Original Article - Evaluative Study

Evaluation of Infraorbital Nerve Recovery and its Effect on Quality of Life following Open Reduction and Internal Fixation of Zygomaticomaxillary Complex Fractures – An Evaluative Study

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Abstract

Introduction: The zygomaticomaxillary complex (ZMC) fractures are the second most common fractures affecting the midfacial skeleton. Neurosensory disturbances of the infraorbital nerve are one of the most common signs of ZMC fractures. The aim of the study was to evaluate the neurosensory recovery of the infraorbital nerve and its effect on the quality of life (QoL) following open reduction and internal fixation of ZMC fractures. **Methods:** Thirteen patients clinically and radiologically diagnosed with unilateral ZMC fractures with neurosensory deficits of the infraorbital nerve were enrolled for this study. All patients were assessed presurgically for neurosensory deficits of the infraorbital nerve using the various neurosensory tests, followed by open reduction with two-point fixation under general anaesthesia. The patients were followed up at one, three and six months postoperatively to evaluate the recovery of neurosensory deficits. **Results:** Recovery of tactile and pain sensation was relatively complete in 84.62% and 76.92% of patients respectively by the end of six months postoperatively. The spatial mechanoreception of the affected side improved significantly. 61.54% of patients led an excellent QoL six months postoperatively. **Discussion:** The majority of the patients with ZMC fractures and neurosensory deficits of the infraorbital nerve, when treated with open reduction and internal fixation, have complete recovery of the neurosensory deficits by the end of six months postoperatively. However, some patients may continue to experience some long-term residual deficits, which can affect the patient's QoL.

Keywords: Infraorbital nerve, pain sensation, quality of life, tactile sensation, two-point discrimination

Introduction

The zygomaticomaxillary complex (ZMC) represents one of the most prominent parts of the facial skeleton. ZMC fractures constitute 45% of all mid-facial and 25% of all fractures of the facial skeleton.[1] The dysjunctions at the zygomaticomaxillary and the zygomatico-sphenoidal sutures include the inferior orbital fissure, infraorbital canal, and the infraorbital foramen which inadvertently leads to damage to the infraorbital nerve. The incidence of infraorbital nerve injury following ZMC fracture ranges from 80% to 94%.[2,3] Infraorbital nerve damage can produce neurosensory disturbances such as hyperaesthesia, hypoaesthesia, paraesthesia, or anaesthesia of the structures innervated by the nerve including lower eyelid, cheek, the skin of lateral wall of the nose, upper lip and intraorally, the mucous membrane of the upper lip, cheek, and anterior as well as posterior teeth of the affected side.[4] Healing of these neurosensory disturbances takes place over a period of time. Mild nerve injuries may heal within a period of two months; moderate nerve injuries may heal within a period of one year.[1] It has been reported that mild to moderately displaced fractures of the ZMC result in Sunderland's grade I-II/mild nerve injury of the infraorbital nerve.[2] Benoliel *et al*., conducted a study to investigate the sensory changes in the infraorbital nerve following zygomatico-maxillary complex fractures in which

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they concluded that nerve recovery is faster and better after open reduction and internal fixation (ORIF).[5] It was found that 77.9% of patients showed complete nerve recovery after ORIF.[6] Neurosensory assessment tests can be divided into: Mechanoceptive and nociceptive based on the specific receptors stimulated through cutaneous contact. Mechanoceptive tests are: Two-point discrimination (TPD), static light touch and brush directional stroke. Nociceptive tests are: Pin-prick and thermal discrimination.[7] The primary objective of the present study was to evaluate the neurosensory recovery of infraorbital nerve following ORIF of ZMC fracture. The secondary objective was to evaluate the effects of the neurosensory disturbances on the patients' quality of life (QoL) postoperatively.

Materials and Methods

The present *in vivo* prospective study was conducted in accordance with the Helsinki Declaration of 1975, as revised in 2003 with prior approval of the Hospital Ethics Committee (YEC2/2018/25) and the Institutional Review Board (IRB), from January 2019 to August 2020. Thirteen patients diagnosed with unilateral ZMC fractures, having neurosensory deficits over the distribution of the infraorbital nerve were included. The protocol and study design was explained to all the patients who were included in this study and written informed consent was obtained before commencement of the study. The study was carried out by a single operator/examiner to prevent operator bias.

Inclusion criteria

Patients diagnosed with unilateral ZMC fractures – Rowe and Killey's Classification Type III, IV and V associated with neurosensory deficits of the infraorbital nerve. American Society of Anaesthesiologists (ASA) I and ASA II patients. Patients of 18–60 years of age. Patients willing to participate in the study.

