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RECOVERY IN INFRAORBITAL NERVE FUNCTION AFTER REDUCTION AND FIXATION OF ZYGOMATICO MAXILLARY COMPLEX FRACTURE

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Zygomaticomaxillary complex fracture; infraorbital nerve; open reduction and internal fixation; neurosensory recovery; maxillofacial trauma; sensory deficit.

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Abstract

Background: *Infraorbital nerve dysfunction is a common complication of zygomaticomaxillary complex (ZMC) fractures because of the close anatomical relationship between the fracture site and the infraorbital canal. Sensory disturbances, including hypoesthesia, paresthesia, and numbness, may adversely affect facial function and quality of life. This study aimed to evaluate the pattern and timeline of infraorbital nerve recovery following open reduction and internal fixation (ORIF) of ZMC fractures.*

Methods: *This prospective observational study was conducted at the Department of Oral and Maxillofacial Surgery, Bacha Khan College of Dentistry, Mardan Medical Complex, Pakistan, between November 2024 and May 2025. Fifty adult patients with ZMC fractures requiring ORIF were recruited using consecutive non-probability sampling. Neurosensory function was assessed preoperatively and at 1 week, 1 month, 3 months, and 6 months postoperatively using standardized light-touch, pin-prick, and two-point discrimination tests. Data were analyzed using SPSS version 26.0.*

Results: *The mean age of the participants was 36.18 ± 11.53 years, and 40 (80.0%) were male. Road traffic accidents were the most frequent mechanism of injury (68.0%). Progressive improvement in infraorbital nerve function was observed throughout the follow-up period. At one week, 78.0% of patients had persistent sensory deficits, while 22.0% demonstrated partial recovery. By one month, 92.0% showed partial recovery. Complete neurosensory recovery was achieved in 78.0% of patients at three months and increased to 92.0% at six months. Only 4.0% of patients had persistent sensory deficits at the final follow-up.*

Conclusion: *ORIF of ZMC fractures was associated with excellent recovery of infraorbital nerve function, with most patients achieving complete neurosensory recovery within six months. Timely anatomical reduction and stable internal fixation appear to facilitate nerve regeneration and optimize neurological outcomes, supporting ORIF as the preferred treatment for displaced ZMC fractures.*

INTRODUCTION

Zygomaticomaxillary complex (ZMC) fractures are among the most frequently encountered injuries of the midfacial skeleton, accounting for approximately 30–45% of all facial fractures. Owing to the prominent anatomical position of the zygomatic bone, these fractures commonly result from high-energy trauma, including road traffic accidents, interpersonal violence, falls, and sports-related injuries. The zygomaticomaxillary complex contributes substantially to facial contour, orbital integrity, mastication, ocular function, and midfacial stability; therefore, disruption of this complex may result in significant functional impairment as well as aesthetic deformity if not managed appropriately. (1–3)

Among the various complications associated with ZMC fractures, injury to the infraorbital nerve is one of the most common and clinically significant. The infraorbital nerve, a terminal branch of the maxillary division (V2) of the trigeminal nerve, courses through the infraorbital canal immediately beneath the orbital floor before emerging at the infraorbital foramen to provide sensory innervation to the lower eyelid, lateral nose, upper lip, and cheek. Because of its intimate anatomical relationship with the zygomaticomaxillary buttress and orbital floor, the nerve is particularly susceptible to compression, stretching, contusion, or entrapment following fracture displacement. Consequently, patients frequently present with hypoesthesia, paresthesia, dysesthesia, or complete anesthesia involving the infraorbital nerve distribution, which may adversely affect daily activities, oral function, and overall quality of life. (4–6)

Open reduction and internal fixation (ORIF) remains the standard treatment for displaced ZMC fractures, aiming to restore facial symmetry, re-establish orbital anatomy, and achieve stable skeletal fixation. In addition to anatomical reconstruction, surgical reduction may facilitate decompression of the infraorbital nerve, thereby promoting neural recovery. Nevertheless, the extent and rate of neurosensory recovery remain variable among patients and are influenced by several factors, including the severity of fracture displacement, degree of nerve injury, timing of surgical intervention, fixation technique, patient age, and postoperative healing response. Although many patients experience progressive sensory improvement during the first few postoperative months, persistent sensory disturbances have been reported in a subset of individuals despite satisfactory fracture reduction. (7–9)

