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RESEARCH

Does mandibular osteotomy affect the infraorbital nerve? a prospective study

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Abstract

Objectives The aim of this study was to evaluate the sensory function of the infraorbital nerve after orthognathic surgery (OS).

Materials and methods Patients who underwent Le Fort I osteotomy with or without BSSO for dentofacial deformity treatment were studied. Two groups were created according to whether BSSO was performed. Class A tests were performed to determine the degree of peripheral nerve damage. The Class B test was performed if decreased sensation was detected in at least one of these tests. A Class C test was performed if abnormal sensation was detected.

Results Twenty-eight patients (n=56) who underwent OS were included in this prospective study. Of the patients, 57.1% were female, 42.9% were male, and the mean age was 24.6 (±3.8). Seven patients were in group 1 (n=14), and 21 patients were in group 2 (n=42). In both groups, there were statistically significant differences between T1 and T2 (p<0.001), and the mean NSD score at T2 was higher than that at T1. The mean NSD score in the single jaw group was higher than that in the double jaw group at all time points.

Conclusions Bimaxillary surgeries had a negative effect on the somatosensory changes that developed in the early period. The upper lip's somatosensorial recovery was faster than IOR and single jaw recovery was faster than double jaw.

Clinical relevance Maxillofacial surgeons performing orthognathic surgery should be aware that in double jaw operations, changes in the somatosensory function of the ION are more severe.

Keywords Infraorbital nerve · Orthognathic surgery · Neurosensorial disorder · Nerve damage

Introduction

Dentofacial deformity correction has been the subject of many systematic investigations due to its effect on stomatognathic function, life quality, aesthetics, and more. The aim of orthognathic surgery is to ensure good aesthetic and functional outcomes for the patient [1, 2]. Although orthognathic surgery is considered safe, it has complications, similar to any other surgical procedure. It can involve many areas, such as the pulmonary or vascular system, or cause pseudoarthrosis, ophthalmological disorders, or infections. Some of these complications are preventable and/or reducible [3, 4].

Neurosensory disorders (NSD) are one of the most common complications of orthognathic surgery. The reason for this is the complex anatomical structure of the head and neck region and the proximity of the nerves to the surgical field [3–5]. Although NSDs frequently involve the inferior alveolar nerve (IAN) and infraorbital nerve (ION), neurologic complications affecting different nerves, such as the lingual, recurrent laryngeal, facial and optic nerves, have also been reported [3–6]. Reportedly, NSDs that develop after orthognathic surgery are usually temporary and quickly resolve within the first 6 weeks, allowing the neurosensory function to return to normal within approximately six to twelve months. However, the recovery rate decreases over time [7].

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The ION passes through maxillary bones and ends in the inferior orbital foramen, just above the Le Fort I osteotomy (LFIO) line. It could be damaged directly and/or indirectly during dissection, retraction, or osteosynthesis plate-screw placement [8, 9].

The aim of this study was to observe the pattern of ION healing in patients who underwent isolated LFIO and combined with bilateral sagittal split osteotomy (BSSO) by investigating it in the early postoperative period at specified time points.

Materials and methods

This prospective study was carried out on patients who underwent orthognathic surgery (LFIO and BSSO) at the Department of Oral and Maxillofacial Surgery for a dentofacial deformity who had class II or III deformity between April 2019 and September 2020. The study was conducted in accordance with the 1964 Helsinki Declaration (İstanbul Medipol University Institutional Review Board and Ethics Committee -Ethical approval no: 183).

Study groups were created by dividing the patients according to the operation type. Group 1 was composed of single jaw (SJ) patients who underwent LFIO patients, and Group 2 was composed of double jaw (DJ) patients who underwent LFIO.

Patients with an ASA status of 3 and above, a history of a NSD/PND in the relevant region, anticoagulant or antiaggregant use, trauma in the maxillofacial region, or revision surgery, who experienced a general anesthesia-related complication that occurred during surgery, underwent multipiece LF1O and were not followed up at specified time points were excluded from the study. Additionally, patients who had previously undergone rhinoplasty, orthognathic surgery, SARPE, and had complex craniofacial syndromes (Treacher Collins syndrome, Crouzon syndrome, etc.) were excluded.

