 7 were female. All repairs were performed by the same surgeon (L.L.C.). The cause of the LN injuries was teeth extraction (11 injuries, 100%), and the causes of the IAN injuries were teeth extraction (5 injuries, 56%), resection of ameloblastoma (2 injuries, 22%), dental implant surgery (1 injury, 11%), and root canal treatment (1 injury, 11%). Patients with LN injuries were younger than patients with IAN injuries (mean ± SD, 28 ± 8.52 years vs. 47.11 ±12.39 years), and the mean time between injury and repair for patients with LN injuries was approximately 2.5 times as long as that for patients with IAN injuries (mean ± SD, 5.45 ±1.38 months vs. 10.55 ± 15.19 months, respectively). Most patients (66.6%) with IAN injuries reported overall satisfaction with allograft nerve repair as “good” or “better” (Figure 5). One patient’s satisfaction level was “excellent” before surgical repair. Postoperative satisfaction was either “great” or “excellent” for 55.6% of patients with LN repair and “good,” “great,” or “excellent” for 77.8% of patients with IAN repair (Figure 1). The time interval between trigeminal nerve injury and surgical repair did not seem to have a substantial effect on patient satisfaction. The longest time interval between injury and surgery was 48 months (4 years), but the patient with this interval had less anesthesia and dysesthesia postoperatively than preoperatively. Of the 7 patients who underwent LN surgeries that happened 6 months or less since the injury, all 7 patients reported postoperative improvement (defined as postoperative patient satisfaction of “good,” “great,” or “excellent”). Three of the 4 patients (75%) who underwent LN repair at least 7 months after injury expressed improvement in their condition.

Improvement was also reported by four of the five patients (80%) of those who underwent IAN repair 6 months or sooner after injury and by three of the four patients (75%) of those who underwent IAN repair at least 7 months after surgery. Results of the FSR assessments are summarized in

Table 3. Comparison of Preoperative and Postoperative Test Results Associated with Functional Sensory Recovery.

Pt. no.	Static 2-point		Light Touch* (Tactile sensation)		Brush Stroke†		MRCS S Category‡		Pt. Satisfaction‡	
	Preop	Postop	Preop	Postop	Preop	Post-op	Preop	Post-op	Preop	Postop
101	1	5	0	1	0	1	S1	S2+	0	1
106	1	10	0	5	0	1	S1	S2+	0	1
2	1	20	0 (neuropathic pain)	5	0	1	S1	S3	0	1
3	1	5	0	1	0	1	S1	S2	0	1
4	1	10	0	5	0	1	S1	S2+	0	1
5	1	1	1	1	1	1	S2	S4	0	1
6	1	5	0	0	0	1	S1	S3	0	1
7	1	5	0	0	0	1	S1	S2+	0	1
8	1	10	0	1	0	1	S1	S2+	0	1
9	1	10	0	10	0	1	S1	S3	0	1
10	1	14	0	10	0	1	S1	S2+	0	1
11	0	10	0	5	0	0	S1	S2+	0	1
12	10	12	0	5	0	1	S1	S2+	0	1
13	1	10	0	1	0	1	S1	S2+	0	0
105	0	0	0	0	0	0	S1	S2	0	0
108	1	5	0	0	0	1	S1	S2	0	0
19	1	10	0	0	0	1	S1	S3	1	1
20	1	10	0	1	0	0	S1	S3	0	0
17	1	10	0	1	0	1	S1	S2+	0	1
18	1	10	0	2	0	2	S1	S2+	0	1

Abbreviations: MRCS, Medical Research Council Scale; lt, patient's left; preop, preoperative; postop, postoperative; pt, patient; rt, patient's right.

*The ability to feel light touch was measured on a scale of 0, no tactile sensation to 10, full tactile sensation.

†The ability to feel a brush stroke was measured on a scale of 0, identified zero brush strokes correct of 5, identified all brush strokes. ‡Pt. Satisfaction: 0= "poor" or "fair," 1= "good," "great," or "excellent." [4]

After surgery, 13 of the 20 nerve sites (65%) achieved functional sensory recovery. The mean length of follow-up was 52.27 ± 33.99 months for patients with LN injury and 33.2 ± 30.73 months for patients with IAN injury. Four patients regained FSR but reported their postoperative satisfaction as "poor" or "fair." In contrast, 2 patients did not regain FSR but reported "good," "great," or "excellent" satisfaction with the surgery. One patient was able to sense some superficial pain and touch, and but the result did not meet the criteria for FSR. One patient had the same MRCS score before and after surgery. Two patients without FSR had a 2-point improvement in discrimination, light touch, and brush stroke

test results; this improvement would have qualified for placement in the S3 category, but the patient also reported hyperesthesia. 10 out of the 11 patients that underwent lingual nerve allografts regained some neurosensory function: with 72% regaining only tactile sensation but no taste identification, and 18% regaining tactile sensation and taste. Spearman correlation analyses were performed for the combined results of patients with LN or IAN injury who underwent repair. Subjective satisfaction and OHIP survey parameters were evaluated (post-score value – pre-score value = Neurosensory Improvement), and results are summarized in Table 4.

