Reliability of TSEP as an Objective Method in Assessment of IAN Neurosensory Function

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Abstract :

Purpose: The aim of this study is to evaluate the reliability of trigeminal somatosensory evoked potential **(TSEP)** as an objective method for assessment of the neurosensory function of the inferior alveolar nerve **(IAN)** following bilateral sagittal split osteotomy **(BSSO)**.

Patients and Methods: The subjects consisted of 12 patients (24 sides) with mandibular retrognathism and prognathism, who underwent mandibular bilateral sagittal split osteotomies using bicortical screws for fixation. Inferior alveolar nerve (IAN) hypoesthesia at the region of the lower lip was assessed bilaterally by the TSEP method. An electroencephalograph recording system (Schnauzer – Myos unit, clinical neurophysiology unit, faculty of medicine, Cairo, Egypt) was used to analyze the potentials. All patients were evaluated with three traditional subjective methods including (light touch **LT**, brush stroke discrimination **BSD** and 2 points discrimination **2P**). Each patient was evaluated pre-operatively and then postoperatively at 2, 8 and 24 weeks.

Results: Comparing pre-operative TSEPs records with 2, 8 and 24 weeks postoperatively showed that there was no statistically significant change in N, P peak latencies and N-P amplitude through all periods. Comparing the pre-operative records of the 2P method with 2, 8 and 24 weeks post-operatively showed statistically significant difference through all intervals. While LT and BSD results showed negative results at 2 weeks post-operatively while at 24 weeks post-operatively LT results showed that 75% of IANs regain normal function. 24 weeks post-operative results of BSD method showed that 79.1% of IANs regain normal function

Conclusion: TSEP could be used after BSSO to predict recovery of IAN function. This could be used to overcome waiting long time to make sure of the neurosensory recovery using subjective clinical tests. TSEP represents an objective, sensitive, reliable and non invasive method of testing neurosensory function. [Sameh A. Seif, Khaled A. Elhayes and Ann A.AbdelKADER. **Reliability of TSEP as an ObjectiveMethod in Assessment of IAN NeurosensoryFunction.** Journal of American Science 2011;7(11):330-338]. (ISSN: 1545-1003).http://www.americanscience.org

Key words: TSEP, IAN, Neurosensory Function

1.Introduction:

Orthognathic surgery refers to surgical procedures designed to correct jaw deformities, including: prognathism, retrognathism and asymmetry, *Westermark et al.,(1999); Lisa and Korczak* (2001); *Yamashita et al.,(2007); Yang et al.,(2007).* There are many types of osteotomies used in mandibular orthognathic surgery. Bilateral sagittal split osteotomy is the most common surgical procedure used to correct mandibular deformities, *Hibi and Ueda (1996).*

The BSSO technique was first described by Trauner and Obwegeser *(1957)* with many modifications of the technique having been introduced with the aim of reducing morbidity and maximizing the stability of the procedure. It is generally recognized that the vertical buccal cut of the Obwegeser–Dal Pont method is positioned more anteriorly than in the Obwegeser method. In an earlier study, it was proven that the recovery period of lower lip hypoesthesia after BSSO was longer after the Obwegeser–Dal Pont method than after the Obwegeser method, *Hashiba et al.,(2007); Takazakura et al.,(2007).*

Corrective jaw surgery posses many risks due to complications, *Kim and Park (2007),* although *Van de Perre et al., (1996)* reported that fatal complications of corrective jaw surgeries are rare. Postoperative neurosensory disturbance of the lower lip and chin is a major concern in all mandibular osteotomies, but particularly with the BSSO, *Turvey (1985); Panula et al., (2001) and (2004).*

Inferior alveolar nerve (IAN) is at significant risk during BSSO. It is at risk in all stages of surgery, including dissection, retraction, bone cuts, mobilization and internal fixation. Nerve damage apparent at operation during BSSO is reported from 1.3% to 18%, *Turvey (1985); Al-Bishri et al.,(2004); Yang et al.,(2007).* Thus, iatrogenic injury is the most frequent cause of sensory disturbances in the distributions of the inferior alveolar and mental nerves, *Greenwood and*

Corbett (2005); Yang et al.,(2007).

