Evaluation of Neurosensory Disturbance Following Orthognathic Surgery: A Prospective Study

Saikrishna Degala · Sujeeth Kumar Shetty ·
M. Bhanumathi

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Abstract

Aim and Objectives The prospective study was to evaluate the incidence, type of neurosensory disturbance (NSD), grade its severity and monitor its recovery occurring in the lower lip and chin due to damage to inferior alveolar nerve following orthognathic surgery involving mandible.

Materials and Methods The study included 10 patients who have undergone sagittal split osteotomy, genioplasty, and anterior subapical osteotomy (ASO). All the patients examined preoperatively and post operatively 1 week, 1 and 6 months according to standardized test to clarify the subjective and objective neurosensory status of the injured nerve. Pin prick test, blunt test, two-point discriminator test, brush stroke direction, light touch test, warm and cold test were used bilaterally to lower lip and chin area.

Results Seven patients underwent bilateral sagittal split osteotomy (BSSO) (70 %), one patient had BSSO with genioplasty (10 %), two patients had BSSO with ASO (20 %). During the operation none of the nerves were transected, in 60 % of patients nerve was not visible and in 40 % of patients nerve was seen in distal segment. 70 % of patients underwent setback, 30 % of patients underwent advancement. The subjective evaluation of the patients revealed the incidence of 90 % at 1 week, 30 % at 1 month, 20 % at 6 months and 10 % at 1 year post operatively. The altered sensation reported subjectively was hypoesthesia in 50 % of the patients, anaesthesia in 40 % of the patients.

There was 100 % recovery in advancement cases and 93.5 % recovery in setback cases.

Conclusion There is a high incidence of NSD of the lower lip and chin after BSSO related to advancement, setback, intraoperative nerve encounter and surgical skill. However, recovery of sensation occurs with increasing frequency during the follow-up period. The clinical neurosensory tests are effective guides to study the neurosensory deficit.

Keywords Bilateral sagittal split osteotomy (BSSO) · Neurosensory disturbance (NSD) · Neuropraxia · Hypoesthesia

Introduction

Sagittal split osteotomy (SSO) was first described by Schuchardt in 1942, then modified by Trainer and Obwegeser in 1957 and further modified by Dal Pont (1961), Hunsuck (1968), Epker (1977), Bell and Schendel (1977). The inferior alveolar nerve (IAN) is at particular risk of division, compression or stretching, edema and pressure from fixation screws in SSO [1]. Genioplasty (GP) was first described in the 1940s by HOFER. Neurosensory disturbance (NSD) of the mental nerve has been suggested as the most common complication encountered with this procedure. The incidence after SSO was between 9 and 85 %. The mechanoreceptive testing and nociceptive testing is based on the specific receptors stimulated through cutaneous contact. Mechanoreceptive testing is further divided into static light touch (LT), brush directional stroke (BSD) and two-point discrimination (TPD). Nociceptive testing is done by pin prick (PR) and thermal discrimination [2].

This study establishes the assessment of NSD in patients after SSO, genioplasty and anterior subapical osteotomy

S. Degala (✉) · S. K. Shetty · M. Bhanumathi
Department of Oral and Maxillofacial Surgery (OMFS), JSS
Dental College & Hospital, Mysore, Karnataka, India
e-mail: degalasaikrishna@gmail.com

M. Bhanumathi
e-mail: bhanumaxfax@gmail.com

Table 1 Two point discrimination test in patients (Mann-Whitney U test)

	tp d p r1	tp d p l1	tp d p r2	tp d p l2	tpd 1w r1	tpd 1w l1	tpd 1w r2	tpd 1w l2	tpd 1m r1	tpd 1m l1	tpd 1m r2	tpd 1m l2	tpd 6m r1	tpd 6m l1	tpd 6m r2	tpd 6x'm l2
Z	.0	.0	.0	.0	.0	−1.856	−1.856	−2.151	−2.151	−2.188	−2.188	−2.188	−.655	−.982	−.976	−.982
P value	1.0	1.0	1.0	1.0	.063	.063	.031	.031	.031	.033	.029	.029	.513	.326	.329	.326

(ASO). This ascertains the time required for neurosensory changes and return to normalcy and whether advancement or setback of the mandible has any effect on neurosensory changes and recovery (Table 1).

