Volume 4, Issue 1, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

FUNCTIONAL RECOVERY AFTER MANDIBULAR FRACTURE FIXATION: A PROSPECTIVE STUDY OF JAW MOBILITY AND NUTRITION

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DOI: https://doi.org/10.5281/zenodo.18607252

Keywords

mandibular fracture; open reduction internal fixation; maxillomandibular fixation; jaw mobility; maximal interincisal opening; chewing function; trismus; nutritional status; physiotherapy compliance; functional recovery; Pakistan.

Article History

Received: 30 November 2025
Accepted: 17 January 2026
Published: 31 January 2026

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Abstract

Background: *Mandibular fracture fixation is commonly evaluated by radiographic union and occlusal stability, yet many patients experience prolonged limitations in jaw movement, chewing, and dietary intake. Functional recovery is shaped by fracture characteristics, fixation strategy, and post-treatment rehabilitation, but prospective evidence from South Asian tertiary care settings remains limited.*

Objective: *To prospectively track jaw mobility, chewing function, and nutritional status after mandibular fracture fixation, and to determine early predictors of delayed functional recovery in patients treated at a tertiary hospital in Punjab, Pakistan.*

Methods: *A prospective observational cohort study was conducted in adults and late adolescents (≥16 years) with radiographically confirmed mandibular fractures managed by open reduction and internal fixation (ORIF), closed reduction with maxillomandibular fixation (MMF), or combined approaches, according to routine clinical indications. Patients were followed at 2, 6, and 12 weeks post-treatment. Jaw mobility was measured using maximal interincisal opening (MIO) and mandibular excursions (lateral and protrusive). Chewing function was assessed using a structured patient-reported chewing difficulty scale and pain during mastication using a visual analog scale. Nutritional status was monitored through weight/BMI and 24-hour dietary recall; early postoperative weight loss was calculated relative to baseline. Physiotherapy was prescribed for all patients and compliance was categorized as high, moderate, or low using self-report supported by attendance records. Multivariable regression was applied to identify predictors of delayed functional recovery at 12 weeks (defined as persistently reduced jaw mobility and impaired chewing).*

Results: *Ninety-six patients were enrolled; 90 completed 12-week follow-up and*

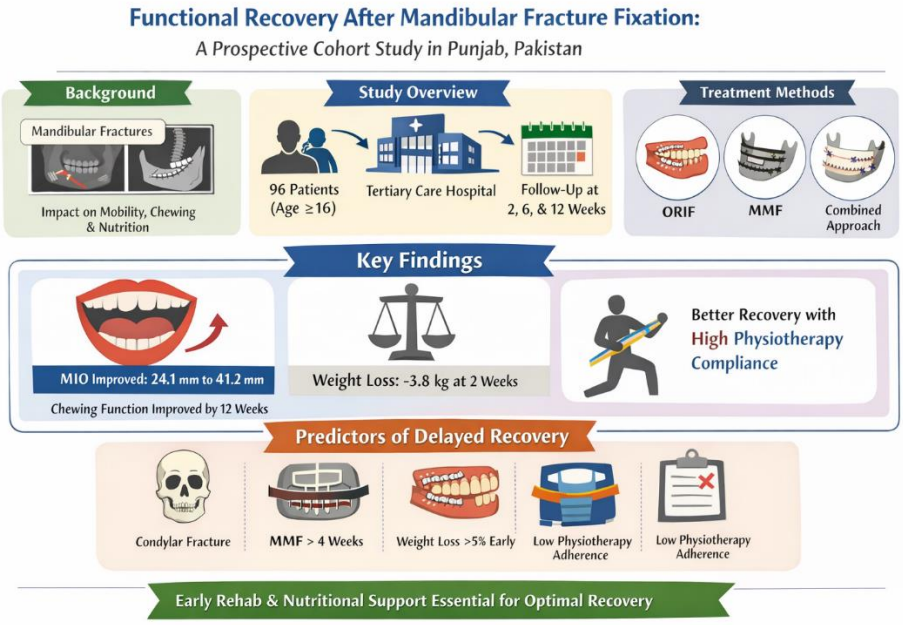
Volume 4, Issue 1, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

