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Contemporary Approaches to Surgical Treatment of Zygomatic–Orbital Complex Fractures: A Clinical Comparative Study and Treatment Algorithm

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Abstract: Zygomatic–orbital complex (ZOC) fractures represent a significant proportion of midfacial injuries and are frequently associated with functional ocular disturbances and persistent facial asymmetry. Despite advances in imaging and fixation technology, optimal surgical timing, access, fixation points, and reconstruction materials remain debated.

Keywords: zygomatic-orbital complex, zygomaticomaxillary fracture, orbital reconstruction, titanium mesh, porous polyethylene, diplopia, enophthalmos, 3D CT.

Introduction

Zygomatic–orbital complex (ZOC) fractures represent one of the most frequent and clinically significant injuries of the midface. Due to the anatomical role of the zygoma in forming the lateral orbital wall, infraorbital rim, and midfacial buttresses, even minimal displacement may result in pronounced aesthetic deformity and functional impairment. The clinical relevance of ZOC trauma is primarily associated with disturbances of orbital volume and geometry, leading to diplopia, enophthalmos, limitation of extraocular muscle movement, infraorbital nerve dysfunction, and secondary facial asymmetry.

Despite substantial progress in maxillofacial trauma surgery, the management of ZOC fractures remains challenging. The main controversies concern the optimal timing of intervention, the number of fixation points required for stable osteosynthesis, and the indications for orbital floor reconstruction. In particular, the decision to perform additional orbital reconstruction is not always straightforward, as early edema may mask enophthalmos, while diplopia may be transient and related to soft tissue swelling rather than true muscle entrapment. Consequently, inadequate primary treatment can result in persistent post-traumatic deformities requiring complex secondary reconstruction.

Modern clinical practice increasingly relies on multislice computed tomography (MSCT) as a mandatory diagnostic modality for ZOC fractures, allowing detailed assessment of fracture displacement, orbital wall integrity, and associated midfacial injuries. However, radiological findings must be interpreted in correlation with clinical and ophthalmological examination. Therefore, structured treatment algorithms based on objective criteria (degree of displacement, orbital symptoms, and orbital floor defects) are essential for standardizing surgical decision-making and improving outcomes.

The aim of this study is to provide a contemporary clinical comparative analysis of surgical strategies for ZOC fractures and to propose a practical treatment algorithm integrating clinical findings, MSCT criteria, and evidence-based principles of fixation and orbital reconstruction. This approach is intended to optimize functional recovery, minimize complication rates, and reduce the incidence of long-term post-traumatic deformities.

Objective

The objective of this study was to perform a clinical comparative evaluation of contemporary surgical strategies for zygomatic–orbital complex (ZOC) fractures and to develop a practical treatment algorithm based on multislice computed tomography (MSCT) findings and key clinical criteria, including fracture displacement, orbital symptoms, and the presence of orbital floor defects.

Materials and Methods

At the first stage of the study, an analysis of archival clinical material was conducted, which included 120 patients with fractures of the zygomatico-orbital complex who underwent treatment between 2021 and 2025.

In parallel, from 2023 to 2025, we observed 104 patients with various types of zygomatico-orbital complex fractures who received appropriate comprehensive treatment. During the work, treatment algorithms were developed and implemented, based on which all patients were conditionally divided into 6 clinical groups depending on the type, location, and nature of the zygomatico-orbital complex fracture.

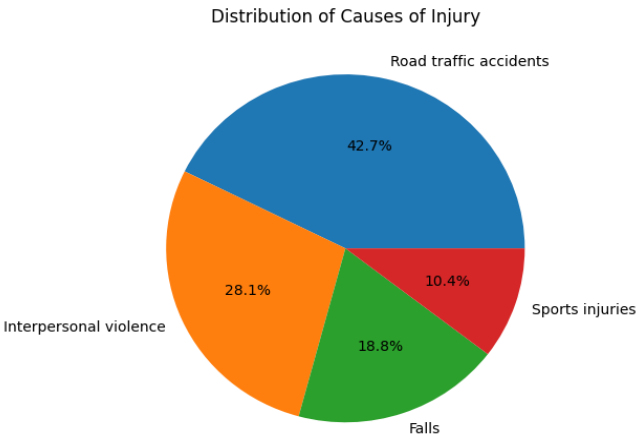
Of the total number of examined patients (n = 224), men predominated - 147 individuals (65.6%), while women numbered 77 (34.4%). The age of the patients ranged from 8 to 65 years, with the majority being individuals aged 21-50 years (78.1%). Among the causes of injuries, domestic accidents and road traffic accidents occupied leading positions, accounting for 47.4% and 38.4% of cases, respectively.

