FACIAL TRAUMA

VOLUME III

Rebuilding the Midface

Nasal, naso-orbito-ethmoid, zygomaticomaxillary, maxillary, palatal, and dentoalveolar trauma

Volume III: reconstruct the midface as a connected frame

1. **Define lost dimensions** — Height, width, projection, rotation, canthal position, arch width, and occlusion.
2. **Find trustworthy references** — Premorbid bite, stable mandible, frontal bar, intact side, orbital rims, and photographs.
3. **Restore the platform** — Reduce palatal width and reproduce the patient's occlusion before trusting the maxilla.
4. **Rebuild strong pillars** — Restore zygomaticomaxillary and nasomaxillary buttresses before thin boundaries.
5. **Restore central and lateral shape** — Reestablish canthal position, nasal support, malar projection, arch contour, and orbit.
6. **Verify globally** — Recheck bite, facial width, projection, trismus, globe position, and symmetry before closure.

Reduction establishes geometry - fixation preserves it

Figure 0.1. Volume III moves from lost facial dimensions to trustworthy references, platform restoration, buttress reconstruction, and global verification.

CENTRAL QUESTION

How do you restore the midface when trauma has disrupted nasal projection, canthal position, malar prominence, facial width, vertical height, and the maxillary dental platform?

Resident-level study guide • Prepared July 2026

How to Use This Volume

Volume III begins after the initial threats and upper-face emergencies have been addressed. The task is now reconstructive: to identify which dimensions of the midface have been lost, decide which landmarks can still be trusted, and restore a stable three-dimensional frame that supports the nose, medial and lateral orbits, maxillary dental arch, and facial soft tissues.

The guide is deliberately not organized as a list of independent fracture diagnoses. Chapters 1 and 2 establish the structural and operative mental model. Chapters 3 through 7 apply that model to the nasal septum, NOE complex, ZMC, Le Fort-level injuries, palate, and dentoalveolar segments. Chapters 8 and 9 focus on surgical exposure, fixation, postoperative assessment, and secondary deformity. Chapter 10 integrates the volume in oral-board cases.

SCOPE

Detailed orbital emergencies and internal orbital reconstruction are covered in Volume II. Detailed mandibular biomechanics and condylar management belong in Volume IV. Volume III repeatedly uses the mandible and orbit as reference structures but focuses on the central and lateral midface.

Learning objectives

- Explain how vertical and horizontal buttresses maintain facial height, width, projection, and the maxillary dental platform.
- Distinguish isolated nasal trauma from septal, NOE, orbital, frontal sinus, or skull-base extension.
- Analyze NOE injury through central-fragment integrity, medial canthal tendon support, nasal projection, medial orbital support, and lacrimal function.
- Interpret ZMC displacement in terms of rotation, malar projection, orbital volume, arch contour, and coronoid clearance.
- Diagnose Le Fort-level instability without assuming that modern injuries reproduce symmetric textbook patterns.
- Recognize palatal and dentoalveolar injuries that make occlusion an unreliable reference until the arch is stabilized.
- Choose reduction references, operative exposures, and fixation points according to the geometry that must be restored.
- Identify early and late failure through malocclusion, telecanthus, widening, flattening, enophthalmos, trismus, epiphora, and nasal obstruction.
- Present a coherent midface reconstruction plan for written and oral boards.

EVIDENCE CALIBRATION

AO Surgery Reference provides a widely used technical framework, but fixation points, timing, and adjunctive technologies remain pattern- and institution-dependent. Systematic reviews of NOE and ZMC repair repeatedly note low-quality and heterogeneous evidence. The guide therefore separates durable reconstructive principles from rigid numerical rules.

Abbreviations

Abbrev.	Meaning	Clinical role
MCT	Medial canthal tendon	Anchors the eyelids to the central NOE fragment and determines canthal position.
NOE	Naso-orbito-ethmoid	Central midface unit linking nose, medial orbit, lacrimal system, and skull base.
ZMC	Zygomaticomaxillary complex	Lateral midface unit controlling malar projection, width, orbit, and arch contour.
MMF	Maxillomandibular fixation	Temporarily reproduces the dental relationship while the skeletal frame is reduced.
VSP	Virtual surgical planning	May support mirroring, guides, models, and patient-specific planning in complex trauma.
ORIF	Open reduction and internal fixation	Direct reduction and stabilization of displaced skeletal units.

Contents

1 The Midface as a Three-Dimensional Frame 4

CHAPTER 1

The Midface as a Three-Dimensional Frame

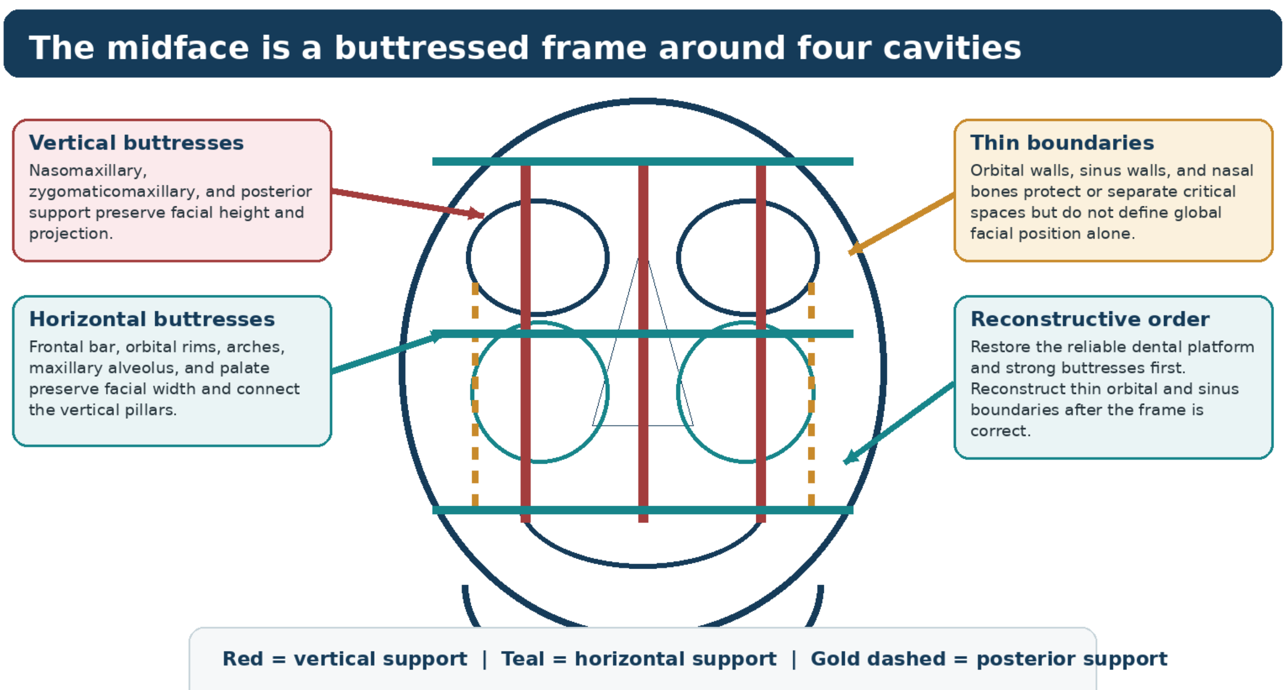
CENTRAL QUESTION
What is the midface designed to preserve, and which dimensions fail when its framework is disrupted?

OPENING CASE
A patient has fractures of both maxillary sinuses, nasal bones, orbital rims, and zygomatic arches. The radiology report lists eleven fracture lines. The reconstructive problem is simpler and harder: the maxillary platform is mobile, the cheeks are rotated posteriorly, the central face is widened, and there is no obvious intact side to use as a template.

1.1 Strength through architecture, not thickness

The midface is built around the nasal cavity, maxillary sinuses, oral cavity, and orbits. Much of its bone is thin because strength is concentrated into vertical and horizontal buttresses. These pillars transmit masticatory forces from the tooth-bearing maxilla toward the cranial base and maintain facial shape despite the surrounding cavities. Trauma therefore does not simply break a solid block; it disconnects a lightweight frame at weak interfaces.

This architecture creates a useful surgical distinction. Thin walls often require reconstruction because of what they contain or separate, but strong buttresses determine where the larger skeletal units belong. A plate placed on an accurately restored buttress preserves facial dimensions. A plate placed across a convenient fracture line without a global reduction can rigidly preserve a deformity.



1.2 The dimensions that define a normal midface

The visible and functional result depends on linked dimensions: vertical height, bizygomatic width, malar and nasal projection, intercanthal distance, orbital position, maxillary arch width, and the anteroposterior and vertical position of the dental platform. These dimensions are not interchangeable. A patient can have good incisor contact while the maxilla remains widened posteriorly, or a well-aligned infraorbital rim while the zygoma is rotated and the cheek remains flat.

Table 1.1. Fracture labels become clinically useful when translated into lost dimensions.

Lost dimension	Typical structural failure	Clinical consequence
Vertical height	Vertical-buttress disruption or maxillary impaction/distraction	Facial elongation or shortening, open bite, loss of projection.
Transverse width	Zygomatic rotation, palatal split, central NOE splaying	Facial widening, posterior crossbite, telecanthus.
Projection	Posterior ZMC displacement, nasal collapse, maxillary retrusion	Flat cheek, saddle or flattened dorsum, concave midface.
Rotation	Zygoma or maxillary unit malrotation	Orbital asymmetry, step-offs, apparent width change, malocclusion.
Arch width	Palatal and dentoalveolar instability	Crossbite, unstable occlusion, false guidance during ORIF.
Canthal position	MCT-bearing central fragment displacement or tendon avulsion	Telecanthus, eyelid malposition, lacrimal dysfunction.

1.3 Central and lateral midface

The central midface includes the nasal bones, septum, frontal processes of the maxilla, ethmoid complex, medial orbital rims and walls, lacrimal apparatus, and MCT-bearing fragments. It controls nasal projection, intercanthal distance, medial orbital support, and lacrimal drainage; its proximity to the frontal sinus and anterior cranial base also makes it a skull-base concern.

The lateral midface is organized around the zygoma and its articulations with the frontal bone, maxilla, temporal bone, and sphenoid. It controls malar projection, facial width, lateral orbital support, and the arch corridor through which the coronoid moves.

1.4 The maxillary platform

The tooth-bearing maxilla and palate form the upper half of the occlusal system and the transverse base from which the midface is rebuilt. When the palate is split or the alveolus is mobile, the arch must be reconstructed before the bite can guide the remainder of the face.

CLINICAL BRIDGE
A fracture line is an anatomic description. A lost dimension is a reconstructive diagnosis. State both.

RESIDENT SYNTHESIS
The operative endpoint is restoration of height, width, projection, rotation, canthal position, orbital support, and a stable maxillary dental platform.

CHAPTER 2

Reduction Before Fixation

CENTRAL QUESTION
Which anatomy can still be trusted, and how should the reconstruction proceed from reliable references to unstable structures?

OPENING CASE
During ORIF of bilateral midface fractures, the maxilla is placed into apparently good MMF and four plates are applied. On release, the patient has a posterior open bite and the cheeks remain flattened. The problem was not plate strength. The palate was widened and the condyles were not seated when the dental relationship was locked.

2.1 Plates preserve a reduction; they do not define it

The most durable principle in midface trauma is that reduction must precede fixation conceptually and technically. A plate can hold bone firmly in the wrong location. Before drilling, the surgeon should be able to state what dimension the maneuver restores and which independent landmark verifies it.