All patients were premedicated in the inpatient clinic and transferred to the operating room. Controlled hypotensive general anesthesia protocol was applied to all the patients in the study. Before the surgical procedure, 1.5 mg per kg of methylprednisolone (Prednol®, Turkey) and 1 g cefazolin sodium (Cezol®, Turkey) were administered intravenously. Half of the preoperative methylprednisolone dose was given by intravenous infusion 8 hours after the preoperative administration. The cefazolin sodium regimen was continued as a 1 gr, 2×1 intravenous infusion in 100 ml saline during the entire hospital stay.

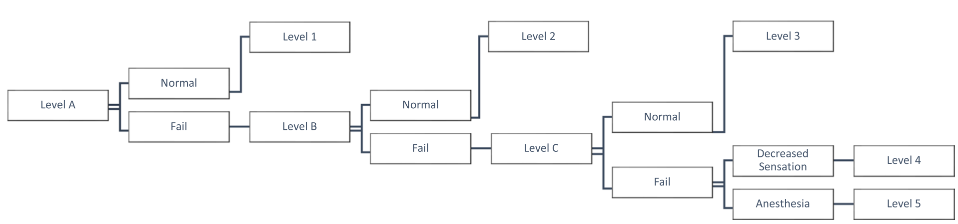
In isolated LF1O and BSSO operations, urinary catheters were not inserted in patients whose surgery was not expected to exceed 3 h. In case of a prolonged operation, a urinary catheter was placed in the patients during the operation. However, in combined operations, the catheter was inserted after general anesthesia while preparing the patient and removed after postoperative mobilization. The same surgical team performed all operations.

For LFIO, a vestibular mucosal incision was performed between the first premolars with a scalpel (no:15). The dissection continued in the superior aspect until the infraorbital foramen was exposed. Posteriorly, pterygomaxillary junction and anteriorly anterior nasal spine and apertura piriformis were exposed. Osteotomy was performed with a reciprocal microsaw from the pterygoid fissure to the apertura piriformis. After down fracture and intermaxillary fixation, osteosynthesis was achieved by four L-shaped miniplate-screw 2.0 systems with 16 screws, (KLS Martin, Germany). For BSSO, the incision was performed from the mesiobuccal aspect of the second molar to the inferior part of the external oblique ridge. With Buccal, superior and medial dissections, the lingula was identified. Obwegeser [10], Dalpont [11], and Hunsuck [12] modification were used in osteotomies with a reciprocal microsaw. Osteosynthesis was achieved by two straight mini-plate with eight screws.

Neurosensory tests (NSTs) were performed on all the patients in a quiet room with a closed door. The tests were performed with the patient in a semi-sitting position with the eyes closed. The tests were performed by the same person who is included as an author of the study, in inpatients before the routine procedures and in outpatients just before any procedure or examination.

The NST algorithm was used, which was described by Zuniga and Essick [13] in 1992 (Table 1), which has three levels. Level A tests were the static two-point discrimination test (2PD), moving brush stroke identification test (MBSI), and stimulus localization test (SL). In level B, the static light touch test (LT) was performed, and in level C, the thermal test (TT) was performed. All tests were performed three times. If a patient failed one of the three tests, level A and level B tests were performed again; however, if a patient failed the level B tests, the level C test was conducted.

Table 1 Neurosensorial test algorithm



NSTs were performed on preoperative day 10 (T0), 6 h after the operation (T1), the first postoperative week (T2), the second postoperative week (T3), the third postoperative week (T4), the first postoperative month (T5), the second postoperative month (T6), and the third postoperative month (T7). The same person conducted all tests.

The NST regions are shown in Fig. 1. The NST algorithms were applied in the same order as the randomized region order. In addition, operation time and intraoperative blood loss were also noted as secondary data.

