

EVALUATION OF NEURO-SENSORY DISTURBANCES OF THE INFERIOR ALVEOLAR NERVE AFTER ORIF PROCEDURE IN MANDIBULAR FRACTURE: A SYSTEMATIC REVIEW

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ABSTRACT

Introduction: Mandibular fracture can cause displacement of bones and affect the nerve that can lead to neuro-sensory disturbances of inferior alveolar nerve. Disturbances can vary among patients due to severity of the fracture and invasion of the procedure. It is important to evaluate these disturbances to inform patients and improve treatment results.

Objectives: To evaluate neuro-sensory disturbances of inferior alveolar nerves after open reduction internal fixation (ORIF) procedure in mandibular fracture.

Material and methods: This review used PubMed, Science Direct, SpringerLink, SCOPUS, Medline, and Cochrane databases as bibliographic resources. Studies with matching key words were analysed and screened with PRISMA recommendations.

Results: A total of 133 studies were reviewed, but only twelve were included in this evaluation. 44.4% of mandibular cases treated with ORIF suffered from neuro-sensory disturbances. Cases were mostly evaluated objectively by clinical neuro-sensory testing (CNST) with Zuniga-Essick algorithm, and subjectively with questioner with visual analogue scale (VAS) scoring system. Post-operative evaluation was performed in 75% in the first week, and 58% of patients were continued to be evaluated in the sixth month.

Conclusions: Neuro-sensory disturbance is the main risk of ORIF procedure in mandibular fracture management. Subjective and objective evaluation is important to obtain information about disturbances due to difficulties for patients to express their feeling. Periodic evaluation should be performed to monitor disturbances recovery.

Key words: neuro-sensory disturbances, inferior alveolar nerves, ORIF procedure, mandibular fracture, evaluation.

J Stoma 2022; 75, 2: 130-137
DOI: https://doi.org/10.5114/jos.2022.117413

INTRODUCTION

Fracture of the mandible is the most frequent trauma in the facial region. The mandible trauma commonly caused by accidental activities, such as accidents, falling, sport injury, or violence [1, 2]. Mandibular fracture can occur in any part of the mandibular bone, either in symphysis, body of the mandible, angle, ramus, or condyle.

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Received: 27.01.2022 • **Accepted:** 04.04.2022 • **Published:** 22.06.2022

These fractures cause displacement of the bone and affect the nerves lying along the mandible [3].

Inferior alveolar nerve lays on the mandible that might be injured after trauma of the mandible or during surgery due to mandible fracture. The injury might occur when the nerve is compressed, stretched, or even sectioned by the bone fragment or surgical instrument [4, 5]. The injury can cause neuro-sensory disturbances in patients with mandible fracture. Disturbances may occur as impairment of sensory and sensation function. Patients often complain of discomfort around chin, lower lip, and gums of the mandible on the fractured side [6].

Management of mandible fracture with open reduction internal fixation (ORIF) can increase the risks of neuro-sensory disturbances of inferior alveolar nerve [2]. It could occur when the opening and proper access to the fracture is not good enough, because the nerve location reduces the visibility thru the fragment, over reduction and not adequate fixation. When the nerves are compressed by the fragment or surgical instrument, the nerve disturbances might occur temporarily or permanent. Prevalence of post-operative neuro-sensory disturbances in ORIF procedure ranges from 77.0% to 91.3%, with permanent disturbance prevalence around 0.9% to 45.0% [4].

The high prevalence and variation of neuro-sensory disturbances of inferior alveolar nerves in mandible fracture make evaluation of post-operative disturbances important. Evaluation of neuro-sensory disturbances would identify the magnitude and risk factor of disturbances, so that the disturbances can be avoided and well-managed [4, 6].

OBJECTIVES

This review evaluated neuro-sensory disturbances of the inferior alveolar nerves after ORIF procedure in the management of mandible fracture.

MATERIAL AND METHODS

To collect adequate data, we followed preferred reporting items for systematic reviews and meta-analysis (PRISMA) 2020 statement procedure.