The incidence of sensory disturbance after BSSO (at 1 or 2 years after surgery) is ranging from 0% to 85%, *Al-Bishri et al.,(2004); Nesari et al.,(2005); Yang et al.,(2007).* However, sensory changes following BSSO tend to be temporary in most cases. A neurosensory disturbance of the lower lip and chin has been described as something that does not bother the patient or only rarely does so, *Van de Perre et al., (1996); Al-Bishri et al.,(2004); Greenwood and Corbett (2005).*

The purpose of the sensory diagnostic evaluation is to document whether or not a neurosensory disturbance exists, to measure the disturbance, to monitor sensory recovery, to determine whether or not microreconstructive surgery may be indicated, and to monitor sensory recovery following microreconstructive surgery. The methods of evaluation of the neurosensory function of the lower lip and chin has varied widely, from pure patient questioning to sophisticated, high-technological examination modalities, *Zungia et al.,(1998); Greenwood and Corbett (2005).*

Evoked potential (EP) was as brain's reception and response to external stimulus, *Chippa (1982).* Trigeminal Somato-sensory Evoked Potentials (TSEPs) have been used to investigate the three divisions of the trigeminal nerve. TSEPs were not only used to determine the exact sites of the lesions within the trigeminal nerve but also to verify the effect of the treatment, *Bennett and Jannetta (1980).* TSEP analysis following stimulation of lower lip was considered objective while the rest tests (LT, BSD and 2P) were subjective or semi objective as they required interpretation by the patient, and can vary from one patient to another, *Ghali(1990).*

Patients and Methods:

2.1. Materials:

2.1.1.Study Sample :

This study was carried out on 12 patients, their ages ranged 21- 29 years old, indicated for bilateral sagittal split osteotomy (BSSO) for correction of mandibular prognathism or retrognathism alone or combined with maxillary surgery.

Subjects included in this study fulfilled the following criteria:

1) No abnormalities in the central nervous system or trigeminal nerve dominant region.

2) No pathological condition in the mandible affecting the inferior alveolar nerve.

3) No previous operation or trauma in the inferior alveolar nerve dominant region.

4) The age of the patients at the time of the surgery was less than 30 years old.

5) No previous history of disorders that can be reflected on neurosensory integrity (e.g. diabetes mellitus, vitamin B_{12} deficiency, and collagen diseases).

All subjects were operated by the same operator. The surgical technique used based on Hansuck's modification. Assessment of IAN function was performed preoperatively (base line), 2, 8, and 24 weeks postoperatively.

IAN assessments included subjective methods (light touch **LT**, brush stroke discrimination **BSD** and 2 points discrimination **2P**) and objective method which is **TSEP**.

2.2.Methods:

2.2.1. Subjective examination of IAN neurosensory function: -

The lower lip and the mental region were divided into four zones, and each zone was measured separately. Testing was performed over a one cm area above and beneath the labiomental fold on both sides of the chin (Fig. 1). Each of the four facial zones was stimulated three times; a correct response was considered two out of three appropriate answers. During testing, the patients closed their eyes and separated their lips comfortably.