IBM SPSS software (IBM SPSS Statistics 19, SPSS Inc., an IBM Co., Somers, NY) was used in the calculations. Descriptive analysis was performed to provide information about the general data of the groups. The conformity of the data to the normal distribution was checked with the Shapiro–Wilk test. The Mann–Whitney *U* test was used to test the differences between two independent groups. Freidman's test was used to compare the two dependent variables. The Kruskal–Wallis test was used to compare three or more independent groups. Cases were considered statistically significant when the *P* value was calculated to be less than 0.05.

Results

The study was carried out on 28 patients with 56 (right and left) dentofacial deformities who underwent orthognathic surgery at the Department of Oral and Maxillofacial Surgery; 16 (57.1%) were female, and 12 (42.9%) were male. The age of the patients ranged from 18 to 33 years old, with a mean age of 24.6 (±3.8). The mean operative time was 248.4 minutes (±68.3). The mean and standard deviation of the operation time were 188.6 ± 47 for the SJ group (*n*=14) and 268.4 ± 62.6 for the DJ group (*n*=42).

The mean NST scores of the patients with dentofacial deformities involving the UL and IOR are given in Figs. 2 and 3, respectively. The scores in each group were compared at specified time points, as shown in Table 2. The mean NST score of the DJ patients with dentofacial deformities involving the UL region was higher than that of the SJ patients at T1, T2, T3, and T5, and the difference was statistically

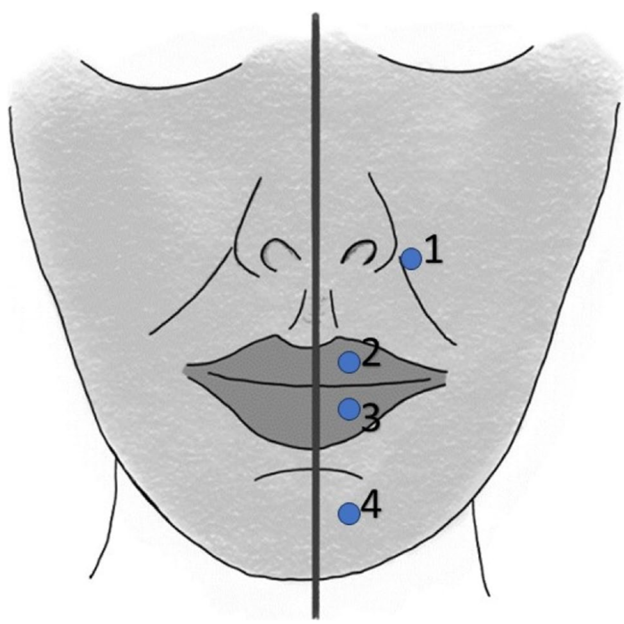


Fig. 1 Neurosensorial test regions, 1. Infraorbital region, 2. Upper lip region, 3 Lower lip region, 4. Mental region

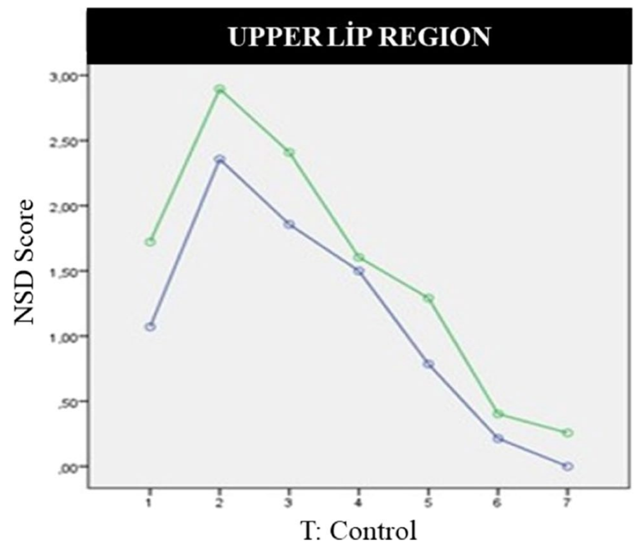


Fig. 2 The mean NST scores of the patients at the specified time points. (Green: DJ, Blue: SJ)