Exclusion criteria

Patients with bilateral ZMC fractures as the contralateral/unaffected side will act as control for the neurosensory assessments. Patients with a previous history of neurosensory deficits of the infraorbital nerve. ASA III and onwards patients as uncontrolled systemic diseases may hamper the neurosensory recovery.

Procedure

Preoperative assessment of the infraorbital neurosensory deficits was performed in relation to the contralateral side which acted as a control. All patients underwent open reduction with two-point fixation at the fronto-zygomatic suture and zygomaticomaxillary buttress under general anaesthesia. Infraorbital nerve was not explored/manipulated. All patients received postsurgical instructions with Tab. Neurobion Forte once daily for 15 days along with analgesics and anti-inflammatory medications. Neurosensory evaluation of the infraorbital nerve was carried out at one, three and six months follow-up postoperatively. Various neurosensory tests were recorded in the innervation area of the infraorbital nerve comprising the skin of the lower eyelid, the skin of the lateral side of the nose, the skin of the cheek and the skin of the upper lip. The various neurosensory tests used were: two-point discrimination test [Figure 1]; tactile test [Figure 2] and pin prick test [Figure 3]. All these tests have been described in Table 1. At each time interval, the patients' QoL was assessed using a QoL questionnaire which was the modified version of the Dystonia Non-Motor Symptoms Questionnaire approved by the IRB.

Statistical analysis

The statistical software namely IBM SPSS Statistics for Windows, Version 23.0. (Released 2015. Armonk, NY: IBM Corp.) was used for the analysis of the data and Microsoft Word and Excel were used to generate the tables. One-way analysis of variance (ANOVA) was used to analyse the results of tactile sensation, pain sensation difference and QoL scores. Repeated-measures ANOVA were used to analyse the results of TPD. The results were considered statistically significant if $P < 0.05$ with power of 80%.

Results

A total of 13 patients (12 male and one female) diagnosed with unilateral ZMC fractures (Rowe and Killey's Classification

Table 1: Neurosensory evaluation tests

Test	Description
TPD test [Figure 1]	Mechanoceptive
	Designed to test for large, myelinated, slowly adapting, Aα sensory nerve fibres
	Geometric metal divider
	The distance between the two tips was gradually increased by 1 mm up to the point at which the patient was able to perceive the two points of the divider, and the distance between the two points was recorded (mm), with the nonaffected side acting as the control group
Tactile test [Figure 2]	Mechanoceptive
	Designed to test for large, myelinated, quickly adapting, Aα and Aβ sensory nerve fibres
	Cotton swab applicator
	The tactile sensation was measured using a scale from 0 to 3, assessing the sensation of the affected side as compared to the nonaffected side; where, 0 is no sensation as compared to nonaffected side and 3 is normal sensation as compared to nonaffected side
Pin prick test [Figure 3]	Nociceptive
	Designed to test for small, myelinated, Aδ and unmyelinated C sensory nerve fibres
	0.25 mm diameter blunted acupuncture needle
	The pain sensation was measured using a VAS scale ranging from 0-10; where 0 is pain free and 10 is unimaginable, unspeakable pain
QoL	QoL questionnaire to be filled by the patient during each follow up visit
	QoL of the patient with the infraorbital nerve injury was evaluated on a score of 0-28, with 0 being excellent QoL and 28 being poor QoL

TPD=Two-point discrimination, QoL=Quality of Life, VAS=Visual analogue scale

Type III, IV and V) associated with neurosensory deficits of the infraorbital nerve were included in the present study. The mean age of the patients in the study was 31.27 ± 12.24, with an age range of 18–56 years. The majority of the patients (38.46%) were in their fourth decade of life. Road traffic accidents was the etiology in all the patients.

Two-point discrimination

At 1-month postoperative follow-up, the difference in the TPD scores was not statistically significant, with only 15.38% ($n = 2$) patients showing complete recovery, indicating that the improvement in the spatial mechanoception on the affected side was not significant as compared to the nonaffected side. The improvement at 3-month and 6-month postoperative follow-up was statistically significant ($P = 0.034$) at each site, with 38.46% ($n = 5$) and 69.23% ($n = 9$) patients showing complete recovery, respectively [Figure 4].

Tactile sensation

The improvement in the tactile sensation scores at 1-month postoperative follow-up was not statistically significant, with only 15.38% ($n = 2$) patients showing complete recovery, indicating the neurosensory deficits of the infraorbital nerve did not improve significantly. The improvement was statistically significant ($P = 0.000$) at the 3-month and 6-month postoperative follow-up, with 53.84% ($n = 7$) and 84.62% ($n = 11$) patients showing complete recovery, respectively [Figure 4].