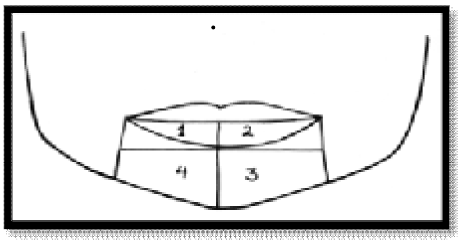


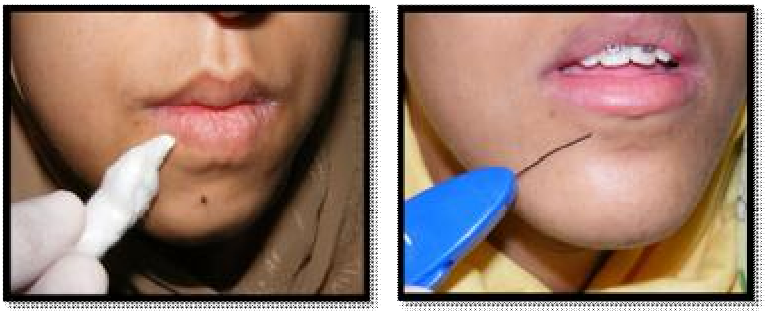
Fig. 1 : The four zones of the lower lip and the mental region

1- Light Touch (LT): -

The patient was asked to respond verbally to each touch. The lower lip was touched with small piece of cotton wool to check if the touch was perceptible. A positive or negative reply was the only option at each point. Regular timed stimuli were avoided so that the patient does not anticipate the test (Fig. 2a).

2- Brush Stroke direction Discrimination (BSD):-

The monofilament was stroked across the skin in 1-cm area, and the patient was asked if he could perceive the sensation and the direction of the stroke (Fig. 2b).



(a) *(b)*

Fig. 2 : (a) Light Touch (LT) using cotton wool. (b) Brush Stroke Discrimination (BSD) test using monofilament

3- Two-point of discrimination (2P):-

Each zone was measured with a sharp millimeter caliper. The test was conducted by beginning with the points closed and progressively opening them in 1 mm increments until the patient could discriminate two points of contact. This distance was then recorded. Care was taken to ensure that the points touched the skin surface at the same time. The average of the two zones at each side represented the record of such side. Distances two millimeters greater than the preoperative value were considered abnormal (Fig. 3).

Fig. 3 : 2P discrimination test using Boley gauge caliper

2.2.2.Objective examination of IAN neurosensory function: Trigeminal somatosensory evoked potentials TSEP were recorded by Schnauzer – Myos unit*; which consists of gold stimulator, filler amplifier, computer and printer to print out responses (Fig.4).

Each patient was informed about the nature of the procedures.

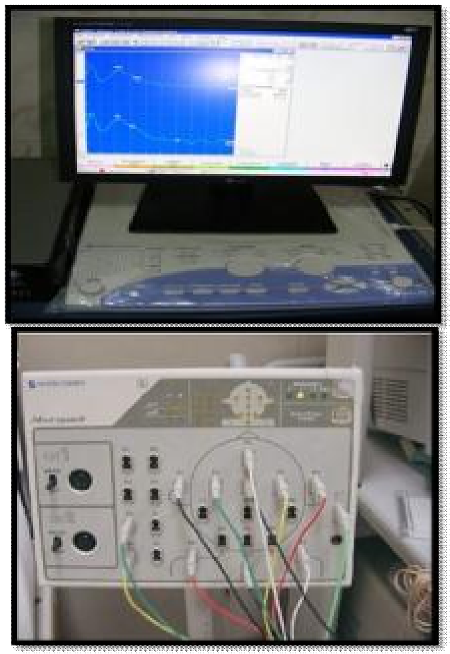
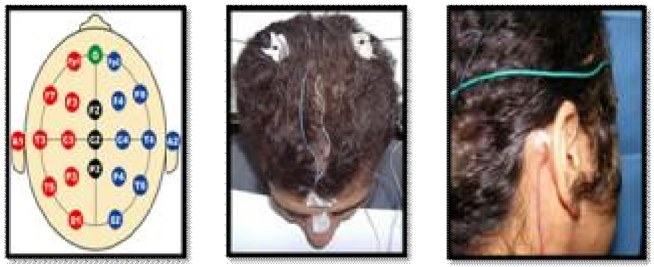


