

## Comparative Evaluation of Surgical Outcomes in Open Versus Closed Reduction of Inferior Orbital Rim Fractures: A Clinical and Radiological Perspective

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### Abstract:

**Background:** Fractures of the inferior orbital rim are common midfacial injuries that can significantly impair ocular function and facial aesthetics. Treatment typically involves either open or closed reduction, but the choice of technique can influence both clinical and radiological outcomes. Accurate assessment is essential for optimal patient management and prognosis.

**Objective:** To evaluate and compare the clinical and radiological outcomes of open versus closed reduction techniques in the management of inferior orbital rim fractures.

**Materials and Methods:** This prospective observational study will be conducted over a period of 18 months at JNKTMCH, Madhepura. A total of 60 patients diagnosed with unilateral or bilateral isolated inferior orbital rim fractures will be enrolled. Patients will be equally divided into two groups (30 each) based on the treatment modality—open or closed reduction. Preoperative and postoperative clinical assessments (e.g., enophthalmos, diplopia, infraorbital numbness) and radiological evaluations using CT scans will be performed. Follow-up will be conducted at 1 week, 1 month, and 3 months postoperatively.

**Results:** Expected outcomes include comparative data on anatomical reduction quality, functional recovery, complication rates, and patient satisfaction across both treatment modalities. Statistical analyses will be applied to determine the significance of differences observed.

**Conclusion:** This study aims to provide evidence-based insights into the efficacy of open versus closed reduction techniques in the management of inferior orbital rim fractures. Findings may guide surgical decision-making and improve individualized treatment planning.

**Keywords:** Inferior orbital rim fracture, open reduction, closed reduction, radiological evaluation, facial trauma, maxillofacial surgery, CT scan.

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### Introduction

Orbital rim fractures, particularly those involving the inferior orbital border, are a critical component of midfacial trauma due to the anatomical and functional complexity of the orbital region. The inferior orbital rim forms a vital boundary of the orbit and contributes to the support of the orbital contents, including the globe, extraocular muscles, and neurovascular structures [1]. Fractures in this region not only compromise facial symmetry but can also disrupt visual function, ocular alignment, and neurosensory integrity, leading to a wide array of clinical symptoms such as diplopia, enophthalmos, infraorbital nerve hypoesthesia, and restriction of ocular motility [2].

The etiology of inferior orbital rim fractures is often linked to high-energy blunt trauma, with road traffic

accidents being the most common cause, followed by physical assaults, falls, and sports-related injuries [3]. These injuries are often isolated but can also occur as part of complex midfacial fractures involving the zygomaticomaxillary complex or orbital floor. Prompt recognition and classification are essential to guide treatment, which is determined by the severity of displacement, the degree of functional impairment, and the presence of associated injuries [4].

Treatment strategies for inferior orbital rim fractures are primarily surgical, with two widely accepted approaches: open reduction and closed reduction. Open reduction allows direct visualization of the fracture site, enabling accurate anatomical realignment and fixation with miniplates and screws

[5]. This technique is particularly valuable in displaced fractures where precise repositioning of bony segments and restoration of orbital volume are essential [6]. However, it involves soft tissue dissection, carries a risk of scarring, and may extend operative and recovery time.

In contrast, closed reduction is a minimally invasive technique that relies on external manipulation of fracture fragments without direct surgical exposure. It is typically reserved for non-displaced or mildly displaced fractures, offering the advantage of shorter operative time, less tissue trauma, and reduced hospitalization [7]. However, the trade-offs include the potential for suboptimal alignment, inadequate restoration of orbital volume, and recurrence of deformity or functional deficits.

Radiological imaging plays a pivotal role in both diagnosis and outcome assessment. Computed tomography is the gold standard for evaluating orbital fractures, as it provides detailed visualization of the bony margins, orbital volume, and associated soft tissue displacement. Postoperative imaging is crucial in assessing the adequacy of fracture reduction, implant positioning, and early detection of complications such as residual enophthalmos or malunion [8,9].

Despite widespread clinical use of both surgical approaches, the literature lacks consensus regarding the superior modality for managing inferior orbital rim fractures. Treatment decisions often rely on surgeon experience, patient preference, and available resources. This highlights the need for comparative studies that assess both clinical and radiological outcomes across these techniques.

The present study aims to fill this gap by evaluating and comparing the effectiveness of open and closed reduction in terms of functional recovery, anatomical alignment, complication rates, and patient-reported outcomes in patients with inferior orbital rim fractures. Such data are critical in formulating evidence-based treatment protocols and improving the quality of maxillofacial trauma care.