Pain sensation difference

The decrease in the pain sensation difference scores at 1-month post-operative follow-up was not statistically significant, with only 7.69% ($n = 1$) patients showing complete recovery, indicating that the improvement in the pain sensation on the affected side was not significant as compared to the non-affected side. The improvement at 3-month and 6-month postoperative follow-up was statistically significant at each site ($P = 0.000$), with 38.46% ($n = 5$) and 76.92% ($n = 10$) patients showing complete recovery, respectively [Figure 4].

Quality of life

The decrease in the QoL scores at each time interval was statistically significant ($P = 0.003$), suggesting the improvement in QoL. At 1-month postoperative follow-up, 30.77% ($n = 4$) patients experienced a fair QoL; 30.77% ($n = 4$)

Figure 1: Two-point discrimination test

Figure 3: Pin prick test

Figure 2: Tactile test

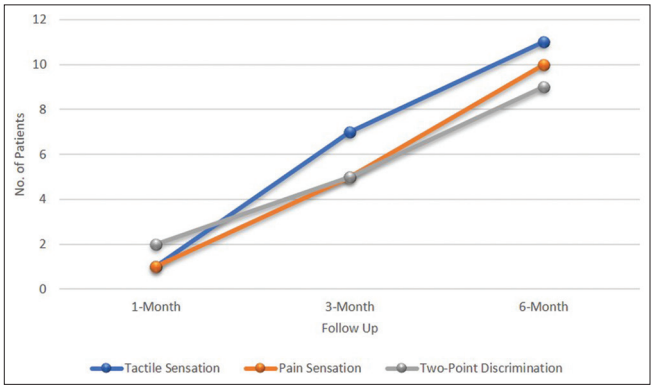

Figure 4: Recovery of patients at each time interval for various neurosensory tests

had a satisfactory QoL; 30.77% (n = 4) had a good QoL; 7.69% (n = 1) had excellent QoL due to neurosensory deficits of the infraorbital nerve. At 3-month postoperative follow-up, improvement in QoL was noted, with 46.15% (n = 6) having satisfactory QoL; 23.08% (n = 3) having good QoL; and 30.77% (n = 4) having excellent QoL. At the end of six months, 61.54% (n = 8) patients had excellent QoL; 15.38% (n = 2) patients had good QoL and 23.08% (n = 3) patients had satisfactory QoL [Figure 5].

Discussion

Maxillofacial fractures account for 13.2% of all the fractures, only next to the lower limb (46.3%) and upper limb (24.7%) fractures.[8,9] The ZMC fractures are the second most common fractures of the mid-facial region.[10] Shin *et al*. studied the incidence of various signs and symptoms associated with mid-face fractures and noted that the incidence of neurosensory deficits of the infraorbital nerve was the second most common symptom (80%), thus, making it one of the typical characteristic clinical features for diagnosis of ZMC fractures.[2]

ORIF is the treatment of choice for mild to moderately displaced ZMC fractures, due to the desired functional and cosmetic outcomes achieved, as well as allowing early return to work after the surgery. De Man and Bax found that 77.9% of patients showed complete nerve recovery after ORIF at the fronto-zygomatic suture and/or zygomaticomaxillary buttress region. They also reported that exploring the infraorbital region might cause further damage to the nerve hampering the recovery.[6] Additionally, Yoon *et al*. stated that primary infraorbital foramen decompression for the ZMC fractures is not essential for the neurosensory recovery of the infraorbital nerve postoperatively.[11] Thus, the surgical management of the patients in the present study was open reduction and two-point fixation (fronto-zygomatic suture and zygomaticomaxillary buttress) without exploration of the nerve. Haapanen *et al*. in a randomized controlled trial concluded that patients who received dexamethasone perioperatively showed better recovery of the neurosensory disturbances of the infraorbital nerve as compared to the control group, however, the results were not statistically significant.[12]

