60 Panfacial Fractures

Kiran S. Gadre, Balasubramanya Kumar, and Divya P. Gadre

60.1 Introduction

Most facial fractures occur in combinations involving various subunits of craniomaxillofacial (CMF) skeleton [1] (Fig. 60.1). Severity of these injuries is determined by multiple factors such as its aetiology, causative factor, force of impact, pre-existing patient factors, etc. High velocity road traffic accidents RTA / assaults are the most common cause of panfacial fractures. With a large number of different patterns these fractures project, it is challenging to have a proper definition of "panfacial fractures". It is well-known that fractures involving multiple bones of the face is known as panfacial fracture. It could be described as "fractures involving upper third, middle third, and lower third of face with at least one condyle, palate and fronto-naso-orbito-ethmoidal complex (FNOE) fracture" (Fig. 60.2). When there is skull base or co-existing neurosurgical involvement, it is termed as craniofacial fracture. Managing these cases is extremely complicated as each of them present with unique pattern of hard and soft tissue injury. This demands a team approach as these injuries are commonly seen in polytrauma with multisystem involvement. Airway compromise, severe haemorrhage, large open wounds, severe ocular/orbital injuries and coincidental surgical procedure being performed are the only indications for immediate definitive surgical intervention. Restoration of form and function at the earliest opportunity should be the goal of maxillofacial surgeons.

K. S. Gadre (✉)
Gadre Clinic, Pune, Maharashtra, India

Department of Oral and Maxillofacial Surgery, Bharati Vidyapeeth Dental College and Hospital, Pune, Maharashtra, India

B. Kumar
Department of Maxillofacial Surgery, St. Marthas's Hospital, Bangalore, Karnataka, India

Bhagwan Mahaveer Jain Hospital, Vikram Hospital, Bangalore, Karnataka, India

D. P. Gadre
Gadre Clinic, Pune, Maharashtra, India

60.2 Epidemiology

Global status report on road safety (2015) indicates that more than 1.25 million deaths, and 15–20 million injuries occur in road traffic accidents (RTA) costing most countries 3% of their GDP [2]. Countries with low and middle income having 54% of vehicles account for 90% of RTA-related fatalities, mostly of subjects aged between 15 and 44 years. RTA is the main cause of mortality in three quarters of males in 15–29 years age group. The true economic and public health impact is not estimated in most developing countries due to lack of infrastructure and resources [3].

Panfacial fractures are caused by high-energy impact, usually generated as a result of RTA or firearm injury directed at CMF skeleton, and it also has a contrecoup component causing associated cranio-cerebral or cervico-spinal injuries with a low Glasgow coma scale. These injuries can also cause associated injuries like rib fracture/pulmonary contusion, pneumothorax or intra-abdominal injuries, limb and pelvic injuries and require immediate treatment.

60.3 Management Philosophy

Restoration of form and function is the ultimate goal in treating panfacial injuries. Proximity to important structures like the brain, eyes, auditory apparatus and spine necessitates a holistic approach to their management involving neurosurgeons, ophthalmic surgeons, ENT surgeons, maxillofacial surgeons and anaesthetists.

It is challenging to follow an established pattern of repair as each case is unique and requires skill and expertise of the surgeon to restore the pre-traumatic anatomy of facial function with aesthetics. Despite all the aggressive treatment, many patients with panfacial trauma may need further correction of residual deformities.

K. Bonanthaya et al. (eds.), *Oral and Maxillofacial Surgery for the Clinician*, https://doi.org/10.1007/978-981-15-1346-6_60