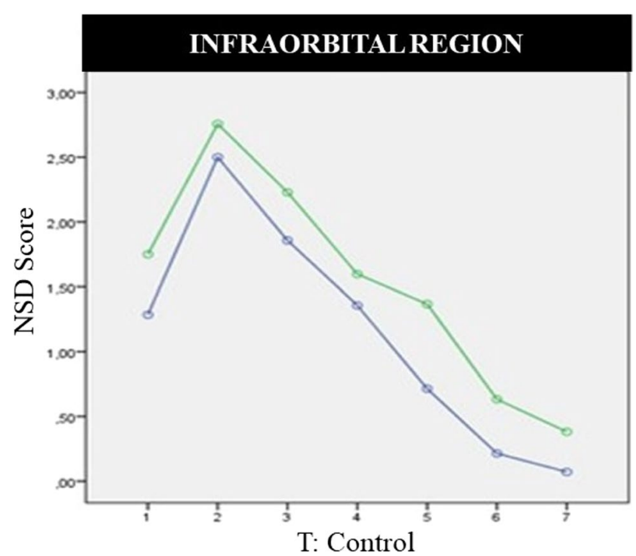


Fig. 3 The NST scores of the groups at each time point. (Green: DJ, Blue: SJ)

Table 2 Statistical analysis of the neurosensorial test scores in each of the groups at the same time point. (UL: Upper Lip, IOR: Infraorbital region)

UL	T1	T2	T3	T4	T5	T6	T7
Asymp. Sig. (2-tailed)	.001	.004	.040	.367	.010	.436	.061
IOR	T1	T2	T3	T4	T5	T6	T7
Asymp. Sig. (2-tailed)	.020	.216	.090	.225	.001	.043	.073

significant (Table 2). The mean NST score of the DJ patients with dentofacial deformities involving the IOR was higher than that of the SJ patients at T1, T5, and T6, and the difference was statistically significant (Table 2).

Table 3 presents the statistical comparison of the NST scores at each time point in the same group. An assessment of the UL and IOR data in Table 3 reveals statistically significant differences between T1 and T2, and the NST scores at T2 were higher than those at T1 in both groups. This is the only instance in which the score increases between time points. Afterward, NST scores decreased with each time point for all the groups.

At T7, all the NST scores of the SJ patients with UL and IOR dentofacial deformities were zero, while 1 and 8 of the DJ patients with an UL deformity had a score of 2 and 1, respectively. Among the DJ patients with IOR deformities, three patients had NST scores of two, and ten patients had a score of 1.

Discussion

There was a decrease in postoperative somatosensory function in almost all the patients who underwent orthognathic surgery. Reportedly, this decrease is usually temporary and function returns to normal between the first postoperative month and the first postoperative year [14]. The aim of this prospective study was to analyze the effect of combined surgical interventions on dentofacial defects involving the ION to obtain more accurate data for further investigations and to obtain data for ION recovery patterns at specified time points. The current study found that NST scores increased between T1 and T2. After T2, the NST scores decreased. Bimaxillary surgery procedures had a more negative effect on the ION than single jaw (LFIO) surgery. Somatosensorial recovery of the IOR was slower than that of the upper lip region, and its NST scores were higher.

Data on somatosensorial function after orthognathic surgery in studies were also quite different. This situation is thought to be related to the variety of tests used [15]. The most commonly used NST in clinical practice is subjective evaluation. In this method, information about the NSD was obtained from the patient's feedback after touching the target area with an object. Although this method is reasonably practical, it is impossible to standardize [16]. However, studies also show that patient-reported symptoms of NSD draw a better picture than clinical NST results. [17]. Zuniga and Essick [13] developed an algorithm for NSD tests, but there were few publications on it due to time restrictions. In this study, these tests were used in combination, and the data were statistically analyzed using these methods [18].

