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NEUROSENSORY ALTERATIONS FOLLOWING ANTERIOR OSTEOTOMIES OF MAXILLA AND MANDIBLE.

Dental Science

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ABSTRACT

Aim: To evaluate the time taken for the recovery of the sensory loss after the maxillary and mandibular osteotomies and to evaluate the amount of sensory loss after these surgical procedures.
Objectives: The objectives of the study were to assess and compare pre and post-operative extent of sensory loss and to assess the rate of recovery.
Materials and method: Fifteen patients were enrolled for evaluation requiring orthognathic surgical procedures for the correction of jaw deformities. Pre and post-operative neurosensory evaluation was done using the neurosensory assessment methods at an interval of first week, first month and second month.
Results: Statistically significant differences occurred at 1 week and 1 month, but over time nerve damage groups 1 and 2 recovered to similar levels. This study showed no statistical significance for age and NSD/recovery.
Conclusion: On the basis of these results, we can say that the NSD rate is very low in surgical applications.

KEYWORDS

Maxilla, Mandible, osteotomy, Neurosensory disturbances

INTRODUCTION:

Contemporary maxillofacial surgical procedures pose significant risk (up to 100%) of injury to sensory branches of the trigeminal nerve. Sensation and sensory function are most often impaired, but seldom completely lost, and only a small percentage of patients develop post-traumatic neuropathic pain.[18] Clinicians and clinical investigators vary in opinion regarding how patients should be evaluated for nerve injury following surgery. Most often patients are questioned about the presence of altered sensation on the face and in the mouth. Less commonly, quantitative sensory testing methods are used to assess the severity of neurosensory impairment.

Anterior osteotomies (AO) are a versatile procedure in the management of a variety of deformities of the anterior maxilla. AO was first described by Cohn–Stock in 1921.[44] Recently, AO has become an effective component of maxillary distraction for the advancement of the anterior segment of the maxilla to create room to unravel a crowded upper arch or to align an impacted tooth into the arch. The technique described by Block and Brister in 1994 using a tooth-borne device is used in the treatment of atrophic maxillas, maxillary clefts, impacted and/or ankylosed teeth and dental crowding[7]

Neurosensory deficits have been reported to be the most common problem following orthognathic surgical procedures and there are numerous studies addressing neurosensory alterations resulting from orthognathic surgery. Neurosensory alterations following Anterior Osteotomies are mostly overlooked. It has been suggested that neurosensory deficits following Anterior Osteotomies occur but usually resolve spontaneously 6–12 months after surgery.[51] Maxillofacial neurosensory deficiencies may be caused by various surgical procedures such as tooth extraction, osteotomies, preprosthetic procedures, excision of tumors or cysts, surgery of TMJ, and surgical treatment of fractures and cleft lip/palate. The major findings described for severe injury include complaint of anesthesia or hypoesthesia for more than 3 months; tongue, cheek, lip biting; altered mastication and taste; triggering sign, and an increase in hot or cold temperature threshold.

The purpose of this study is to evaluate the incidence, severity and type of neurosensory deficiency (NSD) in patients who underwent anterior osteotomies of maxilla and subapical osteotomy of mandible.

AIM:

To evaluate the time taken for the recovery of the sensory loss after the maxillary and mandibular osteotomies and to evaluate the amount of sensory loss after these surgical procedures.

OBJECTIVES:

1) To evaluate the extent of neurosensory loss after the AMO in lower eye lid, nose, cheek, upper lip, vestibular mucosa, palatal mucosa.
2) To evaluate the extent of neurosensory loss after SAO in lower lip and chin at the mucosal and cutaneous regions.

Material and Methods:

Sample size: 15 subjects of age 15-35 years
Sampling method: Convenience sample
Study location : Guntur
Study setting: Department of oral and maxillofacial surgery, Sibar Institute of Dental Sciences.
Prior ethical clearance was obtained from Institutional Ethical Committee (IEC) of Sibar Institute of Dental Sciences. After explaining purpose, risks and benefits of study, written informed consent of all participants was obtained before start of the study.

Inclusion criteria-

1. Patient between the ages of 15 to 35 years.
2. Patient requiring orthognathic surgery.
3. Be scheduled to receive an anterior maxillary osteotomy and/or anterior subapical osteotomy.
4. Maxillary prognathism and retrognathism.
5. Mandibular prognathism and retrognathism.
6. Patients having developmental dentofacial disharmony
7. Patient willing to participate in the study protocol.