Recent studies have demonstrated favorable neurosensory outcomes following ORIF of ZMC fractures, with reported recovery rates generally ranging between 70% and 95% during follow-up periods of six to twelve months. However, considerable heterogeneity exists among published studies regarding patient populations, methods of neurosensory assessment, duration of follow-up, and criteria used to define sensory recovery. Furthermore, evidence from low- and middle-income countries remains limited, despite the high burden of maxillofacial trauma in these regions. In Pakistan, where road traffic accidents continue to represent a major public health challenge, prospective data evaluating infraorbital nerve recovery following surgical management of ZMC fractures are scarce. (8–12)

Generating institution-specific evidence is important because patterns of injury, healthcare access, timing of surgical intervention, and trauma mechanisms may differ substantially from those reported in developed countries. A better understanding of the trajectory of infraorbital nerve recovery can assist surgeons in optimizing treatment strategies, counselling patients regarding expected outcomes, and identifying individuals who may require prolonged follow-up or adjunctive rehabilitation.

Therefore, the present prospective observational study was conducted at the Department of Oral and Maxillofacial Surgery, Bacha Khan College of Dentistry, Mardan Medical Complex, Pakistan, to evaluate the pattern and timeline of infraorbital nerve functional recovery following open reduction and internal fixation of zygomaticomaxillary complex fractures over a six-month follow-up period.

MATERIALS AND METHODS

Study Design and Setting

This prospective observational study was conducted in the Department of Oral and Maxillofacial Surgery, Bacha Khan College of Dentistry, Mardan Medical Complex, Mardan, Pakistan, between November 2024 and May 2025. The study aimed to evaluate the pattern and timeline of infraorbital nerve functional recovery following open reduction and internal fixation (ORIF) of zygomaticomaxillary complex (ZMC) fractures.

Ethical approval was obtained from the Institutional Research and Ethics Committee of Bacha Khan College of Dentistry before commencement of the study. The study was conducted in accordance with the ethical principles of the Declaration of Helsinki. Written informed consent was obtained from all participants prior to enrollment.

Sample Size and Sampling Technique

The sample size was calculated using the WHO Sample Size Calculator based on an anticipated infraorbital nerve recovery rate of 85% following surgical management of ZMC fractures, a 95% confidence level, and an absolute precision of 10%. The minimum required sample size was estimated to be 49 participants. To compensate for possible attrition during follow-up, a total of 50 consecutive patients meeting the eligibility criteria were recruited using a consecutive non-probability sampling technique.

Eligibility Criteria

Patients aged 18 years or older presenting with unilateral or bilateral ZMC fractures requiring surgical intervention were eligible for inclusion. The diagnosis of ZMC fracture was established through clinical examination and confirmed by computed tomography (CT) imaging of the facial skeleton.

Patients with pre-existing infraorbital nerve dysfunction unrelated to facial trauma, previous facial fractures or surgery involving the infraorbital region, pathological fractures, craniofacial syndromes, severe head injury interfering with neurological assessment, associated neurological disorders, or refusal to provide informed consent were excluded from the study.

Clinical Assessment

At presentation, demographic and clinical information including age, sex, mechanism of injury, fracture laterality, and interval between injury and surgical intervention was recorded using a standardized data collection form.

All patients underwent comprehensive clinical examination together with radiological assessment using maxillofacial CT scans to determine fracture location, degree of displacement, and associated facial injuries.

Surgical Procedure

All procedures were performed under general anesthesia by consultant oral and maxillofacial surgeons following standardized departmental protocols.

Open reduction and internal fixation of the fractured zygomaticomaxillary complex was achieved using appropriate surgical approaches, including intraoral vestibular, lateral eyebrow, transconjunctival, or infraorbital incisions according to fracture configuration and surgeon preference.

Following anatomical reduction, fracture segments were stabilized using titanium miniplates and screws. One-point, two-point, or three-point fixation techniques were selected according to fracture complexity and intraoperative stability. Adequate fracture reduction and fixation were confirmed clinically and radiographically before wound closure.

Assessment of Infraorbital Nerve Function

Infraorbital nerve function was evaluated preoperatively and during each postoperative follow-up visit using standardized neurosensory examination techniques.