Table 4. Results of Spearman Correlation Analyses for Selected Variables for Patients with LN or IAN Injury Combined

Outcome Variable*	Subjective Satisfaction		Light Touch		Neurosensory Anesthesia		Neuropathic Pain	
	rho	P	rho	P	rho	P	rho	P
Spearman correlation	rho	P	rho	P	rho	P	rho	P
Subjective Satisfaction	N/A	N/A	0.82	<.01	0.82	<.01	0.98	0.08
OHIP Survey Parameters								
Pronunciation	-0.04	0.44	-0.32	0.09	0.02	0.47	<.01	0.5
Taste Sensation	-0.03	0.45	-0.18	0.26	-0.06	0.42	0.03	0.48
Painful Mouth Ache	0.08	0.36	0.4	0.04	0.16	0.23	0.41	0.15
Eating Discomfort	0.8	<.01	0.6	<.01	0.71	<.01	0.96	0.08
Self-Consciousness	0.02	0.47	-0.18	0.22	0.03	0.45	0.41	0.15
Feel Numb	-0.16	0.25	-0.02	0.46	-0.03	0.96	0.03	0.09
Poor Diet	0.75	<.01	0.44	0.03	0.61	<.01	0.53	0.09
Interrupted Meals	0.7	<.01	0.65	<.01	0.7	<.01	0.66	0.03
Difficulty Swallowing	0.27	0.15	0.03	0.44	0.26	0.12	0.94	0.21
Feel Embarrassed	0.04	0.43	<.01	0.5	-0.02	0.47	-0.28	0.25
Feel Irritable	0.55	0.01	0.36	0.08	0.43	0.03	0.96	<.01
Difficult to Do Job	0.61	<.01	0.16	0.22	0.3	0.1	0.41	0.15
Lower Limb Satisfaction	0.18	0.22	0.04	0.15	0.07	0.39	0.02	<.01

*Subjective satisfaction and OHIP survey parameters were evaluated to assess the extent of improvement (Postoperative score – Preoperative Score = Neurosensory Improvement).^{4, 14}

Subject satisfaction was significantly associated with "eating discomfort" (rho=0.80; P<.01), "poor diet" (rho=0.75; P<.01), "interrupted meals" (rho=0.70; P<.01), "feel irritable" (rho=0.55; P=.01), and "difficult to do job" (rho=0.61; P<.01). Sensitivity to light touch was significantly associated with "painful mouth ache" (rho=0.40; P=.04), "eating discomfort" (rho=0.60; P<.01), and "interrupted meals" (rho=0.65; P<.01). Neurosensory numbness was significantly associated with "eating discomfort" (rho=0.71; P<.01), "poor diet" (rho=0.61; P<.01), "interrupted meals" (rho=0.70; P<.01), and "feeling irritable" (rho=0.43; P=.03). Neurosensory pain was significantly associated with "interrupted meals" (rho=0.68; P=.03), "feeling irritable" (rho=0.98; P<.01),

and “lower life satisfaction” ($\rho=0.92$; $P<.01$). Comparisons of LN preoperative vs. LN postoperative patient satisfaction variables and IAN preoperative vs. IAN postoperative patient satisfaction variables were performed. Postoperative satisfaction was significantly higher than preoperative satisfaction in patients who underwent LN surgical repair and in those who underwent IAN surgical repair (Table 5).

Table 5. Patient Satisfaction

Variable	Group Comparison	p-value*
Satisfaction†	Preoperative LN vs. Postoperative LN	0.003075
	Preoperative IAN vs. Postoperative IAN	0.005206
Sum12‡	Preoperative LN vs. Postoperative LN	0.001448
	Preoperative IAN vs. Postoperative IAN	0.006594
Sum¶	Preoperative LN vs. Postoperative LN	0.001019
	Preoperative IAN vs. Postoperative IAN	0.005576

*Paired t test was used to calculate p values.

*Significance was indicated by p values $< .05$.

†Satisfaction is the score (scale of 0 to 4) corresponding to the patient satisfaction question in the pre-operative and postoperative survey.

