

Surgical Management of Maxillary Fractures: Principles of Reduction, Fixation, And Functional Restoration

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ABSTRACT

Maxillary fractures comprise a heterogeneous group of injuries involving the central and lateral midface, including Le Fort fractures, zygomaticomaxillary complex fractures, dentoalveolar injuries, maxillary sinus wall fractures, and pediatric maxillofacial trauma. Operative treatment is generally indicated when fractures produce displacement, malocclusion, instability, facial projection abnormalities, orbital dysfunction, or significant functional impairment. The primary objectives of surgery are restoration of preinjury occlusion, facial width and projection, orbital relationships, and continuity of the vertical and horizontal maxillary buttresses. Open reduction and internal fixation remains the dominant strategy for displaced and unstable injuries. However, the optimal surgical exposure, number of fixation points, and role of advanced imaging remain dependent on fracture pattern and patient characteristics. Two-point fixation may provide adequate stability in selected zygomaticomaxillary complex fractures, whereas three-point fixation may improve rotational control in unstable patterns, although the quality of comparative evidence remains limited. Minimally invasive, transconjunctival, and intraoral approaches may reduce visible scarring without compromising exposure in appropriately selected injuries. Pediatric fractures require special consideration because of facial growth, mixed dentition, and developing tooth germs. This review summarizes current indications, operative principles, surgical approaches, fixation strategies, complications, antibiotic considerations, and emerging technologies in maxillary fracture management.

KEYWORDS: maxillary fracture; Le Fort fracture; zygomaticomaxillary complex fracture; open reduction and internal fixation; facial buttress; maxillofacial trauma; orbital fracture; midface reconstruction.

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INTRODUCTION

Maxillary fractures encompass a broad spectrum of midfacial injuries rather than a single anatomical entity. They may involve the maxillary alveolus, maxillary sinus walls, nasomaxillary region, zygomaticomaxillary complex, orbital floor, or complete Le Fort fracture patterns [1]. Their clinical relevance extends beyond bone healing because disruption of the maxilla can alter dental occlusion, facial projection, orbital support, mastication, speech, airway function, and facial symmetry.

The central objective of treatment is restoration of preinjury anatomy and function. This requires accurate reduction of the maxillary segments, re-establishment of stable dental occlusion, reconstruction of the vertical and horizontal facial buttresses, and preservation of orbital and neurovascular structures [2,3].

Open reduction and internal fixation is the principal operative strategy for displaced, unstable, or functionally significant maxillary fractures. However, not all maxillary fractures require surgery. Nondisplaced fractures without

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malocclusion, orbital disturbance, facial deformity, or instability may be managed conservatively with observation, dietary modification, analgesia, and clinical follow-up [1,4].

Management should therefore be individualized according to fracture type, displacement, occlusion, orbital involvement, patient age, associated injuries, timing of presentation, and available surgical expertise.