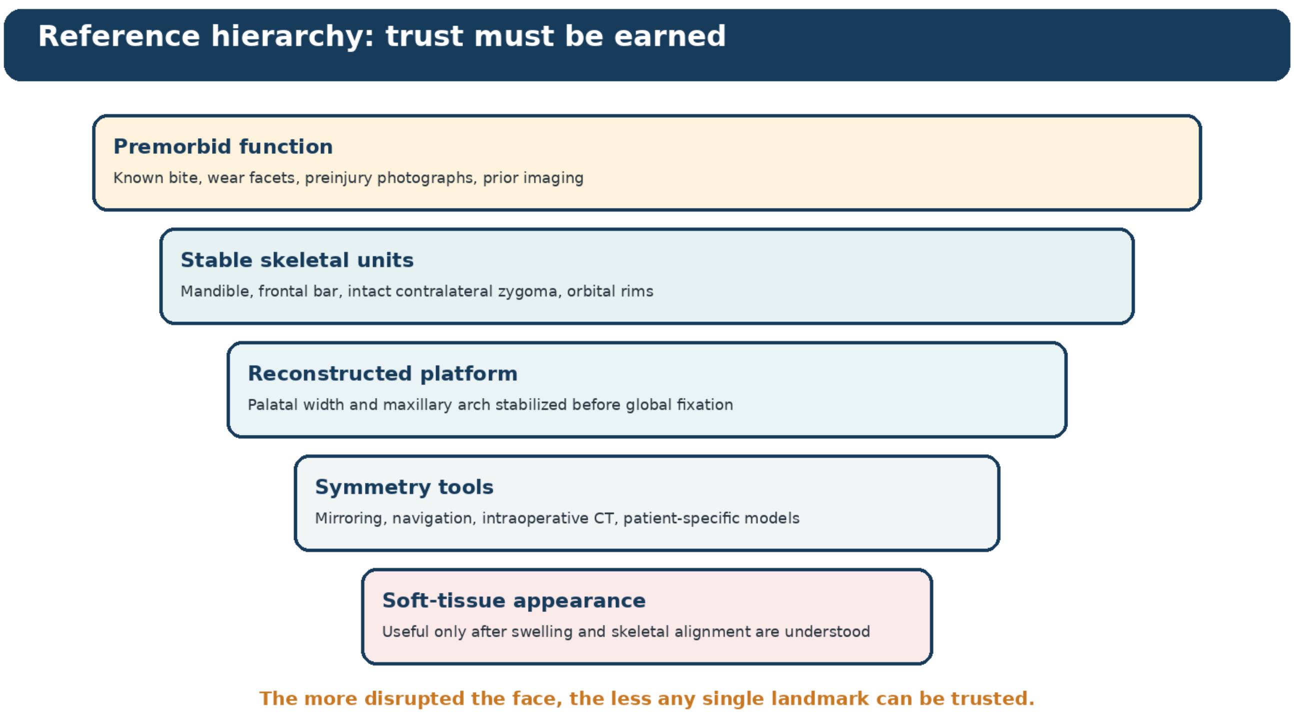


Figure 2.1. Reference points form a hierarchy. Premorbid function and stable skeletal units are usually stronger guides than swollen soft-tissue appearance.

2.2 Potential reference points

The best reference depends on what remains intact. Premorbid occlusion and dental wear facets can be powerful. A stable mandible may define the lower facial frame. The frontal bar, an intact zygoma, orbital rims, the sphenozygomatic interface, and an undisturbed nasal dorsum may provide additional anchors. Preinjury photographs, prior CT, dental models, and orthodontic records become unusually valuable in bilateral or comminuted injury.

Table 2.1. A reference is useful only after its integrity has been questioned.

Reference	Why it helps	When it can mislead
Premorbid occlusion	Recreates a patient-specific functional relationship.	Preexisting malocclusion, missing teeth, palatal split, condylar or mandibular fracture.
Stable mandible	Provides lower facial width and an arch for MMF.	Comminution, edentulism, condylar displacement, loss of ramal height.

Reference	Why it helps	When it can mislead
Contralateral ZMC	Guides projection and rotation.	Bilateral injury or preexisting asymmetry.
Frontal bar / cranial base	Strong superior reference in severe midface injury.	Associated frontal or skull-base disruption.
Orbital rims / sphenozygomatic junction	Checks three-dimensional zygomatic position.	Comminution or incomplete exposure.
Photographs / VSP	Shows premorbid shape and supports mirroring.	Image distortion, facial expression, technology availability.

2.3 Occlusion is a reference, not a religion

MMF reproduces the relationship between dental arches; it does not guarantee that either arch is anatomically correct. A widened palate may still permit anterior intercuspation. An incompletely mobilized maxilla can pull the mandible posteriorly or distract the condyles when elastic force is applied. Edentulous patients, severe dental disease, and preexisting malocclusion further reduce reliability.

Before accepting occlusion, seat the condyles, evaluate palatal width, inspect posterior contacts, compare the dental midlines, and ask whether the bite matches premorbid wear facets or records. AO guidance for Le Fort repair emphasizes complete mobilization and passive stability before fixation; forced traction on an incompletely mobilized segment can create a false bite. [1,7]

2.4 Work from known to unknown

General sequencing principles are more durable than a single universal order: establish a reliable dental platform when possible, restore maxillary width, rebuild strong vertical buttresses, recover zygomatic projection and lateral width, then reconstruct central NOE and orbital details. The exact order changes when the mandible, frontal bar, or one side of the face is more stable than another. Full panfacial sequencing is developed in Volume VI.

- Restore stable units before thin or comminuted fragments.
- Reduce width before accepting projection; a widened frame can make the cheek look falsely prominent.
- Restore zygomatic position before final internal orbital reconstruction.
- Reduce central bony width before final MCT fixation.
- Use provisional fixation and repeatedly reassess occlusion and symmetry before final tightening.
- Do not allow one early plate to block a later reduction.

2.5 Digital planning and intraoperative imaging

VSP, mirrored models, navigation, cutting or positioning guides, and patient-specific implants can improve spatial planning in selected complex injuries, particularly bilateral comminution or delayed deformity. Contemporary series support feasibility in acute maxillofacial trauma, but the technology adds cost, lead time, segmentation error, and dependence on the quality of the proposed reference anatomy.[12] It should make the reconstructive hypothesis more explicit, not replace intraoperative judgment.

2.6 The reconstructive clock

Midface injuries do not share one operative deadline. Emergency treatment is reserved for airway or hemorrhage control, ocular emergencies, infected septal collections, avulsed-tooth first aid, and threatened or contaminated soft tissue. Definitive skeletal reconstruction usually follows after physiologic stabilization and a reliable examination, but before fibrosis and early union make mobilization and landmark identification more difficult. The exact interval depends on ocular and neurologic injuries, swelling, contamination, and whether dependable reference anatomy is available. Delayed presentation or established malunion moves the patient to a secondary-reconstruction pathway rather than a late version of the original operation.[1,12,14]

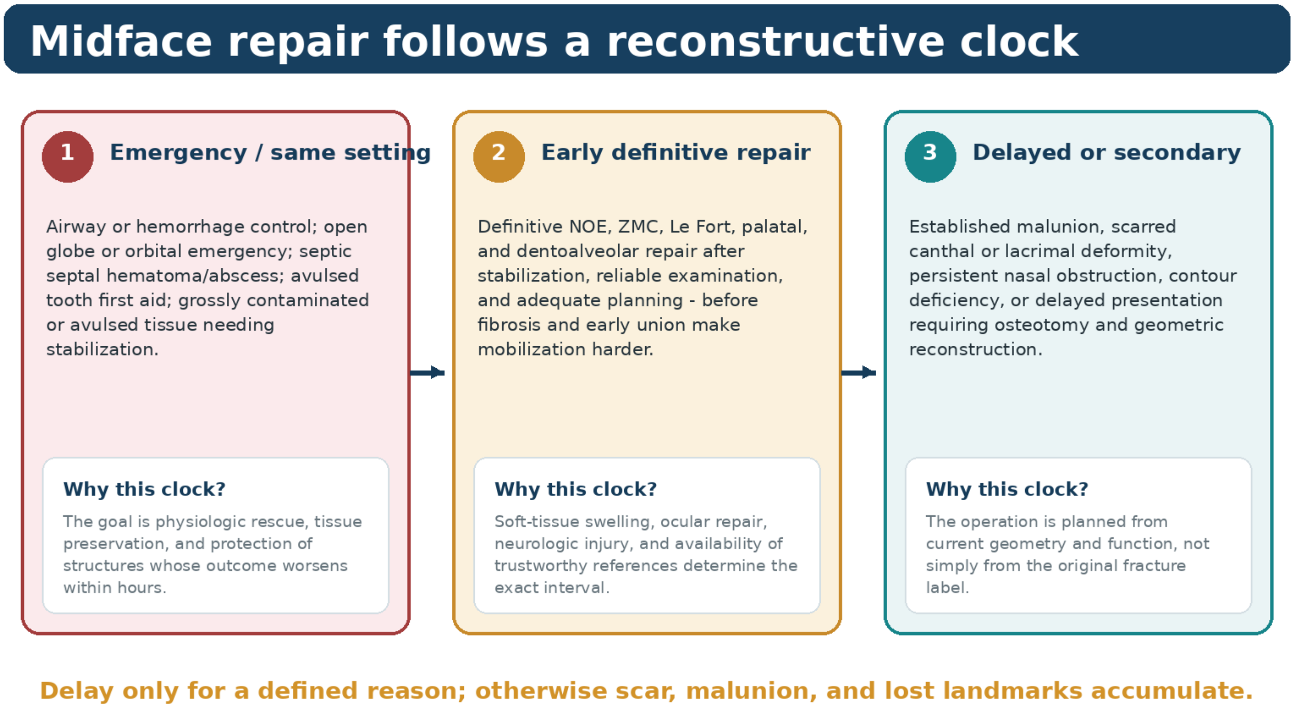


Figure 2.2. Midface timing follows the threatened function, tissue biology, and reconstructive feasibility rather than a universal day count.

2.7 When occlusion is unavailable

Edentulous or poorly dentate patients require a different reference hierarchy. Existing dentures may serve as reduction guides, and Gunning-type splints can recreate arch form and vertical dimension. When these are unavailable, preinjury photographs, prior imaging, the frontal bar, orbital rims, stable mandibular segments, facial width, and VSP become more important. The plan should state explicitly which substitute reference is being used and how it will be independently verified. Detailed panfacial sequencing is developed in Volume VI.

> **OPERATIVE PEARL**
> Before tightening the last screw, release MMF when safe and re-check the bite, condylar seating, maxillary stability, malar symmetry, arch clearance, canthal position, and globe position.

> **RESIDENT SYNTHESIS**
> Reliable reconstruction proceeds from anatomy that can be trusted toward anatomy that cannot. Every fixation point should preserve a reduction that has already been verified by at least one independent relationship.

CHAPTER 3

Nasal Bone and Septal Trauma

CENTRAL QUESTION
When is a nasal injury simple, and when does it signal loss of septal support or a broader central-midface injury?

OPENING CASE
A patient presents one week after nasal trauma with bilateral obstruction and modest external swelling. The emergency department diagnosed a nasal fracture and arranged delayed follow-up. Anterior rhinoscopy shows smooth, fluctuant bilateral septal swelling. The urgent problem is not the nasal-bone alignment; it is threatened septal cartilage.

3.1 The nose is a support system

The nasal bones form the upper bony vault, but durable shape and airflow depend on the septum and its attachments to the nasal bones, upper lateral cartilages, maxillary crest, anterior nasal spine, and lower lateral cartilages. The septum functions as a central strut. Displacement can narrow the airway, destabilize the dorsal and caudal framework, and create delayed valve collapse even when the nasal bones have been reduced.

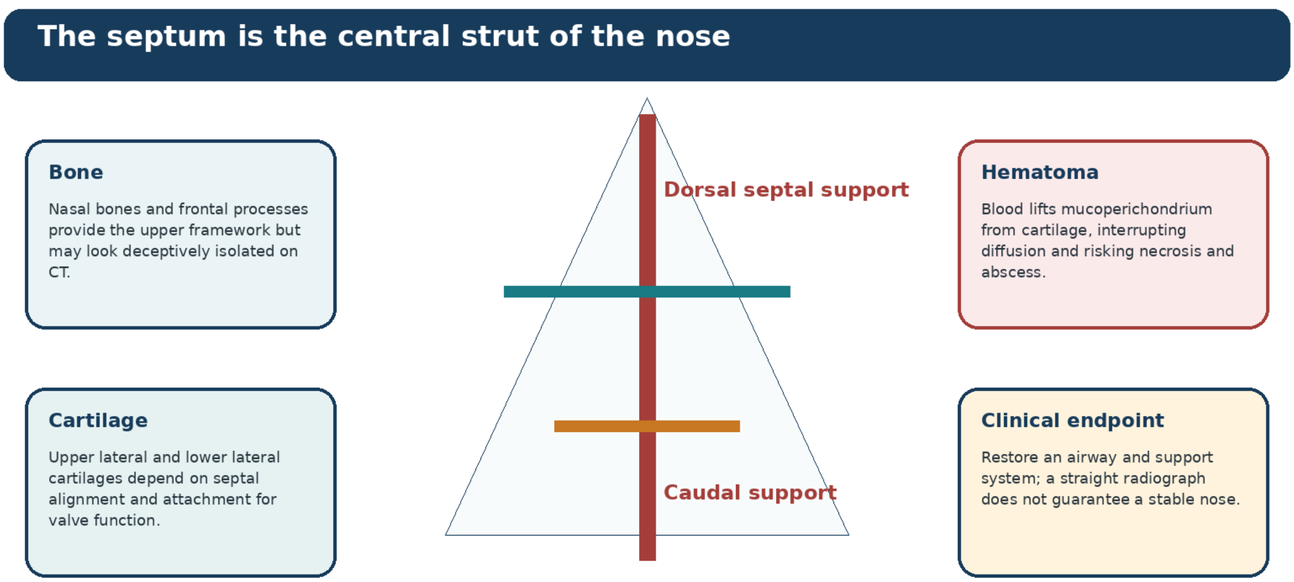


Figure 3.1. Septal support links the bony dorsum, cartilaginous vault, nasal tip, and internal valve.