Fig. 4 : Somatosensory Evoked Potentials machine

The recording was conducted in quiet air conditioned room, where the patient was fully relaxed on a comfortable chair with eyes closed. Monopolar surface recording electrodes (gold) were fixed to scalp by a patch of gauze after the site was cleaned by alcohol and conductive paste was applied. The recording electrode was placed contra lateral to the side of stimulation 2 cm posterior to C_3 and C_4 (according to international 10 – 20 system recording sites). A reference electrode was placed at mid frontal site and the array was earthed by a ground electrode placed behind the ear (Fig.5).



a b c

Fig. 5 : (a) International 10-20 system for electrodes placement (Fath El-Bab, 2008).
(b) TSEP reference electrode at the mid frontal site (white arrow) and TSEPs recording electrode at C4 and C3 (black arrows).
(c) TSEP ground electrode behind ear.

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* Schwarzer GmbH, myos4, Serial number 500588.

The stimulation was achieved by electrical stimulator with contact surface of 4mm in diameter and inter-electrode distance 20 mm.

The stimulating electrodes were covered by conductive paste and applied on skin side of the lip opposite to the premolars. The stimulator was held by the operator to ascertain intimate contact between the stimulating electrodes and skin throughout the experiment (Fig.6).

Fig. 6 : TSEP electrical stimulator. It is placed opposite the premolar region contacting the skin

The electrical stimulator provided stimuli at a rate of 2 / second and each stimulus lasted for 0.1 sec. The stimulus intensity was adjusted by gradual increasing up to the level, where minimal lip twitch could be observed. In this study, the stimulus intensity didn't exceed the level of 8 m. Otherwise, it was associated with painful sensation. TSEP was at least repeated twice to confirm the reproducibility and reliability of the response. TSEP were recorded for both sides. Latencies, amplitude for each TSEP were determined and tabulated. Measurable periods of TSEP were defined as those periods before the peaks of N1, P1, N2, P2, and N3 that were clearly identified on early components of the TSEP wave (Fig. 7).

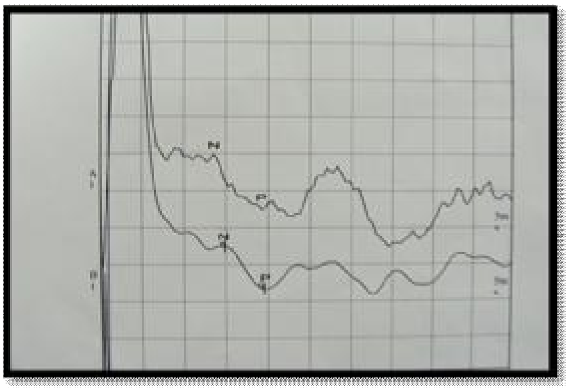


Fig. 7 : Preoperative TSEP wave of right and left side for patient no. 4 group I (base line record).

Trigeminal hypoesthesia was assessed by the latency of P and N in the recorded TSEP spectra. An earlier pilot study in healthy volunteers showed that these peaks produced an accurate figure and tended to result in better reproducibility. Measurable periods of TSEP were defined as periods before the peaks of N1, P1, N2 , P2 and N3 that were identified clearly as early components of the TSEP wave. Actual data were recorded as latency period (m.sec) in each peak. The measurable period was determined as the time when TSEP was first measurable postoperatively. Measurement of TSEP after surgery was continued until TSEP became measurable.

Data were analyzed by Microsoft office XP (Excel) and Statistical analysis was performed with SPSS* 15.0 (Statistical Package for Scientific Studies) for Windows. Quantitative data were presented as means and standard deviation (SD) values. Repeated measures analysis of variance *(ANOVA)* test was used to compare.

The numerical studied variables throughout the study. *Post Hoc test* was done to identify the different group if *ANOVA* test was positive. *Friedman's and chi square tests* were performed for Categorical variables. Result was considered statistically significant if p-value < 0.05.

3.Results :

3.1.During surgeries :

During surgeries all IANs were either embedded in the distal segments or visible but embedded in the distal segments.