Exclusion criteria

1. Systemically compromised patients.
2. Cleft lip and palate patients.
3. Patient who underwent previous orthognathic surgeries.
4. Patients with history of trauma to the facial bones.
5. Syndrome patients.
6. Patients having psychological problems.

Pre-operative evaluation of patients:

1. Detailed history including past history of trauma, orthognathic surgery obtained with special emphasis or history of any systemic diseases.
2. A through clinical examination with various clinical facial photographs will be performed.
3. Routine blood and urine examinations were performed to rule out any systemic diseases.
4. Radiological examination.
5. A standard lateral cephalogram were taken.
6. Preliminary treatment.
7. Pre surgical orthodontics treatment were performed.
8. All the surgical procedures were performed with standard set of instruments using standardized approach under general anaesthesia.
   For each surgical group, deficits were expressed as a mild, moderate, severe and into grades of responses.

Procedure:

Cutaneous touch-pressure sensation was evaluated by testing for light touch, pin prick, and standing two-point discrimination. Patients were evaluated preoperatively (within I week of surgery), and, 1 week, 1 month, 2 months, and 3 months postoperatively. Seven facial regions were examined corresponding to the peripheral distribution of the trigeminal nerve i.e. infraorbital and mental nerves, which included the infra orbital, upper lip, and lower lip regions bilaterally, as well as nose, vermilion border, vestibular mucosa, palate, cheek, chin site.

The testing procedures were explained and demonstrated to the patient before each test session. For each surgical group, deficits were expressed as a percentage of anatomic sites involved.

Two-point discrimination (TPD) was tested using a Boley gauge with the points of the gauge blunted so as not to elicit a painful response from the patient. The gauge was set at 10 mm separation and applied to the skin with equal pressure on each point in a manner intended to stimulate but not blanch the skin. The two-point stimulus was applied three times at each setting, and the distance was changed until the patient could no longer discriminate two points.

All statistical analyses were performed with the Statistical Package for the Social Sciences 24.0 (IBM SPSS Inc., Chicago, IL, USA). Mean standard deviation and median values of patients in global score on different days (7, 30 and 60) were calculated for data variables. The Mann Whitney U test was used to compare the values obtained from different compare examined areas on different days (7, 30 and 60) because the data variables were not normally distributed. After that, the Kruskal Wallis Anova test were performed to compare the values of different neurosensory tests showing recovery of different nerve fibres on different examined areas between paired days.

RESULTS:

RESULTS OBTAINED FOR ANTERIOR MAXILLARY OSTEOTOMY

Twelve patients were enrolled from outpatient Department of Oral and Maxillofacial Surgery, Sibar institute of dental sciences, Guntur, Andhra Pradesh, India, with the age range of 15 to 35 years requiring orthognathic surgical procedures of anterior osteotomies of maxilla.

A total of twelve patients were included in study, 2 were men and ten were women. The considered sample consists of 16.7 male and 83.3% female patients. The mean age of men was 18.50.The mean age of women was 23.80. The total mean age of the patients was 22.92 years.

Table 1: Distribution of samples by gender and Age comparison between Male and Female patients.

Gender	No. of patients	%	Mean Age	Standard deviation
MALE	2	16.7	18.50	4.950
FEMALE	10	83.3	23.80	4.211
TOTAL	12	100	22.92	4.582

In our study it was observed that no postsurgical neurosensory alterations were detected in lower eye lid, 24 sides of the twelve patients with all the clinical tests used. The preoperative and postoperative values were the same.

On postoperative day 7, neurosensory alterations were detected in all sides of cheek as indicated by $p<0.05$. On day 30, the alterations remained, but the deviation size from the preoperative values had decreased. Only two sides were determined as having subnormal sensitivity and on day 60, all tested sides revealed normal sensation.

On postoperative 7, neurosensory alterations were detected in all sides of nose as observed by p value of 0.00, but the deviation size from the preoperative values had decreased on day 30. On day 60, the values reached the preoperative scores. On day 7, 16 sides were normal, six were subnormal and two had intermediate sensitivity levels. On day 30, all tested sides revealed normal sensation.

On postoperative days 7, neurosensory alterations were detected in all sides of lower lip as represented by p= 0.00, but the deviation size from the preoperative values had decreased on day 7. On postoperative day 30, preoperative scores were detected in 24 sides of lower lip. On postoperative day 7, 22 sides revealed intermediate and two sides revealed subnormal sensation values. On day 30, all tested sides revealed normal sensation.