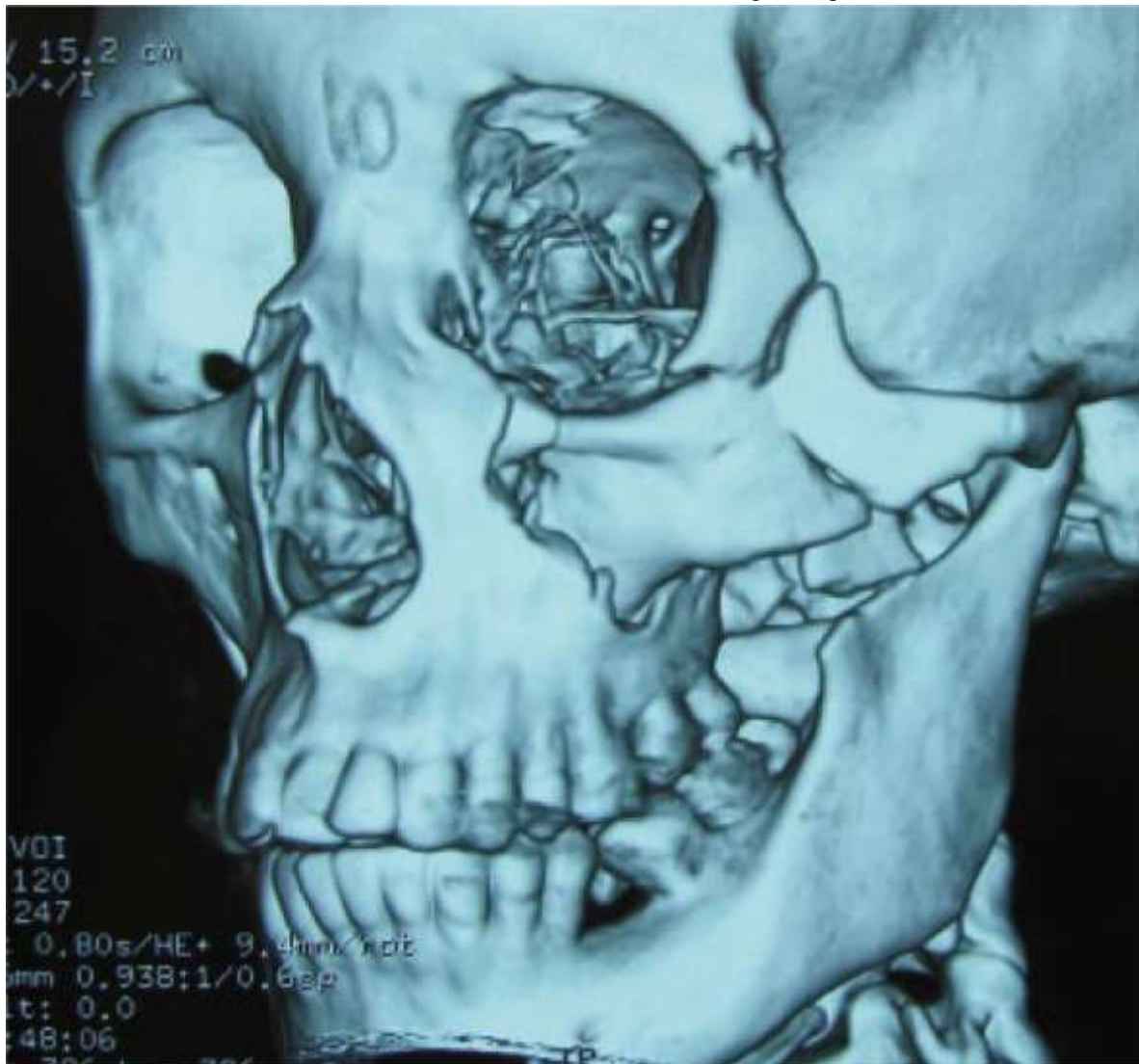


Figure 1. *Figure 1. Three-dimensional computed tomography reconstruction of a complex maxillary fracture. Lateral 3D CT image of the facial skeleton demonstrating a displaced and comminuted midfacial fracture involving the zygomaticomaxillary complex, infraorbit*

METHODS

This narrative review was developed from the provided literature synthesis on surgical treatment of maxillary fractures. The evidence included clinical reviews, systematic reviews, meta-analyses, retrospective studies, randomized trials, technical reports, and case series addressing Le Fort fractures, zygomaticomaxillary complex fractures, fixation strategies, operative approaches, pediatric trauma, antibiotic prophylaxis, and technology-assisted reconstruction. References are presented numerically according to their first appearance in the manuscript.

Classification and Relevant Anatomy

Maxillary fractures may occur as isolated injuries or as part of complex midfacial trauma. Common patterns include:

Dentoalveolar fractures

Fractures of the frontal process of the maxilla

Maxillary sinus wall fractures

Zygomaticomaxillary complex fractures

Nasomaxillary or naso-orbito-ethmoidal injuries

Le Fort I, II, and III fractures

Comminuted panfacial injuries

The facial skeleton is supported by a system of vertical and horizontal buttresses. Important vertical buttresses include the nasomaxillary, zygomaticomaxillary, and pterygomaxillary columns. Horizontal support is provided by the frontal bar, infraorbital rims, and maxillary alveolus.

Successful reconstruction depends on restoring these buttresses rather than merely aligning isolated fragments. Buttress reconstruction restores facial height, width, projection, and load transmission during mastication [3,5].

