Review Article

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Neurosensory Disturbance of the Inferior Alveolar Nerve Following Bilateral Sagittal Split Osteotomy: An Updated Systematic Review

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ABSTRACT

Background: The evaluation of the neurosensory disturbance (NSD) of the inferior alveolar nerve (IAN) following bilateral sagittal split osteotomy (BSSO) can be performed by subjective or objective methods. The aim of this systematic review was to of show the incidence of inferior alveolar neurosensory disturbance following bilateral sagittal split osteotomy and compare the frequency of recovery of the sensory function using subjective and objective methods. Searches were conducted using PubMed, MEDLINE, Science direct and scholar google. 12 studies were included in this study. It was seen in this systematic review that the frequency of nerve impairment evaluated by subjective methods was higher than that indicated by studies adopting objective methods at each time of follow-up after 3 months. In particular at 3 months postoperatively the frequency obtained using the objective methods was 31.56% while that obtained with subjective methods was 34.92%. At 1 year follow-up a frequency of sensory impairment of 8.01% was obtained using objective methods and a frequency of 11% when subjective methods were used. On the basis of the results, objective methods can be said to provide the most sensitive diagnostic test in the subsequent post-operative follow-ups.

Keywords: Neurosensory disturbance, Inferior Alveolar Nerve, Sagittal Split Osteotomy.

INTRODUCTION

Biological variation is a natural consequence of sexually reproducing organisms. Such variation has allowed populations to genetically adapt to changing environments.[1] Dentofacial deformities can affect physical orofacial function in several ways like impaired mastication, lip incompetence, speech, airway, irregular teeth, etc. Mastication can be impaired especially in severe cases affecting physical orofacial function in several ways, including digestion and general nutritional health. In individuals with excessive vertical growth of the maxilla lip incompetence is seen resulting in mouth breathing, which eliminates the physiologic effect of the nose on breathing. Normal temporomandibular function is also affected by several types of dentofacial deformities.

Orthognathic surgery is a means to correct such dentofacial deformities where orthodontic treatment limits itself. For treating mandibular deformities the bilateral sagittal split osteotomy (BSSO) is a common surgery. The mandibular branch of the trigeminal nerve, is often affected

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during this procedure due to compression or stretching.

Neurosensory disturbance (NSD) of the V3 (mandibular branch of trigeminal nerve) has been suggested as the most common complication linked to this procedure. The incidence of NSD after BSSO reported in the literature was between 9% and 85%.[2] The incidence of transection of V3 is reported between 2% and 3.5% and the incidence of some form of long-term neurologic deficit is reported in 10% to 20% of patients, symptomatic or not.[3]

Clinical symptoms of nerve damage vary from hypoesthesia to unpleasant altered sensations and pain in the orofacial region, which usually interfere negatively with daily activities. Persistent pain, neuropathic pain, altered sensation such as allodynia, pain and discomfort with occlusion can occur. Most instances of neurosensory disturbances are reversible, but permanent disturbance may also occur.

The evaluation of neurosensory disturbance along the distribution of the inferior alveolar nerve (chin and lower lip) can be performed by either purely subjective (questionnaires)[4] or objective (static light touch [LT], pin prick test [PPT], contact detection[CD], brush stroke directional discrimination[BSD], 2-point discrimination [TPD], sharp blunt discrimination [BD], thermal discrimination [TD], pain and thermal sensitivity test device [PATH], trigeminal somatosensory evoked potentials[TSEP], blink reflex [BR], electromyographic recording of masseter reflex [ER MR] and sensory nerve action potential [SNAP]) methods.

MATERIALS AND METHODS

A thorough search for articles and the relevant literature linking BSSO with neurological complications and objective testing methods was performed online and manually. Searches were conducted employing PubMed (https://www.ncbi.nlm.nih.gov), MEDLINE (http://search.medscape.com/medlinesearch), Science direct (https://www.sciencedirect.com), and Scholar google (https://scholar.google.co.in/). The search terms used were: orthognathic surgery neurological complications, neurosensory disturbance after orthognathic surgery, bilateral sagittal split osteotomy, inferior alveolar neurosensory disturbance, orthodontic sensory nerve action potentials, and mental nerve blink reflex. No limits were specified. The "related articles" tool was used to improve the PubMed searches and references of included studies were checked.