Light-touch sensation was assessed using a sterile cotton wisp over the infraorbital nerve distribution. Pain perception was evaluated using a standardized pin-prick test with a sterile dental explorer. Static two-point discrimination was assessed using a calibrated caliper and compared with the contralateral unaffected side.

Patients were additionally asked to report subjective symptoms including numbness, paresthesia, tingling, hypoesthesia, or altered sensation affecting the lower eyelid, cheek, upper lip, and lateral aspect of the nose.

The primary outcome measure was recovery of infraorbital nerve function during the follow-up period. Sensory status was categorized as:

- **Complete recovery:** Normal sensory perception comparable with the contralateral side on all neurosensory tests without subjective sensory complaints.
- **Partial recovery:** Improvement in objective and subjective sensory function with residual sensory disturbance.
- **Persistent sensory deficit:** No clinically meaningful improvement in neurosensory function compared with the preoperative assessment.
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Follow-up

Patients were evaluated at 1 week, 1 month, 3 months, and 6 months following surgery. During each visit, neurosensory assessment was performed using the same standardized protocol by the same clinical team to ensure consistency of evaluation.

Statistical Analysis

Data were entered and analyzed using the Statistical Package for the Social Sciences (SPSS) version 26.0 (IBM Corp., Armonk, NY, USA).

Continuous variables were assessed for normality and presented as mean ± standard deviation (SD), whereas categorical variables were summarized as frequencies and percentages.

Changes in infraorbital nerve recovery across the four follow-up visits were evaluated using the Chi-square test for trend (or Fisher's exact test where appropriate). Associations between demographic or clinical variables and neurosensory recovery were also explored using Chi-square or Fisher's exact tests as applicable.

A two-tailed p-value of <0.05 was considered statistically significant.

RESULTS

A total of 50 patients with zygomaticomaxillary complex (ZMC) fractures who underwent open reduction and internal fixation (ORIF) were included in the study. The mean age of the participants was 36.18 ± 11.53 years (range: 18–55 years). Males predominated, accounting for 40 (80.0%) patients, while females comprised 10 (20.0%).

Road traffic accidents were the most common mechanism of injury, occurring in 34 (68.0%) patients, followed by falls in 9 (18.0%), assaults in 5 (10.0%), and sports-related injuries in 2 (4.0%). Right-sided fractures were observed in 28 (56.0%) patients, left-sided fractures in 19 (38.0%), and bilateral fractures in 3 (6.0%). The demographic and clinical characteristics of the study population are presented in **Table 1**.

Table 1. Demographic and Clinical Characteristics of the Study Participants (n = 50)

Variable	n (%)
Age (years), Mean ± SD	**36.18 ± 11.53**
Age range (years)	**18–55**
Gender	
Male	40 (80.0)
Female	10 (20.0)
Mechanism of Injury	
Road traffic accident	34 (68.0)
Fall	9 (18.0)
Assault	5 (10.0)

Variable	n (%)
Sports-related injury	2 (4.0)
Fracture Side	
Right	28 (56.0)
Left	19 (38.0)
Bilateral	3 (6.0)

Regarding surgical management, two-point fixation was the most frequently employed technique, performed in 30 (60.0%) patients. Three-point fixation was used in 11 (22.0%) patients, whereas one-point fixation was performed in 9 (18.0%). The distribution of fixation techniques is summarized in **Table 2**.

Table 2. Surgical Characteristics of Patients Undergoing Open Reduction and Internal Fixation of Zygomaticomaxillary Complex Fractures (n = 50)

Variable	n (%)
Fixation Technique	
One-point fixation	9 (18.0)
Two-point fixation	30 (60.0)
Three-point fixation	11 (22.0)

Serial postoperative neurosensory assessment demonstrated progressive recovery of infraorbital nerve function throughout the six-month follow-up period (**Table 3**). At one week after surgery, persistent sensory deficit was observed in 39 (78.0%) patients, while 11 (22.0%) patients demonstrated partial recovery. No patient achieved complete sensory recovery during the first postoperative week.