The literature has focused on somatosensory changes in the IAN after orthognathic surgery, and it has been reported that there is not much information about the ION [19]. However, the risk of nerve damage during LFIO is not insignificant. The trigeminal nerve's maxillary branch has the highest risk of sustaining nerve damage during LFIO. Reportedly, NSD may develop in the immediate postoperative period or even several days after the operation, and functional recovery may occur within days or months [20]. It is known that the risk of an ION injury is high during incision, retraction, and osteosynthesis procedures [9, 19, 20]. Based on tactile discrimination and detection measures, Essick et al. [21, 22] described the double-jaw surgery patients experience more significant NSD in the lower face than those who undergo BSSO alone. They explained this unexpected situation with respect to the duration of hypotension as a result of general anesthesia, more excessive movements in double jaw surgery than in isolated BSSO, two separate stages of the double-jaw surgery, and ganglionic changes (indirectly by the injury of the infra-orbital nerve). Tsuboi et al. [23] reported in an animal study that after IAN transection,

Table 3 Statistical analyses of the NST scores at different time points in the same group

UL - SJ						
	T2 - T1	T3 - T1	T4 - T1	T5 - T1	T6 - T1	T7 - T1
Asymp. Sig. (2-tailed)	,000	,000	,003	,021	,000	,000
	T3 - T2	T4 - T2	T5 - T2	T6 - T2	T7 - T2	
Asymp. Sig. (2-tailed)	,000	,000	,000	,000	,000	
	T4 - T3	T5 - T3	T6 - T3	T7 - T3		
Asymp. Sig. (2-tailed)	,002	,000	,000	,000		
	T5 - T4	T6 - T4	T7 - T4			
Asymp. Sig. (2-tailed)	,000	,000	,000			
	T6 - T5	T7 - T5				
Asymp. Sig. (2-tailed)	,000	,000				
	T7 - T6					
Asymp. Sig. (2-tailed)	,014					

IOR - SJ						
	T2 - T1	T3 - T1	T4 - T1	T5 - T1	T6 - T1	T7 - T1
Asymp. Sig. (2-tailed)	,000	,000	,157	,000	,000	,000
	T3 - T2	T4 - T2	T5 - T2	T6 - T2	T7 - T2	
Asymp. Sig. (2-tailed)	,000	,000	,000	,000	,000	
	T4 - T3	T5 - T3	T6 - T3	T7 - T3		
Asymp. Sig. (2-tailed)	,000	,000	,000	,000		
	T5 - T4	T6 - T4	T7 - T4			
Asymp. Sig. (2-tailed)	,000	,000	,000			
	T6 - T5	T7 - T5				
Asymp. Sig. (2-tailed)	,000	,000				
	T7 - T6					
Asymp. Sig. (2-tailed)	,046					

UL - DJ						
	T2 - T1	T3 - T1	T4 - T1	T5 - T1	T6 - T1	T7 - T1
Asymp. Sig. (2-tailed)	,000	,000	,564	,000	,000	,000
	T3 - T2	T4 - T2	T5 - T2	T6 - T2	T7 - T2	
Asymp. Sig. (2-tailed)	,000	,000	,000	,000	,000	
	T4 - T3	T5 - T3	T6 - T3	T7 - T3		
Asymp. Sig. (2-tailed)	,000	,000	,000	,000		
	T5 - T4	T6 - T4	T7 - T4			
Asymp. Sig. (2-tailed)	,000	,000	,000			
	T6 - T5	T7 - T5				
Asymp. Sig. (2-tailed)	,000	,000				
	T7 - T6					
Asymp. Sig. (2-tailed)	,014					

