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REVIEW ARTICLE

EVALUATION OF NEUROSENSORY RECOVERY IN INFRAORBITAL AND INFERIOR ALVEOLAR NERVE IMPAIRMENTS AFTER MAXILLOFACIAL FRACTURES: A SYSTEMATIC REVIEW

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Abstract

Background and aims: FSR has a substantial impact on patients' quality of life, but it is yet unknown how age, gender, repair timing, and surgical methods affect this. Optimizing surgical methods and enhancing clinical results depend on closing this knowledge gap. By looking at these factors, this study aims to offer evidence-based recommendations to direct patient treatment and improve recuperation techniques. Assessing the results of sensory neurological recovery in individuals with impairments in the inferior alveolar nerve (IAN) and infraorbital nerve (ION) after mandibular and zygomatico-maxillary complex (ZMC) fractures was the goal of this investigation.
Methods: The PRISMA (Preferred Reporting Items for Systematic reviews and Meta-Analyses) criteria were followed in conducting a systematic review. Age, sex, time from damage to repair, and repair method were prognostic factors. All reviews, animal studies, research papers published before 2014, and those without full-text access were excluded. On February 25, 2025, electronic searches were conducted in the Cochrane Library, PubMed, and Scopus databases.
Results: The analysis included a comprehensive dataset of 3491 patients, with a mean age of 34.25 years. The primary causes of fractures were traffic accidents (58.65 %), falls (20.56%), and assaults (20.79%). Treatment methods included open reduction (72.70%), closed reduction (7.27%), and conservative treatment (20.03%). Recovery outcomes indicated an overall recovery rate of 73.23%, with a mean follow-up duration of 186.5 days. The results were equal in both sexes, with higher rates in open reduction and early inferior alveolar nerve (IAN) repair.
Conclusions: Recovery outcomes indicated a high recovery rate, equally observed in both sexes, with higher rates for open reduction and early inferior alveolar nerve repair. The study emphasizes the critical role of treatment modalities and timing in influencing neurosensory recovery and calls for the adoption of standardized treatment protocols and expanded follow-up care. To validate these results and enhance clinical guidelines, more excellent research is required.
Keywords: Functional Sensory Recovery (FSR), Inferior Alveolar Nerve (IAN); Infraorbital Nerve (ION), maxillofacial fractures, neurosensory recovery.

INTRODUCTION

Facial fractures, particularly those involving the zygomatico maxillary complex (ZMC) and mandible, often result in significant sensorineural deficits affecting the infraorbital nerve (ION) and inferior alveolar nerve (IAN). The ION, a continuation of the maxillary nerve (V2) and a branch of the trigeminal nerve (CN V), innervates the lower eyelid, side of the nose, upper lip, and part of the cheek[1]. Damage to the IAN can result in numbness, loss of sensation, and pain in these areas, significantly impacting quality of life[2]. The inferior alveolar nerve, which arises from the mandibular nerve (V3), provides sensory innervation to the mandibular teeth and branches into the mental nerve, supplying the lower lip and chin[3]. Injury to the IAN can result in sensory deficits affecting mastication and speech and may also cause neuralgia or trigeminal neuralgia[4]. The main causes of zygomatic, ocular, and mandibular fractures include falls, assaults, sports injuries, and traffic accidents (RTAs). RTAs are the most frequent cause of face fractures, accounting for over 59% of all cases[5,6]. About 21% of the cases are caused by assaults and falls, which emphasize the necessity of focused preventative actions in road safety and violence reduction[7-10]. With a mean age of 34 years and a standard deviation of about 9.6 years, the demographic data point to a comparatively youthful patient group with a modest age range.

The relevance of treatment methods has been highlighted by recent research that has demonstrated diversity in neurosensory outcomes after surgical repairs of zygomatic fractures. Although persistent neuropathic pain was uncommon, there has been documented evidence of significant improvement in infraorbital nerve function with plate fixation as compared to reductions without fixation, with notable improvements by the 6 months mark[2]. It has been shown that 37% of patients had persistent sensory problems, especially in C-type fractures that need more secondary repairs[11]. Neurosensory function was significantly improved by photobiomodulation treatment, particularly in two point discrimination and visual analog scale evaluations[12]. It has also been shown that open reduction and internal fixation, as opposed to indirect or no surgical procedures, improve neurosensory deficit recovery[13].