Methodology

Ten patients who underwent SSO (unilateral/bilateral), GP, and ASO between 2010 and 2012 in our institution were included in the study after obtaining ethical clearance (Table 2). All the patients underwent open extraction of third molar at least 6 months prior. Patients after cessation of skeletal growth, bimaxillary deformities secondary to craniofacial anomalies and patients with high cosmetic concern were included in the study. Patients who have undergone previous surgery or trauma in the proposed surgical site, patients with systemic bone diseases, patients with history of pathology in and around ramal region, patients with any history of neurological disturbances prior to surgery due to nerve pathology were excluded.

Pre operatively patients OPG were taken to evaluate the variables of mandibular canal (Fig. 1a). All the patients underwent Obwegeser and Dal Point technique of bilateral sagittal split osteotomy under GA. Soft tissue over medial surface was retracted, lingula and nerve was identified and secured by Howarth periosteal elevator. Osteotomy cut was done over the medial surface of ramus by Lindermann bur, other cuts were made using straight fissure bur. Osteotomy was completed using fine osteotome directed laterally. The two fragments were separated using Smith's bone spreader. All the osteotomised fragments were placed in the designated area and semi rigid fixation was done using 2.0 mm titanium miniplates and screws (Fig. 1b). An extra oral pressure dressing was applied to all patients to reduce oedema and haematoma formation. Splint with intermaxillary fixation was placed following a week of surgery for next 3 weeks. All the subjects received intravenous antibiotics and analgesics from the day of surgery to 5 days postoperatively to prevent post-surgical infection and pain. All the patients received intravenous dexamethasone 8 mg TID which was later on tapered and stopped after 4 days to reduce post-operative oedema. Following this, 5-day course of oral antibiotics and analgesics were prescribed.

Fig. 1 **a** Photograph of pre op OPG showing nerve tracing. **b** Photograph of post op OPG showing fixation of fragments using miniplates

In each case following parameters were considered: Age, Gender, Diagnosis, Variations of mandibular canal, surgical technique/plan, type of mandibular split, Degree of mandibular setback/advancement, Intraoperative nerve encounter, Method of fixation, and Duration of surgery.

Neurosensory Evaluation

Lower chin and lip region was divided into four equal quadrants; right upper (R1), right lower (R2), left upper (L1) and left lower (L2). The individual neurosensory tests were conducted on each of the quadrants pre-operative and post operatively after 1 week, 1 and 6 months. The pre-operative values or forehead values were determined as control values. Postoperative subjective evaluation with questionnaire (Table 3) was recorded using 10 cm Visual analogue scale. For pain 10 indicated unbearable severe pain and 0 indicated no pain. For discomfort 10 indicated severe discomfort and 0 indicated no discomfort. Patients were to mark the specific area of face that had developed altered sensation during same time.

The patients were asked to describe their neurosensory deficit in plain words to be recorded in terms of sensitivity score or instructed to mark on the VAS. As described below,