IOR - DJ						
	T2 - T1	T3 - T1	T4 - T1	T5 - T1	T6 - T1	T7 - T1
Asymp. Sig. (2-tailed)	,000	,000	,867	,012	,000	,000
	T3 - T2	T4 - T2	T5 - T2	T6 - T2	T7 - T2	
Asymp. Sig. (2-tailed)	,000	,000	,000	,000	,000	
	T4 - T3	T5 - T3	T6 - T3	T7 - T3		
Asymp. Sig. (2-tailed)	,000	,000	,000	,000		
	T5 - T4	T6 - T4	T7 - T4			
Asymp. Sig. (2-tailed)	,001	,000	,000			
	T6 - T5	T7 - T5				
Asymp. Sig. (2-tailed)	,000	,000				
	T7 - T6					
Asymp. Sig. (2-tailed)	,001					

ION activity changed, and A-fibers were more affected than C fibers. To our knowledge, the current study is the first to examine the effect of BSSO on somatosensory function and ION recovery. The current study found that BSSO has a negative effect on the somatosensorial function and recovery of both the superior lip and infraorbital region. At all time points, the DJ patients' NST scores were higher than those of the SJ patients and their recovery was slower.

Little is known about somatosensory changes in the trigeminal nerve in the early period after orthognathic surgery [24]. The somatosensory function of the lips and IOR decreased between first postoperative day and the first postoperative week. To the authors' knowledge, no similar data could be found in the literature. Postoperative neural edema increased nerve dysfunction by compressing the nerve, which peaked on the fifth postoperative day and completely resolved on the 14th postoperative day. Reportedly, one of the causes of delayed facial paralysis after middle ear surgery is neural edema in the facial nerve, which usually occurs on the second postoperative day [25]. In addition, reperfusion damage may occur in the nerve, and the Haber-Weiss reaction may be observed in the region after ischemia. This could have an additional negative effect on the nerve [26]. It was reported that no study proved the relationship between postoperative edema and NSD in orthognathic surgical patients [27]. However, facial edema instead of neural edema was investigated in studies examining the relationship between edema and NSD [27–29]. This may be one of the reasons for the change between the NST scores at T1 and T2. Further research on this phenomenon is needed. In addition, facial edema could mislead the reliability of NST results in the first postoperative week; nevertheless, edema does not affect somatosensorial deficiency, as mentioned above.

Schultze-Mosgau et al. [30] found that the two-point discrimination test score for upper lip and IOR was lower at T2 than the preoperative value and that the upper lip was less affected than the IOR at this time point. The present study found that the somatosensorial function of the upper lip region recovered faster than that of the IOR. In addition, upper lip NST scores were lower than those of the IOR group at all time points; therefore, indicating that the operation had a lesser effect on the upper lip region.

The limitation of the study was that the possible effect of surgical movements of the jaws was not analyzed statistically, and magnetic resonance neurography could not be used to obtain more objective data. Additionally, it should be noted that the sample size in this study was limited. Furthermore, the study did not differentiate between "maxilla first" and "mandible first" cases with regard to sample size, making this an unexamined variable in the research.

Conclusion

i. In double jaw operations, changes in the somatosensory function of the ION are more severe. Moreover, recovery of its somatosensory function is slower after double jaw operations than after single jaw operations.
ii. Somatosensorial function decreased between the immediate postoperative period (6 h postoperatively) and the first postoperative week.
iii. The somatosensorial function of the upper lip region recovers faster than that of the infraorbital region.
iv. To evaluate nerve damage in orthognathic surgical patients, it is essential to assess the same type of operation. BSSO has a negative effect on infraorbital nerve function and recovery.

Author contribution Abdullah Özel, Muazzez Süzen, Sina Uçkan, and Kıvanç Berke Ak designed the study and wrote the manuscript; Kıvanç Berke Ak performed the experiments and analyzed the data.

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Declarations

This study is a part of Kıvanç Berke Ak's doctoral thesis.

Ethics approval İstanbul Medipol University, 10840098-604.01 .01-E.8224, 27.02.2019

Consent to participate Permission was obtained from all participants.

Consent for publication We consent to the publication of this work.

Conflict of interest The authors declare no competing interests.

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