On the other hand, when dexamethasone was taken preoperatively, there was no discernible difference in the incidence of neurosensory disturbances between the treated and control groups at 6 months[14]. According to these results, preoperative dexa-methasone administration has no positive effects, however plate fixation and other therapies like photo-biomodulation may improve sensory recovery. The long-term sensory results of individuals with zygomatic fractures are significantly influenced by the surgical approach used. Likewise, studies show that the timing of surgery has a major effect on neurosensory outcomes after orbital fractures. Better results, including fewer instances of postoperative sequelae including diplopia, enophthalmos, and infraorbital nerve hypesthesia, are routinely obtained with early management, usually within two weeks after the injury[15-18].

Studies on mandibular fractures show variation in neurosensory results according to patient characteristics, surgery time, and fracture features. Although body fractures had a greater risk of problems, there was no discernible relationship between the timing of surgery after an accident and the rate of complications[19]. According to reports, most patients experienced immediate post-traumatic neurosensory impairments that healed with time, with better results for fractures that were less displaced[3]. Even though earlier repairs often had better results, the time to surgical repair had no discernible effect on complication rates[4]. Neurosensory degradation after surgery has been found to be significantly predicted by fracture displacement, surgical expertise, and fixation techniques[20]. Age and smoking status were two patient-related characteristics that had a substantial impact on postoperative complications and the requirement for reoperation[21]. The purpose of this study was to evaluate the outcomes of sensory neurological recovery in patients who had mandibular and zygomatico maxillary complex fractures and impairments in the inferior alveolar nerve (IAN) and infraorbital nerve (ION).

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METHODS

Study design: Our study is based on a systematic review and meta-analysis to evaluate neurosensory recovery in cases of infraorbital and inferior alveolar nerve impairment following maxillofacial fractures (zygomatico-maxillary complex, orbital bones, and mandible). The methodology was designed to comprehensively synthesize the available literature, assess study quality, and quantitatively analyze the data to extract conclusive insights.

Data sources and search strategy

Studies published between January 2014 and June 2024 were included in a comprehensive literature search that was carried out across many databases, including PubMed and the Cochrane Library. The search involved the following keywords: “neurosensory recovery”, “infraorbital nerve”, “inferior alveolar nerve”, “maxillofacial injuries”, “zygomatico-maxillary complex fractures”, “orbital fractures”, “mandibular fractures”, “sensory deficits”, along with “neurosensory testing”. To further restrict the search results, boolean operators (AND and OR) were applied. To find other research, the reference lists of pertinent papers were also manually searched.

Inclusion criteria

Inclusion criteria included studies that included patients with maxillofacial fractures (ZMC fractures, orbital fractures, and mandibular fractures) treated with open, closed, or conservative treatment. They assessed neurosensory recovery of the infraorbital and inferior alveolar nerves during the follow-up period. Fracture locations, treatment types, etc. were specified. Prospective and retrospective cohort studies, randomized controlled trials, and other studies involving more than ten patients were included. Studies that assessed neurosensory function using standardized tests such as the Zúñiga-Ésic algorithm, two-point discrimination, and visual analog scale (VAS) were also included. All studies were published in English.

Exclusion criteria

Exclusion criteria included serial studies, case reports, studies with sample sizes less than ten patients, animal studies, in vitro studies, studies lacking sufficient data on neurosensory outcomes, and non-English publications.

Data extraction

Using a standardized data extraction form, two reviewers independently extracted the data. The extracted data included:

Study characteristics

Patient demographics (e.g., age and gender), causes of injury (e.g., traffic accidents, falls, assaults), treatment types (e.g., open reduction and internal fixation, closed reduction, conservative treatment), neuro-sensory assessment methods, recovery outcomes (e.g., complete recovery, non-recovery), and follow-up duration were collected and analyzed.

Ethical considerations

There was no need for ethical approval because this study was a systematic assessment of earlier research. To guarantee openness and reproducibility, PRISMA (Preferred Reporting Items for Systematic Reviews and Meta-Analyses) guidelines were followed when conducting the review.

