FACIAL TRAUMA

VOLUME VI

Rebuilding the Facial Coordinate System

Panfacial sequencing, operative execution, digital planning, altered biology, postoperative failure, and secondary reconstruction

Volume VI: rebuild the coordinate system before locking the fragments

1 Stabilize Airway, hemorrhage, brain, eye, spine, vascular injury, and timing.	**2 Inventory** Name what is intact, reconstructable, and unreliable.	**3 Select axes** Choose the reference, vertical direction, transverse direction, and linkage point.
4 Restore dimensions Occlusion, width, height, projection, orbital volume, and central support.	**5 Verify independently** Clinical checks, imaging, navigation, and repeat inspection before final tightening.	**6 Protect recovery** Airway, vision, nutrition, motion, occlusion, infection, and late deformity surveillance.

KNOWN TO UNKNOWN • GLOBAL GEOMETRY BEFORE LOCAL PERFECTION • FIXATION PRESERVES A VERIFIED REDUCTION

Central question: Which part of this face can still be trusted as a source of truth - and how will you prove it before the rest of the reconstruction depends on it?

How to Use This Volume

Volume VI is the capstone of the facial-trauma series. Earlier volumes address immediate threats, the orbit and skull base, the midface, the mandible, and the facial envelope. This volume begins where those regional frameworks become insufficient: when several reference systems are displaced at once and a technically accurate local reduction can still create a globally wrong face.

CENTRAL MENTAL MODEL

Panfacial repair is not the sum of several regional operations. Every reduction changes the reference frame for the others. The surgeon must repeatedly move between local anatomy and the whole facial coordinate system.

What this guide teaches

- Classify cranial, orbital, occlusal, and soft-tissue references as intact, reconstructable, or unreliable.
- Separate the vertical sequencing axis from the transverse sequencing axis.
- Choose a linkage point and an independent verification method before definitive fixation.
- Restore occlusion, facial width, vertical height, projection, orbital volume, and central support as coupled endpoints.
- Build a complete airway, exposure, provisional fixation, definitive fixation, grafting, and imaging plan.
- Use VSP, splints, navigation, printing, and intraoperative imaging without mistaking precision for clinical correctness.
- Adapt the reference system to children, edentulous or atrophic jaws, frailty, anticoagulation, delay, infection, and ballistic loss.
- Analyze early and late failure by mechanism rather than by symptom alone.

HOW TO STUDY

Read Chapters 1-3 for the mental model, Chapters 4-5 for operative execution, Chapters 6-9 for altered biology and failure, and Chapter 10 aloud as an oral-board framework.

Abbreviations

Abbreviation	Meaning	Abbreviation	Meaning
AAST	American Association for the Surgery of Trauma	NOE	Naso-orbito-ethmoid
CBCT	Cone-beam computed tomography	ORIF	Open reduction and internal fixation
CSF	Cerebrospinal fluid	POD	Postoperative day
CT	Computed tomography	PSI	Patient-specific implant
DOAC	Direct oral anticoagulant	RAPD	Relative afferent pupillary defect
MCT	Medial canthal tendon	TMJ	Temporomandibular joint
MMF	Maxillomandibular fixation	VSP	Virtual surgical planning
VTE	Venous thromboembolism	ZMC	Zygomaticomaxillary complex

Contents

VOLUME ENDPOINT
Look at a panfacial injury, name the lost dimensions, identify the best surviving source of truth, defend a sequence, state how each major reduction will be verified, and recognize when the plan must change.

CHAPTER 1

When the Coordinate System Is Lost

The first operation is intellectual: separate what is known from what is merely fixed.

Panfacial trauma is variably defined, but the operative problem is consistent: several facial thirds or functional units are disrupted and the landmarks normally used to reduce one fracture may themselves be displaced. The surgeon is therefore not returning fragments to obvious sockets. The surgeon is rebuilding the coordinate system that makes those sockets meaningful. [1-6]

The defining injury is loss of a trustworthy reference frame

Reference system	Controls	Common reason it fails
Cranial-base frame	Upper facial height, frontal width, lateral orbital position, relationship of midface to skull.	Frontal sinus, orbital roof, zygomaticofrontal, or skull-base comminution.
Orbital-midface frame	Malar projection, facial width, orbital volume, nasal support, canthal position.	Bilateral ZMC, NOE, orbital, or Le Fort injuries; asymmetric rotation.
Occlusal frame	Mandibular width, ramal height, maxillary arch position, intercuspation.	Condylar fractures, symphyseal widening, palatal split, missing teeth, dentoalveolar injury.
Soft-tissue frame	Globe and eyelid support, scars, facial volume, nerve and duct function.	Edema, avulsion, devascularization, denervation, tissue loss, or delayed contracture.

Known, Reconstructable, or Unreliable?

Every candidate landmark should be assigned to one of three categories. An intact reference can be used immediately. A reconstructable reference may become trustworthy after reduction and verification. An unreliable reference should not drive other reductions until it is corrected or replaced by a stronger source of truth.

Intact

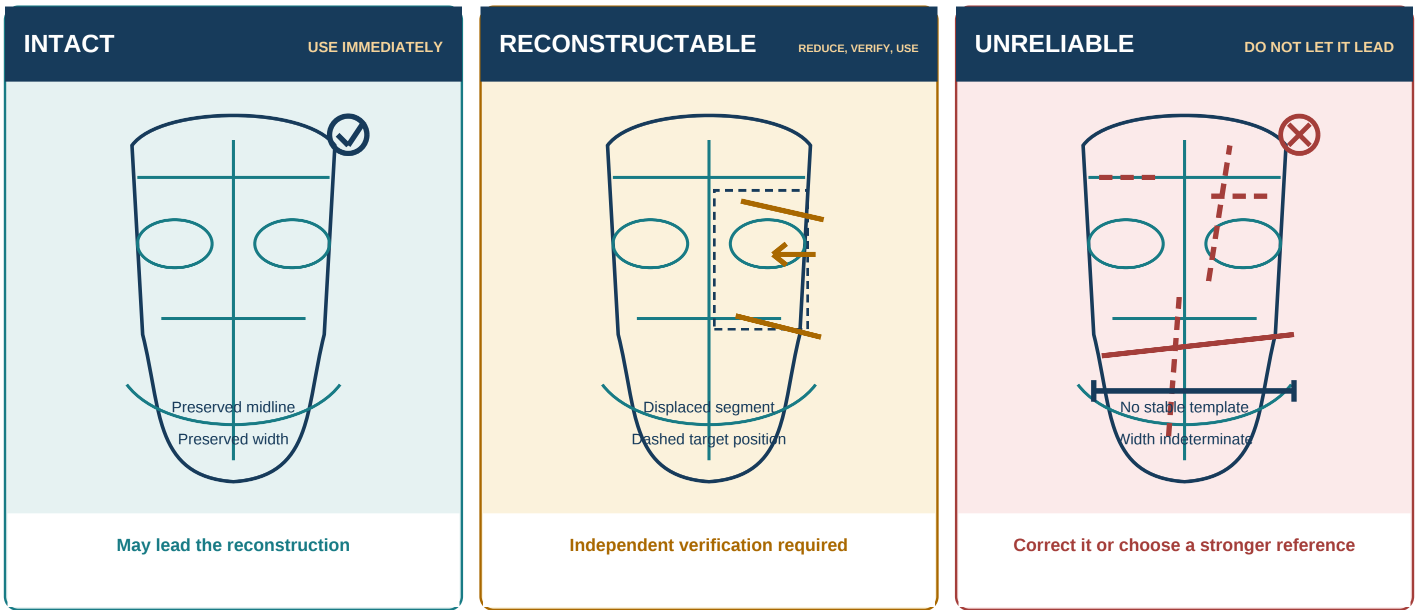
Preserved anatomy with predictable spatial relationships. It may lead immediately.

Reconstructable

Displaced but recoverable anatomy. Reduce it, verify it independently, then use it.

Unreliable

Comminuted, bilaterally displaced, shortened, widened, or impossible to verify.



Trust the geometry before trusting the landmark.

An intact reference can lead immediately; a reconstructable reference must be reduced and independently verified; an unreliable reference must be corrected or replaced before it influences other reductions. Original schematic; not to scale.

DIAGNOSTIC TRAP
A fracture list describes anatomy, not geometry. "Bilateral ZMC, NOE, Le Fort II, parasymphysis, and condyles" does not identify which dimensions are lost, which landmarks are trustworthy, or where the operation should start.

The three questions before sequencing

- Which structure has the best combination of preserved anatomy, size, and verifiability?
- Which dimension will it restore first?
- What independent check will prove that the reference itself is correct?

RESIDENT SYNTHESIS
Before naming a sequence, name the reference. Before trusting the reference, name the verification method.

CHAPTER 2

Choosing the Reconstructive Sequence

Directional sequences are frameworks. The injury pattern - not the surgeon's favorite order - determines the starting point.