‡Sum12 is the sum of all the scores for questions 1 and questions 3-13 in the survey. Question 2, which regarded to taste sensation, was excluded because of differences in the number of “not available” preoperative and postoperative responses for patients with either type of nerve injury.

¶Sum refers to the total when the Satisfaction score and Sum12 score were added together.

In general, patients were significantly more satisfied after either type of surgery than they were before. Improvement in neurosensory light touch was significantly greater for patients whose interval from injury to repair was 7 months or more and for patients who underwent IAN surgery (Table 6).

Table 6. Neurosensory Improvement

Variable	Group Comparison	p-value*
Improved ability to sense light touch	score ≤ 6 vs. score ≥ 7	0.02745
	LN vs. IAN	0.01403
Improvement in neurosensory anesthesia	score ≤ 6 vs. score ≥ 7	0.3866
	LN vs. IAN	0.4867

*Significance was indicated by p values $< .05$.

The type of injured nerve had a significant impact on light touch but not on neurosensory anesthesia (Table 7). Injured IANs that had undergone repair had a significantly better improvement in the ability to sense light touch. There was insufficient evidence to determine

whether patients with LN or IAN injuries had significantly less anesthesia than the other. However, patients with LN injury and those with IAN injury had less postoperative numbness.

Table 7. Relationship between Nerve Type and Improvement Score.

Variable	IAN mean	LN mean	p-value*
Ability to sense light touch	6.000000	2.454545	0.0140
Neurosensory numbness	3.222222	3.272727	0.4867

*Significance was indicated by p values $< .05$.

Discussion

This retrospective analysis of cadaveric nerve grafting secondary to injuries to the LN and IAN included 18 patients with 20 nerve injuries from 2009 to 2016. The main purpose of this study was to evaluate patient satisfaction with microsurgical reconstruction of injured LNs and IANs by using processed nerve allografts from a single supplier. This study also compared preoperative and postoperative patientsatisfaction based on objective and subjective changes and FSR. The hypothesis that there is a strong correlation between increased postoperative patient satisfaction and the neurosensory data of FSR was supported by our data. To date, there has been only a few studies that have examined this relationship between patient satisfaction and FSR status, specifically that of trigeminal nerves. Other key findings of our study demonstrate an improved patient satisfaction was significantly correlated with improved neurosensory anesthesia ($\rho=0.82$; $P<0.0001$). Also, there was a significant positive correlation was found between decreased neuropathic pain and improved quality of life ($\rho=0.92$; $P<0.01$). Processed nerve allografts such as the Avance Nerve Graft (AxoGen®, Inc.) maintain extracellular components and structural organization. The allograft provides decellularized and pre-degenerated human nerve tissue that allows the nerve to have favorable axonal regeneration.^[2,6,8,15] Compared with autografts and hollow tube conduits, the acellularized, deproteinated processed allografts have similar patterns of axonal regeneration and decreased density and clustered distribution.^[16,17] Our study shows that 65% of patients who underwent microneurosurgery for LN or IAN achieved FSR postoperatively and that 66.7% of patients

were satisfied with the surgery outcomes. Our results confirmed those of previous studies by Lam et. al (2003) and Susarla et al. (2005), each of whom found that most patients with trigeminal nerve injuries, specifically IAN or LN injuries, that were surgically repaired reported overall satisfaction with the outcome of the procedure, with ratings ranging from “good” to “excellent.”^[18,19] Our results also confirmed those of previous studies by Zuniga et. al (2015) and Yamplosky et al. (2107), each of whom found that most patients with trigeminal nerve injuries, specifically IAN or LN injuries, that were surgically repaired with nerve allografts had improved neurosensory function.^[18,20] Patient satisfaction was significantly correlated with OHIP score although several patients did not report an improved level of satisfaction, these patients did recover some neurosensory function. Scrivani et al. (2000) reported that 82% of patients in their study showed FSR, but only 35% of patients reported an improvement in taste sensation.⁽²¹⁾ Of the 11 LN allografts in our study, 90% regained at least neurosensory function, with 72% regaining only tactile sensation, and 18% full taste identification and tactile sensation. Our results showed no significant correlation between improvement in taste dysfunction and improvement in patient satisfaction. The sole patient who did not have favorable satisfaction also did not have taste. The timing of surgery may no longer be a factor in obtaining better outcomes. Surgeons may intuitively believe that operating on a nerve injury sooner leads to better outcomes. However, if patients undergo repair after the traditionally recommended interval between the time of injury and repair (i.e., 6 months or less), most will still have a functionally satisfactory outcome and be satisfied with the results. Interestingly, our results suggest that time between injury and repair was not significantly associated with FSR. In other studies, the interval between LN or IAN injury and its surgical repair was not associated with better outcomes.^[1,2,8] The types of symptoms after LN or IAN injury can also influence the outcome of the surgical repair. Our results indicated that patients who experienced dysesthesia prior to surgery tended to have lower satisfaction postoperatively, than did patients who had anesthesia before surgery. If a patient demonstrated minimal or no change in neurosensory function and FSR after LN or IAN surgery it could be