Selected studies were included on the basis of the following criteria: original studies based on humans (randomized and nonrandomized clinical trials, cohort studies, case-control studies, and case reports), publication date: 2009 to 2020, the performance of bilateral sagittal split osteotomy as a type of orthognathic surgery, the use of one of the objective methods for the evaluation of sensory impairment, the length of follow-up at least 3 months. For this review, we also chose studies in which both objective and subjective tests were performed. Nevertheless, this was not one of the criteria of inclusion. The most common reason for exclusion of a study was the use of subjective methods of evaluation only since subjective methods are purely based on patient's perception and lead to evaluation bias. The studies with length of follow- up of less than 3 months were also excluded as any nerve injury as mild as neuopraxia due to compression needs atleast 3 months to recover and resume function.

The quality assessment of the study protocol was made, the data analysis and presentation of the articles according to the fixed criteria of inclusion. The title and abstract of article resulting from the different searches were examined separately and thoroughly. The full-text version of each article was obtained and the Materials and Methods and the Results sections were read and scored if considered article was relevant, it was included in the study.

The main outcome considered was the frequency of sensory disturbance of the IAN assessed using subjective and objective methods of evaluation at various intervals.

RESULTS

The PubMed, MEDLINE, Science direct and scholar google search identified 256 studies on this subject. From the 256 studies initially obtained, 40 were in languages other than English. Of the 216 remaining articles 70 articles with full-text were obtained, of which 22 were published before the year 2009. Of the 48 full-text articles, 36 were not relevant and were excluded and 12 were considered eligible for inclusion in the review. In conclusion, 12 studies were included in this review (Fig 1). The details of the included studies are summarized in Table 1.