The traditional labels are useful only when they are anatomically explicit. The most important correction is to separate **two independent decisions**: the vertical direction of reconstruction and the transverse direction of reconstruction. A case may therefore be top-down/outside-in, bottom-up/inside-out, or a deliberate hybrid. [1-6]

Choose the reference first; then choose a vertical axis, a transverse axis, and a linkage point

Decision	Option A	Option B
Vertical axis	**Bottom-up** Begin from a reconstructed mandible and occlusion.	**Top-down** Begin from a stable frontal or cranial-orbital frame.
Transverse axis	**Outside-in** Establish arches, zygomas, lateral rims, then central midface.	**Inside-out** Establish central facial and medial orbital relationships, then lateral width.

Bottom-up is defensible when...

- Condyles are seated or can be accurately restored.
- Ramal height and mandibular width are recoverable.
- Dentition or dental records define the premorbid bite.
- The mandibular arch can be independently verified.

Top-down is defensible when...

- The frontal bar, orbital roofs, or lateral orbital frame remain reliable.
- The mandible is comminuted, edentulous, shortened, or widened.
- Upper facial width and projection can be restored before occlusal linkage.
- The cranial frame offers better independent checks.

WHY THE DISTINCTION MATTERS

"Top-down" does not automatically mean "inside-out," and "bottom-up" does not automatically mean "outside-in." Conflating the axes can hide the actual reference logic and make an oral-board answer sound memorized rather than reasoned.

Sequence Matrix: Four Common Combinations

Bottom-up / outside-in

Use: reconstructable dentate mandible with reliable condyles; bilateral midface disruption.

Build: mandible - occlusion - maxilla - zygomas/arches - central midface.

Failure: a widened or shortened lower frame propagates error upward.

Top-down / outside-in

Use: stable frontal and lateral orbital frame; unreliable mandible.

Build: frontal/lateral orbit - zygomas/arches - central midface - maxillary linkage - mandible.

Failure: unrecognized upper-frame asymmetry forces a wrong maxillary position.

Bottom-up / inside-out

Use: reliable mandible and central maxillary segment; lateral ZMC/arch comminution.

Build: mandible - central maxilla/piriform - medial orbit/NOE - lateral midface.

Failure: central width is accepted before nasal and medial orbital relationships are proven.

Top-down / inside-out

Use: reliable nasofrontal or medial orbital structures with poor lateral references.

Build: cranial base - central frame/NOE - maxilla - lateral orbit and zygomas.

Failure: central comminution falsely narrows or widens the face.

Two-unit linkage

Some injuries are best understood as two separate reconstructions. The upper unit is built from the cranial frame through the zygomas and central midface. The lower unit is built from the mandible and occlusion. The units are reconciled at the Le Fort I or maxillary level only after each has been independently verified.

Upper unit
Frontal bar - orbit - zygomas - NOE

›

Independent checks
Width, projection, rim continuity, navigation/imaging

›

Lower unit
Condyles - ramal height - arch form - occlusion

›

Link at maxilla
Confirm passive bite and vertical buttress height

FAILURE MODE

Small errors in both units accumulate at the maxilla. The linkage step should expose disagreement, not hide it with stronger plates or forced MMF.

Major-Fragment-First and Operative Staging

Major-fragment-first

The major-fragment theory formalizes a practical principle: begin with the fragment that retains the greatest volumetric footprint and the clearest anatomic relationships, even when that choice departs from a strict directional order. The fragment must still be independently verified; “largest” does not mean “correct.” [6]

Framework	Best use	Strength	Characteristic failure
Directional sequence	At least one upper or lower reference system is predictably reconstructable.	Creates an orderly plan across facial thirds.	The chosen starting frame is assumed rather than proven.
Two-unit linkage	Upper and lower systems can be rebuilt separately but neither defines the whole face.	Makes the reconciliation point explicit.	Minor errors in both units are locked at the maxilla.
Major-fragment-first	Conventional anchors are comminuted but one large fragment preserves useful geometry.	Uses the most information-rich segment.	The fragment is rotated, translated, or distorted without an independent check.

Single-stage versus staged repair

A coordinated single-stage reconstruction is usually preferred when physiology, soft-tissue viability, operating time, and specialty resources permit because all units can be reconciled before fibrosis and early union. Staging is appropriate when the patient is unstable, tissue viability is evolving, contamination or tissue loss prevents definitive closure, the operative burden is unsafe, or required teams and technology are not simultaneously available. [1,2,7]

Good first stage

- Protects airway, globe, brain, and perfusion.
- Debrides clearly nonviable tissue while preserving uncertain tissue.
- Restores a stable functional platform.
- Maintains future exposure and reference points.
- Documents residual geometry with CT and photographs.

Dangerous first stage

- Rigidly fixes an unverified arch or midface.
- Consumes viable exposure tissue unnecessarily.
- Collapses facial width or vertical dimension.
- Creates hardware and scars that obstruct later osteotomy.
- Labels temporization as definitive reconstruction.

ORAL-BOARDS PEARL

Do not answer “bottom-up” as a reflex. State why the mandible is trustworthy, how you will restore condylar position and width, and what finding will make you abandon that sequence.

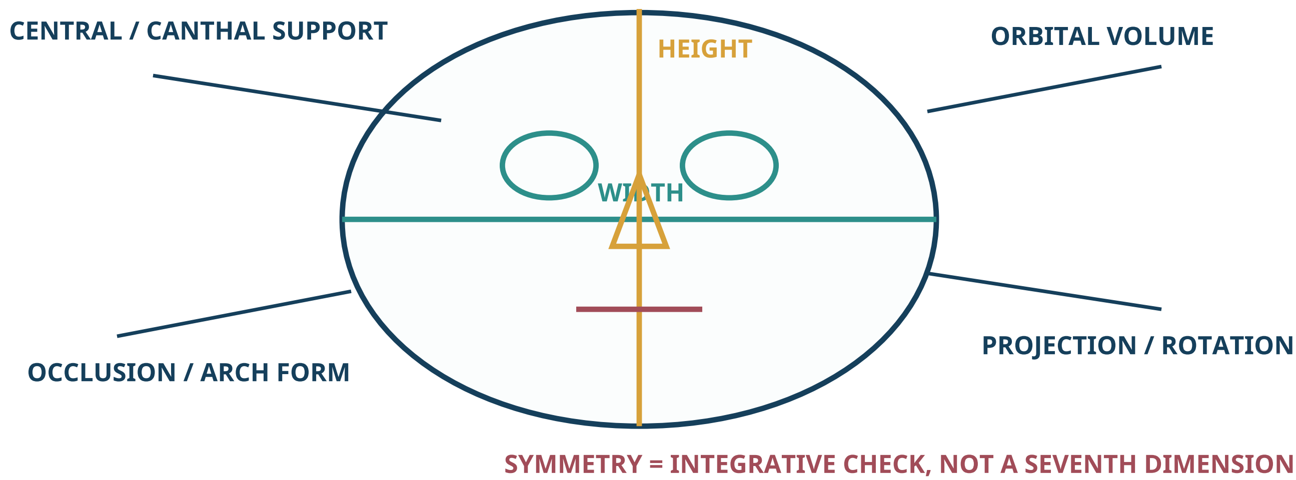
CHAPTER 3

Restoring Occlusion and Facial Dimensions

The face is not reconstructed until the bite, width, height, projection, orbit, and central landmarks agree.

A panfacial reconstruction succeeds only when several linked dimensions agree. Occlusion is indispensable, but it is not sufficient: a patient can have a reproducible bite with a widened face, a shortened ramus, a flat cheek, an enlarged orbit, or a malpositioned canthal complex.

Six reconstructive dimensions plus an integrative symmetry check



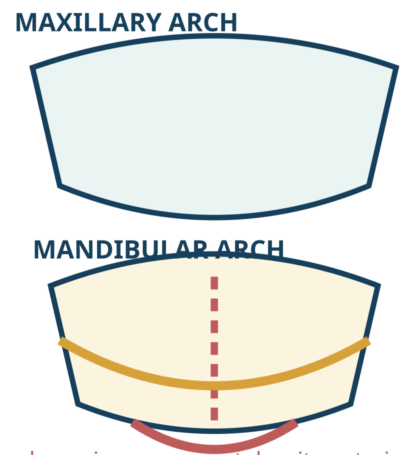
Occlusion Arch form, condylar seat, intercuspation, and passive return without a slide.	**Width** Mandible, palate, zygomatic arches, lateral orbital rims, and central NOE width.	**Height** Ramal height, vertical buttresses, rim levels, and frontal-midface relationship.
Projection / rotation Zygomatic, maxillary, nasal, and frontal contour in three dimensions.	**Orbital volume** The entire orbital box, globe support, posterior ledge, and wall reconstruction.	**Central support** MCT vector, intercanthal distance, nasal bridge, medial orbit, and lacrimal framework.

Occlusion Is a Reference - Not an Isolated Endpoint

Premorbid occlusion is a powerful functional template only when both dental arches and the condylar-ramal units are anatomically credible. Wear facets, dental records, photographs, models, orthodontic history, and the patient's baseline class relationship can be more informative than a few matching contacts.