LITERATURE SEARCH AND SELECTION CRITERIA

Literature was searched by identifying studies with terms "(Neuro-sensory Disturbances OR Neurologic Manifestation OR Neurologic Deficit) AND (Evaluation OR Assessment) AND (Inferior Alveolar Nerve OR Mandibular Nerve) AND (Mandibular Fracture OR Jaw Fracture) AND ORIF." Literature research was performed in PubMed, Science Direct, SpringerLink, SCOPUS, Medline, and Cochrane databases, with publication dates ranging from 2011-2021.

INCLUSION AND EXCLUSION CRITERIA

Inclusion criteria of this review followed PICOS criteria (population, intervention, comparison, outcome, study design). Population (P) were patients with mandibular fracture, with intervention (I) included patients treated with open reduction internal fixation (ORIF) procedure. For comparison (C), no criteria were applicable. Outcomes (O) were evaluations of patients, who suffered from neuro-sensory disturbances of inferior alveolar nerve after ORIF procedures. Study design (S) were study with design of randomized control trial (RCT), retrospective, prospective, or controlled clinical trials. Exclusion criteria for this review were reviews articles, non-English studies, and studies without mandibular fracture discussions.

OUTCOME MEASURES

Outcome measures were evaluation of post-operative follow-up patient's information.

DATA EXTRACTION

Data were extracted from each study based on author, year, study design, number of mandibular fracture cases, management of fracture, number of neuro-sensory disturbances of inferior alveolar nerves cases, evaluation methods, and time.

METHODOLOGICAL QUALITY ASSESSMENT

Newcastle-Ottawa scale (NOS) was applied to obtain methodological quality assessment of the studies. To analyse the studies bias, potential risk classification of bias obtained followed the pre-defined criteria: selection, comparability, and outcomes, as seen in Table 1.

RESULTS

Electronic literature research was performed in November 2021, and 133 studies were identified. Studies were reviewed from six databases, including PubMed, Science Direct, SpringerLink, SCOPUS, Medline, and Cochrane. Fifty-one studies were eliminated for duplication, forty-one studies were excluded by title screening, and 41 studies remained for abstract screening. After abstract reading, twenty-nine studies were excluded. From twenty-nine studies, seventeen studies were eliminated due to inappropriate discussion, and 12 studies were additionally eliminated because the outcome of interest was not included in the studies. Therefore, in total,

TABLE 1. Quality assessment of the studies

Author	Selection				Comparability	Outcome			Total	Risk of bias
	Representative of exposed cohort	Selection of external control	Ascertainment of exposure	Outcome of interest not present at the start of study	Control for treatment	Assessment of outcomes	Sufficient follow-up time	Adequacy of follow-up		
Tay *et al.* [7]	b	a	a	a	a	a	a	a	9	Low
Tabrizi *et al.* [8]	b	a	a	a	a	a	b	a	8	Low
Song *et al.* [9]	b	a	a	a	a	a	a	a	9	Low
B Shrinivas *et al.* [10]	b	a	a	a	a	a	b	a	8	Low
Shams *et al.* [11]	b	a	a	a	a	a	a	a	9	Low
Joachim *et al.* [12]	b	a	a	a	a	a	b	b	7	Low
Chandan *et al.* [13]	b	a	a	a	a	a	a	a	9	Low
Cillo *et al.* [14]	b	a	a	a	a	a	a	a	9	Low
Mayrink *et al.* [15]	b	a	a	a	a	a	a	a	9	Low
Anchilla *et al.* [16]	b	a	a	a	a	a	a	a	9	Low
Singh *et al.* [17]	b	a	a	a	a	a	a	a	9	Low
Zahid *et al.* [18]	b	a	a	a	a	a	b	a	8	Low

**Quality of included studies is assessed by Newcastle-Ottawa scale. A study can be awarded a maximum of one star for each numbered item within selection, comparability, and outcome categories. Total stars are summed to categorize the risk of bias. A study with score from 7-9 is categorized as 'low-risk of bias', 4-6 as 'high-risk of bias', and 0-3 as 'very high-risk of bias'.*

Selection:

1) Representative of exposed cohort: A) truly representative of the community; B) somewhat representative of the community*; C) selected groups of users; D) no description of the derivation of the cohort. 2) Selection of external control: A) drawn from the same community as the exposed cohort*; B) drawn from a different source; C) no description of the derivation of the non-exposed cohort. 3) Ascertainment of exposure: A) secure record*, B) structured interview*; C) written self-report; D) no description. 4) Outcome of interest not present at the start of study: A) yes*; B) no.*

