Functional Sensory Recovery After Trigeminal Nerve Repair

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Purpose: The aim of this study was to estimate the proportion of subjects who achieved functional sensory recovery (FSR) 1 year after inferior alveolar or lingual nerve repair and to identify risk factors associated with failure to achieve FSR.

Methods: Using a retrospective cohort study design, we developed a sample composed of subjects who underwent lingual or inferior alveolar nerve repair. Eligible subjects had at least 1 postoperative visit. For subjects having bilateral nerve repair, 1 side was selected randomly for analysis. Predictor variables were categorized as demographic, anatomic, and operative. The outcome variable was the time to FSR, measured in days. Kaplan-Meier survival methods were used to estimate the proportion of subjects with FSR at 1 year. Uni- and multivariate Cox proportional hazard models were used to identify risk factors for the failure to reach FSR at 1 year.

Results: The study sample was composed of 60 subjects with a mean age of 28.7 ± 8.3 years; 68.3% were female. The majority (86.7%) of subjects presented with a preoperative chief complaint of altered sensation and had lingual nerve damage (93.3%) that was repaired by direct suturing (75%). The mean interval between injury and repair was 145.9 ± 200.0 days. At 1 year postoperatively, 75% of the subjects had achieved FSR (95% confidence interval [CI]: 64% to 86%).

Conclusions: The majority of subjects undergoing trigeminal (V_3) nerve repair achieved functional sensory recovery within 1 year of surgical repair. Patients with evidence of neuroma formation were less likely to achieve FSR at 1 year in a multivariate model.

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A distressing complication of elective removal of third molars (M3) is injury to the inferior alveolar or lingual nerves. Although most nerve injuries resolve spontaneously, some subjects have permanent damage with neurosensory impairment requiring operative management. Common indications for operative intervention are persistent anesthesia, dysesthesia, or pain. Because of the significant disability associated with inferior alveolar and lingual nerve injury, considerable research has been devoted to examining risk factors for nerve damage and developing surgical approaches to treat and prevent injuries.[1-12] Outcomes of nerve repair, from the perspectives of surgeons and subjects have also been examined.[13-16] Although these studies have served to broaden the scope of literature on various aspects of nerve injury and repair, there are few reports that examine objectively the temporal progression of neurosensory recovery after repair.[17]

A serious deficiency in the oral and maxillofacial surgery literature dealing with trigeminal nerve repair is the lack of objective outcome studies. Although many authors have examined outcomes of inferior alveolar and lingual nerve repair, there is significant variability in the terminology, methods of evaluation, and definition of

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successful and unsuccessful outcomes. This makes comparisons between studies difficult. To address these issues, we propose to use functional sensory recovery (FSR) as an objective measure of neurosensory function after inferior alveolar or lingual nerve repair.

As neurosensory function cannot be assessed directly, indirect clinical measurements of sensation (eg, temperature, vibration, pinprick, light touch, 2-point discrimination) are used as proxies for neurosensory function. In this study, we adapted the scoring scale described by Mackinnon and Dellon. This is based on the British Medical Research Council (MRC) scale for grading sensation after the repair of peripheral nerve injuries.[18,19] The MRC scoring scale provides a global assessment of neurosensory function, utilizing a combination of these proxy measurements. It ranges from a score of S0 (no recovery) to S4 (complete recovery by objective testing) (Fig 1). For peripheral nerve injuries, a score of S3 or higher has been defined as useful sensory recovery.[18] The advantages afforded by this scoring system are: *1*) objective criteria for classification of results; *2*) common and accepted usage of the scale to report results in related disciplines (eg, peripheral nerve surgery); and *3*) ability to derive scoring from data published previously, even when the scale was not used by the study authors.[17]

The purpose of this study was to estimate the proportion of subjects who achieved FSR at 1 year after inferior alveolar or lingual nerve repair and to identify any demographic, anatomic, or operative risk factors for failure to achieve FSR. We hypothesized that the majority of subjects undergoing trigeminal (V_3) repair would have functional sensory recovery in this time frame. In addition, we hypothesized that there were discrete risk factors for failure to achieve FSR at 1 year postoperatively. We believe this is the first study utilizing FSR to assess outcomes after inferior alveolar or lingual nerve repair.