How a stable bite becomes wrong

Injury	Hidden geometric error
Bilateral condylar fractures	Loss of ramal height, posterior widening, anterior open bite, or mandibular retrusion.
Symphyseal fracture	Buccal cortex appears closed while the lingual cortex remains open and the arch is widened.
Palatal split	Incisors contact while the maxillary arch remains transversely widened or rotated.
Dentoalveolar injury	Mobile teeth or segments create false intercuspation.
Edentulous patient	No dental index exists; dentures may reproduce an adapted rather than premorbid relationship.



Lingual opening can persist despite anterior closure

DIAGNOSTIC TRAP

A reproducible bite is not necessarily the premorbid bite. It may be the stable relationship created by two malreduced arches.

Proof before the maxilla is locked

- ☐ Condyles are seated or their functional position is explicitly managed.
- ☐ The symphyseal lingual cortex and transverse width are reduced.
- ☐ MMF can be released and the mandible returns without a slide.
- ☐ Ramal height and lower border contour are symmetric.
- ☐ Palatal width and maxillary arch form are restored.
- ☐ The bite agrees with facial width, projection, and vertical dimension.

OPERATIVE PEARL

Before final maxillary tightening, release MMF briefly. Open and close the mandible, confirm passive return, then recheck frontal and basal facial width.

Projection, Orbit, and Central Support Must Agree

Projection and rotation

Projection is not restored by translating a fragment anteriorly until one visible suture aligns. The zygoma can remain rotated despite acceptable zygomaticomaxillary contact. Confirmation should include the arch contour, lateral orbital rim, zygomaticofrontal region, and the deep zygomaticosphenoid articulation when accessible or visible on imaging.

Orbital volume

Orbital reconstruction must occur inside the global skeletal plan. ZMC position determines the lateral orbital box; NOE width determines the medial box; floor and medial-wall reconstruction determine the internal volume. A well-shaped floor implant cannot compensate for a retruded zygoma.

Central support

Telecanthus and nasal flattening are not isolated tendon or dorsal problems. The central bony base must be narrowed and projected before the MCT is fixed. The fixation vector should reproduce the tendon’s posterior and superior pull, not merely reduce visible intercanthal distance.

INTEGRATIVE VIEW

Assess pupils, globe position, canthi, nasal bridge, malar prominences, lip support, and occlusion together before closure.

Postoperative finding	Likely lost dimension	Questions to ask
Anterior open bite	Ramal height, condylar seating, posterior maxillary position.	Were condyles seated? Is the mandibular arch widened? Is the maxilla rotated?
Crossbite / unilateral premature contact	Transverse width or rotation.	Is the palate widened? Is the mandible bowed? Did one maxillary buttress shorten?
Flat cheek with normal bite	Zygomatic projection or rotation.	Do the arch, lateral rim, and sphenozygomatic contour agree?
Wide face	Bilateral zygomatic, palatal, or mandibular width.	Were both arches and the symphyseal lingual cortex restored?
Enophthalmos / hypoglobus	Orbital volume, ZMC position, or implant location.	Is the orbital box enlarged globally, locally, or both?
Telecanthus	Central bony width or MCT vector.	Was the NOE base narrowed before tendon fixation?

CLINICAL BRIDGE

Enophthalmos may be blamed on the floor implant when the primary cause is persistent ZMC retrusion that enlarged the entire orbital box.

CHAPTER 4

Operative Planning and Execution

The operation is an iterative diagnostic process, not a one-way checklist.

The operation should alternate between local reduction and global verification until no regional repair contradicts the whole face. Planning begins before incision by defining threats, specialty dependencies, airway requirements, exposure needs, and the observations that will prove each reconstruction.

Multidisciplinary planning

- Trauma surgery: physiology, hemorrhage, competing injuries, and operative tolerance.
- Anesthesia: airway sequence, extubation risk, blood loss, and duration.
- Ophthalmology: globe clearance, baseline vision, motility, and urgent orbital pathology.
- Neurosurgery: skull base, CSF leak, intracranial injury, and cranialization or repair needs.
- Dentistry/OMFS/prosthodontics: premorbid occlusion, splints, dentures, dental viability, and rehabilitation.
- Interventional radiology/vascular surgery: uncontrolled bleeding or vascular injury.

Airway decision

Prolonged ventilation, repeated access, severe edema, neurologic impairment, or difficult rescue?

Yes: tracheostomy often provides the most durable access.

MMF plus unobstructed oral and nasal fields, with only short-term ventilation?

Selected patient without floor-of-mouth injury or a contraindicating mandibular fracture: consider submental intubation.

Can an oral or nasal tube remain without obstructing reduction or fixation?

Use the least invasive route that is safe for the injury and preserves the required field.

AIRWAY TRAP

Nasotracheal intubation is not prohibited by every facial fracture. Avoid blind nasal instrumentation and avoid the nasal route when a suspected skull-base defect, severe central nasal disruption, active CSF rhinorrhea, or the operative field makes passage unsafe. Submental intubation is a short-term strategy, not a substitute for tracheostomy when prolonged ventilation or repeated airway control is expected. [24,26]

PREINCISION PAUSE

State the initial reference, vertical and transverse axes, linkage point, provisional fixation plan, verification method after each unit, and the trigger that will make you change sequence.

Series bridge: see Volume I for emergency airway assessment and surgical-airway principles.

Exposure: See the Reduction and Its Confirming Points

Exposure should be selected by the reduction that must be seen and by the second articulation that will confirm it. A single beautiful contact is dangerous when the remainder of a fragment can remain rotated.

Approach	What it exposes	What must be protected or anticipated
Coronal	Frontal bar/sinus, superior NOE, lateral rims, zygomatic arches, temporal region.	Frontal branch, supraorbital/supratrochlear nerves, scalp vascularity, alopecia, temporal hollowing.
Transconjunctival / lower eyelid	Inferior rim, floor, medial wall with extension, lateral canthal region.	Lower-lid support, canthal integrity, globe protection, postoperative malposition.
Intraoral maxillary	Piriform, nasomaxillary and zygomaticomaxillary buttresses, palate.	Infraorbital nerve, tooth roots, mucosal closure, oral contamination.
Mandibular intraoral or external	Symphysis, body, angle, ramus/condyle depending approach.	Mental and facial nerves, marginal mandibular branch, periosteal blood supply, lingual cortex.

Release before reduction

Impacted segments must be disimpacted and tethering soft tissue released before they are forced into a visible alignment. False reduction is especially common at the zygomaticosphenoid articulation, palatal split, mandibular lingual cortex, central NOE region, and condylar-ramal unit.

> **OPERATIVE PEARL**
> The combined exposure should show both the chosen reference point and the confirming point that proves the fragment has not simply rotated around it.

Worked Operative Plan: Top-Down / Outside-In

Scenario

Bilateral ZMC and NOE fractures, Le Fort II mobility, comminuted mandibular body fracture, bilateral condylar fractures, intact frontal bone and lateral orbital roofs.

1 Airway and exposure

Tracheostomy if prolonged ventilation/staging is expected; coronal, orbital, intraoral, and mandibular access as required.

2 Establish cranial frame

Confirm frontal bar and lateral roof are truly intact on CT and direct inspection.

3 Reduce lateral midface

Restore zygomatic projection, arch contour, lateral rim level, and sphenozygomatic alignment.

4 Rebuild central midface

Narrow NOE base, reconstruct medial orbit, restore MCT-bearing segment and nasal projection.

5 Reconstruct lower unit

Restore mandibular width and lower border; explicitly manage condylar position and ramal height.

6 Link at maxilla

Set maxilla between verified upper and lower units; release MMF and test passive return.

Checkpoint	Independent proof	Trigger to revise
After lateral midface	Frontal/lateral orbital relationship, arch contour, bilateral projection, deep articulation, intraoperative imaging if available.	One zygoma remains rotated, widened, or posterior despite rim contact.
After NOE	Central width, posterior-superior MCT vector, medial orbital contour, nasal support.	Telecanthus, asymmetric medial orbit, or flattened bridge persists.
After mandible	Condylar seat, ramal height, lower-border continuity, lingual cortex, transverse width.	Open bite, slide, widened arch, or inability to verify condylar position.
After linkage	Passive occlusion, vertical buttress height, facial width/projection, globe and canthal position.	MMF is required to force an otherwise unstable or sliding relationship.

CRITICAL REASONING

The mandible is not the starting template because bilateral condylar and body injuries make both ramal height and transverse width uncertain. It becomes usable only after reconstruction and independent verification.

Worked Operative Plan: Bottom-Up / Outside-In

Scenario

Restorable parasymphyseal fracture, intact condyles, complete dentition, bilateral Le Fort and ZMC fractures, and a comminuted frontal sinus anterior table.

1 Rebuild mandible

Seat both condyles; restore ramal height, width, lower border, and arch form.

2 Establish occlusion

Use records and wear facets; apply MMF without forcing the arches, then confirm passive return.

3 Position maxilla

Restore palatal width, cant, projection, and vertical buttress height to the verified lower frame.

4 Restore lateral midface

Reduce zygomas and arches outside-in; verify projection and rotation at multiple articulations.

5 Restore central face

Rebuild NOE, medial orbit, and nasal support; restore the bony base before final MCT fixation.