3.2 Evaluation: outside, inside, and beyond the nose

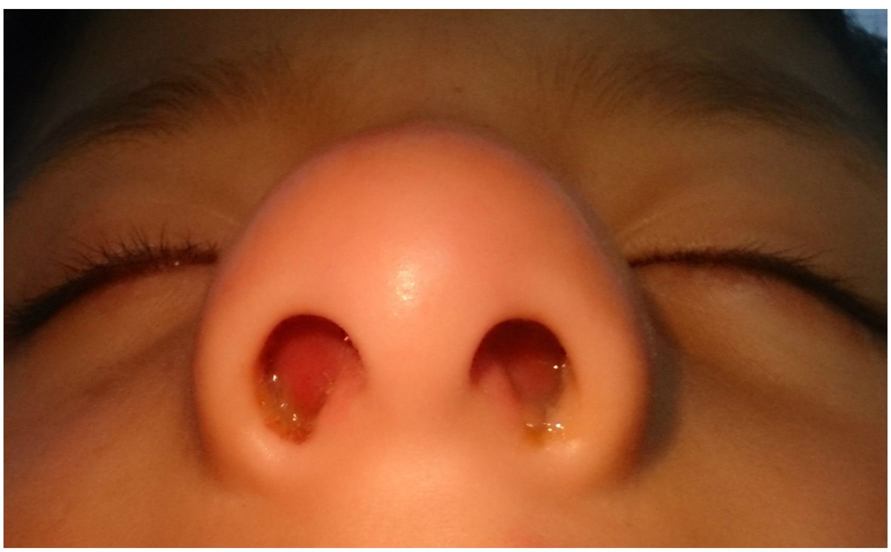
Assess external deviation, depression, widening, dorsal height, tip support, skin viability, and wounds. Then inspect the nasal cavities with suction, topical vasoconstriction when appropriate, and adequate lighting. Document septal deviation, mucosal laceration, hematoma, active bleeding, airway patency, and clear drainage. Palpate the nasal root and assess intercanthal position because an NOE injury can masquerade as a displaced nasal fracture.[2,3]

CT is not routinely required for an uncomplicated isolated nasal fracture. It becomes useful when the mechanism, examination, or associated injuries raise concern for NOE, orbital, frontal sinus, Le Fort, or skull-base involvement. Plain radiographs rarely change management.

Figure 3.2. Axial CT of bilateral nasal-bone fractures. CT can define complex central injury, but an isolated nasal fracture is usually a clinical diagnosis.
Source: James Heilman, MD, Wikimedia Commons, CC BY-SA 4.0.

3.3 Septal hematoma

A septal hematoma forms when blood separates mucoperichondrium from cartilage. Septal cartilage lacks an intrinsic blood supply and depends on diffusion from the mucoperichondrium. Persistent separation therefore causes ischemia, cartilage necrosis, abscess, and eventual saddle deformity. The swelling is typically smooth, fluctuant, and poorly responsive to topical vasoconstriction, often producing bilateral obstruction.



Prompt drainage, irrigation when contaminated, re-apposition of mucoperichondrium, prevention of reaccumulation, and close follow-up are required. Culture and therapeutic antibiotics are indicated for abscess or established infection. For uncomplicated hematoma, systemic antibiotic practice varies; if packing or splints remain, follow the local protocol and keep the evidence uncertainty explicit.[2]

surveillance because loss of septal support can disturb growth.

3.4 Observation and reduction

A fracture without functional obstruction or unacceptable deformity may be observed. Reduction is considered when the patient has a new deformity, airway compromise attributable to displacement, or an unstable open injury. Immediate reduction can be reasonable before major edema develops; otherwise the patient is reassessed after swelling improves but before fracture consolidation makes mobilization difficult. Timing is an interval rather than a universal day count and depends on age, edema, and injury pattern.[2]

Closed reduction mobilizes and repositions the bony vault and, when feasible, the septum. External splinting and selective internal support maintain the reduction. Open reduction or acute structural reconstruction is considered for severe comminution, open fractures, upper-lateral cartilage disarticulation, inability to obtain a stable closed reduction, or associated NOE and frontal injuries requiring exposure. Some deformities are best treated with delayed functional septorhinoplasty after healing and scar maturation.

Table 3.1. Nasal treatment is selected by airway, deformity, support, and stability.

Pathway	Features favoring it	Important limitation
Observation	No meaningful new deformity or obstruction; stable septum.	Requires follow-up because swelling can hide deformity.
Closed reduction	Mobile displaced bony vault with achievable stable alignment.	Does not reliably correct major septal, valve, or comminuted support failure.
Open reduction	Open/comminuted injury, unstable septum, cartilage disarticulation, combined central trauma.	Greater exposure and scar; tissue viability and future reconstruction matter.
Delayed septorhinoplasty	Persistent airway or shape problem after healing.	Requires waiting for stable tissues unless acute support is otherwise unsalvageable.

DIAGNOSTIC TRAP

External symmetry does not exclude a septal hematoma, and a visibly displaced nose does not exclude an NOE fracture.

RESIDENT SYNTHESIS

The internal nasal examination identifies the emergency. The external examination defines later reduction. The broader facial examination decides whether the injury is truly isolated.

CHAPTER 4

Naso-Orbito-Ethmoid Trauma

CENTRAL QUESTION
How do you restore a central unit that simultaneously controls canthal position, nasal projection, medial orbital support, lacrimal drainage, and skull-base relationships?

OPENING CASE
A high-energy collision produces nasal flattening, marked central swelling, epiphora, and apparent widening of the inner canthi. CT shows bilateral comminution around the lacrimal fossae. The central question is not how many fragments exist. It is whether each MCT remains attached to a fragment that can be returned to a stable posterior-superior position.

4.1 A functional crossroads

The NOE complex occupies the confluence of the nasal bones, frontal processes of the maxilla, ethmoid labyrinth, medial orbital walls, lacrimal bones, frontal sinus floor, septum, and anterior cranial base. The MCT inserts on the central fragment through anterior and posterior limbs. This fragment anchors the eyelids and defines intercanthal distance. It is therefore more important than many larger fragments that do not carry a critical attachment.

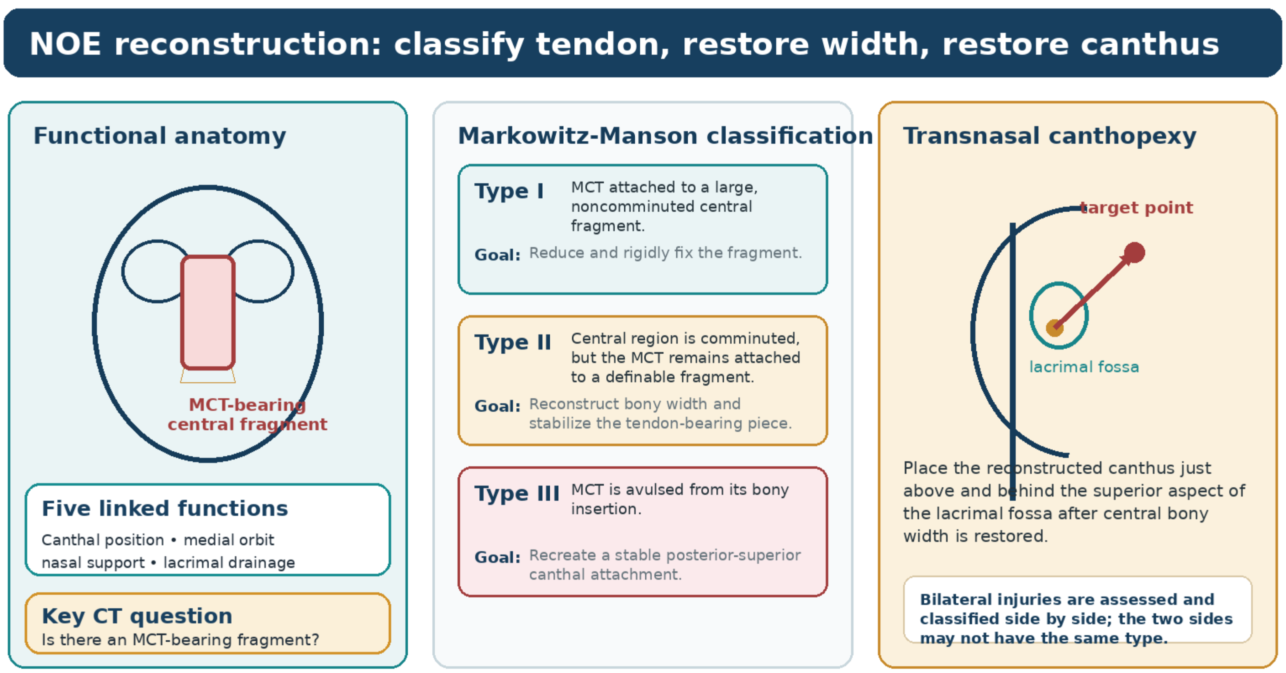


Figure 4.1. NOE reconstruction is organized around functional anatomy, side-specific tendon classification, restoration of central width, and a posterior-superior canthal fixation vector.

4.2 Examination

Look for nasal-root depression, loss of dorsal projection, telecanthus, shortened palpebral fissures, medial canthal instability, epiphora, nasal obstruction, and CSF concern. Measure and compare intercanthal distance when swelling permits. Bimanual palpation and the bowstring test can suggest MCT or central-fragment instability, but pain, edema, and bilateral injuries reduce reliability. The ocular examination and frontal sinus/skull-base assessment remain mandatory.

Telecanthus is increased soft-tissue distance between the medial canthi; hypertelorism refers to increased bony orbital separation. Trauma may create both, but the terms are not interchangeable. A patient can have tendon malposition without true orbital hypertelorism, or widened central bones with an apparently preserved tendon attachment.

4.3 CT: map the fragment the tendon needs

CT should identify the central MCT-bearing fragment, degree of comminution, medial orbital rim and wall, frontal process of the maxilla, nasal bones and septum, lacrimal fossa, frontal sinus floor, cribriform region, and associated Le Fort or orbital fractures. CT does not directly prove tendon integrity. It predicts whether there is a substantial fragment to which the tendon is likely attached and whether that fragment can accept fixation.

4.4 Classification as reconstructive difficulty

The Markowitz-Manson framework is based on the relationship between the MCT and the central fragment. Type I injuries have an intact tendon attached to a relatively large, noncomminuted fragment. Type II injuries are comminuted, but the tendon remains attached to a definable fragment. Type III injuries are defined by avulsion of the MCT from its bony insertion. A tiny but still tendon-bearing fragment remains a Type II injury, even when fixation is technically difficult. Classify bilateral injuries side by side because the two sides may have different types. The classification communicates the challenge of canthal stabilization; it does not replace analysis of central width, orbital walls, nasal support, and the lacrimal system.[3,4,19]

Table 4.1. The classification describes tendon support, not the entire injury.

Type	Central fragment / MCT relationship	Primary reconstructive challenge
I	MCT attached to a large, noncomminuted central fragment.	Accurate reduction and rigid fixation of the fragment.
II	Central region comminuted, but MCT remains attached to a definable fragment.	Reconstruct central bony width and stabilize the tendon-bearing piece.
III	MCT avulsed from its bony insertion.	Recreate a stable posterior-superior canthal fixation point after restoring central width.

4.5 Reconstruction sequence

Classic NOE sequencing remains useful: obtain adequate exposure; identify the tendon and its fragment; restore the medial orbital rims and walls; reduce the central bony framework; stabilize the MCT or perform transnasal canthopexy when necessary; reconstruct the septum and nasal dorsum; and finally redrape soft tissue.[5] The sequence is adapted to associated ZMC, Le Fort, frontal sinus, and orbital injuries.

- Restore central bony width before final canthal fixation.
- Use bony fixation of a viable tendon-bearing fragment whenever it reliably restores the tendon.
- When transnasal fixation is needed, restore the canthus to a posterior-superior position - just above and behind the superior aspect of the lacrimal fossa - after central bony width has been reduced.
- Compare the canthal height, depth, and tension with the opposite side.
- Restore dorsal nasal height after the stable central frame has been established.
- Coordinate lacrimal repair with oculoplastics or a surgeon experienced in the drainage system when injury is evident.

4.6 Lacrimal injury

Epiphora in the acute setting may reflect edema, lacrimal-pump dysfunction, canalicular injury, lacrimal-sac injury, or nasolacrimal duct obstruction. Canalicular lacerations require prompt eyelid-system repair. Sac and duct injuries may be hard to define during comminuted NOE reconstruction. Routine probing or prophylactic intubation of every fracture is not supported; selective stenting is reasonable when the drainage system is directly injured or cannot otherwise be protected. Persistent obstruction after edema resolves may ultimately require dacryocystorhinostomy.[22]

4.7 What the evidence can and cannot say

A 2024 systematic review found that contemporary NOE literature remains dominated by lower-level evidence and heterogeneous techniques, most commonly rigid plate-and-screw fixation with transnasal wiring or canthal repair for unstable Type II and Type III injuries.[4] A 2025 operative review likewise found persistent variation in exposure, plating, and wire use.[19] The durable lesson is not that one construct is universally superior; central bony width and the correct posterior-superior canthal position must be restored and independently verified.