Comparability:

1) Control for treatment: A) study controls for treatment; B) no.*

Outcomes:

1) Assessment of outcomes: A) independent blind assessment; B) tecord linkage*; C) self-report; D) no description. 2) Sufficient follow-up time: A) yes*; B) no. 3) Adequacy of follow-up: A) complete follow-up of all subjects accounted for*; B) follow-up rate > 50%*; C) follow-up rate < 50%; D) no statement.*

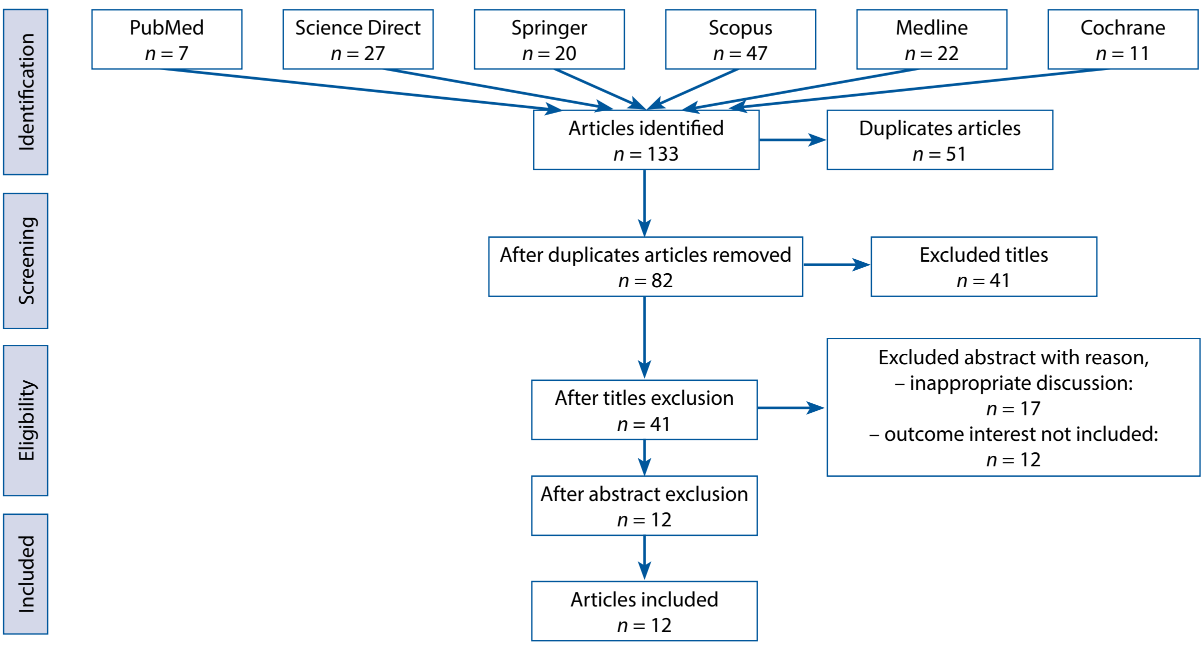

FIGURE 1. Flowchart of the systematic review

TABLE 2. Characteristics of the included studies

Authors	Study design	Mandible fracture cases	Fracture location	ORIF procedure	Neuro-sensory disturbances of inferior alveolar nerves	Evaluation method	Evaluation time (post-operative)	Recovery time	Total recovery
Tay *et al.* [7], 2015	Prospective cohort study	123	All location	92	53.8% (*n* = 66)	CNST	1st, 6th week; 3rd, 6th month; 1 year	12th month	51.0%
Tabrizi *et al.* [8], 2019	Prospective cohort study	45	Body of mandible	45	66.0% (*n* = 30)	TPD, VAS	6th month	6th month	33.0%
Song *et al.* [9], 2014	Retrospective study	293	Between lingula and symphysis	293	13.0% (*n* = 38)	CNST	1st, 4th, 7th day; 1st, 3rd, 6th, 12th, 18th, 24th, 30th, 36th month	4-36th week	87.5%
B. Shrinivas *et al.* [10], 2020	Prospective cohort study	29	Between lingula and mental foramen	29	58.6% (*n* = 17)	CNST	NM	NM	NM
Shams *et al.* [11], 2020	Cross-sectional study	56	Between lingula and symphysis	56	19.6% (*n* = 11)	TPD	1st, 4th, 8th, 12th, 16th week	16th week	45.0%
Joachim *et al.* [12], 2019	Prospective cohort study	297	All location	104	24.2% (*n* = 72)	TPD, VAS, electro-diagnostic test	NM	4th month	36.0%
Chandan *et al.* [13], 2021	Prospective cohort study	293	Angle, body of mandible, symphysis	270	57.0% (*n* = 167)	CNST	1st day; 1st week; 1st ,3rd, 6th month	6th month	28.1%
Cillo *et al.* [14], 2020	Prospective cohort study	26	Symphysis, body of mandible	26	0% (*n* = 0)	CNST, FSR	1st, 6th, 12th week	8th week	100.0%
Mayrink *et al.* [15], 2013	Prospective cohort study	27	All location	12	91.6% (*n* = 11)	CNST, questioner, VAS	1st week; 1st, 3rd, 6th month; 1st year	1st year	100.0%
Anchila *et al.* [16], 2018	Prospective cohort study	20	Unilateral body of mandibula	20	15.0% (*n* = 3)	CNST	1st, 4th, 12th week	4th week	100.0%
Singh *et al.* [17], 2021	Prospective cohort study	40	Between lingula and mental foramen	7	57.1% (*n* = 4)	CNST, questioner, VAS	1st, 3rd, 6th week; 3rd, 6th month	6th month	42.8%
Zahid *et al.* [18], 2018	RCT	60	Between lingula and symphysis	30	60.0% (*n* = 18)	TPD neurosensory, testing score	7th day	3rd month	70.0%