6 Address sinus / skull base

Base management on posterior table, outflow pathway, dura/CSF leak, and durable drainage or separation.

Why the frontal injury does not dictate top-down repair

The comminuted anterior table is a poor geometric reference. Intact condyles, usable premorbid occlusion, and a reconstructable parasymphysis provide a stronger lower-frame source of truth. The frontal sinus and skull base require a deliberate management decision based on the anterior table, posterior table and dura, outflow pathway, CSF leak, and follow-up. Observation, endoscopic management, ORIF, obliteration, or cranialization is selected by the injury rather than by comminution alone. [27]

Mandibular proof

- Both condyles seated
- Ramal height and lower border restored
- Lingual cortex and arch width restored
- Passive premorbid bite without slide

Global proof before closure

- Width and projection symmetric
- Maxillary buttresses equal in height
- Globe and canthi acceptable
- Imaging confirms deep relationships

SEQUENCE-CHANGE TRIGGER

If condylar seating, ramal height, mandibular width, or passive premorbid occlusion cannot be independently verified, stop using the mandible as the definitive template. Maintain provisional fixation and re-establish the coordinate system from a reliable upper or lateral cranial reference.

Series bridge: see Volume II for definitive frontal-sinus and anterior skull-base algorithms.

Provisional Fixation Preserves Diagnostic Flexibility

Temporary wires, clamps, screws, light plates, or partially tightened definitive plates create a testable geometry. Their purpose is not merely speed; it is to preserve the ability to revise a reference before a rigid construct propagates error across the face.

Release
Expose and disimpact until the fragment can move without forced bending.

›

Reduce
Restore the local articulation and the intended global dimension.

›

Hold provisionally
Maintain enough stability to test adjacent units.

›

Verify independently
Clinical checks, imaging, navigation, and movement tests.

›

Fix definitively
Match plate strength to load, comminution, bone stock, and biology.

After this reconstruction...	Verify...	Failure means...
Mandible	Condylar seat, ramal height, transverse width, lingual cortex, lower border, passive occlusion.	The lower frame cannot yet be trusted.
Zygoma	Projection, arch contour, lateral rim, zygomaticofrontal region, sphenozygomatic alignment.	Rotation or facial width remains incorrect.
Maxillary linkage	Premorbid bite, palatal width, vertical buttress height, absence of mandibular slide.	Upper and lower units are mismatched.
NOE / central face	Central skeletal width, MCT vector, nasal projection, medial orbital contour.	The bony base or canthal reconstruction is wrong.
Orbit	Posterior ledge, implant contour and position, orbital volume, globe safety and position.	A local wall repair conflicts with the global orbital box.
Before closure	Pupils and vision when assessable, globe/canthi, bite, width, height, projection, motion, imaging.	A critical or global error remains correctable.

Definitive fixation matches load and biology

Thin orbital and NOE fragments require low-profile fixation that preserves soft tissue. Maxillary buttresses require stable load-sharing fixation. Comminuted or severely atrophic mandibles may require load-bearing reconstruction. Bone grafting, rigid bridging, or vascularized reconstruction is considered when continuity, height, or viable bone cannot be restored with native fragments.

OPERATIVE PEARL

Do not allow the strongest plate to become the strongest argument that the reduction is correct. If global checks fail, return to release or reduction - not to a stronger plate.

CHAPTER 5

Digital Planning, Navigation, and Intraoperative Imaging

A digital plan is a hypothesis. The patient's anatomy is the final test.

Technology is most valuable when it converts an unreliable reference into a measurable and transferable plan. It is least valuable when it gives false confidence in an incorrect target.

Digital plan → physical transfer → clinical validation

1 Thin-cut CT
Segment cranial base, facial skeleton, dentition, defects, and major fragments.

2 Virtual reduction
Mirror intact anatomy, recover premorbid fragments, test occlusion and facial dimensions.

3 Transfer
Splints, guides, models, prebent plates, PSIs, or printed templates.

4 Navigate
Register to a stable cranial reference and confirm planned landmarks.

5 Image
Use intraoperative CT/CBCT to detect residual displacement before closure.

6 Validate clinically
Bite, pupils, globe, canthi, width, projection, motion, and soft-tissue tension.

Evidence in acute panfacial trauma

A 2026 systematic review identified five eligible clinical studies involving 82 patients with acute complex multiregion or panfacial fractures. The evidence was heterogeneous and generally low quality, but it demonstrated feasibility across navigation, VSP, printing, splints, and integrated workflows. One included study reported a marked operative-time reduction; the strictly panfacial cohort reported mean reduction errors below 2 mm across facial thirds. These findings are promising but do not establish universal superiority. [8]

High-value use

- Bilateral injury without a normal opposite side.
- Severe comminution obscuring contour.
- Edentulous or atrophic jaws.
- Secondary osteotomy and repositioning.
- Patient-specific orbital or craniofacial implants.

What it cannot replace

- Condylar seating and passive occlusion.
- Direct globe and pupil assessment.
- Judgment about tissue viability.
- Recognition of a wrong virtual target.
- Ability to revise when anatomy differs from plan.

Digital Tools: Contribution, Assumption, and Failure Mode

Tool	Best contribution	Hidden assumption	Important limitation
Mirroring	Reconstructs unilateral contour, orbital shape, or projection.	The opposite side is normal and correctly segmented.	Preexisting asymmetry or bilateral injury makes the target wrong.
Occlusal splint	Transfers a planned maxillomandibular relationship.	Virtual condyles, arch width, and dental segments are correct.	Faithfully reproduces an incorrect lower-frame geometry.
3D model / guide	Improves spatial understanding, plate contouring, osteotomy, or screw placement.	The model accurately represents the operative anatomy.	Production time; does not model edema, scarring, or exposure constraints.
Navigation	Localizes instruments and landmarks relative to registered CT.	Registration is accurate and the reference remains immobile.	Does not prove mobile fragments are seated or the target is clinically correct.
Intraoperative CT / CBCT	Detects deep malreduction and implant position before closure.	Images are interpretable despite artifact and positioning.	Radiation, workflow burden, and limited soft-tissue functional information.
Patient-specific implant	Reproduces a designed contour precisely.	The skeletal reduction beneath it matches the virtual plan.	Difficult to revise if the target or reduction is wrong.

REGISTRATION PRINCIPLE

Register navigation to the most stable available cranial reference. Accuracy relative to the skull does not guarantee accuracy of a mobile zygoma, maxilla, mandible, or orbital implant unless the segment itself is correctly reduced.

Three layers of accuracy

Technical accuracy
Does the system know where the instrument or guide is relative to the dataset?

Transfer accuracy
Was the virtual plan reproduced in the patient without guide shift, splint distortion, or segment motion?

Clinical correctness
Was the planned target itself anatomically, functionally, and aesthetically appropriate?

DIAGNOSTIC TRAP

Navigation can show that a pointer is exactly where the plan expected while the condyle is unseated, the bite is adapted, the globe is unsafe, or the virtual reduction is wrong.

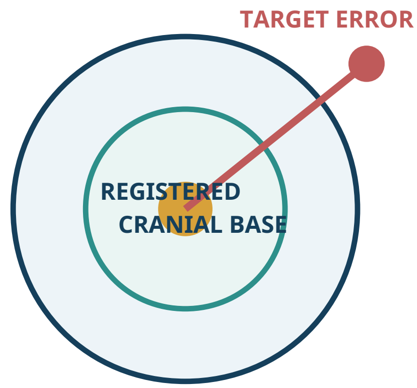
Digital Case: When Precision Still Needs Judgment

Scenario

Bilateral ZMC and orbital injuries with no reliable contralateral template, an edentulous maxilla, and a comminuted central midface. A mirrored orbital target and patient-specific implant are planned.

Where error can enter

1. **Segmentation:** thin comminuted walls or dental artifacts are misclassified.
2. **Target definition:** mirroring assumes the opposite side was normal and representative.
3. **Virtual condylar position:** the lower unit is planned with an unseated joint.
4. **Guide placement:** scar, edema, or fragment mobility prevents full seating.
5. **Registration:** the reference shifts or registration error is concentrated near the target.
6. **Implant dependency:** a PSI fits the model but sits on a malpositioned ZMC.



Small registration error can magnify far from the reference region.

Intraoperative rescue strategy

Check	What it protects against
Reconfirm registration at several cranial landmarks near and far from target.	Registration drift and localized fit error.
Verify ZMC position before accepting the orbital PSI.	A perfect implant seated on a retruded lateral orbital box.
Release MMF and test mandibular return.	A splint that reproduces incorrect condylar or arch position.
Use intraoperative CT/CBCT after major skeletal linkage.	Deep rotational or translational errors not visible through exposures.
Perform direct ocular, canthal, and facial-width checks.	Technical accuracy without clinical correctness.

RESIDENT TAKEAWAY

Digital adjuncts increase the number and quality of measurements. They do not eliminate the need to decide which measurements matter.