All patients underwent comprehensive general clinical examination, including medical history collection, clinical examination, palpation, as well as laboratory, instrumental, and functional diagnostic methods. The examination included laboratory tests (complete blood count and urinalysis, blood biochemistry), electrocardiography, and anthropometric measurements. Additionally, all patients were consulted by specialized experts - ophthalmologist, neurologist, neurotraumatologist, otorhinolaryngologist, and others as indicated.

Radiological diagnostics included examination of the facial skeleton with radiography in two projections (axial and lateral). When necessary, additional imaging methods were employed, including computed tomography or magnetic resonance imaging, depending on the clinical situation.

The obtained numerical data were subjected to statistical processing using medical statistics methods in accordance with modern requirements. To assess the differences between variation series, White's nonparametric W-criterion was used, while Pearson's chi-square test ($\chi 2$) was applied in the analysis of qualitative characteristics.

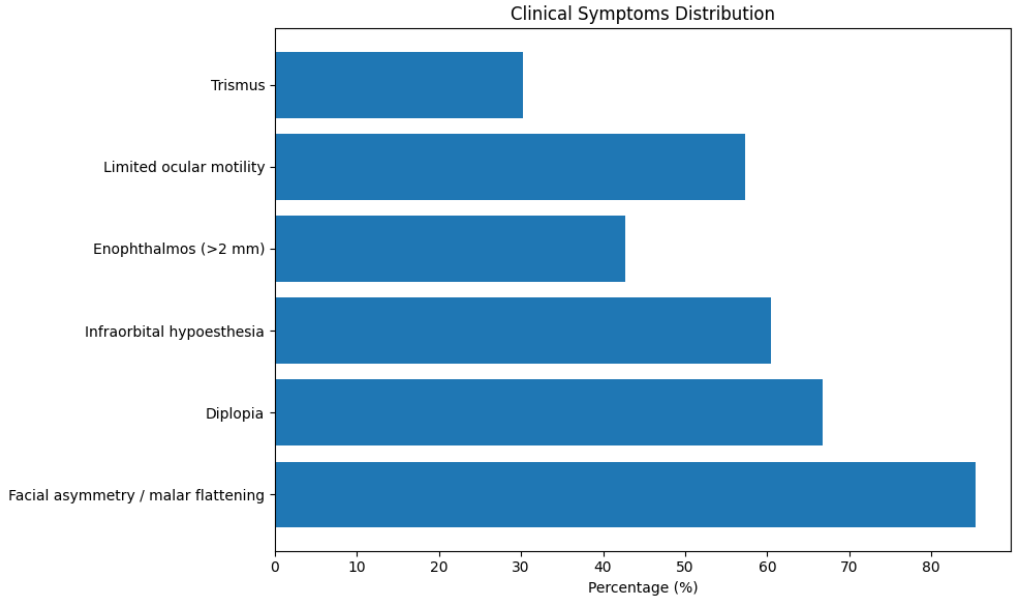
Etiology of Trauma



Distribution of Fracture Patterns

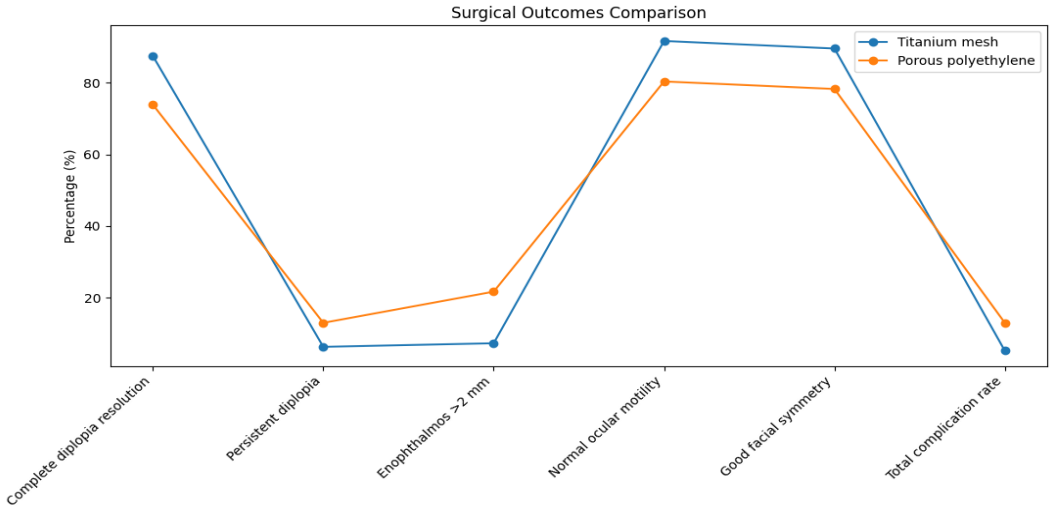
Fracture type	n	%
Isolated ZOC fracture	39	40.6
ZOC + orbital floor defect	37	38.5
Comminuted ZOC fracture	20	20.9

Preoperative Clinical Findings

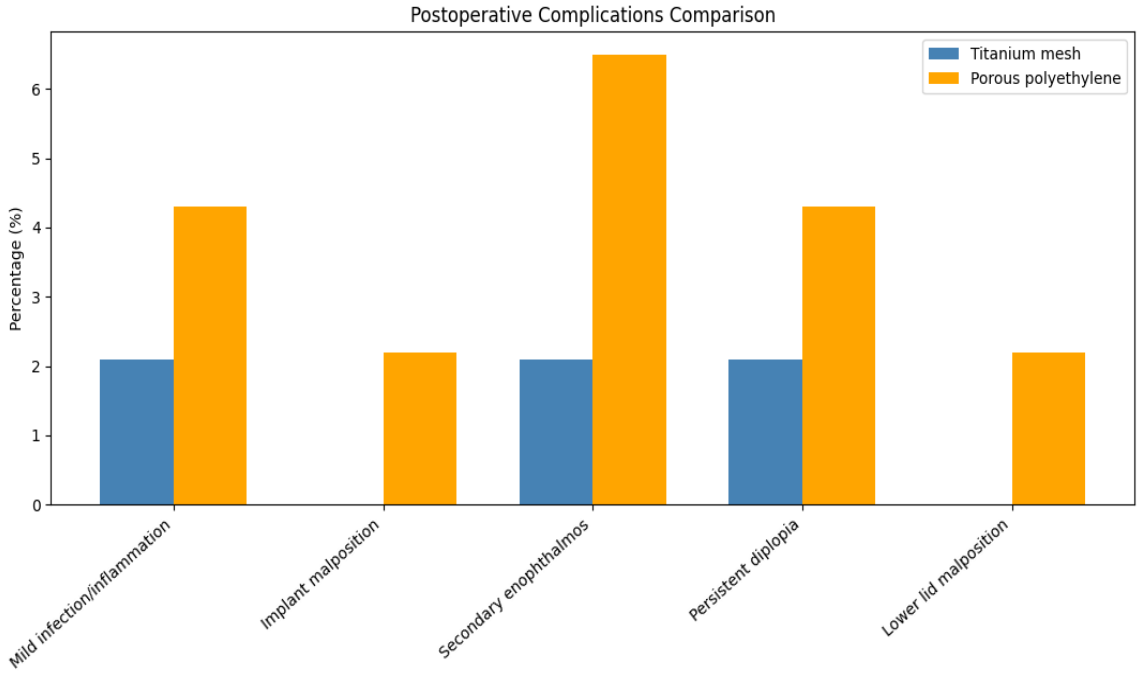


Outcomes at 6 Months

Table: Comparative outcomes (Group I vs Group II)