Methods

STUDY DESIGN/SAMPLE

This was a retrospective cohort study, approved by the institutional review board, enrolling subjects who had inferior alveolar or lingual nerve repair at the Massachusetts General Hospital Oral and Maxillofacial Surgery Unit during the period of January 1998 to January 2004. All repairs were carried out by either of 2 surgeons (L.B.K., R.B.D.). We included only those subjects who had a record of at least 1 postoperative follow-up visit and had preoperative neurosensory scores less than S2.

STUDY VARIABLES

Predictor Variables

Predictor variables were categorized as demographic, anatomic, and operative. Demographic variables were used to provide a general description of the sample and included age, gender, presenting chief complaint (altered sensation, pain, or both), time between injury and repair (days), and preoperative neurosensory status. Any evidence of legal activity (eg, correspondence from an attorney's office) in the chart was also recorded as a demographic variable. Anatomic variables were the nerve involved (inferior alveolar or lingual), side of injury (left or right), and extent of injury (unilateral or bilateral). For subjects with bilateral injuries, 1 side was chosen randomly for analysis. The operative variables included evidence of an incontinuity neuroma (observed intraoperatively and confirmed histologically) and method of repair (direct suturing vs graft, entubulization, or neurolysis).

Outcomes

The primary outcome variable was time to FSR defined as the number of days from the repair to FSR measured using a neurosensory examination. During the neurosensory examination, the surgeon carrying out the exam (L.B.K., R.B.D.) followed a standardized protocol for assessing neurosensory function. Neurosensory parameters assessed were Level A: static light touch, brush stroke direction and static 2-point discrimination; Level B: tensile light touch, using von Frey's hairs; and Level C: pinprick sensation (pain) and temperature. Subjects were classified as having functional sensory recovery according to the criteria specified by the Medical Research Council.[17] Briefly, a subject was classified as achieving FSR if static 2-point

FSR	Grade	Required Parameters
No	S0	No Sensation
	S1	Pain Sensation (Deep)
	S1+	Pain Sensation (Superficial)
	S2	Pain and Touch Sensation
	S2+	Pain and Touch Sensation with Some Overreaction
Yes	S3	As S2+, without Overresponse and w/Static 2PD 15 - 20 mm
	S3+	As S3, Static 2PD 7 – 15 mm
	S4	As S3+, Static 2PD <7 mm

FIGURE 1. Assessment of functional sensory level.[14,16]

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discrimination less than 20 mm and superficial pain/tactile sensation without over-reaction were present on physical examination (Fig 1).

Data Entry/Analyses

Data were entered into a statistical database (SPSS Graduate Pack v.11.0; SPSS Inc, Chicago, IL) over the course of the study. Kaplan-Meier analyses were used to estimate the proportion of subjects who achieved FSR at 1 year. Univariate Cox proportional hazards modeling was used to identify risk factors for failure to achieve FSR during the same period. We decided, a priori, that any association with *P* less than or equal to .15 in the univariate analysis would be included in the multivariate analyses. The multivariate model also included biologically relevant variables (ie, age and gender). Multivariate Cox proportional hazards modeling was then used to identify risk factors for the failure to reach FSR at 1 year. For multivariate analyses, *P* less than or equal to .05 was considered statistically significant.

Results

During the 6-year study period, 85 subjects underwent operative repair of damaged inferior alveolar or lingual nerves. Of 85 subjects who underwent repair, 60 (70.6%) met the eligibility criteria and were included in the study. There were no statistically significant differences between subjects enrolled and those not enrolled in the study in terms of the variables analyzed (Table 1).