### Aims And Objectives

**Aim:** To evaluate and compare the clinical and radiological outcomes of open and closed reduction techniques in the management of inferior orbital rim fractures.

### Objectives

1. To assess the functional recovery in patients undergoing open and closed reduction with respect to ocular motility, diplopia, infraorbital nerve function, and aesthetic restoration.
2. To compare preoperative and postoperative radiological parameters using computed tomography to evaluate the accuracy of fracture reduction and orbital reconstruction.

3. To determine the incidence of complications, including residual enophthalmos, malunion, implant displacement, and sensory disturbances, in both treatment groups.
4. To analyze patient-reported outcomes such as satisfaction with appearance and functional improvement post-surgery.
5. To generate evidence-based recommendations regarding the selection of surgical approach for managing inferior orbital rim fractures in a clinical setting.

### Materials And Methods

**Study Design and Setting:** This was a prospective, hospital-based observational study conducted in collaboration between the Department of Radiology and the Department of Dentistry (Oral and Maxillofacial Surgery Unit) at Jannayak Karpoori Thakur Medical College and Hospital (JNKTMCH), Madhepura, Bihar, India.

**Study Duration:** The study was carried out over a period of 18 months.

**Study Population:** Patients presenting with isolated or combined inferior orbital rim fractures requiring surgical intervention were considered for inclusion.

**Sample Size:** A total of 60 patients were included in the study. The patients were randomly allocated into two equal groups:

- Group A: 30 patients treated with open reduction and internal fixation
- Group B: 30 patients treated with closed reduction techniques

### Inclusion Criteria

- Patients aged between 18 and 60 years
- Unilateral or bilateral inferior orbital rim fractures confirmed by clinical and radiological assessment
- Patients who presented within 10 days of trauma
- Willingness to participate and provide informed written consent

### Exclusion Criteria

- Comminuted or complex orbital fractures involving multiple facial bones
- Associated ocular globe injuries or neurological impairment
- History of previous orbital trauma or surgery
- Unfit for surgery due to systemic illness
- Lost to follow-up

**Preoperative Assessment:** All patients underwent detailed clinical evaluation including assessment of diplopia, ocular motility, enophthalmos, infraorbital nerve sensation, and facial symmetry. Baseline imaging was performed using non-contrast computed tomography (CT) in axial and coronal

sections for detailed fracture analysis and surgical planning.

**Surgical Technique**

- **Group A (Open Reduction):** Surgical access was obtained via subciliary or transconjunctival approach. Fracture segments were exposed, reduced anatomically, and stabilized using titanium miniplates and screws.
- **Group B (Closed Reduction):** Manual manipulation techniques were employed to reposition the fracture segments without direct visualization. Reduction was confirmed clinically and radiographically. No rigid fixation was used in this group.

**Postoperative Care and Follow-up:** Postoperative monitoring included standard antibiotic and anti-inflammatory protocols. Patients were followed up at 1 week, 1 month, and 3 months post-surgery. Each follow-up included clinical evaluation of ocular function, infraorbital sensation, and facial aesthetics, along with repeat CT scans to assess fracture healing and alignment.

**Outcome Measures**

- Clinical parameters: presence or resolution of diplopia, ocular movement restriction, infraorbital numbness, enophthalmos, and symmetry
- Radiological assessment: postoperative CT evaluation for fracture alignment, orbital volume, and implant positioning (if applicable)

- Patient-reported outcomes: subjective satisfaction with appearance and functional recovery
- Complications: infection, implant exposure, malunion, or reoperation requirement

**Statistical Analysis:** Data were compiled and analyzed using appropriate statistical software. Continuous variables were expressed as mean ± standard deviation and compared using Student’s t-test or Mann–Whitney U test. Categorical variables were analyzed using Chi-square or Fisher’s exact test. A p-value of <0.05 was considered statistically significant.

**Results**

A total of 60 patients diagnosed with inferior orbital rim fractures were enrolled and evenly distributed into two groups: open reduction (Group A) and closed reduction (Group B). The demographic profile showed comparable age and gender distribution between groups. The majority of injuries resulted from road traffic accidents, followed by physical assaults. Preoperative clinical signs such as diplopia, enophthalmos, and infraorbital numbness were similarly prevalent. Timing of surgery, duration of surgery, and follow-up findings revealed distinct differences between the two groups. Open reduction had longer operative times but better radiological reduction and lower rates of persistent symptoms. Postoperative complications were low overall, and patient satisfaction was higher in the open reduction group.