RESULTS

Study selection

A total of 263 studies were identified through database searches. After removing duplicate studies, the total number of studies screened was 255.

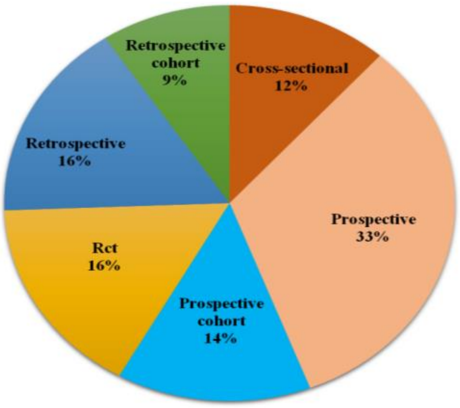

Figure 1: Types of studies that met inclusion criteria for meta-analysis.

Of these, 210 studies were excluded based on their titles and abstracts, with an additional 30 studies included after manual bibliography searches and 75 full-text articles assessed for eligibility. Ultimately, 27 studies[1-4,10-34] met the inclusion criteria for meta-analysis.

Studies analysis: Our systematic review included 43 studies, involving 4,461 patients (ION=2,337, IAN=2,124). Of these, 23 studies addressed infra-orbital nerve (ION) recovery, while 20 addressed inferior alveolar nerve (IAN) recovery. Studies varied in their methodologies. The median follow-up time for patients was approximately 211 days, providing an overview of the follow-up duration across all registries. The median follow-up time for patients was 120 days, indicating that half of the patients had 120 days or less of follow-up, which represents a baseline measure of follow up duration.

Meta-regression results indicate a relationship between recovery rate and several predictors: A positive and statistically significant coefficient (0.2625, *p*=0.017) indicates that a higher number of male patients are associated with improved recovery outcomes.

Table 1: Gender distribution, fracture etiology, treatment types and outcomes of infraorbital nerve (ION) and inferior alveolar nerve (IAN) recovery among patients with maxillofacial fractures.

Characters	Number (%)
Sex	
Males	3413 (76.5)
Female	991 (23.5)
Causes of fractures	
RTA (Road Traffic Accident	1407 (31.5)
Fall	443 (9.9)
Assault	457 (10.2)
Not mention	2154 (48.3)
Treatment Type	
Open reduction treatments	3416 (76.6)
Closed reduction treatments	409 (9.2)
Conservative treatments	636 (14.3)
Outcomes	
Recoveries	3356 (75.23)
Unrecovered	1105 (24.77)
Total	4461 (100)

However, for females, this variable shows a positive, albeit non-statistically significant, relationship with recovery outcomes. For open reduction, a positive and statistically significant effect (0.2424, *p*=0.000) indicates that this type of treatment is strongly associated with improved recovery outcomes. For closed reduction, this coefficient is not statistically significant, indicating a limited association with recovery outcomes. Conservative treatment has a negative and statistically significant association (-0.5963, *p*=0.000), suggesting that it may be less effective in promoting recovery. The model explains approximately 73% of the variance in recovery outcomes (R-squared=0.730), making it reasonably predictive of the selected variables.

The regression results provide insights into the factors that may influence recovery in conservative treatment settings: For male patients, the results indicate a positive coefficient (4.497, *p*=0.058), suggesting that a higher number of male patients may be associated with increased recovery, although this result is only slightly statistically significant. For female patients, the results show a negative correlation (-7.793, *p*=0.070), suggesting that a higher number of female patients may be associated with poorer recovery outcomes under conservative treatment. As for the causes of injury, traffic accidents had a negative impact on recovery (-3.331, *p*=0.115), although the result was not statistically significant. For falls, the results showed a positive coefficient (6.331, *p*=0.085), suggesting that falls may have a positive effect on recovery, but with marginal significance.

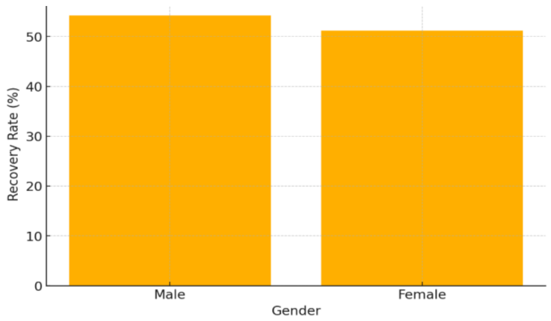

Figure 2: Recovery rates by gender.