CHAPTER 6

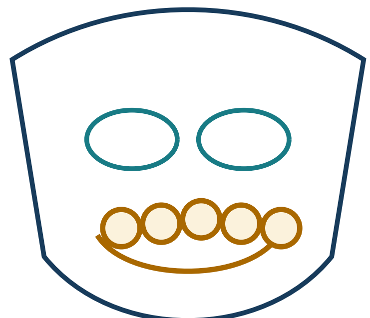
Children: Restore Function Without Creating a Growth Problem

"Pediatric" is not a treatment plan; it is a different anatomy, biology, and time horizon.

Children have flexible bone, changing facial proportions, developing dentition, incompletely pneumatized sinuses, and many years in which growth disturbance may emerge. Treatment is often more conservative than in adults, but threatened vision, airway, occlusion, mandibular motion, or normal future growth still requires timely and accurate intervention. [10-12,28]

Why the reference system changes

- Tooth buds and unerupted teeth occupy potential fixation corridors.
- Facial proportions, dentition, and reliable occlusal landmarks change with age.
- Elastic bone may produce greenstick or trapdoor patterns with limited external signs.
- Mixed dentition can make premorbid occlusion difficult to infer.
- Apparently successful union may still be followed by asymmetry, ankylosis, eruption disturbance, or malocclusion.



Tooth buds and growth potential alter safe fixation corridors and follow-up.

Clinical problem	Management emphasis	Long-term concern
Orbital trapdoor injury with restricted motility, pain, nausea/vomiting, or bradycardia	Urgent ophthalmic assessment. With entrapment or an oculocardiac reflex, release promptly - generally within 24-48 hours. Subtle CT findings do not override a convincing examination.	Persistent diplopia, muscle ischemia, or motility deficit.
Condylar injury	Preserve ramal height and motion; minimize immobilization and begin motion when stability permits. Use ORIF selectively.	Ankylosis, asymmetry, malocclusion, or impaired mandibular growth.
Displaced occlusal or panfacial injury	Restore function accurately with the least exposure and fixation that provide stability. Map tooth buds before fixation.	Dental injury, eruption disturbance, or facial asymmetry.
Frontal sinus or skull-base injury	Interpret by age, sinus pneumatization, dural involvement, and CSF leakage; coordinate neurocranial care.	Delayed contour, sinus, or skull-base complications.

Series bridge: see Volume II for pediatric orbital entrapment and frontal-sinus/skull-base detail.

Pediatric Decision Points and Follow-Up

When conservative treatment is attractive

Minimal displacement, stable occlusion, preserved ocular function, and reliable follow-up favor observation or closed treatment. The rationale is not simply to avoid hardware; it is to preserve periosteum, tooth buds, growth centers, and normal motion when an operation does not improve function.

When ORIF becomes necessary

Threatened function
Vision, entrapment, airway, occlusion, mandibular motion, or unstable skull-base relationship.

Unstable geometry
Displacement cannot be maintained with closed techniques or would heal with a major growth-distorting deformity.

Open / contaminated injury
Devitalized tissue, exposed bone, infection, or tissue loss requires debridement, stabilization, and coverage.

Operative choice	Resident reasoning
Exposure	Use the smallest exposure that permits accurate reduction and protects critical structures; do not accept poor visualization when function is at risk.
Fixation corridor	Map developing tooth buds and roots on CT; choose screw length and plate position accordingly.
Titanium versus resorbable	Neither system is universally superior. Consider fracture load, bone size, removal risk, handling, institutional experience, and evidence limitations.
MMF	Use the shortest immobilization compatible with stability; prioritize nutrition, airway safety, oral hygiene, and early motion where appropriate.
Condylar management	State whether ramal height and motion can be preserved closed; reserve ORIF for selected displaced or mechanically unacceptable injuries.

Longitudinal surveillance

- ☐ Occlusion and eruption.
- ☐ Mandibular range of motion and TMJ symptoms.
- ☐ Nasal airway and sinus development.
- ☐ Facial symmetry and vertical growth.
- ☐ Globe position, motility, and vision.
- ☐ Hardware or growth-related contour problems.

BOARD PEARL

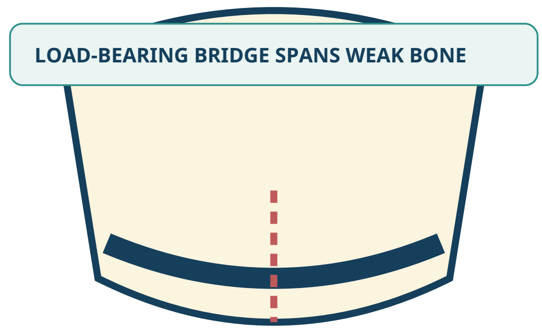
A pediatric answer should always include the acute functional indication, the strategy to minimize growth injury, and a long-term surveillance plan.

Edentulous and Atrophic Jaws: Occlusion Is Absent and Bone May Not Share Load

Loss of teeth removes the most intuitive lower-face reference, while atrophy reduces cross-sectional area, vascularity, and the bone's ability to share load. The reconstructive problem is therefore both geometric and mechanical. [13-15]

Sources of truth without teeth

- Existing dentures or preinjury casts.
- Preinjury photographs and lower-face vertical dimension.
- Basal mandibular contour and inferior border.
- Maxillary-mandibular relationship inferred from prosthodontic records.
- Mirrored or normative digital planning.
- Gunning-type splints or modified dentures in selected cases.



Atrophy reduces load sharing and requires reliable fixation purchase.

Mechanical consequence

In a severely atrophic fracture, the bone may not reliably share functional load. A load-bearing reconstruction plate spanning adequate healthy bone is commonly required, with sufficient fixation on each side of the fracture. Bone grafting or vascularized reconstruction is considered when a segmental defect, nonunion, infection, or inadequate viable stock prevents stable bridging.

Problem	Recommended response	Caveat
No intercuspation	Use denture/splint, basal contour, facial vertical dimension, and digital planning.	A current denture may reflect chronic adaptation and poor fit.
Severe atrophy	Favor load-bearing fixation and minimize periosteal injury.	Short screws, poor purchase, and bilateral fractures increase failure risk.
Frailty / poor nutrition	Coordinate medical optimization, dietetics, and rehabilitation.	An exhaustive reconstruction may not improve the patient's actual priorities.
Denture rehabilitation	Plan plate position and contour with prosthodontic needs in mind.	Hardware can interfere with future prosthesis or implants.

FAILURE MODE

Applying a load-sharing construct to bone that cannot share load leads to mobility, screw loosening, infection, and nonunion.

Older, Frail, and Anticoagulated Patients

Age alone does not determine treatment. Frailty, cognition, nutrition, bone quality, sensory impairment, aspiration risk, medication burden, intracranial injury, baseline function, and rehabilitation capacity often matter more than the radiographic fracture count. Geriatric-trauma guidance emphasizes undertriage and systems-level resource needs. [16]

Physiologic questions first

- Is there occult intracranial injury or ongoing bleeding?
- What is the indication, timing, and last dose of anticoagulant?
- What are renal function, hemoglobin, platelet count, and reversal options?
- Can the patient tolerate a long single-stage reconstruction?
- What airway, swallowing, delirium, and fall risks will follow?

Define meaningful benefit

- Airway stability.
- Vision and globe protection.
- Oral intake and denture function.
- Pain and mobility.
- Ability to communicate and participate in care.
- Prevention of major deformity that impairs function.

Anticoagulation is a perioperative pathway, not a single reversal order

Step	Questions
Identify agent and indication	DOAC, warfarin, antiplatelet therapy, or combination? Atrial fibrillation, VTE, valve, recent stent?
Assess active bleeding and urgency	Is reversal needed for life-threatening hemorrhage, urgent cranial/orbital surgery, or can the operation wait for drug clearance?
Account for clearance	Time of last dose, renal/hepatic function, laboratory limitations, and drug-specific reversal availability.
Plan resumption	Balance hemostasis and operative rebleeding against thrombosis risk; coordinate trauma, anesthesia, medicine, and relevant specialists.

> **SCOPE OF EVIDENCE**
> The geriatric-trauma source supports systems, triage, and resource planning. Drug-specific reversal and resumption should follow current institutional and specialty protocols rather than a generic facial-trauma rule.

Postoperative design

Favor clear airway plans, early mobilization, delirium prevention, hearing/vision aids, nutrition, medication reconciliation, aspiration precautions, and realistic discharge planning. A technically complete reconstruction that prevents oral intake or rehabilitation may be a poor patient-centered result.

Delayed, Infected, and Ballistic Injury: Biology Determines Timing

Delayed presentation

After several weeks, mobile fracture becomes early malunion. Scar contracts, segments resorb, dental contacts adapt, and infection may colonize unstable hardware or devitalized bone. The operation often changes from reduction to osteotomy and planned reconstruction.

Ballistic and high-energy avulsive injury

These injuries combine comminution with cavitation, uncertain tissue viability, contamination, nerve and duct injury, and volumetric tissue loss. Literature supports both early definitive reconstruction in selected stable patients and staged reconstruction when viability, contamination, physiology, or coverage remains uncertain. The correct answer is conditional, not dogmatic. [17-19,25]

Early definitive versus staged reconstruction

Favor earlier definitive restoration when...