CNST – clinical neurosensory testing, VAS – visual analogue scale, FSR – functional sensory recovery, TPD – two-point discrimination, NM – not mention

twelve studies were included to in this review for analysis. PRISMA flowchart of this systematic review is presented in Figure 1.

From the included articles, there were nine prospective cohort studies, a retrospective study, a cross-sectional study, and an RCT. The total of mandible fracture cases were 1,309 cases, with 984 cases treated by ORIF procedure. Among the 984 ORIF-treated cases, 437 patients (44.4%) suffered from neuro-sensory disturbances of inferior alveolar nerve post-operatively. Neuro-sensory disturbances cases were evaluated with different assessment methods. Eight of the articles evaluated the disturbances with CNST and Zuniga-Essick scoring algorithm, two papers assessed the disturbances only with 2-point discrimination (TPD) method, and only one article evaluated the disturbances with TPD and electro-diagnostic test. For subjective examination, five articles assessed the neuro-sensory disturbances with a questioner and

TABLE 3. Percentage of neuro-sensory disturbances of inferior alveolar nerves cases within evaluation time

Author	Total cases	Evaluation times					Total recovered
		1st week	1st month	3rd month	6th month	1st year	
Tay *et al.* [7]	72.00% ($n = 66$)	100.00%	60.14%	37.80%	33.70%	18.90%	81.80%
Tabrizi *et al.* [8]	66.00% ($n = 30$)	66.00%	Not evaluated	Not evaluated	29.00%	Not evaluated	56.60%
Song *et al.* [9]	13.00% ($n = 38$)	Not evaluated	Not evaluated	Not evaluated	52.60%	10.50%	89.50%
B. Shrinivas *et al.* [10]	58.62% ($n = 17$)	58.60%	Not evaluated	Not evaluated	Not evaluated	Not evaluated	NM
Shams *et al.* [11]	19.60% ($n = 11$)	90.90%	72.70%	54.50%	Not evaluated	Not evaluated	45.00%
Joachim *et al.* [12]	24.03% ($n = 25$)	Not evaluated	Not evaluated	Not evaluated	64.00%	Not evaluated	36.00%
Chandan *et al.* [13]	56.30% ($n = 167$)	98.00%	78.44%	58.60%	41.90%	Not evaluated	58.08%
Cillo *et al.* [14]	92.30% ($n = 24$)	92.00%	50.00%	0%	Not evaluated	Not evaluated	100.00%
Mayrink *et al.* [15]	100.00% ($n = 12$)	100.00%	Not evaluated	Not evaluated	Not evaluated	Not evaluated	NM
Anchila *et al.* [16]	15.00% ($n = 3$)	100.00%	0%	Not evaluated	Not evaluated	Not evaluated	100.00%
Singh *et al.* [17]	57.10% ($n = 4$)	Not evaluated	Not evaluated	Not evaluated	57.00%	Not evaluated	42.80%
Zahid *et al.* [18]	60.00% ($n = 18$)	100.00%	Not evaluated	30.00%	Not evaluated	Not evaluated	70.00%