On postoperative days 7, sensation scores in all sides were 0 for vestibular mucosa. On postoperative day 30, the values increased. On day 60, 17 sides reached the preoperative scores. On day 60, all tested sides revealed normal sensation. No postsurgical neurosensory alterations were detected in 24 sides of palatal mucosa with all the clinical tests used. The preoperative and postoperative values were the same.

RESULTS OBTAINED FOR SUBAPICAL OSTEOTOMY OF MANDIBLE:

Eight patients were enrolled from outpatient Department of Oral and Maxillofacial Surgery, Sibar institute of dental sciences, Guntur, Andhra Pradesh, India, with the age range of 15 to 35 years requiring orthognathic surgical procedures of anterior osteotomies of maxilla.

A total of eight patients were included in study, 1 was man and seven were women. The considered sample consists of 12.5 male and 87.5% female patients.The mean age of men was 22.0. The mean age of women was 25.71. The total mean age of the patients was 25.25 years.

Table 1: Distribution of samples by gender and Age comparison between Male and Female patients.

Gender	No. of patients	%	Mean Age	Standard deviation
MALE	1	12.5	22.0	0.000
FEMALE	7	87.5	25.71	4.271
TOTAL	8	100	25.25	4.166

All patients in this group responded to the finest filament for light touch before surgery. Seven days following surgery neurosensory alterations were recorded in vermilion border of lower lip and of chin in mucosal sites and cutaneous sites.

By 1 month after surgery all lower lip and chin sites tested identical to preoperative values. Following surgery at 2 months 100% of the lower lip and 100 % of the chin sites responded identically to presurgical values to Light Touch as shown by p value > 0.05.

All lower lip and chin sites responded before surgery for pin prick test. Seven days after surgery all mucosal sites of lower lip and of chin depicted some neurosensory alterations as shown by p value = 0.00. The single deficit was resolved by the 1 month examination. There were no alterations noted on the cutaneous sites as well.
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Preoperatively, Two-point discrimination, was 10mm for the lower lip and 10mm for the chin. A slight increase in Two-point discrimination was noted after surgery. Seven days following surgery neurosensory alterations were recorded in vermilion border of lower lip and of chin in mucosal sites. Progressive improvement in Two-point discrimination was observed during the study period, by 2 months as shown by p value >0.05.

DISCUSSION:

The purpose of this study was a prospective evaluation of the incidence, severity and type of neurosensory deficiency (NSD) in patients who underwent different kinds of surgeries in the maxillofacial region[2].

The absence of significant NSD claimed for this procedure is supported by this study. Reduction in response to light touch, which has been a sensitive marker for NSD in other studies, had a very low incidence (3.4%). Previous studies have revealed that the risk factors include neurosensory damage, compression or decompression injuries during medial periosteal dissection, fixation methods, postoperative swelling or bleeding, patient age, the osteotomy line, and the direction of mandibular and maxillary movement[49] Studies conducted by Gianni et al. and Geha et al.[24,25] concluded that at the end of 1 week and 1 month, the degree of damage to the nerve is influenced by the amount of sensory loss and rate of recovery. Parallel to this, the results of the current study show that, in the vestibular mucosa, on postoperative day 7, sensation scores in all sides were 0 [2].

Neurosensory recovery of the vestibular mucosa increased between days 7 and first month and was relatively late compared with other tested areas. Neurosensory recovery of the upper lip, nose and cheek were significant by day 7. Therefore, the late recovery of the vestibular mucosa could be attributed to the degree of damage.[42] It could be concluded that the distraction of the anterior segment of the maxilla could have affected the results of the neurosensory tests in the present study which are in accordance with studies done by Labanc and Akal et al.[42,34,20]. In the present study, the greatest frequency of NSD was at 1 week postoperatively (35 % of recovery) and it decreased with. On the first post operative day of this study, almost all of the patients had bilateral neurosensory deficit. The subjective assessment was re-evaluated and objective tests were conducted. On the first post operative day, 85% of the patients did not respond to light touch test and the static two point discrimination was 15 mm.