Table 2 Patients who underwent orthognathic surgery

Sl no.	Age	Gender	Diagnosis	Surgery A	dv/set	Split	Ions	Fixation
1	19	F	Skeletal class II relation	BSSO, AMO, lefort I	5 mm Adv, 4 mm Set, 6 mm Imp	Favorable	Not visible	Miniplates
2	24	F	Skeletal class II relation	BSSO, lefort I	5 mm Adv, 6 mm Imp	Favorable	Not visible	Miniplates
3	18	M	Skeletal class III relation	BSSO, lefort I, GP	7 mm Set, 5 mm Adv	Unfavorable	Visible in distal segment	Miniplates
4	20	M	Skeletal class II relation	BSSO, AMO, ASO	5 mm Adv, 10 mm Set, 5 mm Imp	Favorable	Not visible	Miniplates
5	24	M	Skeletal class III relation	BSSO, lefort I	7 mm Set, 4 mm Adv	Favorable	Not visible	Miniplates
6	21	M	Skeletal class III relation	BSSO, lefort I	7 mm Set, 5 mm Adv	Favorable	Visible in distal segment	Miniplates
7	28	M	Skeletal class III relation	BSSO, lefort I	8 mm Set, 6 mm Adv	Favorable	Visible in distal segment	Miniplates
8	19	M	Skeletal class III relation	BSSO	8 mm Set	Favorable	Visible in distal segment	Miniplates
9	28	M	Skeletal class II relation	BSSO, AMO	5 mm Adv, 6 mm Set and 4 mm Imp	Favorable	Not visible	Miniplates
10	26	M	Skeletal class III relation	BSSO, lefort I	7 mm Set, 4 mm Adv	Favorable	Visible in distal segment	Miniplates

a five-point scale was used to describe the sensation: Numb (VAS 0–2), Almost numb (VAS 3–4), Altered (VAS 5–6), Almost normal sensation (VAS 7–8) and completely normal sensation (VAS 9–10). The patients rated their sensory perception accordingly after doing the tests for PR, TPD, LT, warm (W) and cold (C), blunt discrimination (BD) and BSD (Fig. 2). Each test was confirmed by three repeats and the mean of the same was tabulated.

Pin Prick Test

The device used for the PR test is a sharp probe held between the thumb and index finger and is applied by quick and pricking fashion on the right and left side of the quadrants with neurosensory deficit. This assesses the free nerve endings and the small A delta and C fibres that innervate the free nerve endings responsible for nociception.

- 0–2: no pain (Numb),
- 3–4: very mild pain (Almost numb),
- 5–6: mild pain (reduced),
- 7–8: moderate pain (Almost normal),
- 9–10: Normal.

The Two Point Discriminator

The two point discriminator or aesthesiometer was used on the right and left quadrants to evaluate the two point discrimination. The distance between the points is increased in 2 mm increments until the patient is able to discriminate

two distinct and separate points. The points were moved closer together until the patient is able to discriminate only one point. It assesses the quantity and density of functional sensory receptors and afferent fibres. The sharp points indicate small myelinated A delta fibres and unmyelinated C fibres of 0.5 micrometer in diameter.

Discrepancy from normal value

- >20 mm as Numb,
- Between 16 and 20 mm as Almost numb,
- Between 11 and 15 mm as Reduced,
- Between 6 and 10 mm as Almost normal and
- <5 mm as Normal.

Light Touch

The LT test was done by wisp of cotton wool. The patient's perception of "touch" is evaluated on contact in the region of the right and left quadrants. It is done for detection of the integrity of the Merkel cell and Ruffini ending, which are innervated by myelinated A beta afferent axons of 5–15 μ m in diameter. These receptors are slow to adapt and their putative sensory modality is pressure.

Warm and Cold Test

The warm test was done by applying a test tube with water at temperature of 45°–50°. The cold test is done by applying ice cube on the test area. It is done for

Fig. 2 Neurosensory evaluation. **a** Two point discriminator. **b** Brush stroke test. **c** Pin prick test. **d** Blunt discrimination test. **e** Warm test. **f** Light touch test

determination of the small diameter myelinated fibres and unmyelinated fibres. The warmth sensation is attributed to A delta fibres and cold to C fibres. Discrepancy of more than 30° from normal value was considered to be numb.

Blunt Discrimination

The blunt discrimination was done by placing the blunt end of probe or culture swab on the test area. The blunt points indicate larger myelinated A alpha afferent fibres of 5–15 µm in diameter.

Brush stroke direction was examined using fine camel hairbrushes. The test site (the lower lip and chin on the operated side) was stroked from right to left or from left to right for a length of 1 cm. The patient had to correctly identify the direction in 12 out of 15 times or it was recorded as decreased sensibility. It is a test for proprioception and assesses the integrity of the large A alpha and A beta myelinated axons of 5–15 µm, which innervate the lanceolate endings, Pacinian corpuscles. The sensory modalities for these receptors are vibration, touch and flutters and are rapidly adapting receptors.