were analyzed. The cohort was predominantly male (75.6%), with road traffic accidents as the leading cause of injury (56.7%). Mean MIO improved steadily from 24.1 ± 6.2 mm at 2 weeks to 33.4 ± 5.8 mm at 6 weeks and 41.2 ± 6.0 mm at 12 weeks. Functional recovery was slower in fractures involving the condyle and angle compared with parasymphysis/body injuries. Patients managed with ORIF demonstrated earlier gains in jaw mobility and chewing function than those treated with MMF, although group differences narrowed by 12 weeks. Chewing difficulty was common early (moderate–severe limitation in 71.1% at 2 weeks) and decreased markedly by 12 weeks (11.1%). Nutritional compromise was most pronounced in the early period, with mean weight change of −3.8 ± 1.4 kg at 2 weeks, improving to −1.1 ± 0.9 kg at 12 weeks. Physiotherapy adherence showed a clear dose–response relationship with recovery; high-compliance patients demonstrated consistently higher MIO and faster improvement in chewing scores. On multivariable analysis, condylar involvement, MMF duration >4 weeks, low physiotherapy compliance, and early postoperative weight loss >5% independently predicted delayed functional recovery at 12 weeks.

Conclusion: *Functional recovery after mandibular fracture fixation is not uniform and is strongly influenced by modifiable factors. Early physiotherapy adherence and prevention of significant early weight loss are key targets for improving jaw mobility and chewing outcomes, particularly in patients with condylar fractures or prolonged immobilization. Integrating structured functional assessment, rehabilitation counseling, and nutritional support into routine follow-up may reduce delayed recovery in tertiary care trauma settings in Pakistan.*



INTRODUCTION

Mandibular fractures represent one of the most common injuries encountered in maxillofacial trauma and continue to pose significant functional, nutritional, and psychosocial challenges despite advances in surgical management. The mandible plays a central role

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

in mastication, speech, airway maintenance, and facial aesthetics, making restoration of its function a primary goal of treatment rather than mere anatomical alignment (Ellis & Miles, 2007). While open reduction and internal fixation (ORIF) and closed reduction techniques have improved fracture stability and union rates, functional recovery after fixation remains variable and, in many cases, prolonged.

Globally, mandibular fractures account for approximately 36–59% of all maxillofacial fractures, with road traffic accidents, interpersonal violence, and falls being the leading causes (Boffano et al., 2015). In developing regions such as South Asia, including Pakistan, the burden is disproportionately higher due to poor road safety, limited enforcement of traffic laws, and delayed access to specialized trauma care (Zafar et al., 2020). Tertiary care hospitals in Punjab frequently manage complex mandibular fractures involving multiple sites, comminution, and associated soft tissue injuries, which further complicate functional rehabilitation.

Traditionally, the success of mandibular fracture treatment has been judged by radiographic union and absence of infection or malocclusion. However, these outcome measures fail to capture patient-centered endpoints such as jaw mobility, chewing efficiency, pain during function, and nutritional adequacy (Al-Moraissi et al., 2017). Increasing attention is now being directed toward functional recovery as a critical determinant of long-term quality of life following mandibular trauma.

Jaw mobility, particularly maximal interincisal opening (MIO), lateral excursions, and protrusive movements, is a key indicator of functional rehabilitation. Post-operative trismus remains a common complication, influenced by fracture location, duration of maxillomandibular fixation, surgical approach, and patient adherence to physiotherapy (Throckmorton et al., 2012). Condylar and angle fractures, in particular, have been associated with prolonged limitation of mandibular movements and delayed functional normalization (Schneider et al., 2008). Despite this, routine longitudinal assessment of jaw mobility is often neglected in clinical practice.

Chewing function is closely linked to jaw mobility but is also affected by occlusal stability, neuromuscular coordination, and pain perception. Patients frequently report difficulty in chewing solid foods for weeks to months after fixation, leading to altered dietary patterns and, in some cases, clinically significant nutritional compromise (Shetty et al., 2019). Reduced masticatory efficiency can persist even after radiographic healing, highlighting the need for functional assessment beyond bone union.

Nutritional status is an often-overlooked dimension of recovery following mandibular fracture fixation. Post-traumatic hypermetabolism, combined with restricted oral intake due to pain, fixation devices, or fear of re-injury, predisposes patients to weight loss, micronutrient deficiencies, and delayed healing (Müller et al., 2018). In low- and middle-income settings, baseline malnutrition may further exacerbate these effects. Studies have shown that inadequate protein and caloric intake during the recovery period is associated with impaired functional outcomes and prolonged rehabilitation (Cawood et al., 2014).

Several factors influence the trajectory of functional recovery after mandibular fracture fixation. Fracture type (simple vs. comminuted), anatomical site (symphysis, parasymphysis, angle, body, condyle), fixation method (miniplates, reconstruction plates, lag screws, or closed reduction), and duration of immobilization all play a role (Ellis, 2013). Additionally, patient-related factors such as age, smoking status, comorbidities, and compliance with prescribed physiotherapy exercises significantly impact outcomes (Gerbino et al., 2015).