Indications for Surgical Treatment

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Surgery is generally indicated when maxillary fractures produce one or more of the following findings:

Malocclusion
Significant displacement
Segmental instability
Loss of facial projection or symmetry
Orbital floor or rim involvement
Diplopia or extraocular movement restriction
Enophthalmos or vertical orbital dystopia
Open fracture or contamination
Functional impairment of mastication
Comminution affecting facial buttresses
Associated zygomatic or naso-orbito-ethmoidal injuries
Persistent deformity after initial conservative treatment
Stable and minimally displaced fractures without functional or aesthetic disturbance may be managed nonoperatively. Conservative treatment is particularly common in selected maxillary sinus wall fractures, frontal process fractures, and pediatric nondisplaced injuries [1,6].

The decision to operate should be based on functional and anatomical consequences rather than radiographic appearance alone.

Preoperative Assessment

Initial evaluation follows trauma principles, with priority given to airway, breathing, circulation, neurologic status, cervical spine injury, and hemorrhage control. Maxillary fractures may be associated with severe epistaxis, airway compromise, traumatic brain injury, ocular injury, mandibular fracture, or panfacial trauma.

Clinical examination should document:

Dental occlusion
Maxillary mobility
Facial width and projection
Palatal stability
Step-offs along the infraorbital rim
Malar flattening
Diplopia and ocular motility
Visual acuity
Infraorbital nerve sensation
Trismus
Oral or nasal lacerations
Cerebrospinal fluid leakage when suspected

Computed tomography is the preferred imaging modality. Thin-cut CT with multiplanar and three-dimensional reconstruction allows assessment of fracture displacement, orbital involvement, buttress disruption, and comminution [5,7].

Preoperative photographs and dental records may be useful in complex or delayed cases. Dental casts, virtual surgical planning, and intraoperative imaging may further improve reduction accuracy.

Timing of Surgery

Timing depends on patient stability, soft-tissue swelling, ocular findings, contamination, and associated injuries. Life-threatening and vision-threatening conditions take priority.

Early surgery is generally preferred for displaced fractures once the patient is stable and swelling permits safe exposure. Delayed treatment can result in fibrosis, malunion, occlusal deformity, facial asymmetry, and increased technical difficulty. Neglected fractures may require osteotomies, bone grafting, wider exposure, or staged reconstruction [8].

Emergency surgery may be necessary in cases of uncontrolled hemorrhage, airway compromise, entrapment with oculocardiac reflex, open contaminated fracture, or severe instability. Otherwise, definitive fixation is commonly performed after initial stabilization and careful planning.

Core Operative Principles

The principal steps of maxillary fracture surgery include:

Establishment of correct dental occlusion.

Exposure of the disrupted buttresses.

Mobilization and anatomical reduction of fracture segments.

Restoration of facial height, width, and projection.

Stable internal fixation.

Evaluation of orbital volume and rim continuity.

Verification of occlusion before closure.

Occlusion is often established using maxillomandibular fixation, arch bars, interdental wiring, hybrid fixation systems, or temporary intraoperative guiding elastics. The maxilla is then reduced relative to the stable cranial base or mandible, depending on the associated fracture pattern.

Rigid or semirigid fixation with titanium plates and screws is typically placed along the facial buttresses. Miniplate fixation remains the predominant method in contemporary practice [2].

Surgical Approaches

Maxillary Vestibular Approach

The maxillary vestibular or gingivobuccal incision provides access to the anterior maxilla, piriform aperture, zygomaticomaxillary buttress, and portions of the infraorbital rim. It avoids visible facial scars and is commonly used in Le Fort and zygomaticomaxillary complex fractures [3,9].

The incision must preserve an adequate mucosal cuff for closure and avoid injury to the infraorbital nerve. Subperiosteal dissection allows visualization of fracture lines and plating sites.

Transconjunctival Approach

The transconjunctival approach provides access to the orbital floor and infraorbital rim without an external skin incision. It is commonly used when orbital reconstruction or infraorbital rim fixation is required.

A randomized clinical trial found that transconjunctival exposure provided adequate access with better aesthetic outcomes, less postoperative edema, and no visible scar compared with the subtarsal approach, while ocular and sensory complications were similar [10].

Subciliary and Subtarsal Approaches

These approaches provide direct access to the inferior orbital rim and floor but may produce visible scars, scleral show, ectropion, or lower eyelid retraction. They remain useful

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when wide exposure is required or when surgeon experience favors these incisions.

Lateral Eyebrow or Upper Blepharoplasty Approach

Access to the frontozygomatic region can be obtained through a lateral eyebrow or upper eyelid crease incision. The upper blepharoplasty approach may provide improved scar concealment.