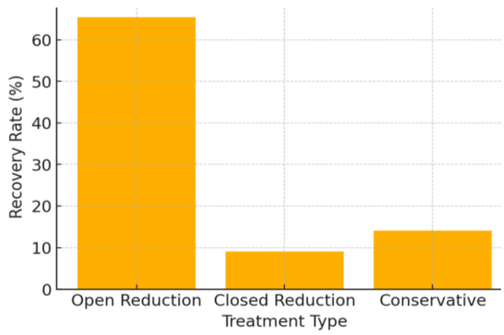

Figure 3: Recovery rates by treatment type.

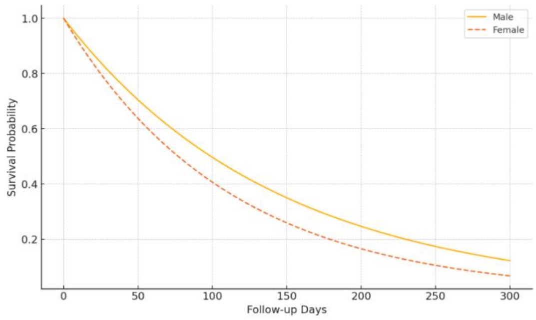

Figure 4: Simulated Kaplan recovery trends by gender.

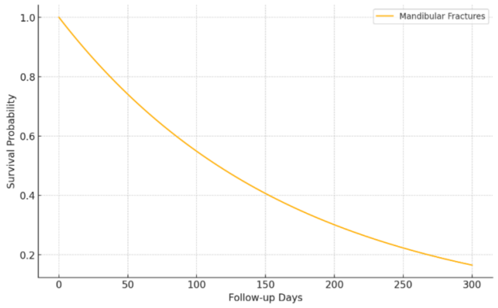

Figure 5: Simulated Kaplan recovery trends for mandibular fractures.

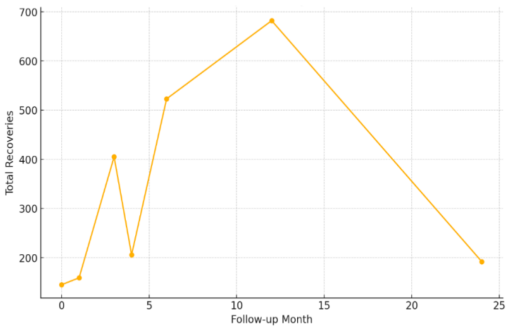

Figure 6: Monthly recovery trends.

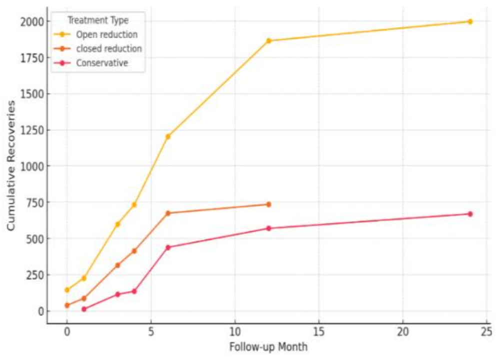

Figure 7: Cumulative recovery by treatment type.

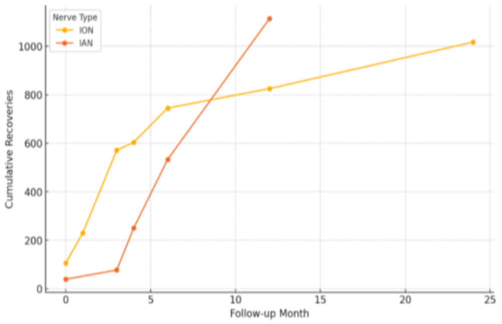

Figure 8: Cumulative recovery by nerve type (ION vs IAN).