Figure 5: Quality of life of patients at each time interval

The TPD test is a spatial mechanoceptive test, during which the patient is asked whether he/she can discriminate between two points of an instrument, the distance at which the patient can perceive the two points is measured.[5] In the case of neurosensory alterations of the infraorbital nerve, the distance at which the patient can perceive the two points of the instrument is increased. The distance decreases as the nerve recovers. At 1-month postoperative follow-up, the TPD scores on the affected side improved, however, the difference between the TPD of the affected and non-affected side was statistically significant, indicating very mild recovery of the neurosensory deficits of the infraorbital nerve. These results are per those reported by Benoliel *et al*. who noted that improvement in the TPD scores on the affected side was not significant, 1-month postoperatively.[5] However, at the 3-month and 6-month post-operative follow-up, the difference was not statistically significant, suggesting recovery of spatial sensory responses of the patient on the affected side. Similarly, the decrease in the TPD during the follow-ups was statistically significant for all the areas tested. Similar results were reported by Vriens *et al*.; Noor *et al*. and Tabrizi *et al*. which showed a steady but constant decrease in the TPD values in the post-operative period, suggesting neurosensory recovery of the infraorbital nerve.[4,13,14]

The loss of static light touch/tactile sensation is one of the features of neurosensory deficits of the infraorbital nerve following ZMC fractures, which is mainly attributed to damage to the large myelinated Aβ fibres.[5] In the present study, only 15.38% of the patients showed complete recovery of the tactile sensation by one month postoperatively. This is as per the results reported by Ahmed *et al*. who noted that 16.26% of patients showed complete recovery.[15] At 3-month postoperative follow-up, 53.84% of patients of the present study showed complete recovery of the tactile sensation, which is similar to the results reported by Noor *et al*. and Yousuf *et al*. who reported complete recovery in 62.26% and 65.1% of patients, respectively.[4,16] Furthermore, in our study, 84.62% of the patients showed complete recovery of the tactile sensation by the end of six months postoperatively. Vriens *et al*. reported that 93% of patients had complete recovery of tactile sensation six months postoperatively.[13] Das *et al*. also reported that 80%–100% of patients had complete recovery of sensations when subjected to mechanical threshold detection test.[17]

The altered pain detection threshold is due to damage to the small myelinated Aδ and unmyelinated C fibres.[5] The results of the present study suggest that there was no significant improvement in the pain sensation on the affected side as compared to the non-affected side at one month postoperatively, with only 7.69% patients showing complete recovery. Kumar *et al*. reported that the difference of pain sensation between the affected and non-affected side one month postoperatively was statistically significant indicating that the recovery was incomplete.[18] At the third month postoperative follow-up, it was noted that 38.46% patients showed complete recovery of the pain sensation. The results are as per those of Ahmed *et al*. who reported complete recovery of pain detection threshold

in 49.66% at three months postoperatively.[15] However, significant improvement was noted at the sixth month postoperative follow-up, with 76.92% of patients showing complete recovery. Similar results were reported by Das *et al*. which showed complete recovery of pain sensation in 80% of patients, six months postoperatively.[17]

The QoL of patients with neurosensory deficits of the infraorbital nerve has not been evaluated previously. Thus, this study also aimed at assessing the effects of neurosensory deficits of the infraorbital nerve on the patients' daily activities (sleep, speech, mental function, employment, academics, housework, etc.). The results of the present study suggest that majority of the patients (61.54%) had an excellent QoL six months postoperatively, indicating complete neurosensory recovery. Few patients led a good (15.38%) to satisfactory (23.08%) QoL, suggesting that persistent neurosensory deficits may negatively affect the patients' daily activities.

The incidence of long-term deficits has been variably reported as from 10% to 50%.[5] Depending on which modality was examined, we found 15.38%–38.46% of patients continued to experience some residual deficit at six months. It is, however, extremely difficult to compare across studies that have employed diverse methodologies to assess nerve function.

The drawbacks of the present study were the small sample size, short follow-up and long follow-up intervals. The current scenario of neurosensory assessment is limited by the lack of standardisation and real-time objective tests. Thus, further studies with larger sample size, longer follow-up, shorter follow-up intervals and objective tests are required to accurately assess the recovery of neurosensory deficits of the infraorbital nerve.

Conclusion

After analysing the results obtained from our study, it is observed that complete recovery of tactile sensation, pain sensation and spatial mechanoception was observed in the majority of the patients, and patients led an excellent QoL six months postoperatively, however, in some cases, a longer period of recovery may be required. Thus, ORIF of ZMC fractures without infraorbital nerve involvement, exploration may be sufficient for the neurosensory recovery of the nerve.

Declaration of patient consent

The authors certify that they have obtained all appropriate patient consent forms. In the form, the patient(s) has/have given his/her/their consent for his/her/their images and other clinical information to be reported in the journal. The patients understand that their names and initials will not be published and due efforts will be made to conceal their identity, but anonymity cannot be guaranteed.

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Conflicts of interest

There are no conflicts of interest.

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