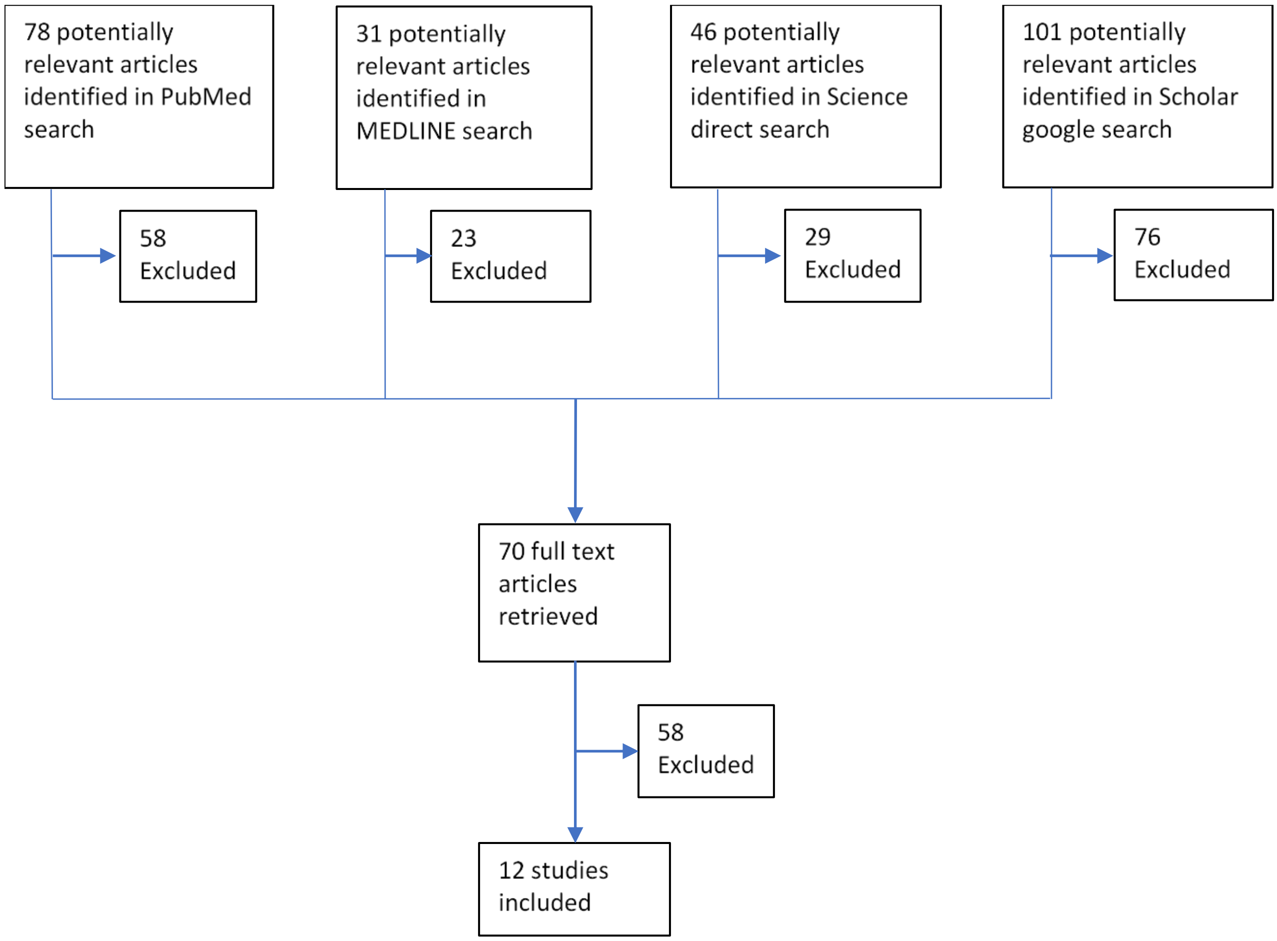

Fig 1: Flow diagram of the selection process of studies for systematic review on neurosensory disturbances of the inferior alveolar nerve after bilateral sagittal split ramus osteotomy.

Table 1: Abbreviations: BD, Blunt discrimination; BSD, Brush Stroke Discrimination; LT, static Light Touch; PPT, Pin Prick Test; SW PAM, Semme-Weinstein Presure Anesthesio Meter; TD, Temperature Discrimination; TPD, Two Point Discrimination; VAS, Visual Analogue Scale

S. N.	Authors, Year of Publication	Partici pant	Ma le	Fem ale	Age Range years	Retro-gnathia	Pro-gnathia	Other	Objective Method used	Control	Legnth of follow up
1	Wijbenga et al, 2009[5]	45	10	35	15-59	~	~	~	SW PAM, TD	VAS	2 years
2	Yoshioka et al, 2011[6]	35	12	23	18-49	~	35	~	LT, TPD, BSD, TD	VAS	3 months
3	Mensink et al, 2012[7]	172	57	115	14-59	166	6	Le Fort I, Genio-plasty	LT, PPT	Subjective Questioning	1 year
4	Yoshioka et al, 2012[8]	35	12	23	18-49	~	35	~	LT, TPD, BSD, TD	VAS	1 year
5	Kuroyanagi et al,	50	18	32	17-34	2	48	~	SW PAM	None	1 year

	2013[9]										
6	Bruckmoser et al, 2013[10]	128	44	84	14-51	~	~	Le Fort I, Genio-plasty	LT, BSD, TPD, BD, SW PAM	Subjective Questioning	1 year
7	Hasegawa et al, 2015[11]	76	28	48	16-54	~	76	~	SW PAM	None	6 months
8	Roychoudhury et al, 2015[12]	15	8	7	22.3 +/- 3	1	14	Bi-Jaw surgery	LT, PPT	VAS	1 year
9	Reza Shahakbari et al, 2015[13]	41	14	27	24.12 +/- 5.42	41	~	~	TPD	None	6 months
10	Verweij et al, 2016[14]	263	104	159	19-30	226	37	Le Fort I	LT	Subjective Questioning	1 year
11	Gennaro et al, 2017[15]	154	~	~	21-35	~	~	Le Fort I	LT, PPT, BSD, TPD, BD, TD	VAS	>6 Months
12	Sadakah et al, 2018[16]	14	5	9	30	~	~	~	TPD	Subjective Questioning	1 year

POST-OPERATIVE OBJECTIVE TESTS:

The amount of impairment was assessed in various studies at different times of follow up. On the seventh post-operative day 7 studies showed neurosensory impairment in 457 of 1104 nerves (41.39%); at 2 weeks post-operatively, 1 study showed 19 nerves damaged out of 28 (67.85%). The least reliable values were at 1st and 2nd month post-operatively, at 1 month post-operatively 2 studies reported neurosensory impairment in 81 nerves out of 204 nerves considered (39.70%); at 2 months post-operatively 1 study showed neurosensory impairment in 62 nerves out of 176 nerves considered (35.22%). At 3 months post-operatively, 5 studies reported 162 of 510 (31.56%) IAN presenting sensory impairment. At 6 months postoperatively, 7 studies reported abnormal responses in 158 of 866 (18.24%) of IAN studied, and in 9 studies, 128 of 1598 IAN (8.01%) a permanent sensory disturbance was found after 1 year, the longest period of follow-up evaluated. The results of the objective tests in postoperative evaluations are reported in Table 2.

POST-OPERATIVE SUBJECTIVE TESTS:

Nine studies were considered. On the seventh day postoperatively the frequency of neurosensory disturbance was 39.73%, where 5 studies were considered. After 2 weeks, only 1 study was considered and reported neurosensory disturbances of 60.7% with 28 IAN considered and 17 damaged. At 1 month follow-up 1 study reported 53.57% damaged IAN; No studies evaluated neurosensory impairment at 2 months. At 3 months the frequency was 34.92%. The more reliable values were at 6 months and 1 year follow-up. At 6 months 4 studies showed a 23% value for nerve damage, with a total of 508 nerves considered and 117 damaged, and, at 1 year follow-up 127 IAN presented with neurosensory disturbances from a total of 1154 considered, at a frequency of 11%. Results of the subjective tests at different times of follow-up are reported in Table 3, in order to compare them with the values obtained with objective methods.

Table 2: Abbreviations: L, left; n, number of nerves examined; R, right; R L, right and left sides together. *Number of abnormal responses are shown in parentheses.

S. N.	Source	Objective Method Used	1 Week	2 Weeks	1 Month	2 Months	3 Months	6 Months	1 Year or more
1	Wijbenga et al, 2009[5]	SW PAM, TD	R+L, n=90(61)	~	~	~	~	~	R+L, =90(7)
2	Yoshioka et al, 2011[6]	LT, TPD, BSD, TD	~	~	~	~	R+L, n=70(28	~	~

							)		
3	Mensink et al, 2012[7]	LT, PPD	~	~	~	~	~	~	R, n= 172(11); L, n=172(9)
4	Yoshioka et al, 2012[8]	LT, TPD, BSD, TD	~	~	~	~	~	R+L, n=70(22)	R+L, n=70(12)
5	Kuroyanagi et al, 2013[9]	SW PAM	R+L, n=100(33)	~	~	~	~	R+L,n=100(11)	R+L, n=100(2)
6	Bruckmoser et al, 2013[10]	LT, BSD, TPD, BD, SW PAM	~	~	~	~	~	R, n=128(25); L, n=128(27)	R, n= 128(18); L, n=128(27)
7	Hasegawa et al, 2015[11]	SW PAM	R+L, 176(95)	~	R+L, n=176(66)	R+L, n=176(62)	R+L, n=176(40)	R+L, n=176(26)	~
8	Roychoudhury et al, 2015[12]	LT, PPD	R+L, 30(20)	~	~	~	~	~	R+L, n=30(2)
9	Reza Shahakbari et al, 2015[13]	TPD	~	~	~	~	R+L, n=82(35)	R+L, n=82(14)	~
10	Verweij et al, 2016[14]	LT	R+L, n=526(173)	~	~	~	~	~	R+L, n=526(27)
11	Gennaro et al, 2017[15]	LT, PPT, BSD, TPD, BD, TD	R+L, n=154(55)	~	~	~	R+L, n=154(49)	R+L, n=154(26)	R+L, n=154(12)
12	Sadakah et al, 2018[16]	TPD	R+L, n=28(20)	R+L, n=28(19)	R+L, n=28(15)	~	R+L, n=28(9)	R+L, n=28(7)	R+L, n=28(1)

Table 3: Abbreviations: L, left; n, number of nerves examined; R, right; R L, right and left sides together. *Number of abnormal responses are shown in parentheses.