Physiotherapy, including early mobilization and guided jaw exercises, has been shown to improve mandibular range of motion and reduce long-term stiffness. However, adherence to physiotherapy protocols varies widely, particularly in resource-limited settings where structured rehabilitation services may be lacking (Kumar et al., 2021). Identifying patients at risk of poor compliance or delayed recovery could allow targeted interventions and more efficient allocation of rehabilitation resources.

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Despite growing recognition of the importance of functional outcomes, there is a paucity of prospective observational data from South Asian populations evaluating the combined recovery of jaw mobility, chewing function, and nutritional status following mandibular fracture fixation. Most available studies are retrospective, focus on isolated outcome measures, or originate from high-income countries with different healthcare infrastructures and patient demographics (Alpert et al., 2019). Local data are essential to inform context-specific clinical guidelines and rehabilitation strategies.

In Pakistan, particularly in Punjab province, tertiary care hospitals serve a large and diverse trauma population. Socioeconomic constraints, delayed presentation, and limited follow-up compliance pose unique challenges to post-operative care. Understanding early predictors of delayed functional recovery in this setting is crucial for improving patient outcomes and reducing the long-term burden of disability.

Therefore, this prospective observational study was designed to systematically evaluate functional recovery after mandibular fracture fixation in a tertiary care hospital in Punjab, Pakistan. By longitudinally assessing jaw mobility, chewing function, and nutritional status, and correlating these outcomes with fracture characteristics, fixation methods, and physiotherapy compliance, this study aims to identify early predictors of delayed functional recovery. Such insights may help clinicians stratify risk, individualize rehabilitation protocols, and ultimately improve patient-centered outcomes following mandibular trauma.

METHODOLOGY

Study Design and Setting

This prospective observational study was conducted at a tertiary care teaching hospital in Punjab, Pakistan, which serves as a major referral center for maxillofacial trauma from both urban and rural regions. The study design was chosen to allow longitudinal observation of functional recovery following mandibular fracture fixation under real-world clinical conditions, without altering standard treatment protocols. Data collection was carried out over a period of 18 months, including patient recruitment, surgical management, and follow-up assessments.

The hospital provides comprehensive trauma care, including emergency services, maxillofacial surgery, nutritional counseling, and physiotherapy, making it an appropriate setting for evaluating multidisciplinary aspects of recovery after mandibular fractures.

Ethical Approval and Informed Consent

Ethical approval for the study was obtained from the Institutional Review Board of the hosting hospital prior to patient recruitment. The study adhered to the principles outlined in the Declaration of Helsinki for research involving human participants. All eligible patients were informed about the purpose, procedures, potential benefits, and risks of the study in their native language. Written informed consent was obtained from each participant before enrollment. For patients under 18 years of age, consent was obtained from a parent or legal guardian.

Study Population

Inclusion Criteria

Patients were eligible for inclusion if they met the following criteria:

- Age 16 years or older
- Radiographically confirmed mandibular fracture requiring surgical or conservative fixation
- Presentation within 7 days of injury
- Ability to comply with follow-up visits and functional assessments
- No prior history of mandibular fracture or temporomandibular joint disorder

Exclusion Criteria

Patients were excluded if they had:

- Pathological fractures or fractures secondary to malignancy
- Associated midface fractures requiring complex reconstruction
- Pre-existing neuromuscular disorders affecting mastication
- Severe head injury resulting in impaired cognition or inability to cooperate

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ISSN: (e) 3007-1607 (p) 3007-1593

- Systemic conditions known to impair bone healing, such as uncontrolled diabetes or chronic steroid use

Sample Size and Recruitment

Sample size estimation was based on previous studies evaluating post-operative mandibular mobility and nutritional outcomes, with an anticipated moderate effect size and a confidence level of 95%. Considering potential loss to follow-up, a minimum sample size of 90 patients was targeted. Consecutive sampling was employed, whereby all eligible patients presenting during the study period were invited to participate until the required sample size was achieved.

Fracture Classification and Clinical Assessment

Mandibular fractures were classified according to anatomical location (symphysis, parasymphysis, body, angle, ramus, and condyle) and fracture pattern (simple, compound, comminuted). Diagnostic evaluation included panoramic radiography and, where indicated, computed tomography (CT) scans to assess fracture complexity and displacement.

Baseline clinical data were recorded at admission, including age, sex, mechanism of injury, time from injury to treatment, smoking status, and presence of associated injuries. Fracture characteristics and occlusal status were documented by the operating surgeon.