> **OPERATIVE PEARL**
> Fixing the tendon to the wrong bony width creates persistent telecanthus even when the suture is tight.

> **RESIDENT SYNTHESIS**
> NOE reconstruction is successful when the central frame, medial orbit, MCT, and nasal dorsum are restored as one system. Fragment count matters only insofar as it changes the ability to rebuild those relationships.

CHAPTER 5

Zygomaticomaxillary Complex and Arch Trauma

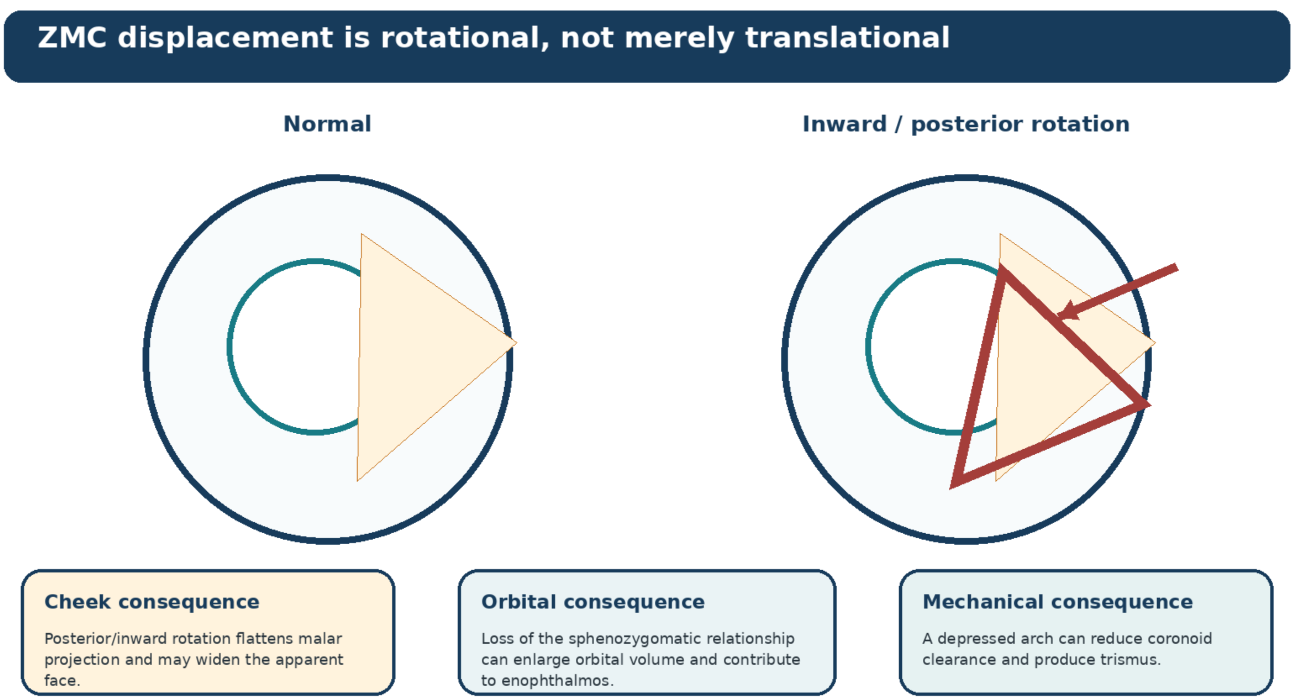
CENTRAL QUESTION
How does displacement of the zygoma alter cheek projection, orbital support, facial width, and mandibular excursion?

OPENING CASE
A patient has a displaced ZMC fracture with normal acuity and no diplopia. The cheek is flat and mouth opening is 18 mm. CT shows a depressed arch contacting the coronoid and a step at the sphenozygomatic junction. The operative indication is not visual loss; it is loss of lateral facial geometry and mechanical trismus.

5.1 The zygoma is a four-point keystone

The zygoma articulates with the frontal bone, maxilla, temporal bone, and sphenoid. These relationships define the frontozygomatic region, infraorbital rim and floor, zygomaticomaxillary buttress, arch, and posterior sphenozygomatic interface. The older term “tripod fracture” underemphasizes the posterior sphenoid relationship, which is often one of the best indicators of three-dimensional rotation.

The zygoma supports the malar soft tissues, lateral orbital wall and floor, and the arch corridor. Posterior displacement of the malar body and outward loss of orbital boundaries commonly enlarge the orbit and flatten the cheek. In contrast, inward displacement of the lateral orbital wall can reduce orbital volume and contribute to exophthalmos. Inferior displacement can produce orbital dystopia, while arch depression can narrow coronoid clearance. The net orbital effect therefore depends on the combined direction of the zygomatic body, lateral wall, and floor rather than the word "inward" or "outward" alone.[8]

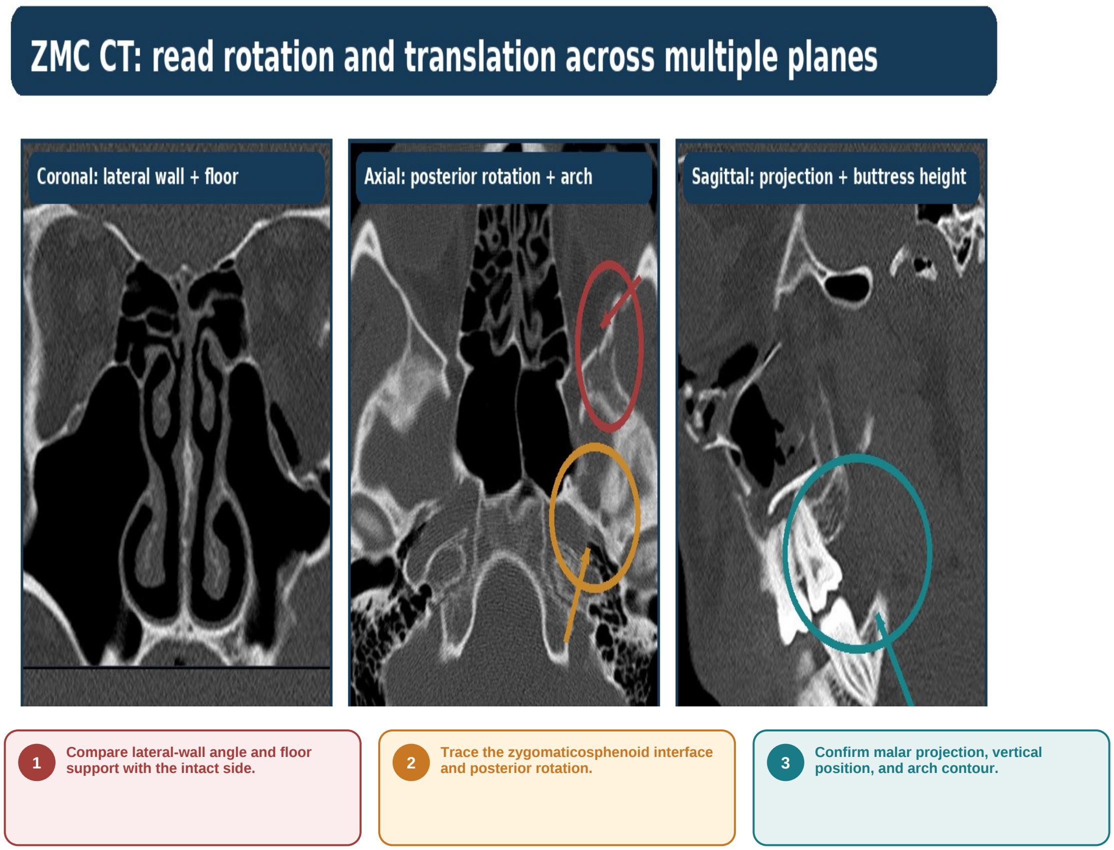


5.2 Examination

Inspect malar projection from frontal, basal, and worm's-eye perspectives. Palpate the frontozygomatic region, infraorbital rim, zygomaticomaxillary buttress, and arch. Determine whether trismus reflects pain and edema or mechanical arch-coronoid impingement. Document globe position, motility, diplopia, visual function, occlusion, and V2 sensation; the ocular pathway from Volume II supersedes elective ZMC management when vision is threatened.

Trace each articulation rather than accepting the label “ZMC fracture.” Axial images show arch contour, posterior rotation, and lateral wall alignment. Coronal images show orbital floor, vertical displacement, and buttress height. Sagittal images help with projection and orbital contour. Three-dimensional views communicate global displacement but can obscure internal orbital and sphenozygomatic detail.

The sphenozygomatic junction is especially useful because a small external step can coexist with major posterior malrotation. Compare sides and ask whether the zygoma has been impacted, rotated, shortened, or widened rather than merely displaced.



Source image: Hellerhoff, Wikimedia Commons, CC BY-SA 4.0; annotations revised.

Figure 5.2. Multiplanar CT of a left complex ZMC injury. Coronal, axial, and sagittal views demonstrate that lateral-wall alignment, posterior rotation, arch contour, and projection must be read together. Source: Hellerhoff, Wikimedia Commons, CC BY-SA 4.0; annotations added.

5.4 Mobilization and reduction methods

Reduction begins by freeing an impacted zygoma, not by pulling an exposed suture into line. A Gillies temporal approach can elevate a depressed arch or zygoma through the temporal fascia; a Keen intraoral approach reaches the zygomatic body from the maxillary vestibule. A Carroll-Girard screw, bone screw, hook, or elevator can provide a controlled handle when direct exposure is available. The selected maneuver should move the zygoma as a unit while avoiding blind force toward the globe, skull base, or thin maxillary fragments.

After disimpaction, verify reduction at more than one relationship: malar projection clinically, the zygomaticomaxillary buttress, frontozygomatic region, arch contour, and the sphenozygomatic interface. Mouth opening should be reassessed immediately when arch impingement was present. Internal orbital reconstruction follows only after the lateral facial framework is correct, because a malreduced ZMC changes the apparent orbital defect.

5.5 Observation, reduction, and fixation

Minimally displaced injuries with preserved projection, normal mandibular excursion, no meaningful orbital consequence, and acceptable appearance may be observed with follow-up. Repair is considered when displacement produces malar flattening, facial asymmetry, trismus from arch impingement, unstable skeletal relationships, or an orbital defect that requires reconstruction.

The zygoma should be disimpacted and reduced as a unit. Confirm projection and rotation at more than one articulation. The number of fixation points depends on stability, comminution, bone quality, orbital involvement, and the ability to verify reduction. AO guidance and systematic reviews support pattern-specific fixation rather than an automatic one-, two-, or three-point rule. Meta-analysis suggests three-point exposure and fixation may reduce postoperative instability in more complex fractures, but the quality of evidence is low and added exposure has morbidity.[6,8]

Table 5.1. Each fixation point provides different information; no single point proves global reduction.

Fixation region	What it controls or verifies	Important limitation
Zygomaticomaxillary buttress	Strong vertical support and lower projection.	Can look aligned despite residual posterior rotation.
Frontozygomatic region	Lateral orbital height and superior alignment.	Small visible gap may not define the entire rotation.
Infraorbital rim	Orbital rim continuity and inferior position.	Thin bone; additional eyelid exposure and morbidity.
Zygomatic arch	Width, contour, and coronoid clearance.	Requires exposure; isolated stable reductions may not need plating.
Sphenozygomatic junction	Posterior three-dimensional alignment.	Often a verification point rather than a direct fixation site.

5.6 Isolated arch fractures

An isolated depressed arch can produce a visible contour defect or mechanical trismus. Closed elevation through temporal or intraoral approaches is often sufficient when the arch is reducible and stable. Open fixation is considered for comminution, instability, open injury, recurrent depression, or combined ZMC trauma. Mouth opening should improve immediately when coronoid impingement is relieved; persistent restriction requires reassessment for muscle, joint, or additional fracture injury.

5.7 Common failures

- Persistent malar flattening from posterior or inward rotation.
- Facial widening from lateral malposition.
- Enophthalmos when ZMC malreduction enlarges the orbit or an internal defect is missed.
- Trismus from unreduced arch impingement or scar.
- Lower-eyelid malposition related to exposure and scarring.
- Infraorbital dysesthesia, hardware palpability, or temporal hollowing.

BOARD PEARL

A normal eye examination does not make a displaced ZMC fracture nonoperative. The cheek and arch are functional structures too.

RESIDENT SYNTHESIS

The zygoma is reduced correctly only when malar projection, rotation, orbital relationships, arch contour, and mandibular clearance are all restored.

CHAPTER 6

Le Fort and Maxillary Fractures

CENTRAL QUESTION

How do you diagnose and restore a mobile maxillary unit when the injury is incomplete, asymmetric, mixed-level, or part of panfacial trauma?

OPENING CASE

A CT report calls bilateral pterygoid fractures a “Le Fort fracture.” Examination shows no maxillary mobility, but the left ZMC and right palate are displaced. The resident must trace the complete fracture pathways rather than allowing one radiographic finding to create a false diagnostic unit.