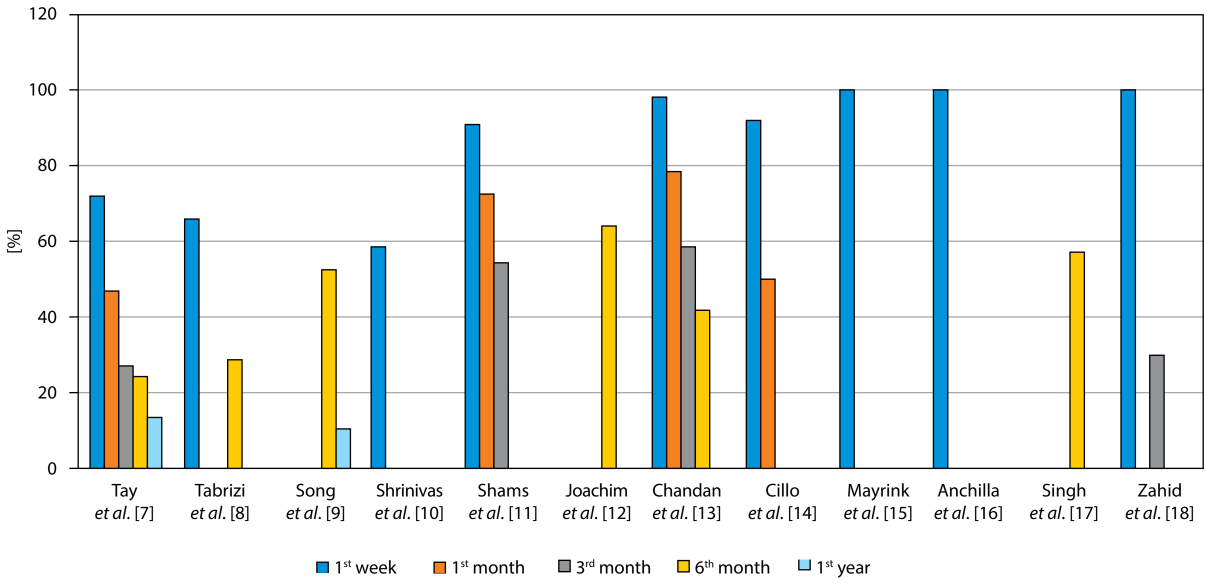

FIGURE 2. Percentage of neuro-sensory disturbances of inferior alveolar nerves cases within evaluation times

VAS system. The evaluation mostly took place in the first week, first month, third month, and sixth months after ORIF procedure. The average number of neuro-sensory disturbances cases recovered were 57.6%, with recovery time ranging from 3 weeks to 12 months.

DISCUSSION

Mandibular fracture is the most common trauma occurring in the facial region. The cause of mandibular fracture varies from falling, abusive trauma, traffic accident, and sport accident. The most common causes of fracture included falling and traffic accidents [2]. Mandibular fracture can occur in any location of the mandibular bone, mostly located in the body of mandible, angle, and condyles [1]. Patients with mandibular fracture might experience pain in their jaw sensory function [19].

Mandibular fracture might affect the mandibular nerve, including inferior alveolar nerve, and cause nerve disturbances, especially when trauma occurs around bearing area of the nerve [2, 19]. The inferior alveolar nerve is a nerve that enter the mandible from the mandible foramen through the canal of mandible and the branch to the mental nerve in the mental foramen [1, 12]. When the inferior alveolar nerve experience disturbances, patient commonly suffer from anaesthesia, paraesthesia, or dysesthesia. The disturbances can be experienced as temporary or permanent loss of sensory. Nerve disturbances of mandibular fracture might occur either pre-operatively or post-operatively [6, 13].