The mean age of subjects was 28.7 ± 8.3 years (range, 16 to 49); 68.3% were female. Preoperatively, most subjects complained of altered sensation (86.7%); the remainder complained of both altered sensation and pain (13.3%). The majority of injuries involved the lingual nerve (93.3%). The remaining 6.7% were in the inferior alveolar nerve. The injured sides were approximately evenly distributed between the left (53.3%) and right (46.7%). Four subjects (6.7%) presented with bilateral injuries; one side was selected randomly for analysis in these subjects. Pre-

Table 1. DESCRIPTIVE STATISTICS FOR STUDY POPULATION

Variable	Follow-Up Group (n = 60)	No Follow-Up Group (n = 25)	*P* Value*
Demographic variables			
Age (yrs)	28.7 ± 8.3 (16–49)	30.6 ± 8.9 (16.8–51.1)	.36
Gender (female)	41 (68.3)	14 (56.0)	.46
Presenting chief complaint			.39
Pain	0 (0.0)	0 (0.0)	
Altered sensation	52 (86.7)	23 (92.0)	
Pain and altered sensation	8 (13.3)	2 (8.0)	
Time between injury and repair (days)	145.9 ± 200 (16–1,606)	120.6 ± 42.2 (29–179)	.35
Preoperative neurosensory level (anesthetic)	48 (80.0)	22 (88.0)	.24
Evidence of legal activity (yes)	12 (20.0)	21 (84.0)	.20
Anatomic variables			
Nerve injured			.24
Lingual	56 (93.3)	25 (100.0)	
Inferior alveolar	4 (6.7)	0 (0.0)	
Side of Injury			.11
Right	28 (46.7)	16 (64.0)	
Left	32 (53.3)	9 (36.0)	
Extent of injury			.24
Unilateral	56 (93.3)	25 (100.0)	
Bilateral	4 (6.7)	0 (0.0)	
Preoperative Tinel-like sign (yes)	37 (61.7)	15 (60.0)	.99
Operative variables			
Method of repair			.14
Direct reanastomosis	45 (75.0)	22 (88.0)	
Vein/nerve graft, neurolysis, entubulization	15 (25.0)	3 (12.0)	
Incontinuity neuroma (yes)	38 (63.3)	16 (64.0)	.10
Outcome variables			
Mean follow-up time (days)	223.4 ± 140 (34–635)	N/A	N/A
FSR achieved at 1 year (yes)	45 (75.0)	N/A	N/A
Time to FSR (days)	180.8 ± 101 (34–361)	N/A	N/A

Abbreviations: FSR, functional sensory recovery; N/A, not applicable.

*There were no statistically significant differences between the follow-up and non-follow-up groups for any of the predictor variables.

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operatively, 80% of the subjects in the sample were anesthetic on objective testing.

Seventy-five percent of the repairs were done by direct suturing. Approximately 60% of subjects had evidence of neuroma formation. Twelve subjects (20%) had evidence of legal activity in their charts.

Time to FSR is summarized in Figure 2. By 12 months after operative repair, 75% of the subjects had achieved FSR (95% confidence interval [CI], 64% to 86%). The mean time to FSR was 273.5 ± 26.4 days (95% CI, 221.8, 325.2); the median time to FSR was 217.9 ± 40.3 days (95% CI, 139.0, 296.8).

Univariate Cox proportional hazards analyses of predictor variables versus the outcome variable are summarized in Table 2. Two variables, method of repair and evidence of an incontinuity neuroma, met the criterion for inclusion in a multivariate model.

Our computed multivariate Cox proportional hazards model is shown in Table 3. Evidence of neuroma formation was statistically significant in the multivariate model. Our model indicated that subjects who have evidence of neuroma formation intraoperatively are approximately 60% less likely (Hazard ratio, 0.40; 95% CI, 0.20, 0.85) to develop FSR within 1 year, compared with subjects who do not have evidence of neuroma formation.