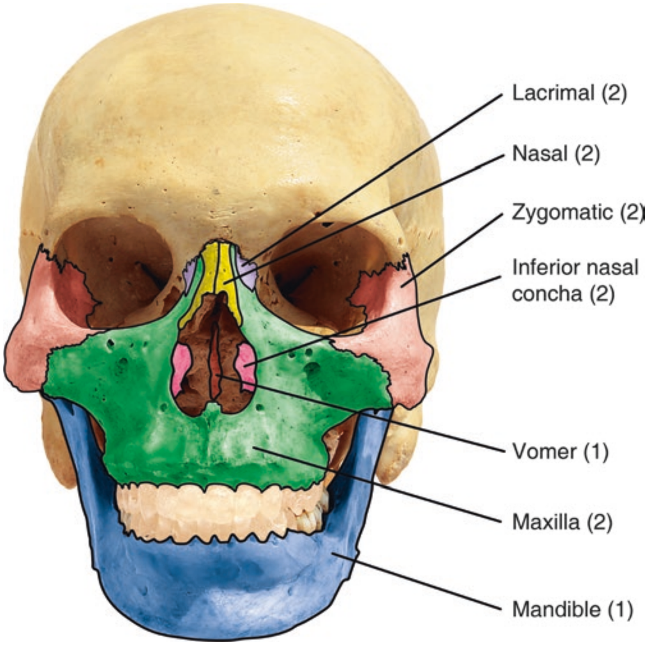

Fig. 60.1 Schematic diagram depicting subunits of facial skeleton

Fig. 60.2 3D CT scan image showing panfacial fracture involving the upper, middle and lower third of face

60.3.1 History of Management

The management of panfacial fractures has changed during past few decades, particularly after the 1990s, when indigenous plating systems were more freely available.

1. Prior to the 1980s, most panfacial fractures were treated with closed reduction using Plaster of Paris (POP) head caps and cranial frames. A variety of trans/interosseous wiring techniques (see Chap. 50 for details on various wiring techniques) and internal suspension methods like cranio-mandibular/maxillary suspension were used (Figs. 60.3a, b and 55.15).
2. The surgeons of the 1990s generation started using combination of plating at key buttresses and internal suspension techniques [4]—the approach which may be attributed to early learning curve of internal fixation (Fig. 60.4).
3. Use of internal fixation has revolutionised the management of panfacial fractures [4] (Fig. 60.5a, b), leading to faster recovery and satisfactory outcome of these injuries. (See Chap. 51 for details on Principles of internal fixation)
   A better understanding of anatomy, pathophysiology, anaesthesia, sterilization and asepsis with advances in intubation techniques (transmylohyoid/submental, bronchoscopic) and instrumentation (fiberoptic and endoscopic) and instrumentation has influenced the management of these complex injuries significantly (Chap. 7 deals with Anesthesia and intubation techniques in maxillofacial surgery). Use of engineering technology like three-dimensional planning, stereolithographic models, endoscopic and navigation techniques has simplified the accurate treatment of these fractures, avoiding injury to other vital structures and saving intra-operative time (Fig. 60.6a–d).

60.3.2 Indications

Panfacial fractures can be disfiguring and cause significant functional problems like difficulty in mastication, deglutition, speech, olfaction and abnormalities of vision. Early fixation of displaced fractures causing the above problems is warranted. Undisplaced/minimally displaced fractures can be left for a few days, buying some time to manage other grievous injuries. It is necessary to understand that sense of urgency for treatment should exist in treating any panfacial fracture (within 15 days, provided other parameters are permitting).

60.3.3 Contraindications

There are no absolute contraindications but relative contraindications which cause delay of treatment, are presented below.