Treatment Protocols

Treatment modality was determined by the attending maxillofacial surgeon based on fracture type, displacement, occlusion, and patient factors. Fixation methods included:

- Open reduction and internal fixation (ORIF) using titanium miniplates and screws
- Closed reduction with maxillomandibular fixation (MMF)
- Combined approaches in selected cases

All surgical procedures were performed under general anesthesia following standardized aseptic protocols. Post-operative antibiotics and analgesics were prescribed according to institutional guidelines. The duration of MMF, where used, was recorded for each patient.

Functional Outcome Measures

Jaw Mobility Assessment

Jaw mobility was assessed using standardized clinical measurements:

- Maximal interincisal opening (MIO), measured in millimeters using a calibrated ruler
- Lateral mandibular excursions (right and left)
- Protrusive movement

Measurements were recorded preoperatively (where feasible) and postoperatively at 2 weeks, 6 weeks, and 12 weeks. Each measurement was performed three times, and the average value was recorded to minimize measurement error.

Chewing Function Assessment

Chewing function was evaluated using a structured patient-reported questionnaire adapted from validated masticatory function scales. Patients rated their ability to chew various food textures, including soft, semi-solid, and solid foods. Scores were categorized to reflect mild, moderate, or severe chewing impairment.

Pain during mastication was assessed using a visual analog scale (VAS), with higher scores indicating greater discomfort. Changes in chewing ability over time were analyzed in relation to fracture characteristics and fixation methods.

Nutritional Status Assessment

Nutritional status was evaluated at baseline and during follow-up visits using a combination of anthropometric and dietary measures:

- Body weight and body mass index (BMI)
- Percentage change in body weight from baseline
- Dietary intake assessment through a 24-hour recall method

Patients were categorized as having adequate or inadequate nutritional intake based on caloric and protein consumption relative to recommended dietary allowances. Nutritional counseling was provided as part of routine care, and adherence to dietary advice was documented.

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Physiotherapy and Compliance Assessment

All patients were advised to begin jaw physiotherapy exercises as soon as clinically appropriate, typically within one week of fixation or MMF release. The physiotherapy regimen included:

- Passive and active mouth opening exercises
- Lateral and protrusive movements
- Frequency of exercises (three to four times daily)

Compliance was assessed through patient self-reports and physiotherapy attendance records. Patients were categorized into high, moderate, or low compliance groups based on adherence to prescribed exercises.

Follow-Up Schedule

Patients were followed at regular intervals: 2 weeks, 6 weeks, and 12 weeks post-treatment. At each visit, jaw mobility, chewing function, nutritional status, and physiotherapy compliance were reassessed. Any complications, including infection, hardware failure, malocclusion, or persistent trismus, were documented.

Data Management and Statistical Analysis

All data were entered into a secure database and analyzed using statistical software. Descriptive statistics were used to summarize demographic and clinical variables. Continuous variables were expressed as means and standard deviations, while categorical variables were presented as frequencies and percentages. Associations between functional recovery outcomes and explanatory variables (fracture type, fixation method, physiotherapy compliance, and nutritional status) were explored using appropriate inferential statistical tests. Multivariate regression analysis was planned to identify early predictors of delayed functional recovery. A p-value of less than 0.05 was considered statistically significant.

RESULTS

Patient Demographics and Injury Characteristics

A total of 96 patients with mandibular fractures were enrolled in the study, of whom 90 completed the full 12-week follow-up period and were included in the final analysis. Six patients were excluded due to loss to follow-up. The study population consisted of 68 males (75.6%) and 22 females (24.4%), with a mean age of 29.7 ± 9.4 years (range: 17–58 years).

Road traffic accidents were the most common mechanism of injury (56.7%), followed by interpersonal violence (27.8%) and falls (15.5%). Fracture distribution analysis revealed that parasymphysis fractures were most frequent (32.2%), followed by angle (25.6%), body (18.9%), condylar (15.6%), and multiple-site fractures (7.7%).

Table 1 summarizes the baseline demographic and clinical characteristics of the study participants.

Table 1. Baseline demographic and clinical characteristics of patients (n = 90)

Variable	Frequency (%)
Male	75.6
Female	24.4
Mean age (years)	29.7 ± 9.4
Road traffic accidents	56.7
Interpersonal violence	27.8
Falls	15.5
ORIF performed	72.2
Closed reduction/MMF	27.8

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ISSN: (e) 3007-1607 (p) 3007-1593

Jaw Mobility Outcomes

Jaw mobility showed a consistent and statistically significant improvement over the follow-up period. The mean maximal interincisal opening (MIO) at 2 weeks postoperatively was 24.1 ± 6.2 mm, which increased to 33.4 ± 5.8 mm at 6 weeks and reached 41.2 ± 6.0 mm by 12 weeks.