3.2. Post-operative:

- The early post-operative follow-up period for all patients went uneventful with no significant complications except in patient (no.2) suffered from wound dehiscence, which was managed through daily irrigation with saline and chlorohexidine 2%. Healing was carried out by secondary intension over 3 weeks.
- Immediate postoperative orthopantograms for all patients revealed that all bicortical positioning screws were placed away from the mandibular canal.
- Six months postoperatively, orthopantograms didn't reveal any sign of resorption or infection around the screws (Fig 8).

3.3.Subjective examination of IAN neurosensory function:-

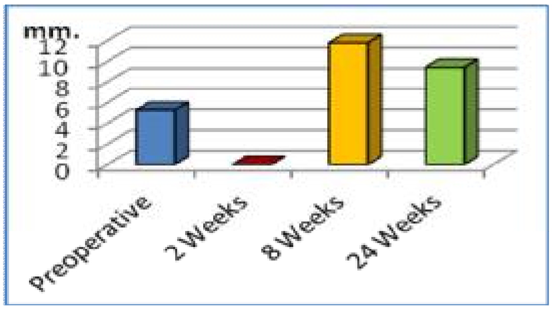
The clinical assessment of IAN by LT, BSD, and 2P, preoperatively revealed normal neurosensory function in the area supplied by the mental nerve in all patients. 2P test showed average of 6mm reading. At 2 weeks postoperatively, clinical

* SPSS, Inc., Chicago, IL, USA

Fig 8 : Postoperative orthopantogram showed that the condyles were properly seated in the glenoid fossae and bicortical positioning screws were placed away from the mandibular canals.

assessment with the same tests revealed neurosensory impairment in all patients bilaterally.
At 8 weeks postoperatively, LT revealed 9 of 24 IANs (37.5%) with normal neurosensory function. BSD test showed 11 IANs (45.8%) with normal function. 2P test showed abnormal discrimination in all patients bilaterally with an average reading of 13 mm.
At 24 weeks postoperatively, LT test resulted in 18 IANs (75%) had normal function while BSD test showed that 19 of 24 IANs (79.1%) had normal neurosensory response. 2P test revealed that 2 IANs (16.6%) had normal discrimination while 10 IANs (83.3%) had abnormal discrimination with an average reading of 9mm. All sides showed improvement of the reading compared with 2 weeks postoperative records.
Comparing 2P mean difference preoperatively with 2, 8 and 24 weeks postoperatively showed statistically significant difference in the mean score (Tables 1,2 & Fig.9).

Fig. 9: showing the changes by time of mean differences of 2P scores



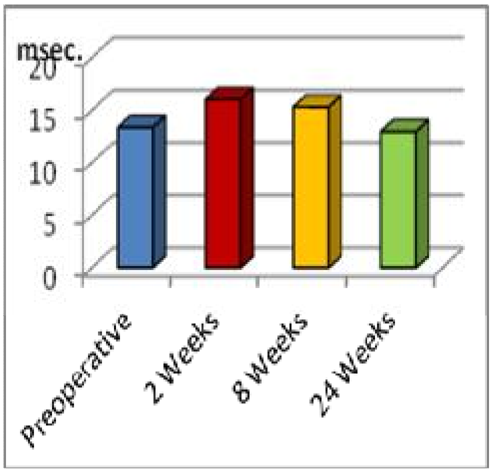


Fig.10 : showing N mean differences through the study intervals

3.4.Objective examination of IAN neurosensory function: (TSEP Results) :

Comparing preoperative with 2, 8, 24 weeks postoperative TSEPs records showed that the mean differences of N peak latencies were -2.55±0.9 m.sec, -1.82±0.8 m.sec and 0.48±0.6 m.sec respectively. There was no statistically significant change in N peak latencies through all intervals (Table 1, 2 & Fig. 10).
Comparing preoperative with 2, 8, 24 weeks postoperative TSEPs records showed that the mean differences of P peak latencies were -2.27±1.1 m.sec, -0.84±0.9 m.sec and 0.35±0.9 m.sec respectively. There was no statistically significant change in P peak latencies through all intervals. The mean differences of N-P amplitude preoperative to 2, 8 and 24 weeks postoperative were -4.23±3.3µv, -1.79±2.6µv and 0.5±2.26µv respectively. There was no statistically significant change in mean N-P amplitude through all time intervals (Table 1)

Table 1 : showing the descriptive data of the results of the study.