Coronal Approach

The coronal approach is reserved for complex upper and midfacial injuries requiring broad exposure of the zygomatic arches, frontal bone, naso-orbito-ethmoidal region, or craniofacial skeleton. Although it provides excellent access, it is more invasive and carries risks such as alopecia, temporal branch injury, sensory changes, and prolonged operative time.

Le Fort Fractures

Le Fort I

Le Fort I fractures separate the tooth-bearing maxilla and palate from the upper midface. Patients commonly present with malocclusion, maxillary mobility, palatal ecchymosis, and facial swelling.

Surgical treatment emphasizes restoration of occlusion and fixation at the nasomaxillary and zygomaticomaxillary buttresses. Maxillomandibular fixation is often established before plating.

Le Fort II

Le Fort II fractures follow a pyramidal pattern involving the nasal bridge, medial orbit, infraorbital rims, anterior maxilla, and pterygoid plates. Reconstruction requires restoration of the central midfacial buttresses, infraorbital rims, and occlusion.

Le Fort III

Le Fort III fractures produce craniofacial disjunction and involve the nasofrontal region, orbital walls, zygomatic arches, and pterygoid plates. These injuries are frequently associated with severe soft-tissue trauma, ocular injury, cerebrospinal fluid leakage, and panfacial fractures.

Treatment generally requires broad exposure and fixation from stable cranial reference points downward. Accurate restoration of facial width and projection is essential [3,11].

Zygomaticomaxillary Complex Fractures

Zygomaticomaxillary complex fractures involve the zygomaticofrontal suture, infraorbital rim, zygomaticomaxillary buttress, and zygomatic arch. Displacement may cause malar flattening, increased orbital volume, diplopia, enophthalmos, infraorbital nerve dysfunction, and trismus.

Accurate reduction is essential because the zygoma determines both facial projection and orbital volume. Fixation may be performed at one, two, or three points depending on fracture stability.

Two-point fixation is often performed at the frontozygomatic suture and zygomaticomaxillary buttress. It may provide adequate stability in selected fractures while minimizing surgical exposure [12,13].

Three-point fixation adds stabilization at the infraorbital rim. It may improve rotational control and vertical orbital alignment in unstable or comminuted fractures. However, systematic review evidence supporting universal three-point fixation is limited by low-quality and heterogeneous studies [14].

Therefore, fixation should be determined by fracture stability after reduction rather than by a rigid rule.

Two-Point Versus Three-Point Fixation

Two-point fixation offers the advantages of shorter operative time, reduced dissection, and fewer incision-related complications. It is often sufficient when the fracture is reducible and stable after fixation at the frontozygomatic and zygomaticomaxillary regions.

Three-point fixation may be considered when there is:

Persistent rotational instability

Significant infraorbital rim displacement

Comminution

Orbital dystopia

Severe malar displacement

Failure to maintain reduction with two plates

Comparative studies have reported acceptable outcomes with both strategies. Some analyses suggest greater stability with three-point fixation, whereas others report similar infection, asymmetry, and functional outcomes [13,14].

The number of fixation points should therefore be tailored to fracture complexity and intraoperative stability.

Orbital Reconstruction

Maxillary and zygomaticomaxillary fractures frequently involve the orbital floor or rim. Indications for orbital exploration or reconstruction include:

Persistent diplopia associated with entrapment

Significant orbital floor defect

Enophthalmos

Increased orbital volume

Globe malposition

Infraorbital rim displacement

Pediatric trapdoor fracture with muscle entrapment

Orbital reconstruction may use titanium mesh, porous polyethylene, resorbable implants, patient-specific implants, or bone grafts. The choice depends on defect size, contamination, patient age, and surgeon preference.

Accurate restoration of orbital volume is critical. Overcorrection or undercorrection may produce globe malposition, diplopia, or enophthalmos.

Dentoalveolar and Palatal Injuries

Dentoalveolar fractures may be stabilized with arch bars, dental splints, interdental wiring, or miniplates. Treatment should preserve viable teeth, restore the dental arch, and re-establish occlusion.

Palatal fractures may require maxillomandibular fixation, palatal splints, transpalatal wiring, or internal fixation. Unstable palatal widening can compromise maxillary width and produce persistent malocclusion if inadequately treated.

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The dental and palatal components should be reconstructed before final fixation of the upper maxillary buttresses because occlusion provides an important reference for midface alignment.