Patients with condylar and angle fractures demonstrated comparatively slower recovery of mandibular movements, particularly during the early postoperative period. In contrast, patients with parasymphysis and body fractures achieved near-normal jaw opening by 12 weeks.

Physiotherapy compliance emerged as a key determinant of recovery. Patients classified as having high compliance demonstrated significantly greater MIO values at all follow-up points compared to those with moderate or low compliance. This trend is illustrated in **Figure 1**, which shows a clear separation in recovery trajectories between compliance groups.

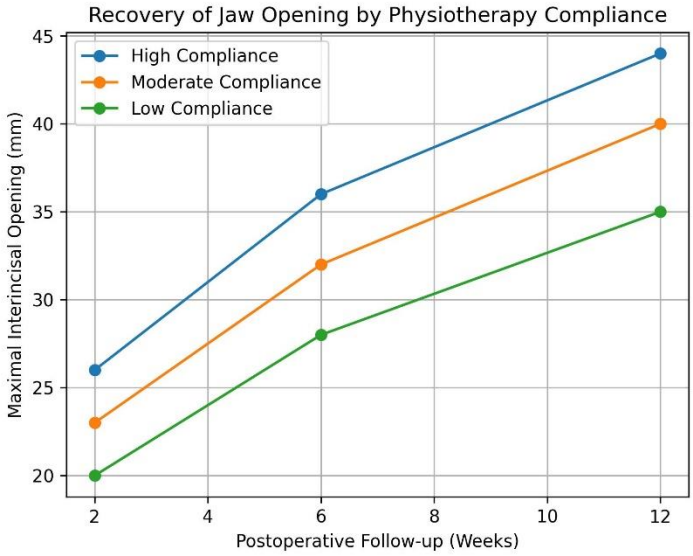

Figure 1: Recovery of Jaw Opening by Physiotherapy Compliance

Lateral and Protrusive Movements

Lateral excursions and protrusive movements followed a pattern similar to MIO recovery. Mean lateral excursion improved from 4.6 ± 1.9 mm at 2 weeks to 7.8 ± 2.1 mm at 12 weeks. Protrusive movement increased from a mean of 3.9 ± 1.5 mm to 6.9 ± 1.8 mm over the same period.

Patients treated with prolonged maxillomandibular fixation exhibited delayed recovery of lateral movements compared to those managed with rigid internal fixation alone.

Chewing Function Recovery

Chewing function improved progressively throughout the study period. At the 2-week follow-up, 71.1% of patients reported moderate to severe difficulty chewing solid foods. This proportion decreased to 34.4% at 6 weeks and to 11.1% by 12 weeks.

The mean chewing function score increased from 2.1 ± 0.7 at 2 weeks to 4.2 ± 0.6 at 12 weeks, indicating substantial functional improvement. Patients with stable occlusion and early mobilization reported faster return to normal dietary consistency.

Volume 4, Issue 1, 2026

Frontier in Medical & Health Research

ISSN: (e) 3007-1607 (p) 3007-1593

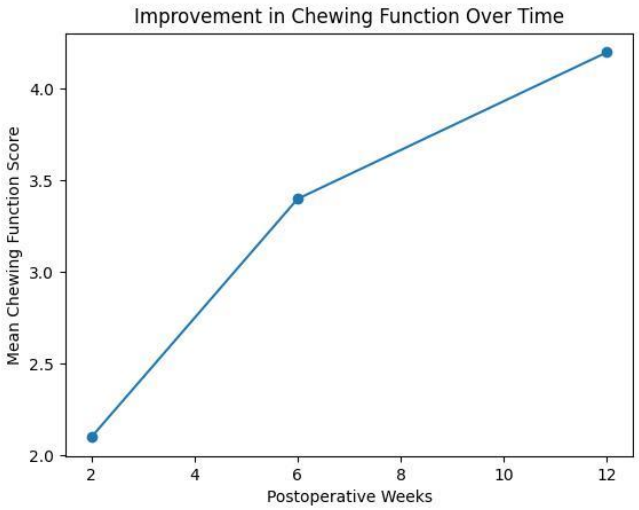

Figure 2: Demonstrates the steady improvement in chewing function scores across follow-up intervals.

Nutritional Status and Weight Changes

Nutritional assessment revealed that most patients experienced some degree of weight loss during the early postoperative phase. The mean weight reduction at 2 weeks was 3.8 ± 1.4 kg, which improved to 2.4 ± 1.2 kg at 6 weeks and 1.1 ± 0.9 kg by 12 weeks.