Discussion

The purpose of this study was to estimate the proportion of subjects who achieve FSR by 1 year after inferior alveolar or lingual nerve repair and to identify any demographic, anatomic, or operative risk factors for failure to achieve FSR at 1 year postoperatively. We hypothesized that the majority of subjects undergoing surgical repair of the inferior alveolar or lingual nerve would achieve functional sensory recovery at 1 year postoperatively. In addition, we hypothesized that there would be identifiable risk factors for failure to achieve FSR at 1 year postoperatively. We believe this may be the first clinical report in which an accepted, objective measure of neurosensory function (FSR) is used to summarize outcomes after operative repair of the lingual or inferior alveolar nerves.

The results of our study showed that 75% of subjects undergoing inferior alveolar or lingual nerve repair had achieved FSR at 1 year postoperatively. We found that intraoperative evidence of neuroma formation was statistically significantly associated with failure to achieve FSR at 1 year postoperatively. This result is biologically plausible, as evidence of neuroma formation may be suggestive of aberrant neuronal healing, and it is conceivable that, in subjects with

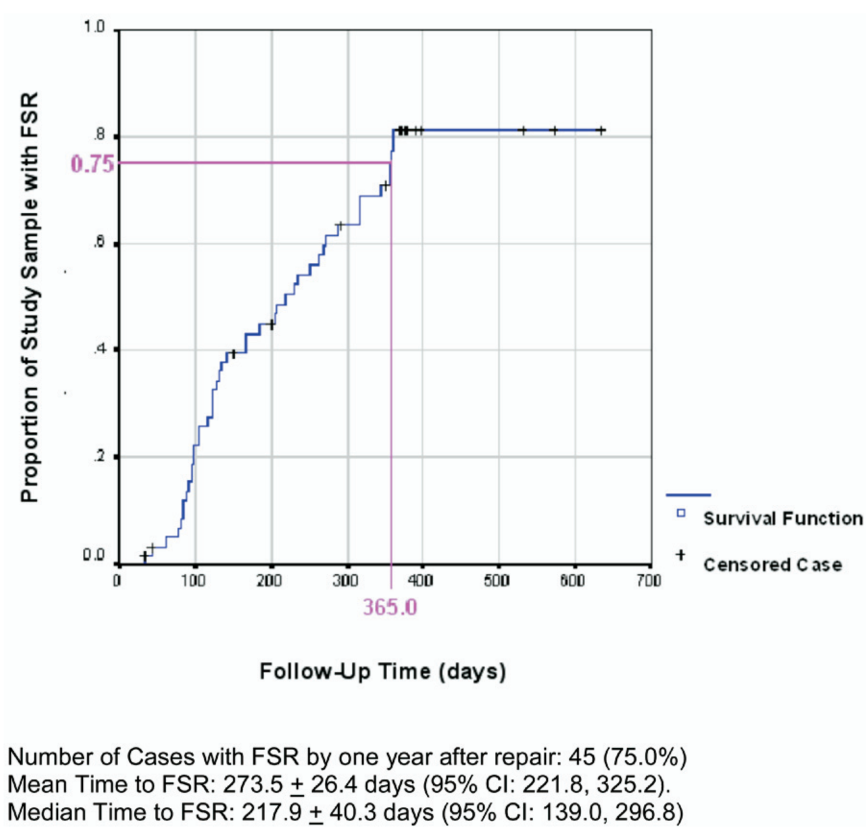

FIGURE 2. Proportion of sample achieving FSR at 1 year.

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Table 2. RELATIONSHIPS BETWEEN PREDICTOR VARIABLES AND TIME TO FSR

Variable*	B	SE(B)	*P* Value
Age (yrs)	−0.01	0.02	.59
Gender	0.11	0.33	.75
Presenting chief complaint	−0.35	0.42	.71
Time between injury and repair (days)	−0.02	0.02	.28
Preoperative neurosensory level	0.07	0.27	.80
Evidence of legal activity	0.23	0.37	.53
Nerve injured	−0.63	0.53	.23
Side of injury	0.06	0.05	.82
Extent of injury	0.57	0.73	.43
Method of repair	**0.64**	**0.35**	**.06**
Incontinuity neuroma	**−0.92**	**0.31**	**<.01**

Abbreviations: B, regression coefficient; FSR, functional sensory recovery; SE(B) standard error.