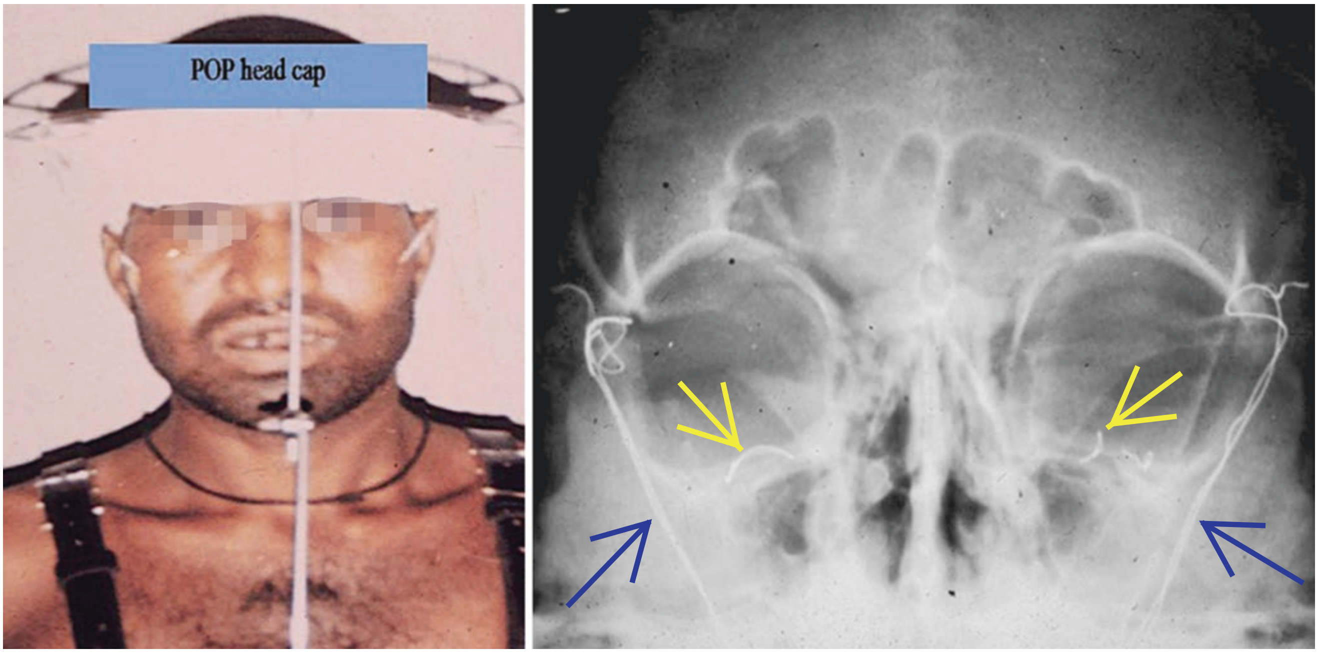

Fig. 60.3 (**a**) POP head cap used in traditional days. (**b**) Interosseous wiring (yellow arrow) with internal suspension (blue arrow)

Fig. 60.4 Plating with internal suspension (blue arrows)

1. Definitive treatment of panfacial injuries may be delayed up to 2 weeks in presence of severe, compromising, concomitant systemic or head injury.
2. It is advisable to operate only when patients are neurologically and systemically stable. This period should be used for further surgical assessment and planning.
   Reduction of facial oedema further unmasks the underlying fractures and facial deformity. This gives an opportunity to review the imaging and prepare necessary splints (see Sect. 55.7.1) (Fig. 60.7a, b). These are very essential to establish width, height and anteroposterior projection of the facial skeleton, particularly where large dento-alveolar segments have been lost along with the presence of bilateral condylar fracture.
3. When a combination of avulsive injury (Chap. 49 deals with management of Soft tissue injuries in maxillofacial region) and panfacial fractures is present, golden hour reconstruction should be utilised, if circumstances and conditions permit. This is the best time as patient is in optimal physiologic and physical condition.

60.3.4 Clinical Findings

The clinical findings in panfacial trauma are a combination of signs and symptoms as seen in various subunits of facial fractures with increased severity (readers are advised to refer the respective chapters on maxillofacial trauma for signs and symptoms and management of fractures of mandible in Chap. 52, Fractures of the Condyle in Chaps. 53 and 54, fractures of maxilla in Chap. 55, fractures of the zygomatic complex in Chap. 56, fractures of the orbit in Chap. 57, fractures of the frontal naso orbit ethmoid region in Chap. 58 and Gun shot injuries in Chap. 59).

Facial oedema makes examination and standard radiography difficult. Bilateral raccoon's eyes and elongated dish-shaped face, with presence of orbital dystopia, traumatic telecanthus and deranged occlusion, are commonly seen. There may be elements of severe dento-alveolar trauma and soft tissue injury which may vary from minor contused or lacerated wounds (CLW) to avulsive injuries.