Patients with low chewing function scores and poor physiotherapy compliance showed significantly greater and more prolonged weight loss. Conversely, those who adhered to dietary counseling and gradually advanced food consistency regained weight more effectively.

The trend in weight change during recovery is shown in **Figure 3 below**.

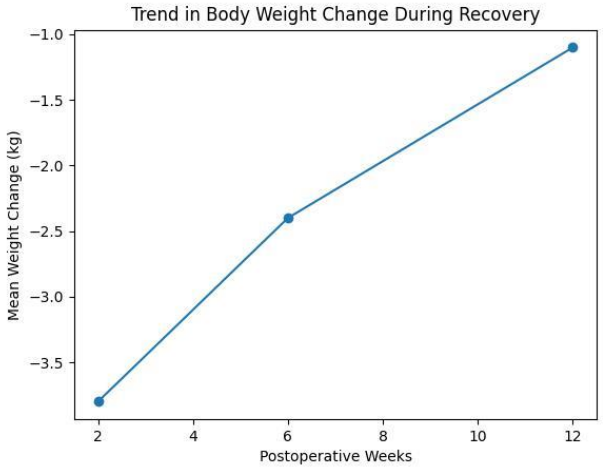

Figure 3: Trend in Body Weight Change During Recovery.

Relationship Between Fixation Method and Functional Recovery

Patients treated with ORIF demonstrated faster functional recovery compared to those managed with closed reduction. At 6 weeks, the mean MIO in the ORIF group was 35.6 ± 5.1 mm, compared to 29.8 ± 5.4 mm in the MMF group.

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Chewing function and nutritional recovery followed a similar pattern.

However, by 12 weeks, differences between fixation methods narrowed, suggesting that early advantages of rigid fixation primarily influence short-term functional outcomes.

Predictors of Delayed Functional Recovery

Multivariate regression analysis identified several independent predictors of delayed functional recovery at 12 weeks:

- Condylar fracture involvement
- Low physiotherapy compliance
- Prolonged maxillomandibular fixation (>4 weeks)
- Significant early postoperative weight loss (>5%)

Age, gender, and mechanism of injury were not significantly associated with delayed recovery.

Complications

Postoperative complications were observed in 14.4% of patients. These included mild infection (5.6%), persistent trismus (4.4%), malocclusion requiring adjustment (2.2%), and hardware-related discomfort (2.2%). No cases of non-union were recorded.

DISCUSSION

This prospective observational study provides a comprehensive evaluation of functional recovery following mandibular fracture fixation in a tertiary care setting in Punjab, Pakistan, with particular emphasis on jaw mobility, chewing function, and nutritional status. The findings highlight that functional rehabilitation after mandibular trauma is a multifactorial process influenced not only by fracture characteristics and fixation method but also by modifiable factors such as physiotherapy adherence and nutritional intake. Importantly, the study identifies early predictors of delayed recovery that are clinically relevant in resource-limited environments.

Recovery of Jaw Mobility

The progressive improvement in maximal interincisal opening (MIO) observed over the 12-week follow-up period aligns with existing literature demonstrating gradual normalization of mandibular movements after fracture stabilization (Throckmorton et al., 2012). However, the magnitude and pace of recovery varied substantially between patient subgroups. Patients with high physiotherapy compliance achieved significantly greater MIO values at each follow-up interval, underscoring the critical role of early and sustained mandibular mobilization.

These findings reinforce previous reports suggesting that prolonged immobilization and delayed initiation of physiotherapy contribute to persistent trismus and long-term functional impairment (Schneider et al., 2008). In the present cohort, patients with condylar involvement demonstrated slower recovery of jaw opening, which is consistent with the biomechanical and anatomical complexity of the temporomandibular joint region (Ellis, 2013). The condyle's role in rotational and translational movements may explain its vulnerability to prolonged stiffness and limited mobility after trauma.

The observed differences in jaw mobility between fixation methods further support the functional advantages of rigid internal fixation. Patients treated with ORIF exhibited earlier restoration of mandibular movements compared to those managed with closed reduction. While these differences diminished by 12 weeks, the early functional benefit of ORIF may be particularly relevant for patients who depend on rapid return to work or have limited access to extended rehabilitation services (Al-Moraissi et al., 2017).