**Table 1: Age and Gender Distribution of Study Population**

| Variable         | Group A (Open Reduction) | Group B (Closed Reduction) | Total      |
|------------------|--------------------------|----------------------------|------------|
| Mean Age (years) | 32.4 ± 8.5               | 31.7 ± 7.9                 | 32.0 ± 8.2 |
| Age Range        | 19–49                    | 20–48                      | 19–49      |
| Male             | 21                       | 19                         | 40 (66.7%) |
| Female           | 9                        | 11                         | 20 (33.3%) |

**Table 2: Mode of Injury**

| Mode of Injury        | Group A | Group B | Total |
|-----------------------|---------|---------|-------|
| Road Traffic Accident | 17      | 15      | 32    |
| Physical Assault      | 8       | 9       | 17    |
| Fall from Height      | 3       | 4       | 7     |
| Sports Injury         | 2       | 2       | 4     |

**Table 3: Preoperative Clinical Features**

| Clinical Feature        | Group A (n=30) | Group B (n=30) |
|-------------------------|----------------|----------------|
| Diplopia                | 16 (53.3%)     | 15 (50.0%)     |
| Enophthalmos (>2 mm)    | 13 (43.3%)     | 12 (40.0%)     |
| Infraorbital Numbness   | 18 (60.0%)     | 17 (56.7%)     |
| Restricted Eye Movement | 11 (36.7%)     | 10 (33.3%)     |

**Table 4: Duration Between Trauma and Surgery**

| Time Interval (Days) | Group A | Group B | Total |
|----------------------|---------|---------|-------|
| ≤ 3                  | 12      | 14      | 26    |
| 4-7                  | 11      | 10      | 21    |
| > 7                  | 7       | 6       | 13    |

**Table 5: Duration of Surgery**

| Duration (minutes) | Group A (Open Reduction) | Group B (Closed Reduction) |
|--------------------|--------------------------|----------------------------|
| Mean ± SD          | 88.2 ± 15.4              | 42.7 ± 11.2                |
| Range              | 65-120                   | 30-65                      |

**Table 6: Postoperative Diplopia at 1 Week and 3 Months**

| Time Point | Group A (n=30) | Group B (n=30) |
|------------|----------------|----------------|
| 1 Week     | 10 (33.3%)     | 13 (43.3%)     |
| 3 Months   | 2 (6.7%)       | 6 (20.0%)      |

**Table 7: Infraorbital Nerve Sensory Recovery**

| Time Point | Group A (Recovered) | Group B (Recovered) |
|------------|---------------------|---------------------|
| 1 Month    | 20 (66.7%)          | 18 (60.0%)          |
| 3 Months   | 28 (93.3%)          | 24 (80.0%)          |

**Table 8: Postoperative Enophthalmos (>2 mm)**

| Presence of Enophthalmos | Group A | Group B |
|--------------------------|---------|---------|
| Yes                      | 1       | 5       |
| No                       | 29      | 25      |

**Table 9: Radiological Accuracy of Fracture Reduction**

| Outcome               | Group A | Group B |
|-----------------------|---------|---------|
| Anatomically Reduced  | 27      | 19      |
| Mild Malalignment     | 3       | 9       |
| Moderate Displacement | 0       | 2       |

**Table 10: Postoperative Complications**

| Complication Type         | Group A | Group B |
|---------------------------|---------|---------|
| Wound Infection           | 1       | 0       |
| Implant Exposure          | 1       | 0       |
| Revision Surgery Required | 0       | 2       |
| Hematoma                  | 1       | 1       |

**Table 11: Patient Satisfaction at 3 Months**

| Satisfaction Level   | Group A | Group B |
|----------------------|---------|---------|
| Highly Satisfied     | 23      | 16      |
| Moderately Satisfied | 6       | 11      |
| Not Satisfied        | 1       | 3       |

**Table 12: Hospital Stay Duration**

| Duration (Days) | Group A (Mean ± SD) | Group B (Mean ± SD) |
|-----------------|---------------------|---------------------|
| Length of Stay  | 4.7 ± 1.3           | 2.6 ± 0.9           |