S. N.	Source	Subjective Method Used	1 Week	2 Weeks	1 Month	2 Months	3 Months	6 Months	1 Year or more
1	Wijbenga et al, 2009[5]	VAS	R+L, n=90(61)	~	~	~	~	~	R+L, n=90(27)
2	Yoshioka et al, 2011[6]	VAS	~	~	~	~	R+L, n=70(28)	~	~
3	Mensink et al, 2012[7]	Subjective Questioning	~	~	~	~	~	~	~
4	Yoshioka et al, 2012[8]	VAS	~	~	~	~	~	R+L, n=70(22)	R+L, n=70(12)
5	Kuroyanagi et al, 2013[9]	None	~	~	~	~	~	~	~
6	Bruckmoser et al, 2013[10]	Subjective Questioning	~	~	~	~	~	R+L, n=256(61)	R+L, n=256(44)
7	Hasegawa et al, 2015[11]	None	~	~	~	~	~	~	~
8	Roychoudhury et al, 2015[12]	VAS	R+L, n=30(22)	~	~	~	~	~	R+L, n=30(4)
9	Reza Shahakbari et al, 2015[13]	None	~	~	~	~	~	~	~
10	Verweij et al, 2016[14]	Subjective Questioning	R+L, n=526(173)	~	~	~	~	~	R+L, n=526(27)
11	Gennaro et al, 2017[15]	VAS	R+L, n=154(55)	~	~	~	R+L, n=154(49)	R+L, n=154(26)	R+L, n=154(12)
12	Sadakah et al, 2018[16]	Subjective Questioning	R+L, n=28(18)	R+L, n=28(17)	R+L, n=28(15)	~	R+L, n=28(11)	R+L, n=28(8)	R+L, n=28(1)

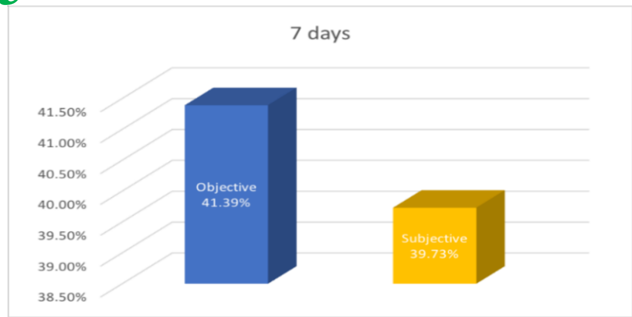

Chart 1: At 7 days Objective tests showed more NSD as compared to Subjective tests by 1.66%

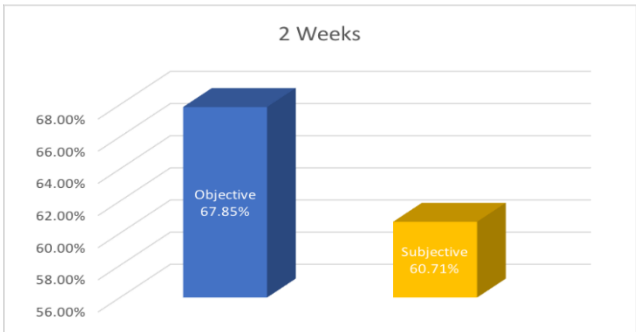

Chart 2: At 2 weeks Objective tests showed significantly more NSD as compared to Subjective tests by 7.14%

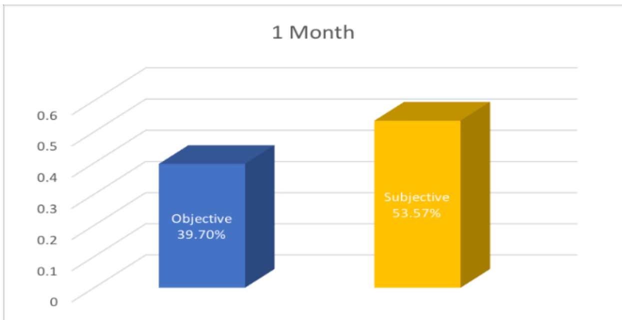

Chart 3: At 1 month Objective tests showed lower NSD as compared to Subjective tests by 13.87 %