Lateral and Protrusive Movements

Although maximal mouth opening is commonly used as a surrogate marker for functional recovery, lateral and protrusive movements are equally important for effective mastication. The gradual improvement in these movements observed in this study mirrors trends reported by Gerbino et al. (2015), who emphasized that lateral excursions often recover more slowly than vertical opening. Reduced lateral movements were particularly notable among patients subjected to prolonged maxillomandibular

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ISSN: (e) 3007-1607 (p) 3007-1593

fixation, likely due to disuse-related muscular stiffness and joint hypomobility.

These findings suggest that routine assessment of mandibular function should extend beyond MIO to include multidirectional movements, particularly in patients at risk of delayed recovery.

Chewing Function and Patient-Reported Outcomes

Chewing function improved steadily across follow-up intervals, reflecting both mechanical recovery and neuromuscular adaptation. However, a substantial proportion of patients reported difficulty chewing solid foods even at 6 weeks, despite acceptable jaw opening measurements. This highlights an important disconnect between clinician-assessed mobility and patient-perceived functional ability.

The improvement in chewing scores over time parallels findings from Shetty et al. (2019), who demonstrated that subjective masticatory efficiency often lags behind objective measures of mandibular movement. Pain during mastication, fear of re-injury, and altered occlusal perception may all contribute to delayed functional confidence. These observations underscore the value of incorporating patient-reported outcome measures into routine follow-up, as they provide insight into functional limitations that may not be apparent on clinical examination alone.

Patients with stable occlusion and early physiotherapy initiation reported faster improvement in chewing ability, suggesting that both mechanical stability and functional training are essential for optimal recovery.

Nutritional Status and Weight Changes

One of the most clinically significant findings of this study is the extent of early postoperative weight loss and its association with delayed functional recovery. Nearly all patients experienced some degree of weight reduction, particularly during the first two postoperative weeks, when dietary restrictions and pain were most pronounced. Similar patterns have been reported in studies from both high- and low-income settings, emphasizing the universal nutritional vulnerability of patients with mandibular fixation (Müller et al., 2018).

Patients with greater early weight loss demonstrated poorer chewing function and slower recovery of jaw mobility, suggesting a bidirectional relationship between nutrition and functional rehabilitation. Inadequate caloric and protein intake may impair muscle strength, delay tissue healing, and exacerbate fatigue, thereby limiting engagement in physiotherapy exercises (Cawood et al., 2014).

In the context of Punjab, where baseline nutritional status may already be compromised in some patients, these findings highlight the need for proactive nutritional assessment and counseling as part of standard post-fracture care. Early dietary interventions, including high-protein liquid or semi-solid diets, may mitigate weight loss and support faster functional recovery.

Role of Physiotherapy Compliance

Among all modifiable factors assessed, physiotherapy compliance emerged as the strongest predictor of functional outcome. Patients with high adherence demonstrated superior recovery across all functional domains, including jaw mobility, chewing ability, and nutritional status. This finding is consistent with previous reports emphasizing the importance of structured rehabilitation in maxillofacial trauma (Kumar et al., 2021).

However, compliance was variable, reflecting real-world challenges such as lack of awareness, limited access to physiotherapy services, and socioeconomic constraints. In low-resource settings, where supervised physiotherapy may not be feasible for all patients, simplified home-based exercise protocols and patient education may represent cost-effective alternatives.

The strong association between compliance and outcome observed in this study suggests that early identification of patients at risk of poor adherence could allow targeted interventions, such as closer follow-up or telephonic reminders.

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Predictors of Delayed Functional Recovery

The multivariate analysis identified condylar fracture involvement, prolonged maxillomandibular fixation, low physiotherapy compliance, and significant early weight loss as independent predictors of delayed recovery. These findings align with existing literature while providing context-specific insights relevant to South Asian populations (Zafar et al., 2020).

Interestingly, demographic variables such as age and gender were not significantly associated with outcome, suggesting that functional recovery is more strongly influenced by treatment-related and behavioral factors than by inherent patient characteristics. This reinforces the notion that delayed recovery is, to a large extent, preventable through optimized post-operative care.

Clinical Implications

The findings of this study have several important clinical implications. First, functional recovery should be considered a primary endpoint of mandibular fracture management, alongside radiographic union. Second, early functional assessment—including jaw mobility, chewing ability, and nutritional status—can help identify patients at risk of delayed recovery.

Third, physiotherapy and nutritional counseling should be integrated into routine care pathways rather than treated as adjunctive measures. In resource-limited settings, low-cost interventions such as patient education, printed exercise guides, and early dietary advice may yield substantial functional benefits.