In all patients an area of unpleasant sensation if present was mapped applying the stimulus within this area and then moving it outward in small steps until a sensation is felt. This position was marked on the skin and the test was repeated at a series of different sites until the region is

outlined. The area of the skin mapped out was taken as the baseline value and during subsequent follow-up the values were compared and postoperative recovery is analyzed.

Results

The following statistical methods were employed in the present study: Frequencies, Descriptive statistics, Chi square test, Wilcoxon signed rank test (Fig. 3), Mann-Whitney U test. All the statistical calculations were done through SPSS 16.0 (2007) for windows. Among 10 patients 8 were males and 2 were females with mean age of 22 years.

Seven patients underwent setback and 3 patients underwent advancement. 60 % of patients underwent setback ranging between 6 and 10 mm, 30 % of patients underwent advancement ranging between 1 and 5 mm and 10 % of patients underwent setback ranging between 1 and 5 mm. Seven patients underwent BSSO (70 %), one patient had BSSO with genioplasty (10 %), two patients had BSSO with ASO (20 %) (Fig. 4). 40 % of patients were under the age group of 16–20 years, 30 % were under the age group of 21–25 years and 26–30 years. During the operation none of the nerves were transected, in 60 % of patients nerve was not visible and in 40 % of patients nerve was seen in distal segment (Fig. 5). Except for one case (10 %) where

Table 3 Questionnaires

- Have you experienced any sensory disturbance after operation in
(a) Upper lip (b) chin (c) lower lip (d) cheek (e) teeth (f) tongue (h) upper lip+ lower lip+ chin
- In which side is your sensation altered?
(a) Right (b) left (c) both (d) none
- When did this begin?
(a) Immediately after the operation (b) sometime after the operation (c) none
- Would you describe the sensory disturbance as
a) Anaesthesia (b) hypoesthesia (c) pinching (d) tingling (e) painful (f) burning (g) other (h) none
- Does the changed sensation cause any problem for you?
(a) Always (b) at touching (c) when chewing (d) when talking (e) others (f) none
- Has the sensory change made you bite/burn yourself on
(a) Lip (b) tongue (c) cheek (d) no
- How would you grade the discomfort you experience as a consequence of altered sensation?
a) No discomfort (b) mild (c) mild-moderate (d) moderate (e) moderate-severe (f) severe
- For how long you had the altered sensation?
(a) <1 month (b) 6 months (c) 1 year (d) more than 1 year and still altered (e) more than one year but normal now (f) none
- Are you satisfied with the result of operation?
(a) Yes (b) no
- With your experience would you recommend this kind of treatment?
(a) Yes (b) no

Fig. 3 Two point discrimination test in patients (Wilcoxon Signed Ranks Test)

bad split was encountered all other cases (90 %) had favourable split with p value of 0.011 which is significant.

The patients had no impaired function of the IAN in any of the four zones in the lower lip and mental region pre-operatively (100 %). The subjective evaluation of the patients revealed the incidence of 90 % at 1 week, 30 % at 1 month, 20 % at 6 months and 10 % at 1 year post operatively. None of the patients had post-operative

Fig. 4 Advancement, setback and surgery distribution in patients **Fig. 5** Intra operative status of nerve in patients

complications other than NSD. The altered sensation reported subjectively was hypoesthesia in 50 % of the patients, anaesthesia in 40 % of the patients. There was no evidence of hyperesthesia post operatively. All the patients (100 %) had hypoesthesia bilaterally involving lower lip and chin with p value of 0.007 and 0.011 which is significant. 40 % of patients had mild discomfort, 30 % had moderate—severe discomfort, 20 % had moderate discomfort, 10 % had no discomfort postoperatively.