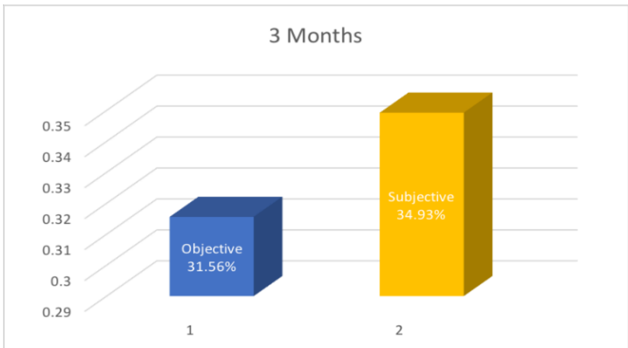

Chart 4: At 3 months Objective tests showed lower NSD as compared to Subjective tests by 3.37%

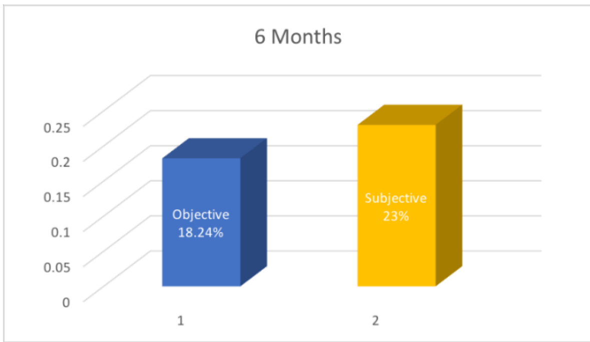

Chart 5: At 6 months Objective tests showed lower NSD as compared to Subjective tests by 4.76%

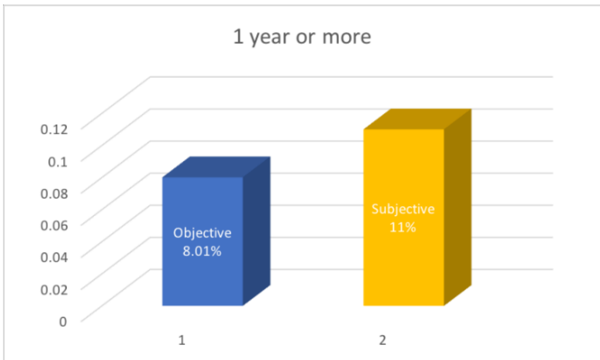

Chart 6: At 1 year Objective tests showed lower NSD as compared to Subjective tests by 3%

DISCUSSION

Various methods have been adopted to test the function of the IAN after nerve lesion, from patient questioning[17,18,29,20] to sophisticated neurosensory testing. The subjective reports of perceived sensory changes after BSSO are initially overestimated, but may be underestimated as the time interval increases. Over time, it is possible that patients become accustomed or adapt to what they consider as "normal" and therefore patient report of what they call "noramal" will vary between and among patients, observers, studies and authors.

Some authors[20] have shown that patients' subjective evaluations gave a much higher incidence of nerve dysfunction than objective or semi-objective records while other[21] showed the opposite, however, good correlation between objective and subjective evaluations have also been reported. Such variability in observations may reflect a situation where our objective measurements – no matter how sophisticated they may be – cannot discover minor changes in the sensitivity of facial skin.

It has also been reported with respect to the intraoperative nerve encounter during the split, there was seemingly significant correlation between degree of nerve manipulation and degree of nerve dysfunction was blurred by the age distribution of the extreme groups.[2]

Fridrich et al, in 1995,[21] studied neurosensory disturbance(NSD) following BSSO with a follow up period of upto 2 years post-operatively using various objective as well as subjective methods. They reported that function of the larger myelinated nerve fibers, as measured by TPD, LT, and BSD for A-alpha, recovered slower and to a lesser degree at all time intervals up to 2 years when compared with the smaller myelinated and unmyelinated nerve fibers. The PPT test was used to select for small myelinated fibers (A-delta), and TD discrimination was selected for small myelinated and unmyelinated, A-delta and C sensory nerve fibers.[22,23,24,25,26,27]

This correlates with what is known: receptors that propagate stimuli via smaller, nonmyelinated nerve fibers (C-fibers) and smaller myelinated nerve fibers (A-delta) regain sensory function sooner than receptors that relay sensations via larger myelinated fibers (A-alpha). Recovery after 6 months was incomplete, and neurosensory improvement was noted through the l- and 2-year intervals, although it was not statistically significant. They also said that while TSEP was the most accurate methods LT, BSD, TPD, PPT and TD were commonly used, inexpensive and accepted.