- Physiology is stable and life-threatening injuries are controlled.
- Viable soft tissue and vascularized coverage are available.
- Debridement has defined the defect.
- Restoring width, height, occlusion, and projection will prevent contracture.
- The reconstructive team and resources are available.

Favor staged reconstruction when...

- Viability remains uncertain or serial debridement is required.
- Contamination, infection, or dead space is uncontrolled.
- Physiology or operative burden makes definitive repair unsafe.
- Composite loss requires temporization before free tissue transfer.
- The functional platform can be preserved without forcing final contour.

Phase	Primary objective	Coordinate-system priority
Resuscitation	Airway, hemorrhage, brain/eye/vascular injury, imaging, conservative debridement.	Preserve viable landmarks and tissue needed later.
Reconstitution	Serial viability assessment, contamination control, temporary stabilization, coverage.	Preserve width, height, occlusal potential, and exposure.
Reconstruction	Definitive skeletal platform, vascularized tissue, orbital and nasal support.	Restore the global frame before refinements.
Rehabilitation	Airway decannulation, intake, speech, dental restoration, scar and contour revision.	Audit function and proportions over time.

TRAP
"Ballistic" does not automatically mean delayed reconstruction. Explicitly justify timing from physiology, viability, contamination, tissue loss, coverage, and the risk of contracture.

CHAPTER 7

Postoperative Care and Early Failure

Early revision is easier than allowing a recognized geometric error to consolidate.

The first postoperative examinations determine whether a correct reconstruction remains safe, stable, and functional. Surveillance intensity should follow the threatened function rather than a generic ward routine.

Postoperative surveillance follows the time-sensitive threat

0-6 hours

Airway, pupils/vision, globe tension, bleeding, bite/slide, MMF safety, neurologic status, and clear rhinorrhea.

POD 0-1

Repeat ocular and occlusal exams; wound, drains, fixation stability; targeted imaging when indicated.

Days 2-7

Infection, wound/hardware, nutrition, oral hygiene, airway/tracheostomy care, motion, and ongoing CSF surveillance.

Weeks

Occlusion, opening, eyelid/diplopia, canthi, nasal airway, sinus/lacrimal symptoms, and sensation.

Months

Enophthalmos, telecanthus, malunion, width/projection error, chronic sinus disease, trismus, TMJ, and dental recovery.

The categories are cumulative. Traumatic CSF leak may be immediate, delayed, or recurrent. [29]

Immediate priorities

- Define the extubation, tracheostomy, suction, and emergency airway plan.
- Document acuity when possible, pupils/RAPD, color when relevant, motility, diplopia, proptosis, globe position, and eyelid closure.
- Do not measure intraocular pressure when an open globe is suspected.
- Record postoperative occlusion, condylar return, MMF/elastics, and emergency release equipment.
- Control pain, nausea, edema, and bleeding while preserving the ability to detect deterioration.
- Define nutrition, oral hygiene, nasal care, wound, drain, donor-site, and CSF-leak precautions.
- Tailor VTE prophylaxis and medication resumption to neurologic, ocular, and bleeding risks.

NEVER ATTRIBUTE THESE FINDINGS TO ROUTINE SWELLING

New visual decline, RAPD, increasing proptosis or orbital firmness, airway change, expanding hematoma, major occlusal shift, a new mandibular slide, mobile fixation, or widening canthi requires immediate evaluation. Suspected orbital compartment syndrome is a clinical emergency; decompression must not be delayed for nonessential imaging.

CSF LEAK ESCALATION

Screen from admission onward for clear rhinorrhea or otorrhea, recurrent leak, meningitis, and pneumocephalus. Selected low-flow traumatic leaks may be observed initially with skull-base precautions and multidisciplinary follow-up. Persistent leakage at about 7 days, high-flow leak, meningitis, significant pneumocephalus, or a defect unlikely to close should prompt definitive repair planning. [29]

MMF Safety, Antibiotics, and Postoperative Imaging

MMF safety and nutrition

Rigid MMF requires bedside release equipment, staff familiarity with release, suction, antiemetic control, and a clear plan for vomiting or airway compromise. Many contemporary constructs permit early release or guiding elastics, but the exact plan depends on stability, dentition, and surgeon preference.

Antibiotic stewardship

Separate prophylaxis from treatment of established infection. The 2024 AAST consensus recommends no prophylactic antibiotics for closed nonoperative facial fractures. For closed, non-contaminated operative fractures, use perioperative prophylaxis according to protocol but do not continue routine postoperative antibiotics. Open mandible fractures, contaminated facial fractures, and posterior-table frontal sinus fractures should receive no more than 24 hours of prophylaxis unless infection or another defined indication requires treatment. [9]

Situation	Principle
Closed, nonoperative facial fracture	Do not prescribe prophylactic antibiotics solely for the fracture.
Closed, non-contaminated operative facial fracture	Give perioperative prophylaxis by local protocol; do not continue routine postoperative antibiotics.
Open mandible, contaminated facial fracture, or posterior-table frontal sinus fracture	Limit prophylaxis to 24 hours or less unless infection or another defined indication is present.
Ballistic or heavily contaminated injury	Base debridement and therapeutic treatment on contamination, viability, retained material, coverage, and evidence of infection; do not extend antibiotics solely for mechanism.
Abscess, osteomyelitis, or infected nonunion	Drain/debride, restore stability and viable coverage, obtain cultures when useful, and provide targeted treatment.
CSF leak without infection	Do not use routine prolonged prophylaxis solely to prevent meningitis; prioritize definitive skull-base management.

Postoperative imaging should answer a question

High-value indications

- Complex bilateral reconstruction
- Limited clinical examination
- Orbit or skull-base involvement
- No intraoperative imaging
- New occlusal, ocular, neurologic, or fixation concern

Questions to specify

- Condylar position and mandibular width
- Zygomatic rotation and arch contour
- Orbital implant and posterior ledge
- NOE width and medial orbit
- Frontal sinus/skull-base and hardware stability

PRACTICE PRINCIPLE
If adequate intraoperative imaging already answers the relevant questions, repeat CT should be driven by a new clinical concern rather than habit. Complex reconstruction still requires adequate radiologic documentation when deep relationships cannot be verified clinically. [1]

Early Failure: Diagnose the Threat Before Naming the Complication

Finding	Immediate concern	Initial response
New visual decline, RAPD, proptosis, tense orbit	Orbital compartment syndrome, globe/optic injury, fragment or implant compression.	Urgent ocular/orbital examination and decompression when clinically indicated; do not delay for nonessential imaging.
Airway change	Edema, bleeding, tongue/floor swelling, secretion or aspiration problem.	Call airway help, oxygenate, suction, release MMF if required, and secure the airway.
New malocclusion or slide	Loss of fixation, condylar displacement, missed arch deformity, or maxillary mismatch.	Repeat examination, release elastics/MMF as appropriate, image, and revise early if skeletal error is clear.
Expanding facial swelling	Hematoma, arterial bleeding, or venous obstruction.	Resuscitate, decompress/open wound or return to OR; consider angiography/embolization.
Fever, drainage, instability	Abscess, devitalized bone, contamination, loose hardware, or nonunion.	Image, drain/debride, culture when useful, restore stability and viable coverage, and target antibiotics.
Clear rhinorrhea	Persistent, recurrent, or new CSF leak.	Skull-base precautions and multidisciplinary evaluation; avoid reflex prolonged antibiotics.

POD 1 open bite + mandibular slide + enophthalmos

1 Threat screen

Acuity, pupils/RAPD, color, motility, globe tension/position, airway, and bleeding.

2 Localize geometry

Condylar seat, ramal height, arch width, maxillary linkage, ZMC, and orbital box.

3 Obtain targeted CT

Confirm skeletal and implant position after immediate clinical threats are addressed.

4 Revise early

Correct a clear skeletal error before union rather than attributing it to edema.

DIAGNOSTIC TRAP

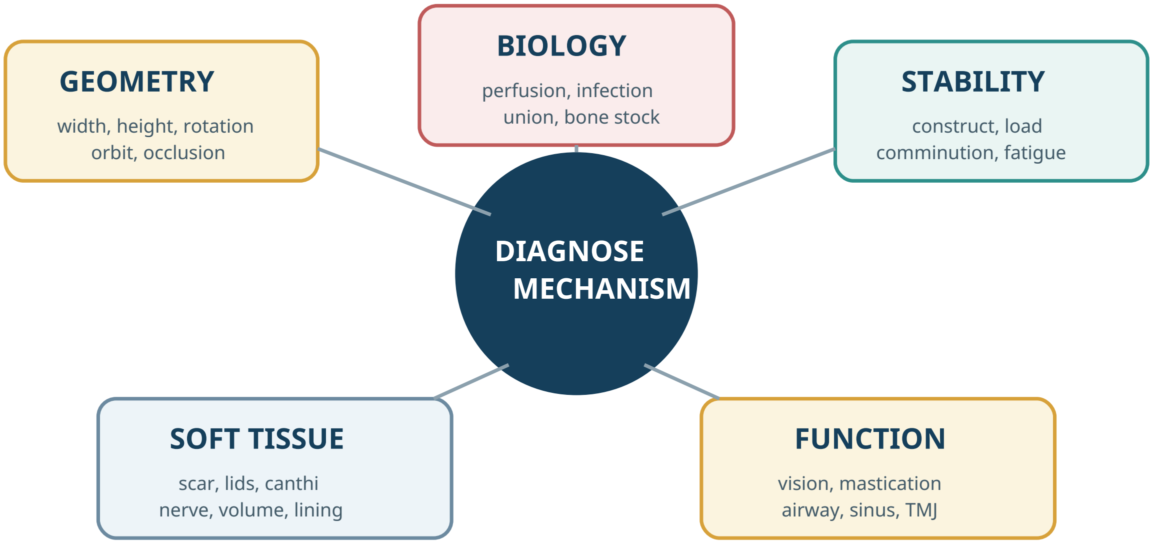
Edema can obscure symmetry, but it does not explain an afferent pupillary defect, a new open bite with slide, a mobile segment, widening canthi, or clear implant displacement.