Postoperative Complications



Discussion - Clinical Relevance of Algorithm-Based ZOC Management

Zygomatic–orbital complex fractures remain a cornerstone problem in maxillofacial trauma surgery due to their high frequency and the functional consequences of orbital involvement. Although the majority of ZOC fractures can be reduced successfully, the challenge lies in maintaining stable anatomical restoration and preventing late complications such as enophthalmos, diplopia, and midface asymmetry.The results of this study support the concept that a structured algorithm based on three key criteria—fracture displacement, orbital symptoms, and orbital floor defects—improves decision-making and clinical outcomes. This approach provides an objective framework for determining when conservative management is acceptable, when early reduction is required, and when fixation and orbital reconstruction become mandatory.Fixation Strategy: Why Stability Matters One of the most important findings from the comparative clinical material is the significance of stable fixation. Archived cases showed that reduction alone, even when technically successful, did not always prevent secondary displacement and late malar flattening. This observation is consistent with modern biomechanical principles: the zygoma functions as a structural buttress of the midface, and insufficient fixation allows muscular traction, edema-related tissue forces, and functional loading to induce gradual relapse. The algorithm-based approach emphasized miniplate fixation in at least two points for moderate displacement and three points for severe displacement. This strategy resulted in improved contour restoration and reduced asymmetry during follow-up.Orbital Floor Reconstruction: Timing and Indications The indications for orbital floor reconstruction remain a debated topic in the literature. Early postoperative edema may mask enophthalmos, while diplopia may be caused by transient swelling rather than true muscle entrapment. However, the data demonstrate that when CT confirms an orbital floor defect—especially comminuted or segmental defects—reconstruction should be considered proactively.Patients with comminuted orbital floor injuries benefited from reconstruction using supportive materials such as titanium mesh. The clinical value of this step lies in restoring orbital volume and preventing delayed globe displacement.

Sinus Involvement and Postoperative Complications Maxillary sinus wall fractures frequently accompany ZOC trauma. In selected patients, maxillary sinus revision and temporary packing were used. The occurrence of sinusitis in a small proportion of cases highlights the need for careful sinus management, adequate drainage, and antibiotic prophylaxis when indicated. Secondary displacement after removal of sinus packing, although rare, suggests that sinus-based stabilization should not be relied upon as a primary fixation method in unstable fractures. Instead, rigid internal fixation remains the cornerstone of stable reconstruction.

Secondary Deformities: The Cost of Inadequate Primary Treatment

The group of patients with post-traumatic deformities (late admissions) demonstrated the most severe functional and aesthetic problems. These cases required complex secondary procedures, including orbital reconstruction with grafting and revision osteosynthesis. This finding emphasizes a key clinical message: prevention of deformity through adequate primary treatment is significantly more effective than delayed correction.

Limitations

The study has several limitations. First, the comparison between archived and algorithm-based cohorts includes differences in surgical technology and fixation materials over time. Second, the study design combines retrospective and prospective elements, which may introduce selection bias. Third, detailed standardized quality-of-life assessment was not available for all patients.

Clinical Implications Despite limitations, the results strongly support:

1. mandatory MSCT-based evaluation for all ZOC fractures,
2. early reduction in displaced fractures,
3. rigid fixation in at least two points for moderate displacement,
4. three-point fixation for severe displacement,
5. mandatory orbital reconstruction for comminuted orbital floor defects

Conclusion

Zygomatic–orbital complex fractures represent a clinically significant category of midfacial trauma due to their high risk of functional impairment and persistent aesthetic deformities. The findings of this study demonstrate that an algorithm-based approach combining clinical evaluation with mandatory MSCT assessment provides a more reliable basis for selecting treatment tactics than isolated clinical judgment. Early reduction with rigid internal fixation remains the key factor in preventing secondary displacement and late malar flattening. In patients with moderate-to-severe displacement, two- and three-point osteosynthesis significantly improves midface stability and facial symmetry. Furthermore, the presence of orbital symptoms and CT-confirmed orbital floor defects should be regarded as strong indications for timely orbital reconstruction in order to prevent delayed enophthalmos and persistent diplopia. Overall, standardized stratification of ZOC fractures and structured surgical planning improve anatomical restoration, reduce postoperative complications, and minimize the need for secondary reconstructive procedures, thereby enhancing both functional and aesthetic outcomes.

Practical Recommendations

- perform 3D-CT in all suspected ZOC fractures;
- operate preferably within 14 days;
- use transconjunctival approach for orbital floor access when possible;

- choose titanium mesh for defects >2 cm²;
- apply 2–3 point fixation depending on fracture stability.

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