Jääskeläinen et al, in 1995,[28] were the first to introduce an intraoperative method to diagnose a nerve injury during BSSO by recording the sensory nerve action potential(SNAP) of the IAN, the method of which has been described in previous chapters. Post-operatively the clinical testing was done with the help of mental nerve blink reflex (MNBR) at 2 weeks and 3 months after the surgery. These are purely objective methods which do not depend on the patients perception of NSD, unlike other clinical tests, but it is not always to conduct such tests in all surgical/clinical settings which is a major drawback.

The sensory diagnostic tests are conducted to assess and document whether a neurosensory disturbance exists or not, to quantify it, to monitor its recovery, to determine whether micro-reconstructive surgery is indicated, and to monitor its recovery following the micro-reconstructive surgery.

At present, clinical sensory tests are most widely used for diagnosis of sensory disturbances of the IAN. They can be divided into 2 basic categories, mechanoceptive and nociceptive, based upon the specific receptors stimulated through cutaneous contact. Mechanoceptive tests include static light touch [LT], contact detection[CD], brush stroke directional discrimination[BSD]and 2-point discrimination [TPD]. Pin prick test [PPT], sharp blunt discrimination [BD] and thermal discrimination [TD] are nociceptive tests. Specific categories of receptors and axons are assessed through each test.

There are many published studies of sensory disturbances that make use of these methods to provide a diagnosis of nerve injury. Objective sensory tests are pain and thermal sensitivity test device [PATH], trigeminal somatosensory evoked potentials [TSEP], blink reflex [BR], electromyographic recording of masseter reflex [ER MR] and sensory nerve action potential [SNAP].

This systematic review has shown that the frequency of nerve impairment evaluated using subjective methods was similar or lower during the first month of follow up and higher later than that indicated by the studies adopting objective methods at each time of follow-up.

On the seventh postoperative day the frequency obtained with the objective methods was 41.3% while that obtained with subjective methods was 39.73%. At 2 weeks follow-up the value obtained with the objective methods was 67.85%, while that obtained with subjective methods was 60.7%. After 1 month the frequency obtained with objective methods decreased to 39.7% while the studies using subjective methods obtained a frequency of 53.57%. At 2 months follow-up the value of nerve impairment was 35.22% for the objective methods and no study was included for subjective methods.

After 3 months the frequency obtained with the objective methods was 31.56% while that obtained with subjective methods was 34.92%. At 6 months postoperatively the value of neurosensory disturbance with objective methods was 18.24%, while that with subjective methods was 23%. The last value taken into consideration was at 1 year follow-up; this showing a frequency of sensory impairment of 8.01% with objective methods and a value of 11% when subjective methods were used.

This systematic review has shown various difficulties in collecting information about patients. The variability (or complete absence) of definitions of results at several points of follow-up was the main recurring problem in obtaining studies to be included in this review. The small number of samples and the heterogeneity of the methods used for testing sensory changes were the other notable limitations.

Many studies showed a combination of 1 to 3 objective tests that could reliably predict neurosensory disturbance. The huge lack of these studies is the waste of a large part of the data, because only the frequencies are reported in the discussion. These studies could not be included in this systematic review, although the methods of investigations were of value. The test result can provide an index of the severity of nerve injury, and changes recorded over time provide significant information with respect to recovery.

CONCLUSION

Through the above discussion, we can conclude that the objective testing methods showed almost similar results initially but were superior in diagnosing NSD after 3 months of surgery as compared to subjective methods. In general, the efficacy of diagnostic tests is defined as their ability to indicate the presence or absence of disease. An ideal diagnostic sensory test would always be positive in the presence of nerve injury and negative in the absence of injury.

This study should be seen as a starting point for detailed patient evaluation with standardization, longer follow-up periods and forming a protocol to evaluate neurosensory disturbance following bilateral sagittal split osteotomy.

CONFLICTS OF INTEREST

The authors declare they have no potential conflict of interests regarding this article.

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