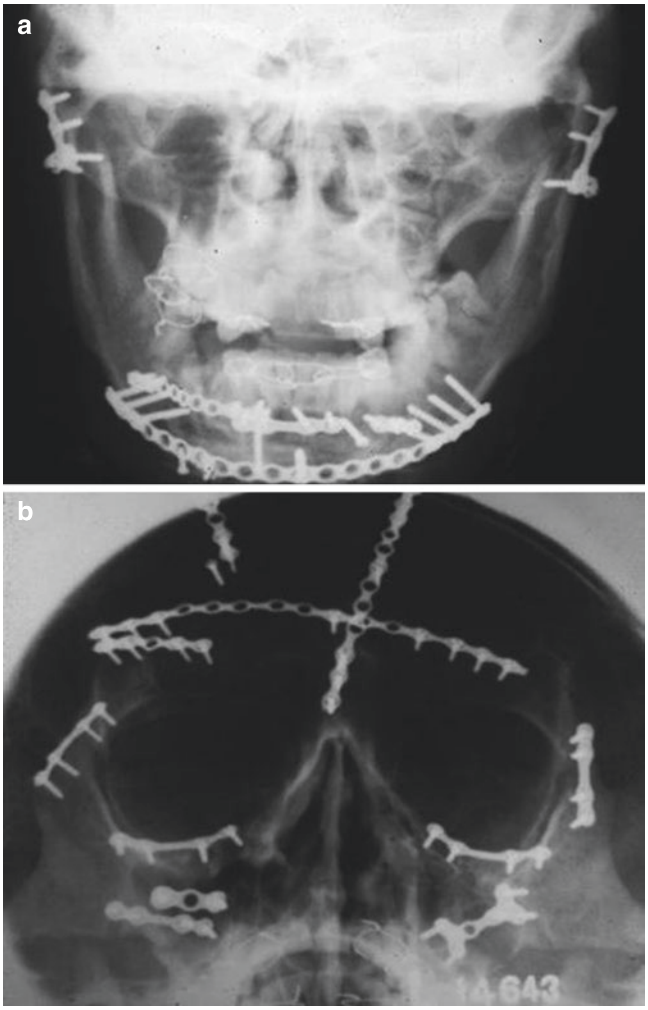

Fig. 60.5 (**a**, **b**) Plating of panfacial fractures as seen on (**a**) posterior-anterior Caldwell view of mandible and (**b**) posterior-anterior Water sinus view radiographs

Presence of cervical, cranial and other concomitant injuries must be assumed till proved contrary. Similarly absence of teeth, dentures in mouth must be assumed to have been swallowed or aspirated until proven otherwise.

60.4 Workup

The pre operative planning consists of two parts: (a) imaging and (b) diagnostic procedures.

Imaging:
Standard radiographs like posterior-anterior (PA) view, Caldwell view of mandible, Water's view, submento-vertex view, cervical spine radiographs have been used as a baseline in any emergency and are easily available in most settings. Computed tomography (CT) images with 3D reconstruction is now considered the gold standard in complex facial trauma patients as it provides a 1:1 information of the fracture pattern. 3D planning softwares help the surgeon in meticulously planning cases preoperatively.

CT imaging is commonly done for assessment of brain and spinal cord in a head injury patient to exclude intracranial haemorrhage and other grievous injuries. Facial skeleton should be included in the same scan in suspected facial bone fractures.

Coronal and sagittal sections of the CT scan could be obscured by the endotracheal tube in intubated patients. Axial and three-dimensional images with computer-generated models can be used for assessing most facial fractures in these cases (Fig. 60.8a, b).

Diagnostic Procedures:
Occlusion of teeth is the key to reduction and fixation of facial bone fractures. Mock surgery using dental models help in repositioning the teeth-bearing segments including dento-alveolar and palatal fractures and aid in fabricating acrylic stents and splints (Fig. 60.7). They are essential in cases where there is gross occlusal disturbance, splaying of basal bone or multiple fractures of dento-alveolar segment.