Similarly, pin pressure nociception test was negative for 85% of patients and 25% patients. The return of neurosensory response was seen in all the 15 patients at the end of three months. The neurosensory response returned to the pre surgical situation in almost all the patients by six months, irrespective of type of nerve damage during osteotomy. In a study conducted by L.George Upton, he found recovery of sensitivity in all of his patients within 8 months and neuropraxia was found to be recovered within several days to a week. In our study, 16 patients (66.7%) responded to static light touch test on the first postoperative week. Among these patients, the inferior alveolar nerve was not seen during surgery. At the end of one week 66.7% did not respond to brush directional stroke. Such diminished neurosensory response to brush directional stroke is due to surgical edema and absence of such a response on the first week is not indicative of sensory disorder because of the higher percentage presence of static light touch. At the end of first post op day, 4 patients who responded for light touch also responded for pin pressure nociception test. As per the literature factors that are believed to produce a neurosensory deficit are fixation devices, age of the patient, magnitude of movement of the osteotomised fragments etc.

In this study, the degree of intraoperative nerve manipulation played a vital role in the neurosensory recovery. In all the 15 patients the nerve was not at all seen intraoperatively showed rapid recovery of neurosensory function (ie. within one month).Subjectively they reported tingling sensation in the lower lip and chin on the first postoperative day, which lasted for 3 weeks. At the end of one month, they had absolutely no complaints. Objective analysis correlated with subjective information are given. Light touch (both static and brush directional stroke) test showed positive results and static two point discrimination showed 10 mm in the lower lip and 15 mm in the chin. However, they regained their sensation at various intervals of time. Somatosensory evoked potential was described by Ghali, Jones et al., which is a non-invasive electrophysiological study of the conduction of the nerve impulse along central and peripheral pathways.

CONCLUSION:

There is a high incidence of neurosensory disturbance of the lower lip and chin after subapical mandibular osteotomy; lower eye lid, cheek, upper lip following AMO. The disturbance disappeared completely within one to three months postoperatively in most sites with mild disturbance. All the patients had almost similar pattern of recovery.

Based on this study, we can conclude that neurosensory alterations would occur following AMO and SAO surgery and resolve in 1 month. Hence the risk of this transient complication should not defer the use of AMO and SAO. Some limitations of the current study were small sample size, and the small number and subjectivity of sensory tests used. Further studies with larger samples and different objective neurosensory tests could provide more definitive results regarding the recovery rate of sensory loss following AMO operations.

REFERENCES:

1. Acebal-Bianco F, Vuylsteke PL, Mommaerts MY, De Clercq CA. Perioperative complications in corrective facial orthopedic surgery: a 5-year retrospective study. J Oral Maxillofac Surg 2000;58(7):754–60.
2. Akal UK, Sayan NB, Aydoğan S, Yaman Z. Evaluation of the neurosensory deficiencies of Aoral and maxillofacial region following surgery. Int J Oral Maxillofac Surg. 2000 Oct;29(5):331-6.
3. Baddour HM, Watson J, Erwin BJ: Life-threatening hemorrhage from a Le Fort I osteotomy. J Oral Maxillofac Surg 40:117, 1982.
4. Baek SH, Kim BH. Determinants of successful treatment of bimaxillary protrusion: orthodontic treatment versus anterior segmental osteotomy. J Craniofac Surg 2005;16:234-246 .
5. Bengi O, Gurton U, Okcu KM, Aydıntug YS. Premaxillary distraction osteogenesis with an individual tooth-borne device. Angle Orthod 2004;74:420–31.
6. Bennett AJ, Wastell DG, Barker GR, Blackburn CW, Rood JP. Trigeminal somatosensory evoked potentials: a review of the literature as applicable to oral dysesthesias. Int J Oral Maxillofac Surg 1987;16:408-15.
7. Block MS, Brister GD. Use of distraction osteogenesis for maxillary advancement: preliminary results. J Oral Maxillofac Surg 1994 ;52(3):282-6
8. Bock JJ, Maurer P, Otto C, Fuhrmann RAW, Schubert J. Complications of orthodontic–orthognathic surgery treatment in mentally handicapped patients. J Craniomaxillofac Surg 2006;34(3):156–61.
9. Boye T, Doyle P, McKeown F, Sandler J. Total subapical mandibular osteotomy to correct class 2 division 1 dento-facial deformity. J Craniomaxillofac Surg. 2012 Apr;40(3):238-42.
10. Bradley, W. G.: Disorders of peripheral nerves. Blackwell, Oxford (1975) 150.
11. Campbell RL, Shamaskin RG, Harkins SW. Assessment of recovery from injury to inferior alveolar and mental nerves. Oral Surg Oral Med Oral Pathol. 1987 Nov;64(5):519-26.
12. Chau MN, Jonsson E, Lee KM: Traumatic neuroma following sagittal mandibular osteotomy. Int J Oral Maxillofac Surg 18:95, 1989.
13. Chu YM, Bergeron L, Chen YR. Bimaxillary protrusion: an overview of the surgical-orthodontic treatment. Semin Plast Surg 2009;23:32-39.
14. Chu YM, Po-Hsun Chen R, et al. Surgical approach to the patient with bimaxillary protrusion. Clin Plast Surg 2007;34:535-546 .
15. Cunningham LL, Tiner BD, Clark GM, Bays RA, Keeling SD, Rugh JD. A comparison of questionnaire versus monofilament assessment of neurosensory deficit. J Oral Maxillofac Surg. 1996 Apr;54(4):454-9; discussion 459-60.
16. D'Agostino A, Trevisiol L, Gugole F, Bondí V, Nocini PF. Complications of orthognathic surgery: the inferior alveolar nerve. J Craniofac Surg 2010;21(4):1189–95.
17. de Vries K, Devriese PP, Hovinga J, et al: Facial palsy after sagittal split osteotomies. A survey of 1747 sagittal split osteotomies. J Craniomaxillofac Surg 21:50brustu, 1993.
18. Donoff RB. Nerve regeneration: basic and applied aspects. Crit Rev Oral Biol Med. 1995;6(1):18-24. Review.
19. Essick GK, Austin S, Phillips C, Kiyak HA. Short-term sensory impairment after orthognathic surgery. Oral Maxillofac Surg Clin N Am 2001;13(2):295–313.
20. Farhadieh RD, Nicklin S, Yu Y, Gianoutsos MP, Walsh WR. The role of nerve growth factor and brain-derived neurotrophic factor in inferior alveolar nerve regeneration in distraction osteogenesis. J Craniofac Surg 2003;14:859–65.
21. Francisco LDS, Jaramillo VPM. Complicaciones asociadas con osteotomía Le Fort I. Rev Fac Odontol Univ Antioq 2009;20(2):205–21.
22. Freihofer JR, Hans PM, Petresevic D: Late results after advancing the mandible by sagittal splitting of the rami. J Oral Maxillofac Surg 3:250, 1975.
23. Fridrich KL, Holton TJ, Pansegrau KJ, Buckley MJ. Neurosensory recovery following the mandibular bilateral sagittal split osteotomy. J Oral Maxillofac Surg. 1995 Nov;53(11):1300-6; discussion 1306-7.
24. Geha HJ, Gleizal AM, Nimeskern NJ, Beziat JL. Sensitivity of the inferior lip and chin following mandibular bilateral sagittal split osteotomy using Piezosurgery. Plast Reconstr Surg 2006;118:1598–607.
25. Gianni AB, D'Orto O, Biglioli F, Bozzetti A, Brusati R. Neurosensory alterations of the inferior alveolar and mental nerve after genioplasty alone or associated with sagittal osteotomy of the mandibular ramus. J Craniomaxillofac Surg. 2002 Oct;30(5):295-303.
26. Guerissi J, Stoyanoff J: Atypical Frey syndrome as a complication of Obweseger osteotomy. J Craniofac Surg 9:543, 1998.
27. Hashiba Y, Ueki K, Marukawa K, Shimada M, Yoshida K, Shimizu C, Alam S, Nakagawa K. A comparison of lower lip hypoesthesia measured by trigeminal somatosensory-evoked potential between different types of mandibular osteotomies and fixation. Oral Surg Oral Med Oral Pathol Oral Radiol Endod. 2007 Aug;104(2):177-85.
28. Hegtvedt AK, Zuniga JR: Lingual nerve injury as a complication of rigid fixation of the sagittal ramus osteotomy: Report of a case. J Oral Maxillofac Surg 48:647, 1990.
29. Herna´ndez-Alfaro F, et al. Inferior subapical osteotomy for dentoalveolar decompensation of class III malocclusion in 'surgery-first' and 'surgery-early' orthognathic treatment, Int J Oral Maxillofac Surg (2016).
30. Hernandez-Alfaro F, Guijarro-Martinez R, Molina-Coral A, Badia-Escriche C. Surgery first in bimaxillary orthognathic surgery. J Oral Maxillofac Surg 2011;69:e201–7.
31. Hernandez-Alfaro F, Guijarro-Martinez R, Peiro-Guijarro MA. Surgery first in orthognathic surgery: what have we learned? A comprehensive workflow based on 45 consecutive cases. J Oral Maxillofac Surg 2014;72:376–90.
32. Hernández-Alfaro F, Guijarro-Martínez R. On a definition of the appropriate timing for surgical intervention in orthognathic surgery. Int J Oral Maxillofac Surg. 2014 Jul;43(7):846-55.
33. Horster W. Experience with functionally stable plate osteosynthesis after forward displacement of the upper jaw. J Maxillofac Surg 1980;8:176–81.
34. Hu J, Tang Z, Wang D, Buckley MJ. Changes in the inferior alveolar nerve after mandibular lengthening with different rates of distraction. J Oral Maxillofac Surg 2000; 59:1041–5.
35. Hummes B, Moesch A, Schneider LE, Crusius KC, Lima PVP, Krause RGda S.Complicac¸ ões no tratamento cirúrgico da deficiência transversa do osso maxilar. Stomatos 2008;14(27)
36. Jääskeläinen SK, Peltola JK, Lehtinen R. The mental nerve blink reflex in the sdiagnosis of lesions of the inferior alveolar nerve following orthognathic surgery of the mandible. Br J Oral Maxillofac Surg. 1996 Feb;34(1):87-95.
37. Jones JK, Van Sickels JE. Facial nerve injuries associated with orthognathic surgery: a review of incidence and management. J Oral Maxillofac Surg. 1991 Jul;49(7):740-4.
38. Kannan VS, Narayanan GR, Ahamed AS, Velaven K, Elavarasi E, Danavel C. Anterior maxillary osteotomy: A technical note for superior repositioning: A bird wing segment. J Pharm Bioallied Sci. 2014 Jul;6(Suppl 1):S107-9.
39. Kim JR, Son WS, Lee SG. A retrospective analysis of 20 surgically corrected bimaxillary protrusion patients.Int J Adult Orthod Orthognath Surg 2002;17:23-27.
40. Kim JW, Chin BR, Park HS, Lee SH, Kwon TG. Cranial nerve injury after Le Fort I osteotomy. Int J Oral Maxillofac Surg. 2011 Mar;40(3):327-9.
41. Kobayashi A, Yoshimasu H, Kobayashi J, Amagasa T. Neurosensory alteration in the lower lip and chin area after orthognathic surgery: bilateral sagittal split osteotomy versus inverted L ramus osteotomy. J Oral Maxillofac Surg 2006;64(5):778–84.