6.1 What Le Fort patterns mean

Le Fort patterns describe levels at which the maxilla and midface are separated from the cranial base. The classification remains useful because it predicts maxillary mobility, occlusal instability, and associated nasal, orbital, and zygomatic injury. Modern trauma, however, is frequently asymmetric, incomplete, comminuted, and mixed-level. A patient may have a Le Fort II pathway on one side and Le Fort III components on the other, with an independent palatal split.

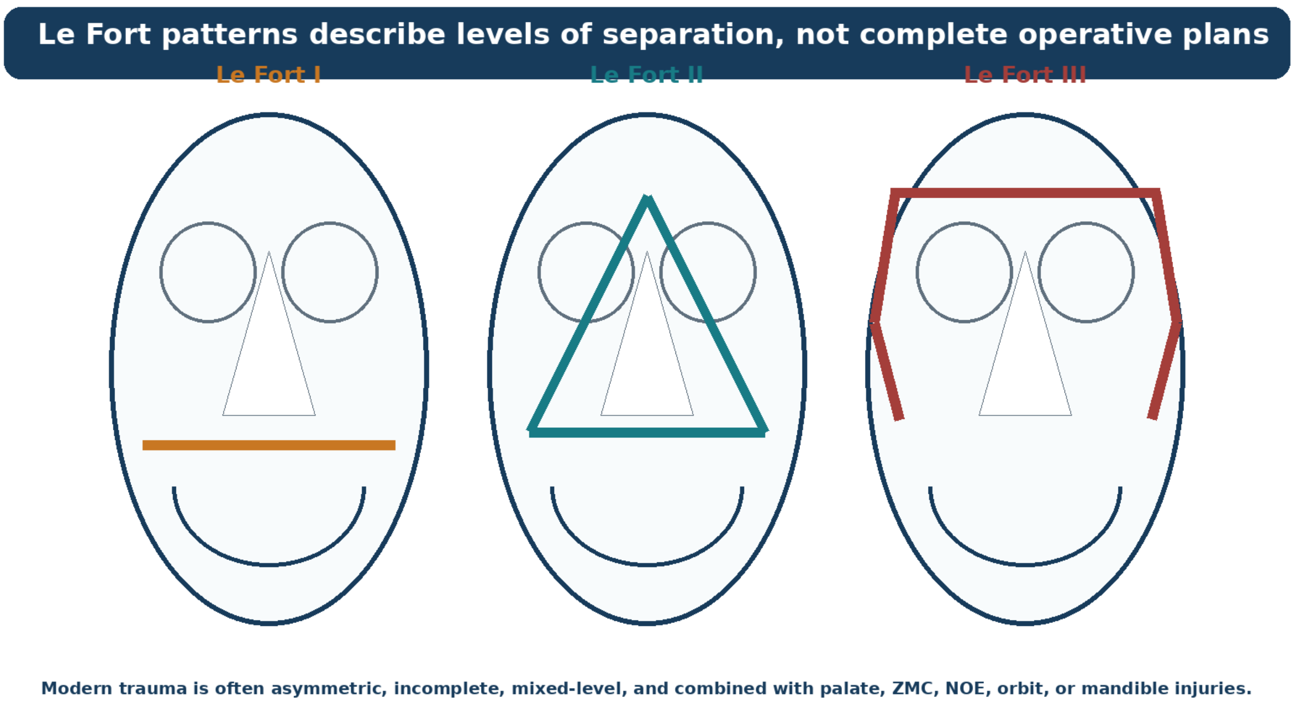


Figure 6.1. Classic Le Fort levels are communication tools. Modern injuries must be traced side by side and fracture by fracture.

6.2 The three classic levels

Table 6.1. The classification predicts a mobile unit but does not define every fracture or the operative sequence.

Pattern	Anatomic concept	Expected functional problem
Le Fort I	Horizontal separation of the tooth-bearing maxilla and palate above the dental roots.	Mobile maxillary alveolus, malocclusion, palatal instability.
Le Fort II	Pyramidal central-midface separation through nasal, medial orbital, infraorbital, and maxillary structures.	Maxillary mobility plus nasal and orbital involvement; facial elongation or flattening.
Le Fort III	Craniofacial dissociation through nasofrontal, orbital, frontozygomatic, and arch relationships.	Broad midface mobility, severe loss of projection, orbital and airway risk.

6.3 Pterygoid plates: required but not sufficient

A classic Le Fort fracture includes pterygoid-plate disruption, but pterygoid fractures also occur in non-Le Fort high-energy patterns. The diagnosis requires tracing a complete pathway through the anterior and lateral midface. Conversely, an incomplete pattern may still produce clinically important maxillary mobility. CT and the mobility examination are complementary.

6.4 Examination

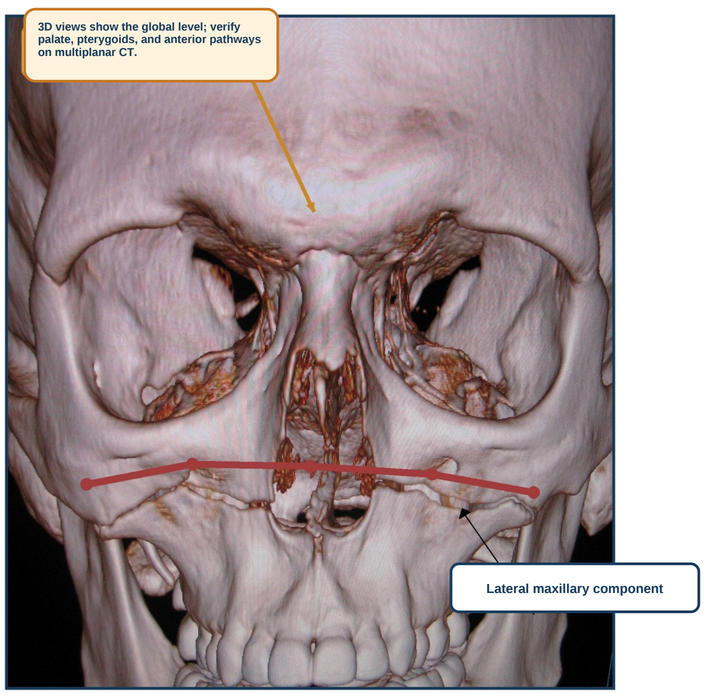
Stabilize the forehead and gently test the tooth-bearing maxilla for mobility at different levels. Evaluate the bite, dental midlines, posterior contacts, open bite, crossbite, palatal ecchymosis or laceration, nasal obstruction, epistaxis, V2 sensation, globe findings, and facial height. Markedly mobile midface fractures can worsen airway obstruction through bleeding, edema, or posterior displacement; airway and hemorrhage priorities from Volume I remain active.

6.5 Restore the platform before the pillars

The maxillary segment must be fully mobilized so it can sit passively in the intended position. MMF is then used to reproduce premorbid occlusion after condylar seating and palatal-width assessment. In incomplete fractures, forceful use of Rowe forceps can propagate fractures into the orbit or skull base; AO references note that some surgeons prefer controlled completion at a Le Fort I osteotomy level rather than uncontrolled forced disimpaction.[7] This is an advanced, pattern-specific decision.

Once the arch is reliable, restore maxillary width, vertical height, and projection. Strong fixation is commonly applied at the zygomaticomaxillary buttresses, with additional stabilization at the piriform/nasomaxillary region. Higher-level injuries require reconstruction of the frontozygomatic, nasofrontal, arch, and orbital relationships. Internal orbital walls are generally reconstructed after the major facial unit is reduced because zygomatic and maxillary position define orbital geometry.[1,7]

Le Fort I: demonstrate the complete mobile pathway, not one fracture line



A complete Le Fort assessment

Anterior pathway
Trace piriform, zygomaticomaxillary, and palatal components.

Posterior pathway
Confirm pterygoid disruption without treating it as sufficient alone.

Clinical unit
Correlate CT with mobility, occlusion, and palatal width.

Figure 6.2. A complete Le Fort I assessment traces the anterior maxillary pathway, confirms posterior pterygoid and palatal relationships, and correlates the imaging with a clinically mobile unit. Source CT: James Heilman, MD, Wikimedia Commons, CC BY-SA 3.0; annotations added.

6.6 Airway and complete mobilization

Airway planning must anticipate the need to establish and repeatedly check occlusion. Orotracheal intubation may obstruct MMF; nasotracheal intubation is used selectively only when the nasal and skull-base anatomy is suitable; submental intubation or tracheostomy may be considered in complex cases. The airway plan should be coordinated before draping rather than improvised after fixation begins.

The maxillary segment must be mobilized until it can be positioned passively. Incomplete release at the pterygoid, piriform, or posterior maxillary interfaces can create elastic recoil and a false bite. Rowe forceps and controlled osteotomy completion are advanced pattern-specific tools; force should never be transmitted blindly toward the orbit or cranial base. Seat the condyles, correct palatal width, and reproduce premorbid occlusion before using MMF as a temporary jig.

6.7 Buttress fixation sequence

Once the dental platform is reliable, restore transverse width and vertical height at strong bony contacts. Commonly, the zygomaticomaxillary buttresses are reduced and provisionally fixed first because they provide robust lower lateral support; the nasomaxillary or piriform regions then refine central height and projection. Higher-level injuries require coordinated frontozygomatic, nasofrontal, arch, and orbital reconstruction. Apply plates to stable bone with enough strength for the load and comminution, but leave provisional constructs adjustable until the global face, posterior contacts, and condylar seating agree.

6.8 Fixation and stability

Plate strength is matched to instability, comminution, bone quality, and whether postoperative MMF is planned. The zygomaticomaxillary buttress carries substantial masticatory load and generally requires more robust fixation than thin perinasal bone. At least one reliable bony contact is needed to establish vertical height in comminuted injuries; gaps may require bridging, grafting, or digital planning. Provisional plates can be loosened while the global reduction is refined.

6.9 Complications

Malocclusion is the most visible failure, but it may reflect several distinct errors: wrong palatal width, incomplete maxillary mobilization, condylar distraction, maxillary rotation, loss of vertical buttress height, or associated mandibular injury. Other complications include facial elongation or retrusion, widening, nonunion, infection, infraorbital neuropathy, nasal obstruction, dental injury, and hardware exposure.

> **DIAGNOSTIC TRAP**
> Bilateral pterygoid fractures do not automatically prove a complete Le Fort pattern. Trace the pathway and test the mobile unit.

> **RESIDENT SYNTHESIS**
> A Le Fort diagnosis identifies a level of separation. The operation restores the mobile maxillary platform within the full facial frame by reproducing occlusion, width, height, projection, and stable buttress continuity.

CHAPTER 7

Palatal and Dentoalveolar Trauma

CENTRAL QUESTION
How do injuries of the palate and dental arch destabilize occlusion and make the maxilla an unreliable reconstructive reference?

OPENING CASE
A patient with a Le Fort I injury is placed in MMF. The incisors and canines fit well, but the molars remain in crossbite and CT shows a sagittal palatal split. The anterior bite has hidden a widened posterior maxillary arch.

7.1 The palate is a transverse stabilizer

The hard palate forms the floor of the nose, roof of the oral cavity, and a transverse bridge between the maxillary alveolar segments. A split permits the hemipalates to splay, rotate, or collapse. The result is not merely a mucosal wound; it is an unstable dental platform that can misdirect the entire midface reconstruction.

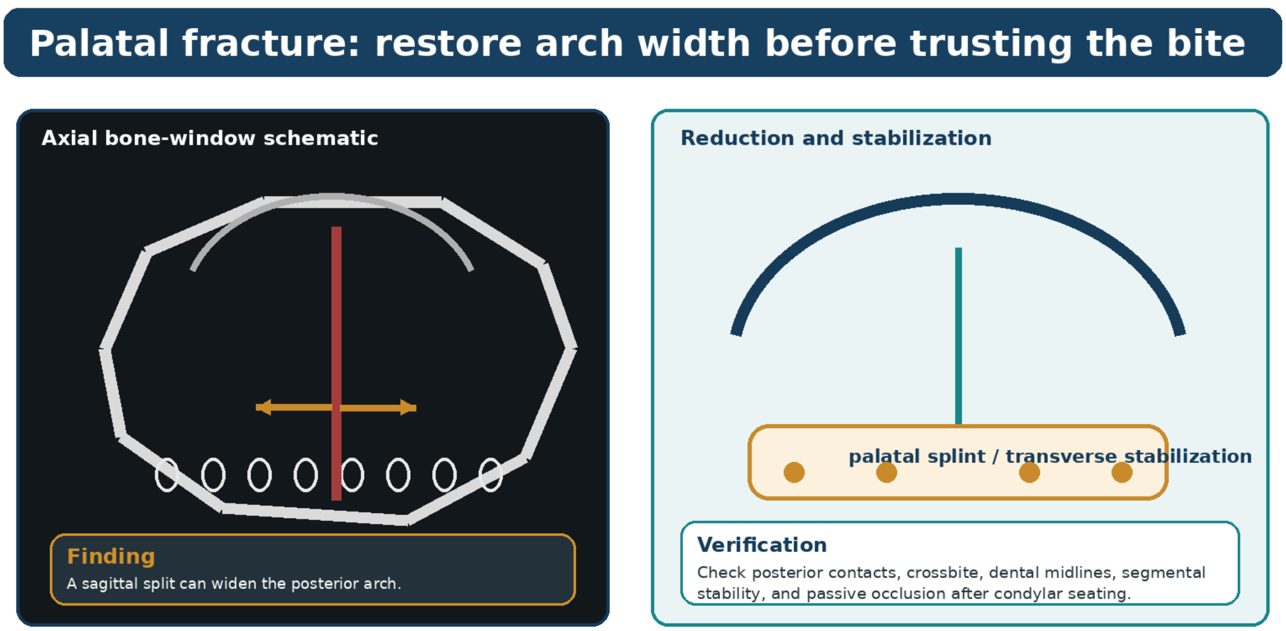


Figure 7.1. A palatal split can widen the posterior arch despite acceptable anterior contacts. Reduction restores transverse shape before a splint, wire, plate, or MMF preserves it.