The analysis of the relation of advancement and setback to neurosensory tests for evaluation of the neurosensory recovery was done by Mann-Whitney U test (Table 1). Pre-operatively all test had P value of 1.000. In LT after 1 week $P = 0.083$, after 1 month $P = 0.029$ which is significant, after 6 months $P = 0.513$ which is not significant. In BSD test after 1 week $P = 0.023$, after 1 month $P = 0.029$ which is significant, after 6 months $P = 0.513$ which is not significant. In TPD test after 1 week $P = 0.063$, after 1 month $P = 0.031$ which is significant, after 6 months the $P = 0.513$ which is not significant. In WARM test after 1 week $P = 0.023$, after 1 month $P = 0.029$ which is significant, after 6 months $P = 0.329$ which is not significant. In COLD test after 1 week $P = 0.059$, after 1 month $P = 0.028$ which is significant,

Fig. 6 Neurosensory disturbance of patient 1. **a** Pre op. **b** 1 week post op. **c** 1 month post op. **d** 6 months post op

after 6 months $P = 0.329$ which is not significant. In PR test after 1 week in right side $P = 0.059$, after 1 month $P = 0.028$ which is significant, after six months $P = 0.205$ which is not significant. In BD test after 1 week ($P = 0.050$), after 1 month $P = 0.031$ which is significant, after 6 months $P = 0.329$ which is not significant.

Among 10 patients, set back was done to 7 patients. They showed 25 % of neurosensory recovery during first 1 week, 55.7 % of recovery in the first one month and 91.4 % of recovery in 6 months. Three patients underwent advancement; they showed 80 % of neurosensory recovery during first one week, 100 % of recovery in the first 1 month. On an average 35 % of recovery was seen in 10 patients in the first 1 week, 67.5 % of recovery in first 1 month and 93.5 % of recovery in 6 months (Fig. 6).

Discussion

The bilateral sagittal split osteotomy has become a standard procedure for mandibular correction. Despite several risks inherent with this technique, it is the best choice for correction of severe malocclusion and deformation of mandible. NSD of the lower lip and chin induced by damage to the IAN is the most common immediate finding after BSSO [3]. Dal Point [4] modified in 1961 which is currently in use where the buccal cut is placed more anteriorly and is

Fig. 7 Neurosensory disturbance of patient 2. **a** Pre op. **b** 1 week post op. **c** 1 month post op. **d** 6 months post op

Fig. 8 Neurosensory recovery in patients

directed vertically as opposed to an oblique cut aimed at the antegonial notch. Hunsuck modified in advocating shorter horizontal medial cut just past the lingula to minimize the soft tissue dissection. Epker suggested minimal stripping of the masseter muscle and limited medial dissection which would reduce postoperative swelling, haemorrhage, and manipulation of neurovascular bundle [5, 6]. Sensation is the acceptance and activation of receptors and propagation of impulses from the afferent nerves to the central nervous system. Three primary modes of sensation that are recognised by peripheral terminal endings of sensory axons include mechanoreception (touch-pressure), nociception (pain), and thermoreception (cold and warmth) [7].

In our study among 10 patients there were 8 (80 %) male patients and 2 (20 %) female patients in age group of 19–28 years of age. The mean age of male patients was 23 years and female patients was 21 years. This study had only 10 patients, and larger number of patients may be required to know the effect of age and gender on NSD. MacIntosh found that the incidence of NSD persisting at one year postoperatively was overwhelming in patients older than 40 years [8, 9].

Mandibular split was favourable in 90 % of the cases in our study except for one case where bad split was encountered. Bad split is related to increased incidence of NSD. In our study patient with bad split had only 75 % of recovery after 6 months of follow-up. It has been reported that the IAN is located as close as 0.5 mm to the buccal cortex, with a mean value of <2 mm, hence shorter distance between canal and buccal cortex increases the risk of NSD after BSSO [10]. Presence of bifid canal increases the risk of nerve injury during splitting. In our study all patients had single canal hence this parameter did not give significant value to compare the occurrence of NSD with the type of canal.