42. Labanc JR, Reconstructive microneurosurgery of the trigenimal nerve.Bell WH, editor. Modern practice in orthognathic and reconstructive surgery, vol. II. Philadelphia: W.B. Saunders Company; 1992. p. 108–27.
43. Lee JK, Chung KR, Baek SH. Treatment outcomes of orthodontic treatment, corticotomy-assisted orthodontic treatment, and anterior segmental osteotomy for bimaxillary dentoalveolar protrusion. Plast Reconstr Surg 2007;120:1027-1036.
44. Lundborg G. Nerve injury and repair. Edinburgh: Churchill Livingstone, 1988: 142-143.
45. Macintosh RB: Experience with the sagittal osteotomy of the mandibular ramus: a 13 year review. J Oral Maxillofac Surg 9:151, 1981.
46. Malik S, Singh V, Singh G, Anand SC. Role of Le fort I Osteotomy in orthosurgical management of maxillary deformities in north Indian population. Int J Med and Dent Sci 2014; 3(2):471- 483
47. Morris DE, Lo L-J, Margulis A. Pitfalls in orthognathic surgery: avoidance and management of complications. Clin Plast Surg 2007;34(3): e17–29.
48. Nesari S, Kahnberg K-E, Rasmusson L. Neurosensory function of the inferior alveolar nerve after bilateral sagittal ramus osteotomy: a retrospective study of 68 patients. Int J Oral Maxillofac Surg 2005;34(5):495–8.
49. Newhouse RF, Schow SR, Kraut RA, et al: Life-threatening hemorrhage from a Le Fort I osteotomy. J Oral Maxillofac Surg 40:117, 1982.
50. Nishioka GJ, Mason M, Van Sickels JE. Neurosensory disturbance associated with the anterior mandibular horizontal osteotomy. J Oral Maxillofac Surg. 1988 Feb;46(2):107-10.
51. Panula K, Finne K, Oikarinen K. Incidence of complications and problems related to orthognathic surgery: a review of 655 patients. J Oral Maxillofac Surg 2001;59(10):1128–36.