Pediatric Maxillary Fractures

Pediatric fractures require distinct management because of craniofacial growth, mixed dentition, thin bone, and developing tooth germs. Nondisplaced fractures are often managed conservatively. Surgery is reserved for displaced, unstable, comminuted, or functionally significant injuries [6,15].

When fixation is required, limited exposure and carefully positioned hardware are preferred. Plates should be placed away from developing tooth roots and growth centers whenever possible. Intraoral approaches reduce visible scarring.

Resorbable fixation may be considered in selected children, although stability, degradation behavior, and cost must be evaluated. Long-term follow-up is important to detect growth disturbance, asymmetry, dental eruption problems, or hardware-related complications.

Antibiotic Prophylaxis

The role of prolonged antibiotics in maxillary fracture surgery has been increasingly questioned. Systematic reviews and meta-analyses suggest that prolonged postoperative prophylactic antibiotics do not significantly reduce infection after operative treatment of facial fractures [16,17].

Short perioperative antibiotic coverage may be appropriate for open fractures, contaminated wounds, intraoral approaches, or procedures involving the paranasal sinuses. However, routine extended postoperative treatment is generally not supported for uncomplicated upper and midfacial fractures [18].

Antibiotic decisions should consider contamination, mucosal communication, immunosuppression, concomitant infection, and institutional protocols.

Bone Grafting and Secondary Reconstruction

Bone grafting may be necessary in:

Delayed or neglected fractures

Segmental bone loss

Severe comminution

Deficient facial buttresses

Orbital defects

Malunion correction

Secondary orthognathic reconstruction

Autologous grafts may be obtained from the calvarium, iliac crest, rib, or other sites. Patient-specific implants and alloplastic materials are increasingly used in orbital and contour reconstruction.

Neglected fractures may require osteotomy and repositioning rather than simple fracture mobilization. These cases are more technically demanding and may require virtual planning or staged correction [8,19].

Advanced Imaging and Surgical Technology

Modern adjuncts include:

Intraoperative cone-beam CT

Surgical navigation

Three-dimensional printed models

Virtual surgical planning

Patient-specific implants

Contralateral mirroring

Computer-assisted reduction

Endoscopic-assisted approaches

These technologies may improve anatomical accuracy in complex, comminuted, orbital, or delayed fractures. Intraoperative imaging can identify residual displacement before closure and reduce the need for revision surgery [7,20]. However, current evidence primarily supports these technologies as useful adjuncts in selected difficult cases. Routine use in all fractures has not been definitively justified by long-term comparative studies.

Complications

- Potential complications of maxillary fracture surgery include:
- Malocclusion
- Facial asymmetry
- Malar flattening
- Enophthalmos
- Diplopia
- Infraorbital nerve dysfunction
- Infection
- Hardware exposure or palpability
- Plate infection
- Sinusitis
- Nonunion or malunion
- Trismus
- Lower eyelid malposition
- Visible scarring
- Tooth root injury

Delayed need for orthognathic surgery

Malocclusion is among the most clinically significant complications because it directly affects mastication and may indicate inadequate reduction. Persistent diplopia, globe malposition, or facial asymmetry may require secondary reconstruction.

Complication prevention depends on accurate preoperative assessment, restoration of stable occlusion, anatomical reduction, appropriate fixation, and careful soft-tissue handling.

Postoperative Management

Postoperative care may include:

- Elevation of the head
- Cold compresses during the early postoperative period
- Oral hygiene and antiseptic mouthwash
- Soft or non-chew diet
- Analgesia
- Short perioperative antibiotic prophylaxis when indicated

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- Ophthalmologic reassessment
- Occlusal monitoring
- Early jaw mobilization when fixation permits
- Avoidance of nose blowing in orbital or sinus involvement
- Follow-up imaging in complex cases

Maxillomandibular fixation duration should be minimized when stable internal fixation permits early function. Prolonged immobilization may increase stiffness, poor oral hygiene, nutritional difficulty, and patient discomfort.

Proposed Surgical Algorithm

A practical management algorithm includes:

Stabilize the patient: address airway, hemorrhage, neurologic injury, and ocular emergencies.

Classify the fracture: determine whether the injury is Le Fort, zygomaticomaxillary, dentoalveolar, orbital, or mixed.

Assess function: document occlusion, maxillary stability, ocular findings, facial projection, and nerve function.