	N	Minimum	Maximum	Mean	Std. Deviation
Age	12	21.00	29.00	25.0000	2.76340
Amount of movement	12	3.00	8.00	5.0833	1.37895
Preoperative N	24	11.80	18.45	13.4804	1.83142
2 Weeks N	24	11.67	24.83	16.0342	4.12315
8 Weeks N	24	9.11	26.62	15.3071	3.84615
24 Weeks N	24	7.98	18.99	12.9917	2.62535
Preoperative P	24	14.91	25.30	18.3283	2.84846
2 Weeks P	24	13.49	29.84	20.6033	4.81785
8 Weeks P	24	11.50	26.62	19.1779	3.83468
24 Weeks P	24	10.80	24.98	17.9696	3.30470
Preoperative Amp	24	2.00	47.30	8.1621	10.21672
2 Weeks Amp	24	2.24	63.20	12.4017	12.47331
8 Weeks Amp	24	2.35	38.70	9.9575	7.92507
24 Weeks Amp	24	3.33	20.80	7.6600	4.28908
2P Pre	24	4.00	8.00	5.2917	1.04170
2P 2 Weeks	24	.00	.00	.0000	.00000
2P 8 Weeks	24	.00	22.00	11.7917	6.40638
2P 24 Weeks	24	.00	21.00	9.4583	3.68285

Table 2 : showing changes by time of mean differences of 2P scores & N peak latencies.

	2P scores			**N peak Latencies**		
Period	Mean difference	SE	P-value	Mean difference	SE	P-value
Pre-operative – 2 weeks	5.29	0.21	0.01	-2.55375	0.92093	0.054
Pre-operative – 8 weeks	-6.50	1.32	0.01	-1.82667	0.86955	0.234
Pre-operative – 24 weeks	-4.16	0.78	0.01	0.48875	0.65341	0.975

4.Discussion:

BSSO is a versatile technique to advance and set back the mandible. Postoperative complications, such as anesthesia or parasthesia of the lower lip, chin and the teeth are common. The sensory impairment may lead to long term discomfort in some patients.

In the current study, the age was ranged between (21 – 29 years) in order to limit the effect of age on the neurosensory recovery. We believe that old ages might affect the incidence and recovery of neurosensory disturbances after BSSO because the effect of age on tissue healing ability. This was also emphasized in previous studies, *Ylikontiola et al.,(2000); Al-Bishri et al.,(2004); Nesari et al.,(2005).*

The patients selected for the study included both males and females because sex predilection was not reported in most of the previous studies, *Bennett and Jannetta (1980);Chippa (1983); Ghali et al.,(1990);Zungia et al.,(1998); Ylikontiola et al.,(2000);Nesari et al.,(2005).*

Some authors reported that one gender might have neurosensory impairment more than the other after BSSO but they concluded that this was due to other factors such as age, amount of movement or nerve manipulation, *Al-Bishri et al.,(2004).*

In this study, the correlation between the magnitude of mandibular movement and the severity of neurosensory disturbance was insignificant at 6 month postoperatively. Previous reports showed that no correlation was found between the number of millimeters the mandible was moved and the incidence of neurosensory disturbances, *Fridrich et al.,(1995); Pratt et al.,(1996); Westermark et al.,(1998*). This is somewhat unexpected since a large movement stretches the nerve more than a shorter one**.** However, several authors revealed that when movement was more than 7 millimeters, there was a significant correlation with the severity of neurosensory disturbance, *Ylikontiola et al.,(2000).*

After splitting was completed all IANs were embedded in the distal segment or exposed but still embedded in the spongiosa of the distal segment. Our results confirm the finding of a significant correlation between intra-operative nerve manipulation and duration of neurosensory disturbance after BSSO which has also been found in some studies, *Leira and Gilhuus-Moe (1991); Fridrich et al.,(1995);Ylikontiola et al.,(2000).* There are also studies where no correlation or only a weak correlation has been found, Westermark et al.,(1998); Teerijoki-Oks et al.,(2004) .