*Variables that met the criterion for inclusion in the multivariate model are indicated in bold type-face.

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neuromas, the scar tissue impedes healing. They may also exhibit more Wallerian degeneration and a greater size discrepancy between the proximal and distal nerve stumps once the scar tissue has been excised, in comparison to subjects with neurotmesis injuries.

Our results may confirm the notion that surgical repair of the inferior alveolar and lingual nerves is an effective therapy for treating subjects with nerve injuries who do not have spontaneous remission of symptoms. This result may help to allow surgeons to provide subjects with realistic expectations for their surgery. In addition, the survival function shows that 50% of subjects undergoing microsurgical repair of the inferior alveolar nerve or the lingual nerve achieve FSR by approximately 7 months after the repair.

Although we identified few risk factors for failure to achieve FSR at 1 year, the lack of statistical significance with other factors may be a function of our relatively small sample size. Interestingly, time between the injury and repair was not statistically significantly associated with failure to achieve FSR at 1 year ($P = .28$). Time between injury and repair is reported variably in the literature as an important predictor of outcome. In some reports, early repairs have better outcomes than later repairs.[14,20,21] In other studies, time to repair is not associated with better outcomes.[13,15] In addition, it seems that there is no difference with regard to the method of repair on the time to FSR; the coefficient was near statistically significant ($P = .06$) in univariate analyses but not in multivariate analyses ($P = .67$).

There are some biases with respect to this study that should be addressed to apply appropriate weight to the results. First, our eligibility criteria for the study stipulated that subjects have at least 1 postoperative follow-up visit. Therefore, there is the potential for selection bias, as our results can only be generalized to the population of subjects who present for at least 1 follow-up visit. The mean follow-up time was 223 days, with a range of 34 to 635 days (median follow-up, 203 days). Given the relatively wide range of follow-up times, and our cutoff of establishing FSR at 1 year postoperatively, there is the potential that we are missing some individuals who achieved FSR after 1 year, along with those who achieved FSR but chose not to follow-up. However, if we operate under the conservative assumption that those subjects who did not follow-up did not achieve FSR within 1 year of their operation, then our estimate for the proportion of subjects who achieve FSR at 1 year postoperatively is 52.9% (95% CI, 42.1% to 63.7%). Even under this conservative assumption, approximately 50% of the subjects who undergo surgery achieve functional neurosensory recovery at 1 year postoperatively. If we examine the proportion of subjects who achieve FSR at any point during the total follow-up time, we see that 88.3% of subjects who presented for follow-up achieved FSR (95% CI, 80.0% to 96.7%). Finally, if we use the more conservative estimate, and assume that those who did not follow-up never achieved FSR, then we find that 62.4% of subjects achieved FSR (95% CI, 51.8% to 72.9%). From these data, we can state that, among those subjects who have nerve repair and present for at least 1 follow-up visit, approximately 85% achieve FSR.

Table 3. MULTIVARIATE COX PROPORTIONAL HAZARDS MODEL

Variable	B	SE(B)	HR (95% CI)	*P* Value
Gender	−0.2	0.35	0.8 (0.4, 1.6)	.54
Age	0.001	0.02	1.0 (0.96, 1.0)	.96
Method of repair	0.2	0.39	1.2 (0.5, 2.6)	.67
Intraoperative evidence of neuroma formation	−0.9	0.36	0.4 (0.20, 0.85)	.02

Abbreviations: B, regression coefficient; 95% CI, 95% confidence interval; HR, hazard ratio; SE(B) standard error.

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The goal of future studies will be to examine the relationships between subject satisfaction measures and functional sensory recovery status, as well as examine risk factors for FSR in a larger cohort.

The majority of subjects undergoing trigeminal (V_3) nerve repair achieve functional sensory recovery within 1 year of surgical repair. Evidence of neuroma formation intraoperatively was associated with a decreased likelihood for achieving FSR within 1 year postoperatively.

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