expected that the patient will have a lower level of satisfaction postoperatively and have more oral dysfunction, anesthesia, and dysesthesia. Even if the patient experiences less dysesthesia after surgery, the patient still experiences neurosensory pain, and that influences their perception of their outcome. Yamplosky et al. (2017) reported a similar finding that the outcome of trigeminal nerve surgery treat neuropathic pain is unpredictable.^[12] In their study, 2 patients experienced preoperative neuropathic pain, but after surgery the neuropathic pain receded, and the patient's postsurgical MRCS value was 3. However, another patient who experienced preoperative neuropathy experienced no change in neuropathic pain after surgery. Two additional patients experienced significant improvement in the 2-point discrimination tests, light touch sensation, and brush stroke sensation; however, because of hyperesthesia, the patient's MRCS value was measured as 2+. Despite satisfaction with outcome and significant improvement in descriptive data and sensory tests, the presence of neuropathic pain and hyperesthesia prevented the patient from reaching FSR by definition.^[20] Our study yielded findings similar to those of Yamplosky et al. 2017 and Noordenbos et al. 1981, i.e., the outcome of treatment of neuropathic pain in peripheral nerves outside and within the trigeminal nerve distribution is unpredictable.^[20,23] Due to our study being a single-center retrospective cohort study, further research is needed to delineate the effect of biologic prognostic factors such as health status, smokers, gender, and age. Future studies toward a multicenter prospective clinical trial are needed to support these findings. Overall, the results of our study suggest a strong, statistical correlation between patient satisfaction and functional improvement in neurosensory status with trigeminal nerve reconstruction surgery. Most patients who underwent surgical repair of injured LNs or IANs had significantly greater postoperative satisfaction than preoperative satisfaction. The results also indicated that anesthesia and neurosensory numbness as well as neurosensory pain and dysesthesia are related to patient satisfaction. Most patients experienced improved patient satisfaction and improved oral function after surgical repair. These results are consistent with the findings of other studies. This study supports the use of acellular

processed allografts during trigeminal nerve reconstruction surgery as an alternative to autogenous nerve grafting. Acknowledgments We thank Julia C Jones, PharmD, PhD, for substantively editing our article.

Declarations

Human Ethics and Consent to Participate

This study was reviewed and approved by the University of Kentucky Institutional Review Board All patients signed informed consent and authorized the use of their data for research. All procedures conducted followed the Helsinki Declaration in 1964.

Consent for publication

The authors affirm that human research participants provided informed consent for publication for all images in this research. Availability of data and material The data that support the findings of this study are available from the corresponding author upon reasonable request.

Competing interest

The authors have no relevant financial or non-financial interests to disclose.

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REFERENCES:

[1] Kulkarni V, Sahoo NK, Roy ID, Ghosh S. Neurosensory evaluation of inferior alveolar nerve following mandibular fracture fixation using modified Zuniga and ESSICK'S protocol. *Advances in Oral and Maxillofacial Surgery*. 2021 Oct;4:100171.

[2] Mahardawi B. Inferior alveolar and lingual nerves injury and repair: A literature review on microneurosurgery [Internet]. 2019. Available from: <https://www.researchgate.net/publication/351770531>

[3] Renton T, Van der Cruyssen F. Diagnosis, pathophysiology, management and future issues of trigeminal surgical nerve injuries. Vol. 13, *Oral Surgery*. Blackwell Publishing Ltd; 2020. p. 389–403.

[4] Bagheri SC, Meyer RA, Cho SH, Thoppay J, Khan HA, Steed MB. Microsurgical repair of the inferior alveolar nerve: Success rate and factors that adversely affect outcome. *Journal of Oral and Maxillofacial Surgery*. 2012 Aug;70(8):1978–90.

[5] Renton T, Van der Cruyssen F. Diagnosis, pathophysiology, management and future issues of trigeminal surgical nerve injuries. Vol. 13, *Oral Surgery*. Blackwell Publishing Ltd; 2020. p. 389–403.

[6] Kushnerev E, Yates JM. Evidence-based outcomes following inferior alveolar and lingual nerve injury and repair: A systematic review. Vol. 42, *Journal of Oral Rehabilitation*. Blackwell Publishing Ltd; 2015. p. 786–802.