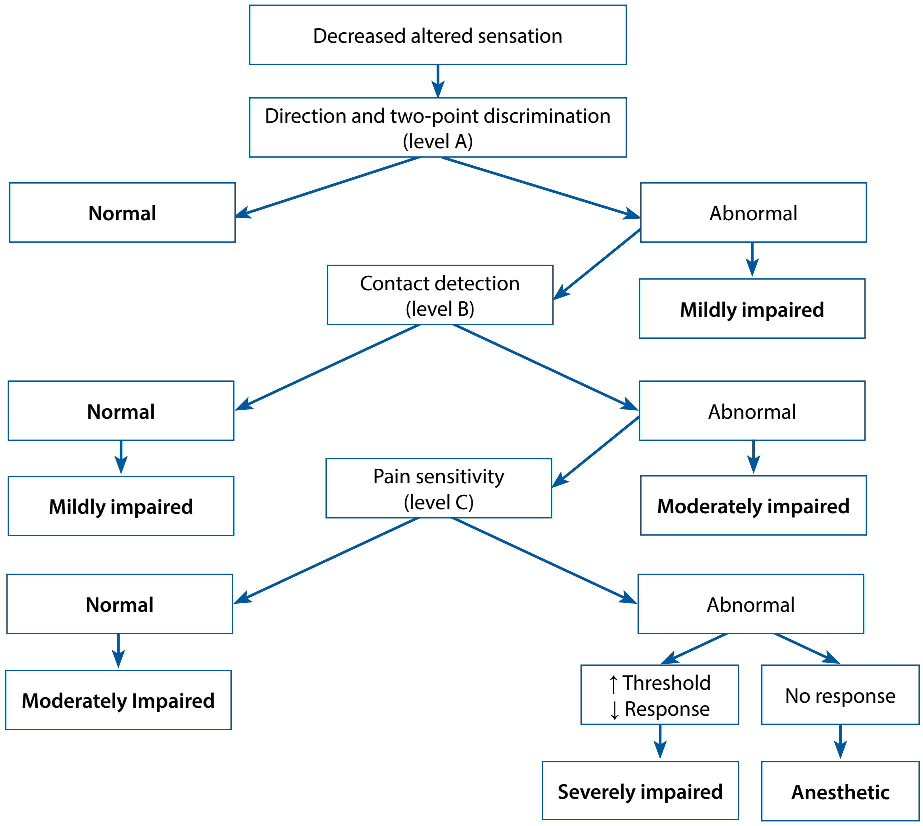

Figure 3. Zuniga-Essick grading algorithm

Post-operative nerve disturbances occur according to management of the fracture. Mandibular fracture could be managed by open reduction internal fixation (ORIF), closed reduction (CR), inter-maxillary fixation (IMF), and conservative approach. Neuro-sensory disturbances have the highest prevalence in patients treated with ORIF [12, 13, 18]. It is reviewed that 46% of cases in this study experienced disturbances on inferior alveolar nerves post-operatively after ORIF procedure.

The nerve can get trauma once it gets compressed, dissected, or stretched by surgical instrument or bone fragment [4, 5]. Neuro-sensory disturbances might vary in area with sensory deficit, magnitude of the sensory deficit, and character of the sensory deficit, due to severity of the nerve trauma [6]. Patients may express their complaints for having numbness around the jaw. This situation would reduce their compliance for the treatment and affect their activities [6, 12].

To obtain the nerve injury information, evaluation of neuro-sensory function, especially post-operative, should be performed [4, 6, 19]. Evaluation and scoring of neuro-sensory traumas are mostly done by clinical neuro-sensory testing methods with scoring algorithm of Zuniga and Essick. In this review, eight articles evaluated the nerve disturbances with clinical neuro-sensory testing methods and scored the disturbance with Zuniga and Essick algorithm system. Medical research council or MRC scoring system reported by Cillo *et al.* were applied, which evaluated the functional sensory recovery. Medical research council scoring system is often used to evaluate the tri-geminal nerve injury [17]. Only one article assessed the nerve disturbances with electrodiagnostic test. For subjective evaluation, questioner with VAS scoring system was applied in two articles.