7.2 Injury patterns and examination

Palatal fractures may be sagittal, parasagittal, transverse, alveolar, or comminuted and often accompany Le Fort or panfacial injuries. Inspect for palatal laceration, ecchymosis, step-off, exposed bone, segmental mobility, arch widening, missing teeth, and oronasal communication. Palpate the alveolar segments while observing the teeth; a small mucosal laceration may overlie a substantial fracture.

7.3 Dentoalveolar trauma

Document crown fractures, root fractures, intrusion, extrusion, lateral luxation, avulsion, and mobile alveolar segments. Account for every missing tooth because aspiration or ingestion may require imaging. The periodontal ligament and pulpal blood supply may fail after apparently successful repositioning, so dental follow-up is part of trauma care rather than an optional cosmetic service.

Table 7.1. ENT management should preserve airway and skeletal relationships while securing timely dental care.

Injury	Immediate priority	Definitive issue
Avulsed permanent tooth	Handle by crown; replant immediately when safe or store moist in HBSS, cold milk, saliva, or saline; document dry time.	Flexible splint about 2 weeks; more rigid/longer stabilization with alveolar fracture; antibiotics, tetanus, endodontic and periodontal follow-up.
Luxation / intrusion	Protect airway, document position, urgent dental evaluation.	Repositioning strategy depends on direction, root development, and alveolar injury.
Alveolar segment fracture	Reduce the segment as a unit and stabilize it.	Occlusion, tooth vitality, periodontal support, and segment union.
Crown/root fracture	Control pain and sharp edges; protect exposed pulp.	Restoration, endodontic care, or extraction.
Missing tooth	Search wound, airway, chest, or GI tract as indicated.	Replacement planning after skeletal healing.
Avulsed primary tooth	Protect airway, control bleeding, and arrange dental assessment. Do not replant.	Monitor the socket and developing permanent successor.

7.4 Avulsion: what the resident must do

First determine whether the tooth is primary or permanent. An avulsed primary tooth should not be replanted because replantation can injure the developing permanent successor. For a permanent tooth, immediate replantation at the scene offers the best chance of periodontal-ligament survival when it is safe and the patient is cooperative. Handle only the crown, gently rinse gross debris without scrubbing the root, and do not force the tooth into the socket.

If replantation is not immediately possible, keep the tooth moist in HBSS, cold milk, saliva, or saline and record the extraoral dry time and storage medium. After replantation, verify position clinically and radiographically, reposition socket wall or alveolar fractures when necessary, provide passive flexible splinting for approximately two weeks, and use more rigid stabilization for approximately four weeks when an alveolar or jaw fracture coexists. Review tetanus status, provide systemic antibiotics according to the dental protocol, and arrange urgent endodontic and periodontal follow-up.[20,21]

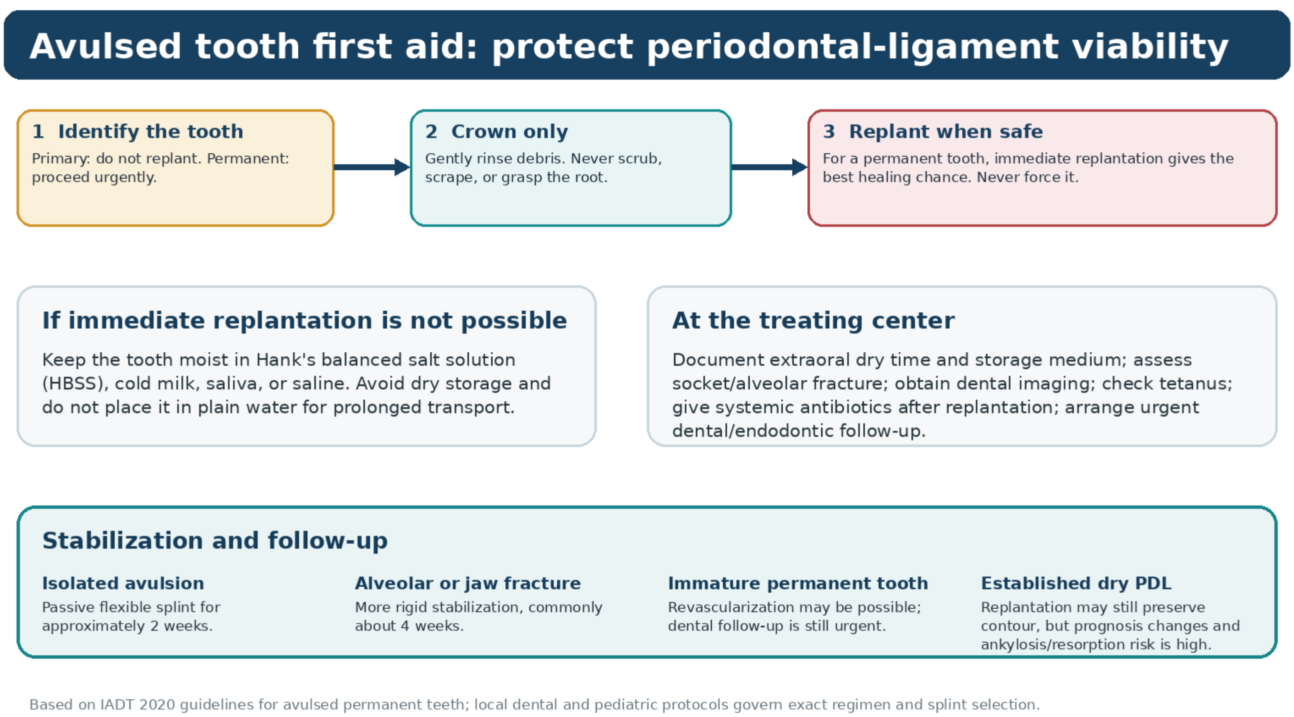


Figure 7.2. Avulsed tooth first aid preserves periodontal-ligament viability and distinguishes permanent teeth, which are usually replanted, from primary

IADT AVULSION TIMING

Extraoral dry time greater than about 60 minutes usually means the periodontal-ligament cells are nonviable. Replantation may still preserve alveolar contour, but the prognosis and counseling change because ankylosis and replacement resorption become likely.[20]

7.5 Reconstructing arch width

The correct technique depends on the fracture pattern and residual stability. Options include arch bars and MMF, interdental wiring, palatal splints, transpalatal wiring or plates, and direct fixation through palatal or intraoral exposure. A splint can preserve the planned transverse shape when the palate is comminuted or dental segments are unstable. Direct fixation may improve rigidity but requires attention to palatal mucosal blood supply and dental roots.

Large case series emphasize that palatal fractures mark high-energy injury. Select the construct according to whether closed reduction restores a stable arch, where rigid fixation can be placed, and whether the palate remains unstable after the maxillary buttresses are reduced.[9-11] No single construct is ideal for every pattern.

7.6 Teeth in the fracture line

A tooth is not removed simply because it lies within a palatal or dentoalveolar fracture. Retention is favored when the tooth is stable or salvageable, useful for occlusion or splinting, and does not block reduction. Remove a tooth for a fractured root, severe periodontal disease, active infection, gross mobility, a nonrestorable injury, or interference with reduction or hardware.

7.7 Antibiotics and oral hygiene

Closed nonoperative midface fractures do not require prophylactic antibiotics. For closed, noncontaminated operative midface fractures, use perioperative prophylaxis without routine postoperative continuation. Defined open or contaminated injuries may receive 24 hours or less unless established infection, a bite injury, or another separate indication requires treatment.[13] Agent selection follows local protocols and allergy profiles. Irrigation, oral hygiene, nutrition, and removal of devitalized tissue remain essential.

> **BOARD PEARL**
> The palate must be reconstructed before it can function as an occlusal reference.

> **RESIDENT SYNTHESIS**
> Correcting the bite without correcting the arch can lock the entire face into a transverse malreduction.

Palatal reconstruction: restore width before trusting the bite

1 Restore width
Reduce the split before accepting the apparent occlusion.

2 Stabilize the arch
Select a splint, wire, plate, or MMF according to residual instability.

3 Verify independently
Recheck posterior contacts, crossbite, and transverse width after fixation.

The bite is a measurement tool—not a substitute for restoring facial geometry.

CHAPTER 8

Exposure, Reduction, and Fixation

CENTRAL QUESTION
How do you obtain enough exposure to restore the frame while minimizing eyelid, facial nerve, dental, scalp, and soft-tissue morbidity?

OPENING CASE
A patient has a displaced ZMC fracture, type II NOE injury, and Le Fort I-level instability. Three separate incisions could expose every fracture, but the correct combination depends on which reduction points must be seen and which structures require direct repair. More exposure is not automatically more accuracy.

8.1 Exposure should answer a reconstructive question

Select approaches by the structure that must be reduced, the fixation point that must be reached, and the independent landmark needed for verification. Existing lacerations can be valuable but should not be extended blindly across facial nerve branches, aesthetic units, or devitalized tissue. The soft-tissue approach is part of the reconstruction and can create its own deformity.

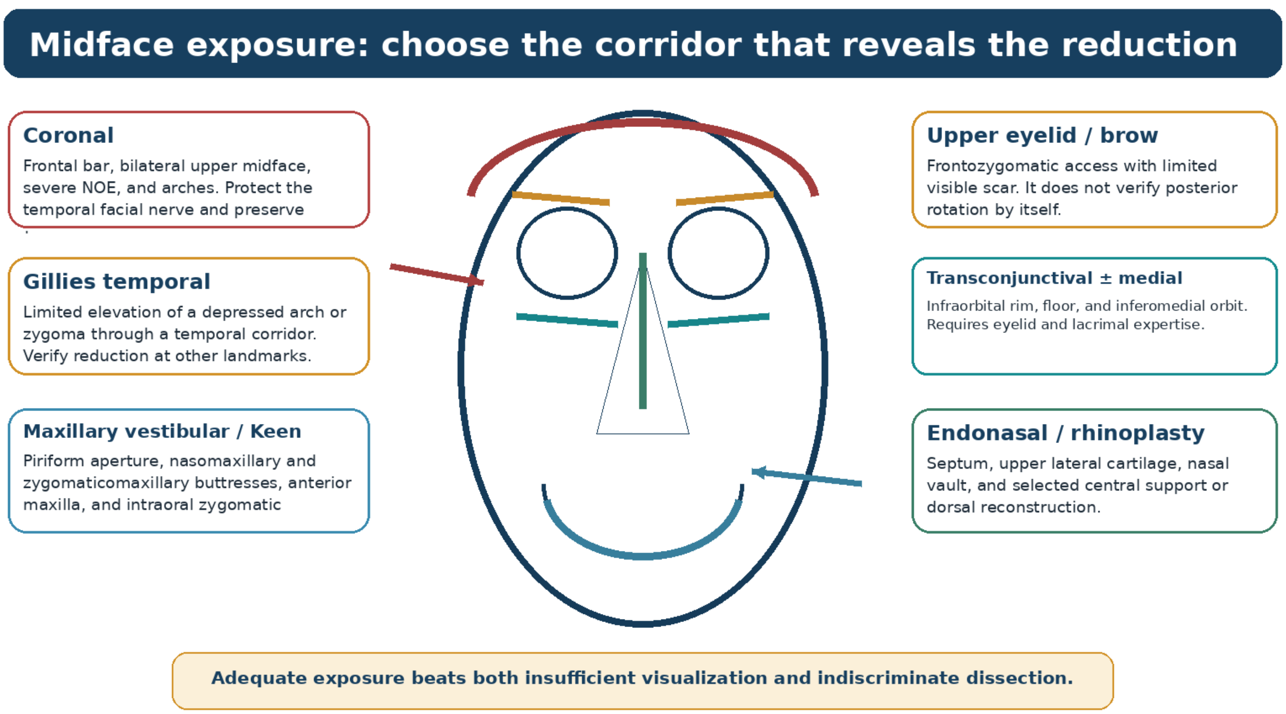


Figure 8.1. Common midface corridors include coronal, Gillies temporal, maxillary vestibular/Keen, upper-eyelid, transconjunctival, and endonasal approaches. Each is selected by the reduction it must expose.