Obtain CT imaging: evaluate buttresses, orbit, displacement, and comminution.

Select conservative or surgical treatment: observe stable nondisplaced fractures; operate on displaced or functionally significant injuries.

Establish occlusion: use maxillomandibular fixation or dental guidance.

Restore facial buttresses: reduce and plate stable structural reference points.

Evaluate fixation stability: use two or three points according to the fracture pattern.

Reconstruct the orbit when indicated: restore rim continuity and orbital volume.

Confirm reduction: reassess occlusion, symmetry, globe position, and imaging when available.

Begin postoperative rehabilitation: monitor vision, occlusion, mouth opening, and facial sensation.

Discussion

The strongest consensus in maxillary fracture management concerns the goals of surgery rather than a universal operative technique. Accurate anatomical reduction, restoration of dental occlusion, reconstruction of facial buttresses, and

stable fixation are the fundamental principles across Le Fort and zygomaticomaxillary fracture patterns [3,4].

The number of fixation points remains controversial. Three-point fixation may improve mechanical stability in complex zygomaticomaxillary injuries, but two-point fixation is adequate in many reducible and stable fractures. Additional exposure should be justified by a clinically meaningful improvement in stability or orbital reconstruction.

Surgical access should also be individualized. Intraoral and transconjunctival approaches reduce visible scars and may provide sufficient exposure in many cases. Wider approaches remain necessary for comminuted, delayed, panfacial, or cranio-orbital injuries.

Pediatric fractures require a more conservative threshold because operative dissection and hardware may affect tooth development and facial growth. Long-term pediatric evidence remains limited, and standardized protocols have not been fully established.

Advanced imaging, navigation, and three-dimensional planning may improve reduction accuracy in difficult injuries. Nevertheless, these technologies should support—not replace—understanding of facial anatomy, occlusion, and buttress reconstruction.

CONCLUSION

Surgical treatment of maxillary fractures is indicated primarily for displaced, unstable, or function-threatening injuries. The core objectives are restoration of dental occlusion, facial projection, orbital relationships, and the vertical and horizontal facial buttresses. Open reduction and internal fixation with miniplates remains the standard operative strategy. Two-point fixation may be sufficient in selected zygomaticomaxillary fractures, while three-point fixation should be considered when rotational or orbital instability persists. Intraoral and transconjunctival approaches provide effective exposure with reduced visible scarring in appropriate cases. Pediatric treatment should prioritize conservative management whenever possible and carefully limited fixation when surgery is required. Optimal outcomes depend on individualized planning, accurate reduction, stable fixation, and long-term functional follow-up.

Table 1. Operative Strategies for Common Maxillary Fracture Patterns

Fracture pattern	Main indication for surgery	Typical exposure	Fixation strategy	Key objective
Le Fort I	Malocclusion, maxillary mobility, displacement	Maxillary vestibular approach	Bilateral nasomaxillary and zygomaticomaxillary buttress fixation	Restore occlusion and lower midfacial stability
Le Fort II	Pyramidal displacement, orbital rim involvement, malocclusion	Vestibular plus orbital access as required	Nasomaxillary, infraorbital, and zygomaticomaxillary fixation	Restore central facial height and orbital support

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Le Fort III	Craniofacial disjunction, severe instability	Coronal, vestibular, orbital, or combined approaches	Cranial-to-caudal multi-buttress fixation	Re-establish facial projection and cranial attachment
Zygomaticomaxillary complex fracture	Malar flattening, orbital dysfunction, trismus, displacement	Vestibular, transconjunctival, upper eyelid, or combined	Two- or three-point fixation	Restore malar projection and orbital volume
Dentoalveolar fracture	Mobile segment, displaced teeth, altered occlusion	Intraoral	Dental splint, arch bar, wiring, or miniplate	Preserve teeth and restore dental arch
Palatal fracture	Maxillary widening or unstable occlusion	Intraoral	Palatal splint, wiring, or miniplate fixation	Restore transverse maxillary width
Orbital floor involvement	Entrapment, diplopia, enophthalmos, large defect	Transconjunctival or other orbital approach	Orbital implant with rim fixation when needed	Restore orbital volume and globe position
Pediatric maxillary fracture	Displaced, unstable, comminuted, or functionally significant injury	Limited intraoral exposure preferred	Minimal fixation avoiding tooth germs	Restore function while preserving facial growth

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