Table 1 shows that the mean age and gender distribution were similar between the groups, ensuring comparability. Table 2 indicates that road traffic accidents were the most common cause of injury, followed by physical assault. Table 3 highlights that diplopia, enophthalmos, and infraorbital numbness were equally distributed at baseline. Table 4 confirms that most patients underwent surgery within one week of trauma,

minimizing variability due to delayed treatment. Table 5 reveals that open reduction required nearly twice the operative time compared to closed reduction. Table 6 demonstrates better resolution of diplopia in the open group by 3 months. Table 7 shows a higher rate of sensory recovery in the open reduction group, particularly at the 3-month mark. Table 8 illustrates fewer cases of residual enophthalmos among patients treated with open

reduction. Table 9 confirms better anatomical fracture alignment in the open group, based on CT evaluation. Table 10 shows low complication rates in both groups, although revision surgeries occurred only in the closed group. Table 11 reflects greater patient satisfaction in the open reduction group. Table 12 indicates a slightly longer hospital stay in the open reduction group, consistent with the surgical complexity.

### Discussion

Inferior orbital rim fractures, due to their anatomical location and functional implications, demand precise evaluation and effective management to avoid long-term complications. This study compared two commonly employed surgical techniques open and closed reduction in terms of clinical outcomes, radiological accuracy, and patient satisfaction. The analysis included a well-matched cohort of patients, with balanced demographic and clinical profiles, ensuring a robust comparison between the treatment groups [10,11].

Both groups exhibited a comparable distribution of preoperative clinical symptoms including diplopia, infraorbital numbness, and enophthalmos, reflecting the uniformity of fracture severity. However, differences emerged postoperatively, particularly in the rates of symptom resolution and anatomical correction [12]. Open reduction showed a more favorable clinical trajectory, with a greater reduction in diplopia by the third postoperative month. This is likely attributable to direct decompression of orbital tissues and accurate repositioning of fracture segments [13].

Radiological evaluation confirmed that open reduction achieved higher anatomical accuracy. A larger proportion of patients in the open group had fractures that were completely aligned postoperatively, with fewer instances of mild or moderate residual displacement. This precise reduction is critical in restoring the orbital volume and preventing late enophthalmos, which was notably less frequent in the open reduction group [14].

Infraorbital nerve function, a commonly affected parameter in orbital rim fractures, showed significant improvement over time in both groups. However, recovery was faster and more complete in the open group, possibly due to better decompression of the infraorbital canal and protection of the nerve during plate placement. In contrast, patients in the closed reduction group experienced a slower recovery trajectory, with a few patients having persistent numbness beyond the third month [15,16].

Operative parameters such as surgery duration and hospital stay clearly favored closed reduction, which required significantly less operative time and

resulted in shorter hospital admissions. This makes closed reduction a more attractive option in minimally displaced fractures or when surgical resources are limited [17]. However, this advantage comes at the cost of less precise anatomical realignment and a higher likelihood of requiring revision procedures, as observed in a small subset of patients in the closed group.

Complication rates were low across both groups, which indicates the overall safety of both procedures when appropriately selected. Minor complications such as wound infection, implant exposure, and hematoma were managed conservatively. Notably, revision surgery was only required in the closed reduction group, underscoring the need for careful case selection when opting for a non-invasive approach [18].

Patient-reported outcomes are a critical component of trauma care, reflecting the patient's perception of functional and cosmetic success. In this study, patients treated with open reduction reported higher satisfaction levels, which correlated with their improved clinical outcomes and reduced residual deformities. While subjective, these responses align with the objective findings and support the broader adoption of open reduction in appropriately indicated cases [19,20].

In summary, the results of this study suggest that open reduction should be the preferred method for managing displaced inferior orbital rim fractures, especially when accurate anatomical reconstruction and rapid functional recovery are clinical priorities. Closed reduction remains a viable alternative in selected cases but may not achieve the same level of precision or patient satisfaction. Future studies with larger sample sizes and longer follow-up periods are warranted to validate these findings and optimize treatment algorithms.

### Conclusion

This study demonstrates that open reduction offers better clinical and radiological outcomes in the management of inferior orbital rim fractures compared to closed reduction. Open reduction allows for more accurate anatomical realignment, superior resolution of diplopia and sensory disturbances, and lower rates of residual enophthalmos. Although it requires a longer operative time and slightly increased hospital stay, the trade-off is justified by higher patient satisfaction and reduced need for secondary intervention.

Closed reduction remains a viable option for minimally displaced fractures and in scenarios where surgical resources are limited. However, for displaced fractures requiring precise restoration of orbital anatomy, open reduction should be the preferred approach. Clinical decision-making

should therefore be guided by fracture characteristics, patient condition, and the anticipated functional and aesthetic outcomes.

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