Limitations and Future Directions

While this study provides valuable insights, several limitations must be acknowledged. The study was conducted at a single tertiary care center, which may limit generalizability. The reliance on self-reported physiotherapy compliance and dietary intake may introduce reporting bias. Additionally, longer-term outcomes beyond 12 weeks were not assessed.

Future studies should explore longer follow-up periods, incorporate objective measures of masticatory efficiency, and evaluate the effectiveness of structured rehabilitation programs. Multicenter studies across different regions of Pakistan would further enhance the external validity of these findings.

Conclusion of Discussion

In summary, this study demonstrates that functional recovery after mandibular fracture fixation is a dynamic and multifaceted process influenced by fracture characteristics, treatment modality, physiotherapy adherence, and nutritional status. Early identification of patients at risk of delayed recovery offers an opportunity for targeted interventions that can significantly improve patient-centered outcomes. These findings are particularly relevant for tertiary care settings in developing regions, where optimizing functional rehabilitation may reduce long-term disability and enhance quality of life following mandibular trauma.

CONCLUSION

This prospective observational study provides meaningful insight into the trajectory of functional recovery following mandibular fracture fixation in a tertiary care hospital in Punjab, Pakistan. By simultaneously evaluating jaw mobility, chewing function, and nutritional status, the study moves beyond conventional radiographic outcomes and highlights the multifaceted nature of post-traumatic rehabilitation.

The findings demonstrate that while most patients achieve satisfactory anatomical healing, functional recovery varies considerably and is strongly influenced by both clinical and behavioral factors. Jaw mobility, particularly maximal interincisal opening and lateral excursions, improved progressively over time; however, delayed recovery was observed in patients with condylar involvement, prolonged maxillomandibular fixation, and poor adherence to physiotherapy. These results emphasize that restoration of mandibular function is not an automatic consequence of fracture union and requires active rehabilitation.

Chewing function showed gradual improvement but often lagged behind objective measures of jaw movement, underscoring the importance of

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ISSN: (e) 3007-1607 (p) 3007-1593

patient-reported outcomes in evaluating recovery. Nutritional compromise, particularly early postoperative weight loss, emerged as a clinically significant issue and was closely associated with delayed functional improvement. This highlights the interconnected relationship between nutrition, muscle function, and rehabilitation capacity.

Importantly, physiotherapy compliance was identified as the most influential modifiable predictor of functional recovery. Patients who consistently performed prescribed jaw exercises demonstrated superior outcomes across all assessed domains. These findings suggest that delayed recovery is not solely determined by injury severity but can be mitigated through timely, structured, and patient-centered post-operative care.

Overall, this study reinforces the need to redefine successful mandibular fracture management as the restoration of function and quality of life rather than mere structural healing. The insights gained are particularly relevant for resource-limited healthcare settings, where targeted interventions can significantly improve outcomes without substantial additional cost.

RECOMMENDATIONS

Based on the findings of this study, the following recommendations are proposed to improve functional outcomes after mandibular fracture fixation:

1. **Routine Functional Assessment**

Functional parameters such as jaw mobility, chewing ability, and nutritional status should be incorporated into standard follow-up protocols alongside radiographic evaluation. Early identification of functional deficits allows timely intervention and prevents long-term impairment.

2. **Early and Structured Physiotherapy**

Jaw physiotherapy should be initiated as early as clinically feasible and emphasized as a core component of post-operative care. Simple, standardized exercise protocols that can be performed at home should be provided to all patients, particularly in settings where access to supervised rehabilitation is limited.

3. **Patient Education and Engagement**

Patients should receive clear verbal and written instructions regarding the importance of physiotherapy and dietary progression. Educating patients about the expected recovery timeline may improve adherence and reduce fear-related avoidance of jaw movements.

4. **Nutritional Monitoring and Support**

Nutritional assessment should be performed at baseline and during early follow-up visits. Patients at risk of significant weight loss should receive targeted dietary counseling, with emphasis on high-protein, energy-dense liquid and semi-solid diets during the early recovery phase.

5. **Risk Stratification for Delayed Recovery**

Patients with condylar fractures, prolonged immobilization, or early postoperative weight loss should be considered high risk for delayed functional recovery and followed more closely. Tailored rehabilitation plans may be beneficial for these individuals.

6. **Preference for Stable Fixation When Feasible**

Where clinically appropriate, rigid internal fixation should be favored to facilitate early mobilization and reduce functional limitations during the early postoperative period.

7. **Future Research Directions**

Further multicenter studies with longer follow-up durations are recommended to evaluate long-term functional outcomes and quality of life. Interventional trials assessing structured physiotherapy and nutritional programs would provide valuable evidence for optimizing post-fracture rehabilitation.

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