60.5 Emergency Treatment

Complex maxillofacial trauma are mostly high impact injuries and are usually a part of life-threatening injuries involving other organ systems like central nervous system, chest, abdomen, pelvis or limbs. It is important that these injuries be assessed and managed prior to or simultaneously as facial injuries.

Current standards of care for trauma patients, whether polytrauma or those involving the CMF skeleton, mandate that one must follow the Advanced Trauma Life Support (ATLS) protocol relating to airway, breathing, circulation, disability and exposure in that sequence. Airway and circulation should have the highest priority (Table 60.1). This is followed by an assessment of the patient's neurological, visual and cervical spine status. The details of primary and emergency management of polytrauma patients are dealt in Chap. 48 of this book.

Patients with polytrauma/panfacial fractures can require immediate or late treatment depending on the mechanism and kind of injury. Occasionally, immediate treatment can be the definitive procedure. An immediate intervention may be done merely for initial stabilization of the patient; procedures demanding a more detailed assessment and planning will need to be postponed. Immediate initial treatment in patients with maxillofacial injuries is indicated in following situations.

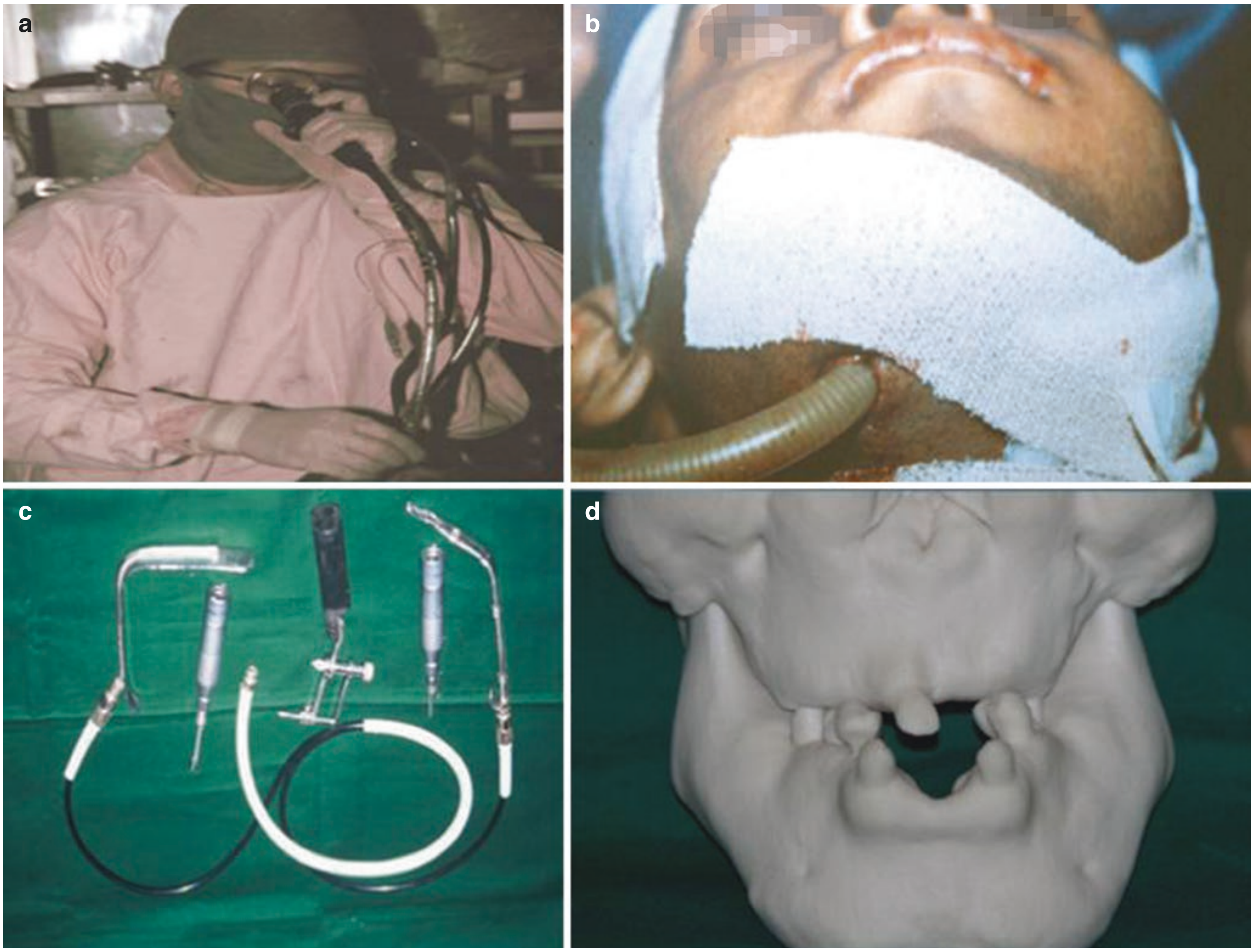

Fig. 60.6 (**a**–**d**) Showing few of advances from various specialities of medicine and engineering contributing to advances in management of panfacial fractures. ((**a**) Bronchoscopic intubation, (**b**) transmylohyoid intubation, (**c**) fibreoptic instruments, surgical saw, (**d**) stereolithographic model)

60.5.1 Airway Compromise

Obstructed airway is an important sequel of panfacial fractures and is managed either by temporarily reducing and stabilizing the fractured facial bones and attached soft tissues or performing a surgical tracheostomy. Patients with C-spine injury can be challenging to intubate due to inability to flex or extend the neck, as is establishment of a surgical airway like tracheostomy.

60.5.2 Severe Haemorrhage

Reduction and stabilization of fractured segments not only helps to correct airway but also controls severe bleeding. Haemorrhage not amenable to the above procedure may necessitate packing, identification of causative bleeder and its cauterisation or ligation. Occasional ECA control may be required, if multiple ipsilateral bleeding areas or unidentified areas of bleeding are seen. In centres where the facility is available, uncontrollable bleeding from facial region (especially after comminuted midface fractures) is controlled with selective embolisation by a interventional radiologist.

60.5.3 Large Open Wounds

These are commonly used to fix the fractures beneath them. In such situations initial washout and primary approximation should be done when possible for haemostasis and maintaining continuity of vascular supply, especially in cartilaginous areas like the ears and nose. This closure is basically a primary tacking of the wound margins. Layered closure is better done under controlled conditions along with fixation of the fractures under anesthesia [1].