8.2 Intraoral exposure

A maxillary vestibular incision exposes the piriform aperture, nasomaxillary and zygomaticomaxillary buttresses, anterior maxillary wall, and alveolar region without an external scar. Protect the infraorbital nerve and tooth roots, preserve mucosal vascularity, and close the vestibule securely. Contamination is expected and managed with irrigation and perioperative prophylaxis rather than avoidance of the approach.

8.3 Periorbital exposure

Transconjunctival and selected transcutaneous lower-eyelid approaches expose the infraorbital rim and floor. Upper-eyelid or lateral-brow approaches reach the frontozygomatic region. The choice balances direct visualization against ectropion, entropion, canthal malposition, visible scar, and injury to orbital contents. Detailed orbital approach selection is reviewed in Volume II.

8.4 Coronal exposure

The coronal approach provides broad access to the frontal bar, bilateral upper midface, zygomatic arches, and severe NOE or combined injuries. It can also support pericranial flap harvest. Its morbidity includes facial nerve injury, temporal hollowing, alopecia, scalp numbness, hematoma, and longer dissection. It is justified when broad superior exposure changes the accuracy or safety of reconstruction, not merely because the injury looks complex.

8.5 Mobilization and provisional reduction

Impacted segments must be fully mobilized before fine reduction. Hooks, elevators, screws used as handles, Rowe forceps, and controlled osteotomy completion may be used according to the pattern and surgeon experience. The danger is force transmitted into the orbit, skull base, teeth, or incompletely visualized fragments. Reduction should become passive enough that the intended position is maintained without elastic distortion.

Use provisional fixation to test the global geometry. A plate can be placed loosely while occlusion, arch width, zygomatic projection, and canthal symmetry are reassessed. Definitive tightening follows only after the major units agree.

8.6 Plate strategy

Match implant profile and strength to load and bone stock. The zygomaticomaxillary buttress and major vertical supports generally require stronger fixation than the infraorbital rim or delicate central fragments. Avoid tooth roots, the infraorbital canal, orbital contents, and visible or palpable plate positions. Comminution may require bridging fixation, mesh, bone graft, or patient-specific planning; excessive stripping of small fragments compromises perfusion.

Table 8.1. The least morbid adequate exposure is preferable to both inadequate visualization and indiscriminate exposure.

Approach	Best access	Characteristic tradeoff
Maxillary vestibular	Piriform, nasomaxillary and zygomaticomaxillary buttresses, alveolus.	Hidden scar but oral contamination and infraorbital/tooth-root risk.
Transconjunctival	Infraorbital rim and floor, lateral extension.	Low visible scar; requires eyelid and orbital expertise.
Upper eyelid / brow	Frontozygomatic region.	Limited exposure with usually acceptable scar.
Coronal	Frontal bar, bilateral upper midface and arches, severe NOE.	Broad access with scalp, nerve, alopecia, and temporal-hollowing morbidity.
Existing laceration	Direct local fracture access.	May be contaminated, poorly oriented, or cross critical structures.
Endonasal / rhinoplasty	Septum, nasal vault, selected central support.	Limited skeletal reach but direct control of nasal framework.

8.7 Pediatric midface trauma

Children require the same restoration of airway, vision, width, height, projection, and occlusion, but the biology and reference anatomy differ. Elastic bone can create incomplete patterns, rapid healing shortens the window for mobilization, and mixed dentition can make occlusion transient or unreliable. Developing tooth buds constrain screw placement, and broad periosteal stripping may disturb blood supply and growth. Selected pediatric ZMC injuries may remain stable after limited fixation; hardware should be no more extensive than the reduction requires.[15]

Septal and central-midface injuries warrant long-term growth surveillance. Pediatric dentistry, orthodontics, ophthalmology, and craniofacial expertise are incorporated according to the injury. Conservative treatment should mean conservative exposure and hardware - not acceptance of persistent obstruction, telecanthus, malocclusion, or facial asymmetry.

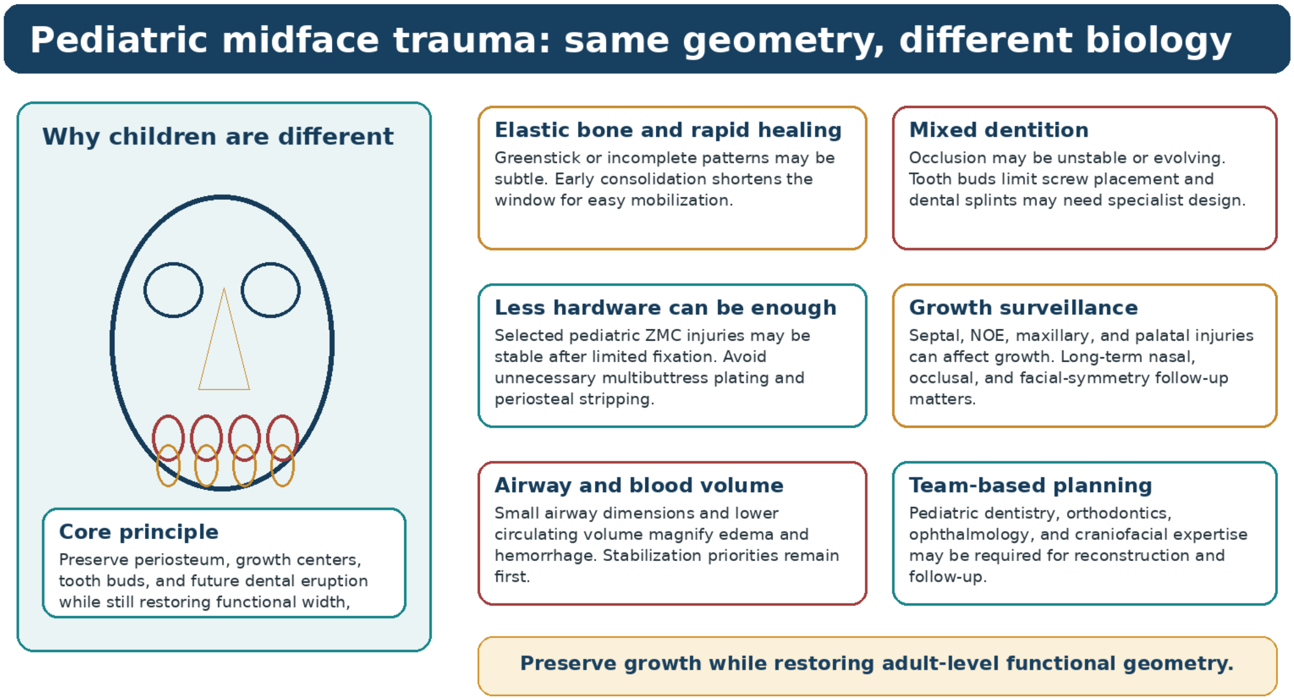


Figure 8.2. Pediatric midface reconstruction preserves growth and tooth development while still restoring adult-level functional geometry.

8.8 Final intraoperative check

- Airway and hemostasis are secure; if postoperative MMF is used, an emergency-release plan and tool are immediately available, and nausea/aspiration risk is addressed.[18]
- Condyles are seated and occlusion reproduces the premorbid bite.
- Palatal and dental arch width are correct and stable.
- Maxillary height and projection are symmetric.
- Malar projection and zygomatic rotation agree at several interfaces.
- Arch contour permits full mandibular excursion.
- Central facial width and canthal height/depth are symmetric.
- Nasal dorsum and septal support are stable.
- Orbital rims, globe position, and forced ductions are satisfactory when relevant.
- Postoperative vision, neurologic, dental, and lacrimal examinations are planned.

OPERATIVE PEARL
An approach is successful only if it lets you see the reduction that matters. Exposure by itself is not accuracy.

RESIDENT SYNTHESIS
Midface surgery uses the smallest combination of approaches that permits complete mobilization, multidimensional reduction, independent verification, and stable fixation with acceptable soft-tissue morbidity.

CHAPTER 9

Postoperative Care and Secondary Deformity

CENTRAL QUESTION

How do you detect early failure and analyze a late deformity according to the dimension that was not restored?

OPENING CASE

On postoperative day 1 after bilateral midface repair, the patient reports that the bite feels “off.” The incisors contact, but there is a unilateral posterior open bite. The correct response is not reassurance that swelling will resolve. Occlusion is an objective test of skeletal alignment and should be reassessed immediately.

9.1 Immediate priorities

Postoperative monitoring includes airway, bleeding, pain, nausea, vision and pupils when the orbit was involved, facial nerve function, nasal airway, wounds, and occlusion. Visual decline, proptosis, a tense orbit, or a new afferent deficit requires immediate evaluation. New malocclusion triggers assessment of condylar seating, MMF, palatal width, plate stability, and maxillary position. If MMF remains postoperatively, the team and patient must know the emergency-release method and have the necessary tool immediately available.[18]

9.2 Diet, oral care, and rehabilitation

Diet restriction is matched to fracture stability, fixation strength, and dental injury. Oral rinses, gentle tooth brushing, nutrition, and dental follow-up reduce morbidity during a no-chew or soft diet. Early mandibular range of motion is important when safe, especially after arch impingement has been relieved, because prolonged guarding and scar can produce persistent trismus.

9.3 Nasal and sinus care

Head elevation, saline, avoidance of nose blowing when the orbit or sinus walls are involved, and selective short-term decongestion may be used. These measures do not replace treatment of septal hematoma, CSF leak, orbital compartment syndrome, or structural obstruction. Splints and packing require a defined removal and airway plan.

9.4 Antibiotics

Closed, noncontaminated operative midface fractures receive perioperative prophylaxis without routine postoperative continuation; closed nonoperative fractures receive none. Defined open or contaminated facial fractures may receive 24 hours or less unless established infection, bite injury, osteomyelitis, or another separate indication requires treatment.[13] A sinus fracture alone is not evidence of sinusitis.

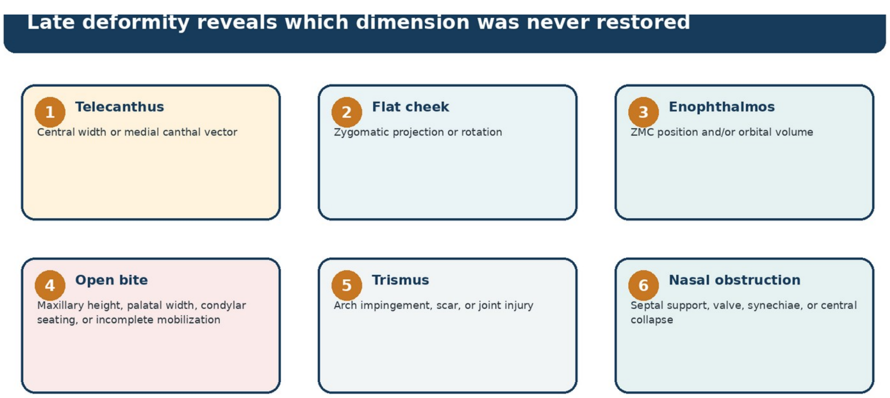


Figure 9.1. Late deformities are clues to the dimension or functional relationship that was not restored.

9.5 Early patterns of failure

Table 9.1. Postoperative abnormalities should be localized rather than attributed reflexively to swelling.

Finding	Possible mechanism	Immediate response
New visual deficit	OCS, globe injury, optic neuropathy, implant or hematoma.	Urgent ocular examination and decompression pathway as indicated.
Posterior open bite	Condylar distraction, incomplete maxillary mobilization, palatal malreduction.	Release or adjust fixation as appropriate; repeat examination and imaging.
Persistent telecanthus	Central width not reduced or MCT vector incorrect.	Early operative reassessment before scar matures.
Trismus	Residual arch impingement, pain, hematoma, joint injury.	Examine mechanics; CT if uncertain; begin appropriate motion when stable.
Wound drainage / fever	Contamination, dental infection, plate or sinus infection.	Culture/source control when indicated; targeted antibiotics rather than empiric prolongation.
Nasal obstruction	Septal hematoma, packing, septal displacement, edema.	Internal examination; drain hematoma or correct structural problem.

9.6 Late geometry

After edema resolves, the pattern of deformity often reveals the original error. Telecanthus suggests persistent central widening or an incorrect posterior-superior canthal position. A flat cheek suggests zygomatic posterior rotation. Enophthalmos may reflect ZMC malposition, uncorrected orbital-volume expansion, or both. Crossbite suggests palatal-width error. Facial elongation or retrusion suggests vertical-buttress or maxillary-position failure.

Secondary reconstruction begins with updated thin-cut CT, dental and occlusal analysis, photographs, and comparison with premorbid records when available. The correction may require osteotomy, repositioning, bone graft, orbital revision, canthoplasty or transnasal canthopexy, septorhinoplasty, dacryocystorhinostomy, scar revision, or hardware removal. Revision should be planned around the missing dimension rather than the historical fracture label.