Direct damage can be caused by protecting retractors, the Lindermann burs, chisels, and compression by rigid fixation. Indirect damage may be due to edema developing immediately after surgery. All patients underwent BSSO performed by 2 oral maxillofacial surgeons who have worked together for a long time. Thus, the surgical methods and instruments used were very similar. However, it appears to be true in our study and other studies [7] that surgery involving protective bony canal of a nerve may be associated with a high degree of morbidity, that is, a decreased likelihood of complete recovery. In the present study, the greatest frequency of NSD was at 1 week post operatively (35 % of recovery) and it decreased with time but only 93.5 % of recovery was seen after 6 months.

Lag screw fixation has been reported to lead to a greater incidence of hypoesthesia [4, 10]. Pratt et al. [1] reported that miniplates osteosynthesis after SSO was followed by better function of the IAN than intermaxillary fixation in combination with upper border wire which could be correlated to our study. Westermarck [11] used position screw to avoid compression of the fragments there by reducing the incidence of damage to nerve.

Westermarck [11] has inferred in his study that the bundle is particularly vulnerable to compression at the mandibular foramen; setback procedures are more likely to compress the bundle at this point of entry into the medial aspect of the ramus. The advancement procedure would disturb the nerve by greater traction or tearing and was not associated with permanent damage. This study is consistent with above study; there was only 20 % of NSD seen in advancement cases when compared to setback cases which showed about 80 % of NSD, but for period of 6 months

follow-up there was 100 % recovery in advancement cases and 93.5 % recovery in setback cases. However long term follow up period with larger sample size is required to evaluate for complete recovery among advancement and setback cases.

Westermarck said that during the subperiosteal dissection on the medial aspect of the mandibular ramus the nerve might be bent in two places and torn in between. The medial dissection on the mandibular ramus is a rather difficult procedure until it has been properly learned, and this might explain why the less experienced surgeons had a lower sensitivity score [11].

Posnick et al. [13] and Lindquist [14] reported more neurosensory disturbance after SSO with additional GP than SSO alone [12]. They related this to a double crush of the IAN. Our results showed similar findings after GP was added to BSSO but did not give significant difference as the sample size was too small to correlate.

A good correlation in the subjective evaluation and TPD, BSD test was seen in this study. The Semmes–Weinstein pressure aesthesiometer stimulates a localised area of skin with increasingly stiff nylon filaments, which vary in the pressure required to bend the filament. This is probably the most direct and basic method of stimulating-touch perception. 93.5 % of the patients recovered within a period of 6 months, 6.5 % of the patients took more than 6 months to recover added factor could be intraoperative nerve damage by bad split, compression within fragments, direct trauma, additional procedures like genioplasty, indirect trauma after maxillary surgery, increased manipulation of nerve by greater degree of fragment movement. Assuming all other factors can be kept constant, peripheral sensory nerves that are completely severed (neurotmesis) or are crushed (axonotmesis) are more likely to suffer residual damage than those which are merely exposed in the surgical area (neuropaxia). The transient NSD that occurred in nearly all of the nerves in our group would probably represent neuropaxia and axonotmesis injuries under Seddon's classification (Figs. 7, 8).

Modification of the sagittal split procedure, such as limiting the degree of medial periosteal reflection and stretching, taking care to penetrate only the cortex when the rotatory instrument is used, maintaining the split adjacent to the facial cortex with minimal medial cancellous penetration by the osteotome or saw and limiting the extent of the split in the body of mandible, should reduce the chances of nerve injury as observed in our study.

Conclusion

In BSSO, a prolonged NSD had correlation with intraoperative magnitude of mandibular movement and

intraoperative encounter of nerve within the fragments. But larger group of subjects may be required for confirmation and also to correlate the incidence of NSD among patients with BSSO alone and BSSO with genioplasty and ASO. The TPD test was more reliable in terms of assessment of neurosensory deficit. All the patients had almost similar pattern of recovery. The damage to the IAN seems to be sensitive to surgical technique (bad split) and to the skill of the surgeon. There is a requirement of more than 6 months follow-up to study neurosensory recovery in other subjects who have not achieved neurosensory recovery within 6 months.

Conflict of interest None declared.

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