[7] Leung YY, Cheung LK. Longitudinal treatment outcomes of microsurgical treatment of neurosensory deficit after lower third molar surgery: A prospective case series. *PLoS One*. 2016 Mar 1;11(3).

[8] Zuniga JR. Sensory outcomes after reconstruction of lingual and inferior alveolar nerve discontinuities using processed nerve allograft - A case series. *Journal of Oral and Maxillofacial Surgery*. 2015 Apr 1;73(4):734–44.

[9] Orchard A, Adatia A, Moore R, Prabhu S. Management of inferior alveolar nerve and lingual nerve injuries in the UK – a cross-sectional study. *British Journal of Oral and Maxillofacial Surgery*. 2022 Sep 1;60(7):927–32.

[10] Pogrel MA, Thamby S. The etiology of altered sensation in the inferior alveolar, lingual, and mental nerves as a result of dental treatment. *J Calif Dent Assoc*. 1999;27(7).

[11] Suhaym O, Miloro M. Does early repair of trigeminal nerve injuries influence neurosensory recovery? A systematic review and meta-analysis. Vol. 50, *International Journal of Oral and Maxillofacial Surgery*. Churchill Livingstone; 2021. p. 820–9.

[12] Miloro M, Zuniga JR, Meyer RA. How Many Oral Surgeons Does It Take to Classify a Nerve Injury? *Journal of Oral and Maxillofacial Surgery*. 2021 Jul 1;79(7):1550–6.

[13] Antony PG, Sebastian A, Varghese KG, Sobhana CR, Mohan S, Soumithran CS, et al. Neurosensory evaluation of inferior alveolar nerve after bilateral sagittal split ramus osteotomy of mandible. *J Oral Biol Craniofac Res*. 2017 May 1;7(2):81–8.

- [14] Abinayashri R V. The Ability of Panoramic Radiography To Predict Neurosensory Disturbances Of Inferior Alveolar Nerve Following Surgical Removal Of Mandibular Third Molar Department Of Oral Medicine And Radiology Coorg Institute Of Dental Sciences Virajpet-571 218. 2014.
- [15] Vyloppilli S, Thangavelu A, Vichattu SV, Kumar N, Ahmad F, Srinivasan P. Neurosensory Deficit of Inferior Alveolar Nerve after Bilateral Sagittal Split Osteotomy, Advancement versus Setback: An Observational Study. *Journal of International Oral Health*. 2022 Nov 1;14(6):618–23.
- [16] Miloro M, Ruckman P, Kolokythas A. Lingual nerve repair: To graft or not to graft? *Journal of Oral and Maxillofacial Surgery*. 2015 Sep 1;73(9):1844–50.
- [17] Suhaym O, Miloro M. Does early repair of trigeminal nerve injuries influence neurosensory recovery? Asystematic review and meta-analysis. Vol. 50, *International Journal of Oral and Maxillofacial Surgery*. Churchill Livingstone; 2021. p. 820–9.
- [18] Lam NP, Donoff RB, Kaban LB, Dodson TB. Patient satisfaction after trigeminal nerve repair. *Oral Surgery, Oral Medicine, Oral Pathology, Oral Radiology, and Endodontology*. 2003 May;95(5):538–43.
- [19] Susarla SM, Lam NP, Donoff RB, Kaban LB, Dodson TB. A Comparison of Patient Satisfaction and Objective Assessment of Neurosensory Function After Trigeminal Nerve Repair. *Journal of Oral and Maxillofacial Surgery*. 2005 Aug;63(8):1138–44.
- [20] Yampolsky A, Ziccardi V, Chuang SK. Efficacy of Acellular Nerve Allografts in Trigeminal Nerve Reconstruction. *Journal of Oral and Maxillofacial Surgery*. 2017 Oct;75(10):2230–4.
- [21] Scrivani SJ, Moses M, Donoff RB, Kaban LB. Taste perception after lingual nerve repair. *Journal of Oral and Maxillofacial Surgery*. 2000 Jan;58(1):3–5.
- [22] Susarla SM, Kaban LB, Donoff RB, Dodson TB. Functional Sensory Recovery After Trigeminal Nerve Repair. *Journal of Oral and Maxillofacial Surgery*. 2007 Jan;65(1):60–5.
- [23] Noordenbos W, Wall PD. Implications of the failure of nerve resection and graft to cure chronic pain produced by nerve lesions. *J Neurol Neurosurg Psychiatry*. 1981 Dec1;44(12):1068–73.