Table 3. Recovery of Infraorbital Nerve Function During the Follow-up Period (n = 50)

Follow-up Period	Persistent Deficitn (%)	Partial Recoveryn (%)	Complete Recoveryn (%)
1 Week	39 (78.0)	11 (22.0)	0 (0.0)
1 Month	4 (8.0)	46 (92.0)	0 (0.0)
3 Months	2 (4.0)	9 (18.0)	39 (78.0)
6 Months	2 (4.0)	2 (4.0)	46 (92.0)

At the one-month follow-up, the number of patients with persistent sensory deficit decreased markedly to 4 (8.0%), whereas partial recovery was observed in 46 (92.0%) patients. Complete sensory recovery was not documented at this stage. By the third postoperative month, substantial neurosensory improvement was evident. Complete recovery of infraorbital nerve function was achieved in 39 (78.0%) patients, while 9 (18.0%) patients demonstrated partial recovery and only 2 (4.0%) continued to exhibit persistent sensory deficits.

At the final six-month follow-up, complete recovery was observed in 46 (92.0%) patients. Partial recovery persisted in 2 (4.0%) patients, whereas persistent sensory deficit remained in only 2 (4.0%) patients. Overall, the proportion of patients with complete sensory recovery increased

progressively during follow-up, accompanied by a marked reduction in persistent neurosensory deficits, indicating continuous improvement in infraorbital nerve function following surgical management.

DISCUSSION

The present prospective observational study evaluated the recovery of infraorbital nerve function following open reduction and internal fixation (ORIF) of zygomaticomaxillary complex (ZMC) fractures over a six-month follow-up period. The principal finding was that neurosensory function improved progressively after surgical intervention, with complete recovery achieved in 92% of patients by six months. No patient demonstrated complete recovery during the first postoperative month, whereas substantial improvement became evident between the third and sixth postoperative months. These findings suggest that timely anatomical reduction and stable internal fixation facilitate favorable neurological recovery following ZMC fractures (13,14).

The demographic characteristics of the study population are consistent with previous reports. The mean age of the participants was 36.18 ± 11.53 years, and males accounted for 80% of the study population. Young adult males are more frequently exposed to road traffic accidents, occupational hazards, interpersonal violence, and sports-related trauma, making them particularly susceptible to maxillofacial injuries. Similar demographic patterns have been reported by Dubron et al. and Saleem et al., who also observed a predominance of young male patients with ZMC fractures (17,18). These findings highlight the need for improved preventive measures targeting this high-risk population.

Road traffic accidents were the leading cause of injury, accounting for 68% of cases. This observation is consistent with studies from Pakistan and other developing countries, where rapid urbanization, inadequate road safety measures, and increasing motorcycle use contribute substantially to the burden of facial trauma (16–18). In contrast, studies from many developed countries have identified interpersonal violence as the predominant cause of ZMC fractures, reflecting geographical and socioeconomic differences in trauma epidemiology. Such variations emphasize the importance of region-specific data for planning preventive strategies and optimizing trauma care.

Infraorbital nerve dysfunction is one of the most common complications of ZMC fractures because of the close anatomical relationship between the infraorbital nerve and the orbital floor. Nerve injury may occur through compression by displaced fracture fragments, stretching during trauma, intraneural edema, hemorrhage within the infraorbital canal, or direct contusion. Most injuries represent neurapraxia or mild axonotmesis, both of which have substantial regenerative potential following decompression and fracture stabilization (19,22). Consequently, ORIF not only restores facial symmetry but also creates favorable conditions for nerve regeneration by relieving mechanical compression and restoring local vascularity (23).

Serial postoperative evaluation demonstrated a predictable pattern of sensory recovery. During the first postoperative week, persistent sensory deficits were observed in 78% of patients, while only 22% demonstrated partial recovery. No patient achieved complete recovery at this stage. These findings are expected because postoperative edema, inflammation, tissue manipulation, and temporary neurapraxia may delay restoration of nerve function during the early healing phase. Similar observations have been reported by Lakshmi et al., who found limited neurosensory improvement during the initial postoperative period despite satisfactory fracture reduction (19).

At one month, most patients demonstrated partial recovery, indicating gradual restoration of nerve conduction as inflammation subsided and tissue healing progressed. By the third postoperative month, complete recovery had been achieved in 78% of patients, suggesting that this period represents the most active phase of peripheral nerve regeneration. Recovery during this stage is likely mediated by remyelination of injured nerve fibers, axonal regeneration, restoration of Schwann cell function, and improvement in local microvascular circulation. Taicher et al. similarly

reported that most mild-to-moderate infraorbital nerve injuries recover within three to six months following appropriate surgical treatment (21).