Subjective assessment tests (LT,BSD and 2P) used measure mainly mechanoreception. Therefore, they were used for preliminary evaluation of IAN function. Meanwhile, TSEPs was used as a quantitative measure for evaluation of IAN neurosensory function. This goes in agreement with other studies by which considered TSEPs an objective, and non-invasive way of testing neurosensory nerve function in maxillofacial region, *Arcuri et al.,(2007); Koichiro et al.,(2007); Colella et al.,(2007); Hashiba et al.,(2007).*

In our study LT and BSD tests results showed better improvement compared with 2P discrimination test scores. Our results are consistent with previous studies which revealed that 2P discrimination test is the slowest to become normal, because it must not wait not only for myelination and maturation of the nerve fiber but also for Meissner's Corpuscles to become connected (slowly adapted A- alpha nerve fibers). LT and BSD become normal faster because they were indicative of large quickly adapting, myelinated A-alpha nerve fibers, *Greenwood and Corbett (2005).*

The results of this study indicated that the increase in the latencies of first upward (N) and downward (P) peak events was the most marked features of sensory impairment postoperatively. Although it was impossible to estimate the proportions of damaged fibers in individual nerve injuries, it might be reasonable to expect that latency delays might be a consequence of such injuries. This was consistent with the study by *Bakr et al (1987)* who found that latency delay between traumatized and control sides up to 2 or 3 m.sec could indicate for nerve injuries.

Our results confirmed the results of a previous study which showed that the preoperative latency period was significantly shorter than other postoperative periods in N and P peak latencies following Le Fort I osteotomy. This showed that surgical invasion could induce a prolongation of the latency period for TSEP, *Koichiro et al.,(2007)*

The present study revealed that the mechanism of IAN parasthesia after BSSO could be divided into two categories: direct damage to the nerve which occurs during medial dissection, sagittal splitting or as a result to exposure to the air and indirect damage to the nerve by postoperative edema or hematoma. TSEP results comparing 2 weeks postoperatively with the preoperative data showed statistically insignificant difference as regarding latencies and amplitude. The IAN parasthesia in most of our patients disappeared within 24 weeks postoperatively considered due to indirect nerve damage. On the other hand, recovery of directly damaged IAN prolonged more than 24 weeks and considered due to medial dissection. Our results are in accordance with previous studies, *Takeuchi et al.,(1994); Smith and Robinson(1995); Nakagawa et al.,(2003)*

It was worthy to mention that our patients subjectively reported more sensory impairment than what could be confirmed objectively by TSEPs testing. Subjective results as revealed from the patients' own assessment scores showed statistically significant difference in all follow up periods (Table 3&4), while TSEP results were not statistically significant at all intervals. This was consistent with results of ***Bailey (1984)***, who found that the level of subjective complaint was higher when compared with objectively tested level of deficit. This was also reported by *Cunningham (1996),* who studied neurosensory deficit of IAN preoperatively and 6 month postoperatively after BSSO, and concluded that patients appear to over report neurosensory problems.

The results of the present study emphasized the importance of pre-surgical patient counseling regarding the risks of neurosensory disturbances. There was a high incidence of neurosensory disturbance immediately after BSSO, but most of the patients returned to their presurgical status within six months postoperatively.

Conclusions:

From the evidences observed in this study, we might conclude that TSEP could be used after BSSO to predict recovery of IAN function. This could be used to overcome waiting long time to make sure of the neurosensory recovery using subjective clinical tests. TSEP represents an objective, sensitive, reliable and non invasive method of testing neurosensory function.

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11/11/2011