9.7 Sensory, lacrimal, and dental surveillance

V2 neuropraxia is common after ZMC and maxillary injury and often improves over months, but the baseline and trajectory should be documented. Persistent dysesthesia, worsening pain, or new deficit prompts reassessment for compression, malunion, infection, or hardware. Epiphora after NOE trauma may improve as edema resolves; persistent symptoms require lacrimal evaluation. Teeth within injured segments need vitality and periodontal follow-up because late pulpal necrosis may be clinically silent.

DIAGNOSTIC TRAP

Swelling can obscure contour; it does not explain a reproducible new malocclusion, unstable canthus, or objective visual change.

RESIDENT SYNTHESIS

Postoperative care tests the reconstruction. Early objective dysfunction deserves early localization, while late deformity should be described as a lost dimension that may require geometric revision.

CHAPTER 10

Integrated Cases and Final Workflow

CENTRAL QUESTION
Can the resident convert a complex midfacial injury into a prioritized, defensible reconstructive plan?

Case 1 — The “simple” nasal fracture with widening

CASE
A patient has nasal-root flattening after an assault. The nasal bones are displaced, but the intercanthal distance is increased and CT shows comminution around both lacrimal fossae.

Questions to answer

- What distinguishes isolated nasal trauma from NOE injury?
- How will MCT support be assessed?
- Which associated structures require review?
- What are the reconstructive goals?

Reasoning

The widened central face, lacrimal-fossa comminution, and nasal-root depression indicate NOE trauma rather than an isolated nasal-bone fracture. Complete the ocular, frontal sinus, skull-base, lacrimal, septal, and maxillary assessment.

The plan must restore central bony width, medial orbital support, canthal position, and nasal projection. Closed nasal reduction alone would leave the functional central unit untreated.

BOARD PEARL
Central widening after nasal trauma should trigger an NOE search.

Case 2 — The flat cheek with normal vision

CASE
A patient has intact acuity and motility after a displaced ZMC injury but has visible malar flattening and V2 numbness.

Questions to answer

- Does normal vision exclude operative treatment?
- Which CT relationships define rotation?
- How many fixation points are required?

Reasoning

Normal vision removes an ocular emergency but does not restore malar projection or lateral facial geometry. Evaluate the arch, zygomaticomaxillary buttress, frontozygomatic region, infraorbital rim, and sphenozygomatic interface.

The number of fixation points is determined after reduction by stability and the ability to verify global alignment. A rigid one-point fixation is inadequate if posterior rotation persists.

BOARD PEARL
Treat the displaced zygoma as a spatial unit, not an orbital diagnosis.

Case 3 — Severe trismus after lateral impact

CASE
A patient can open only 12 mm after a blow to the cheek. CT shows a depressed isolated arch abutting the coronoid.

CASE 3 - Severe trismus after lateral impact (continued)

Questions to answer

- What is the mechanism of trismus?
- Is closed reduction reasonable?
- What confirms a successful reduction?

Mouth opening should improve when coronoid clearance is restored. Persistent restriction raises concern for residual impingement, hematoma, muscle injury, or TMJ pathology.

> **BOARD PEARL**
> Immediate improvement in excursion is an intraoperative functional check.

Case 4 — The mobile maxilla with “good” incisors

> **CASE**
> A patient with Le Fort-level mobility has matching incisors in MMF but a widened posterior palate and bilateral posterior crossbite.

Questions to answer

- Can the bite be trusted?
- What should be reduced first?
- How can width be maintained?

Reasoning

The dental platform is not reliable because the palate is split and widened. Restore transverse arch width with direct reduction and appropriate splinting or fixation before using occlusion to position the maxilla.

Only after the platform is stable should the vertical buttresses be reduced and plated. Otherwise, the entire midface will be fixed to a transverse deformity.

> **BOARD PEARL**
> Anterior contacts can hide a posterior arch-width error.

Case 5 — Pterygoid fractures without a Le Fort unit

> **CASE**
> CT after high-energy trauma shows bilateral pterygoid fractures, a right ZMC fracture, and a left palatal fracture. The maxilla is not mobile as a single segment.

Questions to answer

- Does this meet a Le Fort diagnosis?
- How should the injury be described?
- What drives treatment?

Reasoning

Pterygoid fractures are necessary for classic Le Fort patterns but are not sufficient. Trace each pathway. This patient has mixed midfacial and palatal injuries rather than a proven symmetric Le Fort unit.

Treatment is driven by the displaced ZMC, palatal instability, occlusion, and any other functional deficits—not by forcing the CT into a classic label.

> **BOARD PEARL**
> Trace the pathway; do not diagnose from the pterygoids alone.

Case 6 — Type II NOE with uncertain canthal stability

> **CASE**
> CT shows a comminuted central fragment on the left, but the MCT appears clinically stable despite severe swelling.

Questions to answer

- How reliable is the bedside test?
- What must be confirmed at surgery?
- When is transnasal fixation needed?

Reasoning

Swelling and pain can mask instability. CT predicts whether a usable tendon-bearing fragment exists but cannot prove tendon attachment.

At surgery, identify the tendon-bearing fragment and restore bony width. If stable fixation of that fragment reproduces the correct canthal depth, height, and tension, separate transnasal fixation may not be necessary. If the tendon is avulsed or lacks reliable bony support, recreate a posterior-superior attachment above and behind the superior lacrimal fossa.

If the contralateral NOE complex is also injured, classify and plan each side independently; bilateral injuries need not share the same type.

> **BOARD PEARL**
> Classify tendon support after deliberate assessment, not from CT alone.

Case 7 — Bilateral ZMC and Le Fort injury

> **CASE**
> Both zygomas are displaced and the maxilla is mobile. There is no intact side to mirror clinically.

Questions to answer

- Which references remain useful?
- How should sequencing be chosen?
- When could VSP or intraoperative CT help?

Reasoning

Assess the mandible, occlusion, palatal width, frontal bar, orbital rims, and any relatively less comminuted side. Preinjury photographs or imaging may become important.

VSP, mirroring, models, and intraoperative imaging can support the reconstruction when bilateral injury removes the usual contralateral template, but the plan must still be verified through occlusion, width, projection, and orbital relationships.

> **BOARD PEARL**
> Technology is most useful when it clarifies which reference the surgeon intends to trust.

Case 8 — Delayed widening, flat cheek, and malocclusion

> **CASE**
> Six months after repair, a patient has a widened midface, left malar flattening, epiphora, and posterior open bite.

Questions to answer

- How should the deformity be analyzed?
- What records and imaging are needed?
- Which corrections may be required?

CASE 8 — Delayed widening, flat cheek, and malocclusion (continued)

REASONING

The findings suggest several lost dimensions: central width and canthal/lacrimal relationships, left zygomatic projection, and maxillary or palatal alignment. Obtain thin-cut CT, dental models or scans, occlusal analysis, photographs, and prior operative or imaging records.

Secondary correction may require osteotomy and repositioning of the zygoma or maxilla, canthal revision, orbital reassessment, lacrimal surgery, and staged septorhinoplasty. Build the plan from current geometry-not simply a list of old fractures.

BOARD PEARL
Secondary reconstruction begins by naming each lost dimension.

Final resident workflow

Ten steps from geometry to verified reconstruction

1. **Define dysfunction**
Airway, vision, occlusion, canthal/lacrimal function, globe, projection, and trismus.

2. **Name lost dimensions**
Height, width, projection, rotation, arch width, and canthal position.

3. **Map disrupted units**
Central, lateral, vertical, horizontal, palatal, and orbital relationships.

4. **Identify remaining threats**
Vision, skull base, hemorrhage, airway, aspiration, and soft tissue.

5. **Choose trusted references**
Bite, mandible, frontal bar, intact side, rims, photographs, and VSP.

6. **Decide indication and timing**
Observation, urgent treatment, early repair, combined management, or revision.

7. **Set the reduction sequence**
Platform and width, strong supports, major units, then thin boundaries.

8. **Choose necessary exposures**
Use the smallest combination that permits reduction and independent verification.

9. **Plan fixation**
Preserve reduction with pattern-specific plates, splints, wires, grafts, or guides.

10. **Verify and surveil**
Recheck occlusion, symmetry, excursion, canthi, globe, airway, dental, and lacrimal status.

Figure 10.1. A ten-step workflow for translating examination and CT into a verified midface reconstruction.

Table 10.1. The midface reconstruction workflow.

1	Which functions are abnormal?	Airway, occlusion, canthal/lacrimal function, globe position, projection, trismus.
2	Which dimensions are lost?	Height, width, projection, rotation, arch width, canthal position.
3	Which buttresses are disrupted?	Central, lateral, vertical, horizontal, palatal.
4	Which associated threats remain?	Vision, skull base, hemorrhage, airway, dental aspiration, soft tissue.
5	Which references can be trusted?	Bite, mandible, frontal bar, intact side, rims, photographs, VSP.
6	Is operation indicated and on what clock?	Observation, interval repair, urgent combined management.
7	What is the reduction sequence?	Platform and width, strong pillars, zygoma/NOE, orbit/nose.
8	Which exposures are necessary?	Smallest combination allowing reduction and verification.
9	How will fixation preserve the reduction?	Pattern-specific plates, splints, wires, grafts, or guides.
10	How will success be verified and followed?	Occlusion, symmetry, excursion, canthi, globe, airway, dental/lacrimal surveillance.

FINAL RESIDENT TAKEAWAY
A successful midface repair is not a collection of well-positioned plates. It is a patient-specific restoration of the maxillary platform, facial height and width, malar and nasal projection, canthal and orbital relationships, and functional movement—verified before the soft tissues conceal the frame.

CHAPTER A

Practical Appendices

CENTRAL QUESTION
What can the resident carry into the trauma bay, CT workstation, operating room, and postoperative floor?

Appendix A — Midface CT review checklist

Region	Review
Nasal / septum	Bony displacement, septal fracture, nasal spine, central widening, adjacent frontal and orbital injury.
NOE	Central MCT-bearing fragments, medial rims/walls, lacrimal fossae, frontal sinus floor, cribriform region.
ZMC	Frontozygomatic, infraorbital rim/floor, zygomaticomaxillary buttress, arch, sphenozygomatic alignment.
Maxilla / Le Fort	Complete pathways, pterygoids, piriform aperture, buttresses, maxillary mobility correlate.
Palate / dentoalveolar	Sagittal or transverse split, arch width, roots, sockets, alveolar segment displacement.
Associated	Orbit, frontal sinus, skull base, mandible, foreign body, soft-tissue avulsion, vascular concern.

Appendix B — Midface examination checklist

- Objective ocular examination and examination reliability.
- Nasal airway, septum, hematoma, dorsal and tip support.
- Intercanthal distance, MCT stability, medial eyelid and lacrimal symptoms.
- Malar projection, facial width, rim and buttress step-offs.
- Mouth opening and coronoid/arch mechanics.
- Maxillary mobility at different levels.
- Premorbid occlusion, wear facets, midlines, anterior and posterior contacts.
- Palatal laceration, width, and segmental mobility.
- Every tooth accounted for; dentoalveolar segment stability and aspiration risk.
- V1/V2/V3 sensation and facial movement; wounds over critical structures.

Appendix C — Operative planning worksheet

Planning field	Resident entry
Functional deficits	______________________________
Lost dimensions	______________________________
Unreliable references	______________________________
Trusted references	______________________________
Reduction sequence	______________________________
Required exposures	______________________________
Provisional fixation	______________________________
Definitive fixation	______________________________
Independent verification	______________________________
Postoperative risks / monitoring	______________________________

Appendix D — Dental and palatal quick reference

- Document premorbid bite before edema, intubation, or MMF when possible.
- Account for every missing tooth; image the airway/chest or GI tract when clinically indicated.
- Do not extract a tooth solely because it is in a fracture line.
- Reduce a mobile alveolar segment as a unit and obtain dental support for splinting and vitality follow-up.
- Confirm posterior arch width; anterior intercuspation can be falsely reassuring.
- A palatal splint is a three-dimensional template, not merely a protective appliance.
- Never replant an avulsed primary tooth; replant a permanent tooth immediately when safe or store it moist in HBSS, cold milk, saliva, or saline.

Appendix D - Dental and palatal quick reference (continued)

- Record extraoral dry time and storage medium; after permanent-tooth replantation, coordinate splinting, systemic antibiotics, tetanus review, and endodontic follow-up.
- In children, identify tooth buds before drilling and obtain long-term growth and dental surveillance.

Appendix E - Oral-board presentation template

TEMPLATE

"This is a [stable/unstable] patient after [mechanism]. Airway, vision, skull base, and hemorrhage are [state]. Functionally, the patient has [key findings]. CT shows disruption of [buttresses and units] with loss of [height/width/projection/rotation/arch width]. My reliable references are [state]. I would [observe/operate] because [indication]. My sequence is [state], using [approaches and fixation]. I will verify [relationships] and monitor for [specific complications]."

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SCOPE

Volume III focuses on reconstructive midface geometry. Orbital and skull-base emergencies are developed in Volume II; mandibular biomechanics in Volume IV; full panfacial sequencing in Volume VI.