CHAPTER 8

Complications as Failure Analysis

Complications are often the delayed expression of an earlier reference, biology, or stability error.

The useful question is not merely “what complication occurred?” but “which domain failed, what mechanism produced it, and what must be corrected before the visible symptom can improve?”



Geometric failure

Malocclusion, widening, loss of projection, occlusal cant, shortened ramus, enophthalmos, hypoglobus, telecanthus, nasal flattening, contour asymmetry.

Biologic failure

Infection, osteomyelitis, nonunion, sequestration, wound breakdown, graft or flap loss.

Stability failure

Loss of reduction, screw loosening, plate fracture, progressive malocclusion, or motion at a bridged defect.

Soft tissue and function

Lower-lid malposition, canthal dystopia, scar contracture, nerve weakness, lacrimal obstruction, nasal valve collapse, trismus, TMJ pain, dysesthesia, and chronic sinus disease.

> **CORE PRINCIPLE**
> Treating the visible symptom without correcting the failure domain produces repeated failure.

Common Complications: Mechanism and Corrective Concept

Complication	Primary domain	Mechanism to investigate	Corrective concept
Malocclusion	Geometry / stability	Condyle, ramal height, mandibular or palatal width, maxillary rotation, hardware failure.	Early re-reduction while mobile; osteotomy/ orthognathic correction after union.
Enophthalmos / hypoglobus	Geometry / soft tissue	ZMC retrusion, orbital volume, posterior ledge, implant position, fat atrophy, scar.	Restore skeletal box and support; add soft-tissue volume selectively.
Telecanthus / epiphora	Geometry / soft tissue / function	Central widening, MCT detachment or wrong vector, lacrimal injury.	Narrow bony base first; reconstruct canthal support; treat lacrimal pathway separately.
Infection / nonunion	Biology / stability	Devitalized bone, contamination, loose hardware, poor perfusion, nutrition, smoking.	Debride, culture when useful, restore stable fixation, viable coverage, targeted therapy.
Trismus / TMJ dysfunction	Function / geometry	Arch or coronoid impingement, joint injury, ankylosis, scar, prolonged immobilization.	Remove mechanical block, structured therapy, arthrolysis/joint or scar procedure as indicated.
Lower-lid malposition	Soft tissue / geometry	Scarring, canthal disruption, inadequate support, orbital rim or globe malposition.	Restore skeletal and canthal support; release scar and reconstruct lid selectively.
Nasal obstruction	Geometry / soft tissue / function	Septal displacement, bony narrowing, valve collapse, scar, loss of support.	Correct skeletal and septal framework before soft-tissue valve refinement.
Chronic sinus / mucocele	Function / biology	Outflow obstruction, retained mucosa, frontal sinus/skull-base injury, infection.	Define sinus anatomy and drainage; endoscopic or open revision according to site and extent.

Hardware removal

Asymptomatic titanium hardware is not routinely removed in most adults. Consider removal for infection, exposure, palpability, clearly hardware-related pain, interference with dental rehabilitation, selected growth concerns, or planned secondary osteotomy. Hardware removal alone is inadequate when instability, infected nonunion, or devitalized bone persists.

CLINICAL BRIDGE

A plate fracture may be the endpoint of an underbuilt construct, but it may also reveal an initially wrong reduction that concentrated load. Stronger hardware will fail again if geometry and biology are not corrected.

CHAPTER 9

Secondary Reconstruction of the Healed Deformity

Secondary reconstruction corrects a healed coordinate system - not simply a visible contour defect.

Once fractures have healed, the operation changes from reduction to planned osteotomy and reconstruction. Revision begins by converting dissatisfaction into measurable structural and functional problems. [20-23]

1 **Define complaint**
Bite, vision, symmetry, airway, tearing, pain, motion, scar, or appearance.

2 **Measure deformity**
CT, dental models, photographs, cephalometry, globe/canthal metrics.

3 **Recover target**
Premorbid records, mirrored anatomy, original fragments, patient priorities.

4 **Rebuild skeleton**
Osteotomy, repositioning, graft, vascularized bone, custom implant.

5 **Restore soft tissue**
Canthi, eyelids, nose, scar, volume, lining, nerve and lacrimal pathways.

6 **Stage and reassess**
Function first; refine after healing and soft-tissue settling.

Establish the target

Use premorbid photographs, dental records, prior CT, family photographs, mirrored intact anatomy, cranial-base landmarks, cephalometric relationships, and the patient's ranked functional priorities. A preexisting asymmetry should not automatically be replaced with a mathematically symmetric but unfamiliar face.

Primary versus secondary timing

Early revision
Corrects a recognized malreduction before union. The operation is still primarily re-release, re-reduction, and refixation.

Mature deformity
Requires infection control, target definition, osteotomy, planned repositioning, and often staged soft-tissue refinement.

DIAGNOSTIC TRAP

Scar maturation may improve surface irregularity, but it will not correct a widened palate, shortened ramus, malpositioned zygoma, enlarged orbit, or persistently wide NOE base.

Corrective Operations by Region

Deformity	Analysis	Potential reconstructive pathway
Stable malocclusion	Condylar position, arch width, ramal height, maxillary/mandibular position, dental compensation.	Le Fort I, segmental maxillary osteotomy, mandibular osteotomy, genioplasty, orthodontics, dental rehabilitation.
Flat or wide midface	Zygomatic rotation, arch width, maxillary projection, bone loss, soft-tissue volume.	Zygomatic osteotomy/repositioning, Le Fort-level advancement, grafting, custom augmentation after skeletal correction.
Enophthalmos / hypoglobus	Orbital volume, ZMC position, implant, posterior ledge, fat and scar.	ZMC repositioning and/or orbital re-reconstruction; staged fat or soft-tissue volume when required.
Telecanthus / flat bridge	Central skeletal width, MCT attachment, nasal support, medial orbit, lacrimal function.	NOE osteotomy/narrowing, posterior-superior canthal fixation, nasal framework reconstruction, lacrimal treatment.
Frontal contour / sinus deformity	Anterior table, posterior table/skull base, outflow tract, retained mucosa, infection.	Contour osteotomy or implant, sinus revision/obliteration/cranialization according to pathology.
Trismus / TMJ dysfunction	Mechanical block, ankylosis, condylar position, scar, occlusal instability.	Remove block, coronoidectomy, arthrolysis/joint reconstruction when indicated, aggressive rehabilitation.
Infected nonunion / segmental loss	Union, viable bone, hardware, culture, defect size, soft-tissue coverage.	Debridement, stable bridging, bone graft or vascularized osseous flap, viable soft-tissue envelope, targeted antibiotics.

Sequence the revision

1. Establish a stable occlusal and craniofacial base.
2. Restore maxillary, mandibular, zygomatic, orbital, and central relationships.
3. Reconstruct missing skeletal volume and lining.
4. Restore canthi, eyelids, nose, and lacrimal function.
5. Refine scars and soft-tissue volume after the platform heals.

BOARD PEARL

Soft-tissue camouflage cannot rescue an unstable or geometrically wrong skeleton. State the skeletal osteotomies and reference system before discussing filler, fat grafting, scar revision, or eyelid refinement.

Planning the Secondary Reconstruction

Why VSP is especially useful in mature deformity

The deformity is stable, planning time is available, and osteotomies can be simulated against premorbid, mirrored, or reconstructed targets. Existing preinjury or immediate postinjury CT can help recover original fragment relationships. Models, splints, cutting guides, prebent plates, and patient-specific implants can improve communication and transfer, although the evidence remains largely case-level. [20,23]

Plan the skeleton

- Segment current anatomy and existing hardware.
- Recover the intended target.
- Simulate osteotomies and collision-free movement.
- Plan occlusion, orbital volume, canthal width, and projection together.
- Decide whether graft or vascularized tissue is required.

Plan the staging

- Control infection and establish viable coverage first.
- Correct large skeletal relationships before eyelid/nasal refinements.
- Separate procedures when edema or scarring would obscure the next decision.
- Build rehabilitation and dental restoration into the sequence.

Expectation management

Revision can improve function, proportion, and recognizability, but it rarely recreates the exact premorbid face after major tissue loss, nerve injury, infection, or repeated surgery. The patient’s priorities should be ranked before the plan is finalized, and each stage should have a defined functional endpoint.