Clinical neuro-sensory testing to determine the grade of impairment is evaluated within three levels. Level A consists of direct sense and 2-point discrimination. Level B consist of contact detection test by a tensile light touch with monofilaments, while level C comprise pain sensation test by pin-prick test or thermal detection [6, 7, 13]. The neuro-sensory test can be performed on the affected side, such as lower lip, chin, or mental nerve area. The control side would be in unaffected side, which include upper lip or forehead. Clinical neuro-sensory testing methods divide the affected area into four area, including right lower lip, left lower lip, right chin, and left chin. The lower lip would describe the labial branch of inferior alveolar nerves, and the chin would define the mental branch of inferior alveolar nerves [5, 12]. In level A, 2-point discrimination is performed with a calliper with millimetre ruler. The calliper begins closed and open progressively in 0.5 mm incremental. Patient's eyes close, and they need to discriminate two points where the calliper lands [7, 13]. This test is designed to identify the trauma in large, myelinated slow adapting A alpha sensory nerve [17]. The brush direction stroke uses monofilament, which would stroke left-right and right-left. Patients have to determine the direction of monofilament. When the patient is not able to discriminate the points and cannot determine the stroke direction, it is classified as A or abnormal [13]. Then, the evaluation continues to level B. Patient undergoes static light touch test to identify the large myelinated, quickly adapting sensory nerve fibres [17]. In the static light touch, monofilament is touch until bend. In level C, pinprick and thermal test are performed. In the pinprick test, a gauge needle is used to puncture the area and to draw a dot of blood at the site [7, 13]. Last, in the thermal test, patient is given two cottons: the first one saturated with ethyl chloride and one for placebo. Patients have to response which one is cold, and which one is cool [6, 13]. This test was designated to identify the small myelinated, unmyelinated, A delta, and C sensory nerve fibres [17].

Zuniga and Essick grading algorithm classify patient's response within three level of impairment, as seen on Figures 2 and 3. In mid impairment is the patient with abnormal result in level A test, but normal test in B level. Moderate impairment consists of patient with abnormal result in level A and B, with normal test in level C test. Patient with abnormal result in level C test is classified as severely impaired [6].

A short questioner was given to assess patient's neurosensory function subjectively. The questioner provided description about patient's altered sensation and how they affect their activities. Patients mostly complain of discomfort during eating [6, 12, 15, 17]. Subjective evaluation often gets biased because patients found it difficult to express their feeling. Thus, it is important to perform objective neuro-sensory test in order to confirm the neuro-sensory disturbances [6, 12].

Evaluation time was mostly performed in the first week (75.0%), first month (41.6%), third month (41.6%), sixth month (50.0%), and first year (16.6%) after ORIF procedure (Figure 1 and Table 4) [2]. Most of the patients experienced the peak of post-operative neuro-sensory disturbances during first week. Then, recovered gradually from neuro-sensory disturbances on bearing side 1 month to 12 months from ORIF procedure due to severity of nerve injury during surgery [7]. As it can be seen from the table, at the first, third, and sixth month of evaluation, 70-50% of the cases recovered from sensory disturbances. Only two articles showed a 100% recovered cases in 1-3 month post-operative due to mild sensory disturbances of the cases. At the first year of evaluation, it was found that more than 80% of cases had recovered from the remaining neuro-sensory disturbances cases either in one year or in permanent disturbances cases. Nerves recover swiftly only in the first 3 months, and after that the time of recovery slows down. Nerve can take months to recover from injury, which depends on severity of the injury. As a result, only 56.6% of cases recovered from neuro-sensory disturbances, possibly due to insufficient evaluation time. Sufficient periodic evaluation is important to monitor the recovery of neuro-sensory disturbances [4].

CONCLUSIONS

Neuro-sensory disturbance is the main risk of ORIF procedure in mandibular fracture management. Subjective and objective evaluations of the neuro-sensory disturbances are important to obtain information about disturbances due to difficulties for patients to express their feeling. Sufficient periodic evaluation time should be given to monitor the disturbances recovery.

ACKNOWLEDGEMENTS

The authors would like to thank the Head of Study Program of Oral and Maxillofacial Surgery Department, Faculty of Dentistry, Universitas Indonesia for supporting this study.

CONFLICT OF INTEREST

The authors declare no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

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