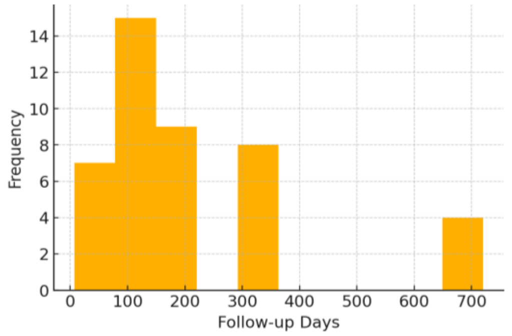

Figure 9: Distribution of follow up times.

As for assault, there was a negative correlation (-9.789, *p*=0.056), indicating that assault-related injuries may lead to lower recovery rates under conservative treatment, and it approached the significance level. Finally, short follow-up days had a very small negative effect (-0.066), but it was not statistically significant.

DISCUSSION

Important information on demographic distribution, injury etiology, therapy kinds, and recovery results was uncovered by analyzing treatment outcomes in patients with zygomatico-maxillary complex (ZMC) and infraorbital nerve (ION) fractures. With a standard deviation of 11.76 years, the mean age of 36.96 years suggests a moderate age group with a large age range. The primary cause of ZMC fractures was determined to be traffic accidents, highlighting the necessity of specific traffic safety measures. These injuries were also largely caused by attacks and falls, underscoring the significance of preventative measures in these domains.

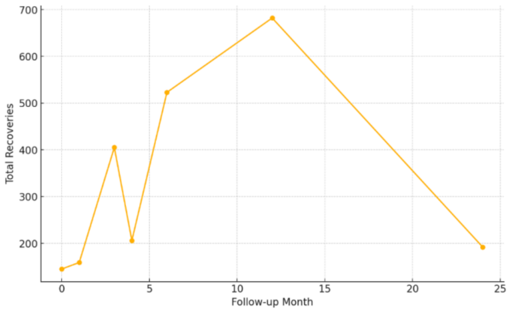

Figure 10: Monthly recovery trends.

Table 2: The average recovery rate with follow up period.

Follow-up period	Average recovery rate (%)
≤3 months	0.69
3-6 months	0.75
6-12 months	0.84
12-24 months	0.76

When treatment efficacy data were analyzed, the most common treatment method was open reduction and internal fixation (ORIF), with a high healing rate of 67.72%. This finding confirms the effectiveness of ORIF in restoring anatomical alignment and function, particularly in infraorbital nerve recovery[2]. However, the high use of conservative treatments suggests variability in treatment approaches, possibly due to differences in fracture severity or patient preferences. Despite the remarkable healing rate, the -32.28% non-healing rate underscores the need for improved treatment protocols and follow-up care to enhance recovery outcomes. The mean follow-up duration of 173.06 days provides a reasonable timeframe for assessing recovery, although extended follow-up may be necessary in more severe cases. In contrast, analysis of patients with inferior alveolar nerve (IAN) fractures and mandibular fractures showed a different demographic pattern, with a mean age of 31.71 years, indicating a younger patient population.

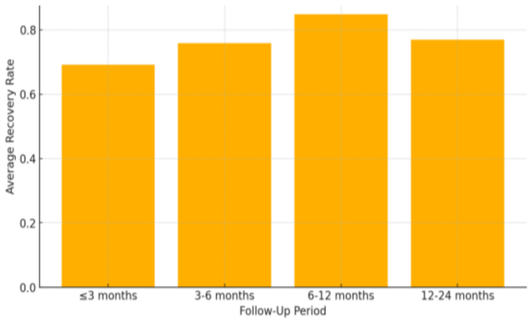

Figure 11: Average recovery rate by follow up period.

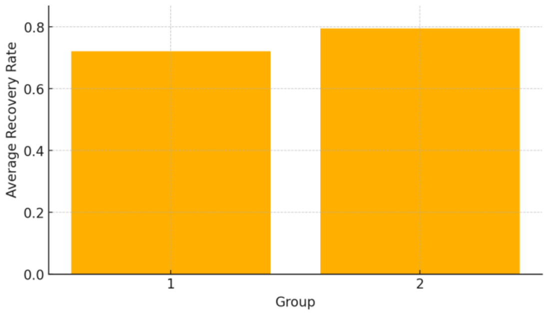

Figure 12: Average recovery rate in group 1 (ION) and Group 2 (IAN).