Priority	Measurable endpoint	Reasonable caveat
Occlusion / oral function	Stable bite, adequate opening, diet progression, dental rehabilitation plan.	Orthodontics or prosthodontics may still be required.
Vision / globe position	Safe orbit, improved projection, diplopia and field assessment.	Neuromuscular or soft-tissue injury may limit full recovery.
Nasal airway / support	Improved framework, valve support, septal relationship, symptom scores.	Scar and lining deficits may require staged revision.
Symmetry / appearance	Improved width, projection, canthal and malar relationships.	Exact premorbid symmetry may be impossible or undesirable.

RESIDENT TAKEAWAY

Secondary reconstruction is a planned recovery of targets and relationships, followed by selective refinement - not an attempt to camouflage every visible defect in one operation.

CHAPTER 10

Integrated Cases: Reference Selection

A board-level answer makes the hidden reference problem explicit.

Case 1 - Intact frontal bar, unreliable mandible

Bilateral ZMC/NOE and Le Fort II injuries with comminuted body and bilateral condylar fractures. Use the intact cranial-lateral orbital frame top-down, restore zygomatic width/projection, rebuild the central face, reconstruct the lower unit separately, and link at the maxilla. Intraoperative imaging is high-value.

Case 2 - Reliable mandible, destroyed upper frame

Restorable parasymphysis, intact condyles, complete dentition, bilateral Le Fort/ZMC injury, comminuted frontal anterior table. Reconstruct the mandible and premorbid bite, then proceed bottom-up/outside-in. Manage the frontal sinus without using its comminuted anterior table as the reference.

Case 3 - Symphysis + bilateral condyles + Le Fort injury

The hidden deformities are transverse widening and loss of ramal height. Reduce the symphysis through the lingual cortex and restore or convincingly reproduce condylar seating and ramal height before using the mandible as a template. If those dimensions cannot be verified, change to an upper-frame or two-unit strategy rather than forcing the maxilla to the lower arch.

Case 4 - Edentulous older patient on apixaban

Prioritize intracranial injury, anticoagulant timing/reversal pathway, frailty, nutrition, denture function, and operative burden. Reconstruct the absent bite with denture/splint, basal contour, vertical dimension, and digital planning. Use load-bearing fixation for severe atrophy when necessary; treat the ZMC according to functional and contour consequences.

BOARD PATTERN

Each answer should name the threat, lost dimensions, reliable reference, sequence axes, linkage point, confirming checks, and trigger to change plan.

Integrated Cases: Altered Biology and Failure

Case 5 - Pediatric panfacial injury

Vision and airway take priority. Accurately reduce displaced functional injuries while minimizing dissection and fixation, protecting tooth buds, preserving mandibular motion, and arranging years of growth and dental surveillance.

Case 6 - Six-week delayed presentation

Anterior open bite, facial widening, and flat cheek at six weeks represent early malunion. Use CT, dental models, photographs, and prior imaging to measure arch width, ramal height, maxillary position, zygomatic rotation, and orbital volume. Plan osteotomies rather than assuming fracture lines can simply be remobilized.

Case 7 - POD 1 open bite, slide, and enophthalmos

Perform immediate airway and ocular threat assessment, then localize condylar, mandibular, maxillary, ZMC, and orbital geometry. Obtain targeted CT after urgent threats are addressed. Correct a clear skeletal error early rather than waiting for swelling to resolve.

Case 8 - Late telecanthus, epiphora, and flat nasal bridge

Analyze central bony width, MCT attachment/vector, nasal support, medial orbit, and the lacrimal pathway. Canthal tightening alone will fail if the skeletal base remains wide. Treatment may require NOE narrowing, transnasal canthal fixation, nasal reconstruction, and separate lacrimal care.

The final oral-board presentation

1. Physiologic stability and time-sensitive airway, ocular, neurologic, vascular, and hemorrhagic threats. 2. Examination limitations and associated injuries. 3. Fracture units and lost dimensions. 4. Intact, reconstructable, and unreliable references. 5. Vertical and transverse axes, linkage point, and rationale. 6. Airway and exposures. 7. Release, reduction, provisional fixation, and confirming points. 8. Definitive fixation, grafting, and digital adjuncts. 9. Postoperative surveillance and early revision triggers. 10. Rehabilitation and secondary reconstruction.

Final Resident Workflow and Practical Checklists

1. **Resuscitate** — Airway, hemorrhage, brain, eye, spine, vessels.
2. **Map injury** — CT, dentition, soft tissue, records.
3. **Name lost dimensions** — Occlusion, width, height, projection, orbit, canthi.
4. **Classify references** — Intact, reconstructable, unreliable.
5. **Choose axes** — Top/bottom, outside/inside, linkage point.
6. **Plan airway/ exposure** — See both reduction and confirming points.
7. **Release and reduce** — Disimpact globally; restore dimensions.
8. **Fix provisionally** — Preserve ability to revise.
9. **Verify independently** — Bite, motion, width, projection, imaging.
10. **Fix definitively** — Match construct to load and biology.
11. **Protect recovery** — Airway, vision, nutrition, motion, infection.
12. **Audit outcome** — Detect early failure; analyze late deformity.

Before final tightening

- ☐ Condylar position, ramal height, mandibular width, lower border, passive return.
- ☐ Palatal width, arch form, buttress height, absence of occlusal slide.
- ☐ Zygomatic projection, rotation, arch contour, lateral orbital position.
- ☐ Orbital wall/implant, globe position, pupils and vision when assessable.
- ☐ Central width, MCT vector, canthal distance, nasal projection.
- ☐ Frontal/skull-base relationship and sinus/CSF plan.

Postoperative orders

- ☐ Explicit airway and MMF release plan.
- ☐ Ocular examination frequency and decompression trigger.
- ☐ Baseline occlusion and response to new slide/open bite.
- ☐ Nutrition, antiemetics, oral/nasal care, and therapy.
- ☐ Antibiotics only for a defined indication.
- ☐ Imaging question, timing, and follow-up domains.

> **FINAL RESIDENT TAKEAWAY**
> A panfacial fracture is solved by rebuilding a trustworthy coordinate system. Start from the best surviving reference, restore global dimensions before local perfection, preserve the ability to revise, and independently verify every major unit before final fixation.

Practical Appendices

Appendix A - Panfacial reference inventory

Domain	Questions	Status
Physiology	Airway secure? Hemorrhage controlled? Brain, eye, spine, and vascular injuries addressed?	Intact / reconstructable / unreliable
Cranial base	Frontal bar stable? Lateral orbital roof/rim or skull-base landmarks trustworthy?	________________
Orbit / midface	Which ZMC, rim, arch, NOE fragment, or nasal structure preserves useful geometry?	________________
Occlusal unit	Condyles seated? Ramal height and width restorable? Palate intact? Bite premorbid?	________________
Soft tissue	Globe, canthi, eyelids, nerve, ducts, lining, scars, and volume preserved?	________________
Records / technology	Prior CT, photographs, dental models, dentures, VSP, navigation, intraoperative imaging?	________________

Appendix B - Sequence planning worksheet

Planning field	Resident entry
Most reliable initial reference	
How it will be verified	
Primary lost dimensions	
Vertical axis / transverse axis	
Linkage point and rationale	
Airway and exposures	
Provisional fixation plan	
Confirming points after each unit	
Definitive fixation / graft plan	
Trigger to change sequence	

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LINKED EDITION

Each reference entry is clickable in the digital PDF. AO webpages include exact titles, stable URLs, and an access date.

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EVIDENCE STATEMENT

Recommendations distinguish broadly accepted trauma principles from low-quality sequencing literature, case-level digital and revision evidence, institution-dependent practice, and unresolved controversy. Local protocols and direct multidisciplinary judgment remain essential.

Figure Credits and Editorial Notes

Figure credits

- All figures, schematics, algorithms, flowcharts, and tables in this edition are original educational syntheses created for the ENT Resident Library.
- The page 5 reference-state triptych is an original schematic and is not intended to depict a specific patient or fracture classification.

Editorial revisions in this edition

- Replaced the two externally sourced CT examples with a clinically neutral original vector schematic.
- Clarified injury-specific airway selection, submental-intubation limits, and prolonged-airway indications.
- Updated frontal-sinus wording to an anatomy-driven management decision rather than automatic operation.
- Strengthened pediatric trapdoor timing and corrected the postoperative CSF-leak timeline.
- Separated antibiotic prophylaxis from treatment and stated the 24-hour prophylaxis ceiling where applicable.
- Added page numbers, internal contents links, live reference links, exact AO titles, and current citations.
- Expanded the abbreviation key, standardized POD styling, darkened low-contrast accent text, and refreshed metadata.

USE DISCLAIMER
This guide is an educational synthesis for resident study. Algorithms do not replace direct examination, attending judgment, current institutional protocols, device instructions, specialty consultation, or review of primary source material.

Final resident takeaway

A panfacial reconstruction is complete only when the restored bite, width, height, projection, orbital volume, and central support describe the same face.