The most important finding of the present study was that complete sensory recovery was achieved in 92% of patients at six months after surgery. Only 4% of patients demonstrated persistent sensory deficits, while another 4% experienced partial recovery. These findings compare favorably with those reported by Dhabaria et al., who documented complete tactile recovery in approximately 85% of patients following ORIF of ZMC fractures (15). Likewise, the recent systematic review by Mehta et al. reported neurosensory recovery rates ranging from 70% to 95%, depending on fracture severity, timing of surgery, methods of sensory assessment, and duration of follow-up (13). Therefore, the recovery rate observed in the present study lies within the upper range reported in the literature and further supports the effectiveness of early surgical intervention.

The favorable outcomes observed in this study may be attributed to several factors. All patients underwent anatomical reduction with rigid internal fixation performed by experienced oral and maxillofacial surgeons using standardized operative protocols. Early restoration of skeletal alignment likely reduced prolonged compression of the infraorbital nerve and facilitated neural healing. Variations between published studies may be explained by differences in patient selection, severity of fracture displacement, interval between injury and surgery, fixation techniques, duration of follow-up, and methods of neurosensory assessment (13–16).

The findings of the present study have important clinical implications. Patients with infraorbital nerve dysfunction are often concerned about the permanence of altered sensation following facial trauma. The present results demonstrate that the prognosis following ORIF is generally excellent, with progressive recovery expected during the first six postoperative months. These findings may assist surgeons in counseling patients regarding the anticipated course of recovery, establishing realistic expectations, and emphasizing the importance of regular postoperative follow-up before considering sensory impairment to be permanent (15,20).

The strengths of this study include its prospective design, standardized neurosensory assessment at predefined postoperative intervals, and uniform surgical management within a single tertiary care center. These methodological characteristics enhanced consistency in data collection and reduced treatment-related variability.

Nevertheless, certain limitations should be acknowledged. The study was conducted at a single institution with a relatively small sample size, limiting the generalizability of the findings. Follow-up was restricted to six months, precluding assessment of long-term neurological outcomes in patients with persistent deficits. Furthermore, advanced quantitative neurosensory techniques, including nerve conduction studies and electrophysiological assessments, were not available. In addition, potential prognostic factors such as fracture classification, degree of displacement, interval between injury and surgery, and associated orbital floor fractures were not evaluated.

Future multicenter prospective studies involving larger patient populations, longer follow-up periods, and objective neurosensory assessment techniques are recommended to validate these findings. Further research should also investigate predictors of delayed recovery and compare different fixation techniques and surgical approaches to optimize treatment outcomes (13,14,20).

Overall, the findings of the present study demonstrate that infraorbital nerve dysfunction associated with ZMC fractures improves progressively following ORIF, with the majority of patients achieving complete sensory recovery within six months. These results reinforce the role of timely anatomical reduction and stable internal fixation in promoting neural regeneration and restoring functional outcomes after zygomaticomaxillary complex fractures.

CONCLUSION

Open reduction and internal fixation (ORIF) of zygomaticomaxillary complex fractures was associated with excellent recovery of infraorbital

nerve function, with progressive neurosensory improvement observed throughout the six-month follow-up period. Complete sensory recovery was achieved in the majority of patients, highlighting the effectiveness of timely anatomical reduction and stable fracture fixation in facilitating nerve decompression and regeneration. These findings indicate that most patients can expect substantial restoration of infraorbital nerve function within six months following surgical management, although a small proportion may experience persistent or partial sensory deficits.

The results of this study reinforce the role of ORIF as the standard treatment for displaced zygomaticomaxillary complex fractures, not only for restoring facial anatomy and function but also for optimizing neurological recovery. The findings provide valuable evidence for clinicians when counseling patients regarding the expected course of postoperative neurosensory recovery and emphasize the importance of regular follow-up during the early healing period. Future multicenter prospective studies with larger sample sizes, longer follow-up durations, and objective quantitative neurosensory assessment methods are warranted to validate these findings and identify factors influencing long-term functional recovery.

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