Similar to ZMC fractures, RTA injuries were the primary cause of injury, but the incidence of assaults was higher in this group, suggesting potential demographic or socioeconomic differences. Open fixation (ORIF) was overwhelmingly preferred, reflecting its effectiveness in the management of mandibular fractures. The limited use of conservative treatments clearly indicates a consensus regarding the importance of surgical intervention for these injuries. The higher recovery rate of 77.29% in this group compared to ZMC fractures highlights the effectiveness of current treatment protocols for mandibular fractures. However, a significant minority (22.71%) did not fully recover, suggesting areas for improvement. The mean follow-up duration of 201.63 days, which was longer than the ZMC group, suggests that extended follow-up is beneficial in ensuring complete recovery and identifying late complications.

Regarding the impact of surgical timing and techniques, the timing of surgical intervention has emerged as a critical factor in neurosensory recovery. Early surgical intervention, typically within two weeks of injury, consistently achieved better outcomes. This finding is consistent with previous studies confirming that rapid surgical repair reduces secondary damage to neural tissue, reduces the risk of fibrosis, and facilitates optimal healing conditions[15]. Delayed surgical interventions are associated with higher rates of complications, such as diplopia, glaucoma, and persistent sensory impairment[16].

Regarding factors influencing recovery outcomes, patient demographics, fracture characteristics, and surgical experience have been found to significantly influence recovery outcomes. Younger patients generally demonstrated better recovery outcomes, possibly due to increased nerve regeneration capacity and fewer comorbidities[3]. Severe fractures, particularly those involving significant displacement or complication, are associated with higher rates of non-recovery[20]. Surgeon experience and commitment to meticulous surgical techniques enhance the likelihood of successful nerve repair and recovery. Differences in surgical techniques, including the type of fixation used and the approach to nerve decompression, also influence recovery outcomes[21]. Postoperative care and rehabilitation, including physical therapy, pain management, and nutritional support, have been found to play a vital role in recovery. Rehabilitation programs that include sensory rehabilitation exercises and functional training can significantly improve neurosensory outcomes[12]. Extended follow-up to monitor recovery and address late-onset complications is crucial for patients' recovery.

CONCLUSIONS AND RECOMMENDATIONS

Neurosensory recovery after facial fractures is influenced by multiple factors, including fracture type, treatment modality, and patient characteristics. This systematic review highlights the importance of early and appropriate surgical intervention and the potential benefits of open reduction therapies for recovery. Standardizing treatment protocols and ensuring extensive follow-up care are critical to improving patient outcomes. Future research should focus on improving treatment approaches and exploring novel therapeutic modalities to promote recovery and improve the quality of life of facial fracture patients.

Among the recommendations provided by the results of selected studies is the development and implementation of standardized treatment protocols for the management of facial fractures to ensure consistency and improve patient outcomes. These protocols should be evidence-based and take into account patient-specific factors, such as age, health status, and fracture severity. They also emphasize the importance of early surgical intervention to significantly improve recovery outcomes. Healthcare systems should prioritize rapid diagnosis and timely surgical management to optimize patient recovery. Further research into innovative treatments is also needed. Comprehensive post-operative care plans, including physical therapy, sensory rehabilitation, and nutritional support, should be incorporated to improve recovery rates. Long-term follow-up is essential to monitor progress and manage any complications. Patients should also be educated about the importance of lifestyle factors, such as smoking cessation, proper nutrition, and adherence to rehabilitation programs, as these positively impact recovery. Psychological support should be provided to address the psychological and emotional aspects of recovery. As for future research directions, future research should focus on identifying specific biological markers for nerve injury and recovery, developing advanced imaging techniques for early diagnosis, and exploring the genetic and molecular mechanisms underlying nerve regeneration. Finally, the role of modern pharmacological agents in promoting nerve repair should be studied to provide new therapeutic avenues.

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AUTHOR'S CONTRIBUTION

Al-Shameri AM: writing original draft. **Al-Rahbi LM:** literature survey. **Al-Ashwal AA:** data curation. **Al-Shamahy HA:** critical review, editing. Final manuscript was checked and approved by all authors.

DATA AVAILABILITY

Data will be made available on request.

CONFLICT OF INTEREST

None to declare.

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