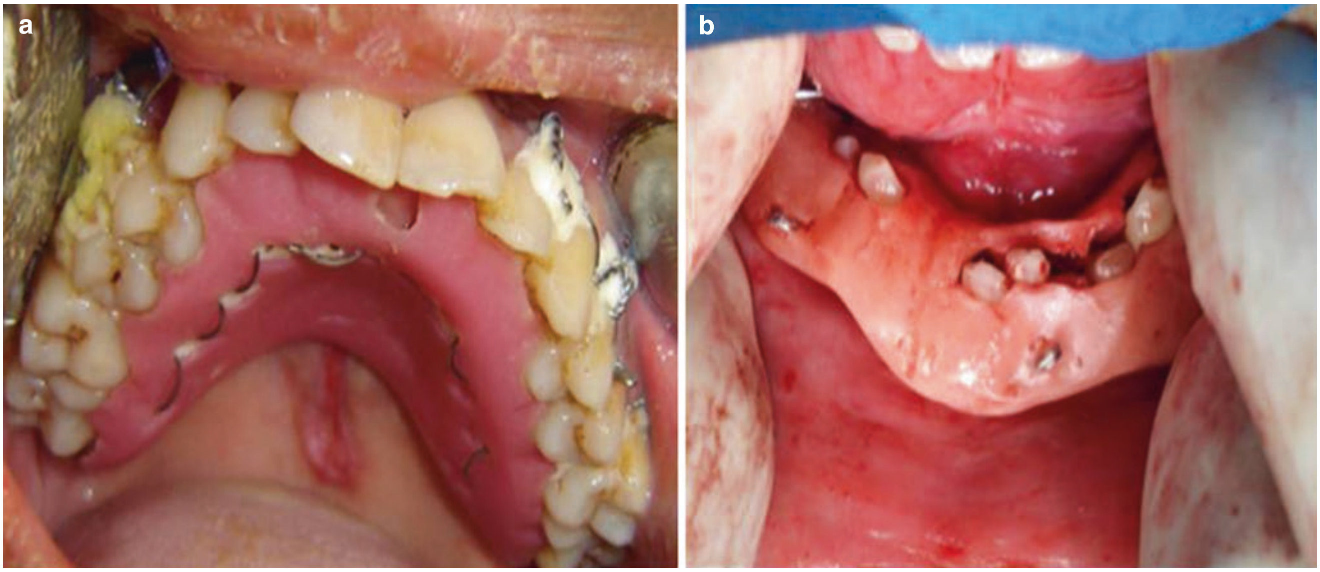

Fig. 60.7 (**a**, **b**) Showing utility and essentiality of splints in management of panfacial fractures

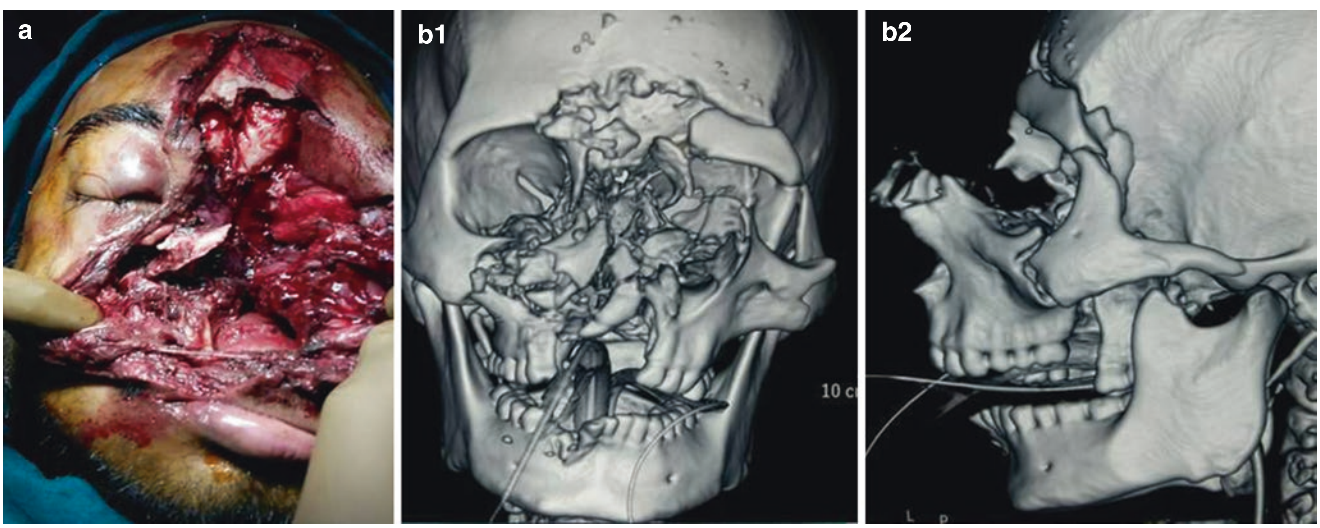

Fig. 60.8 (**a**, **b**) Depicting importance of high-resolution CT scan in an avulsive injury to assess nature and extent of injury and achieve predictable outcomes

60.5.4 Surgery for Associated Life-Threatening Injuries

Occasionally, patients with polytrauma undergo immediate surgery to treat other grievous injuries. This provides an opportunity to perform initial debridement, assessment and stabilisation and make dental impressions for fabrication of a customised splint. Considering the planning and surgical time required for comprehensive management of panfacial fractures, it is usually not advisable or possible to perform fixation during emergency management of other more severe injuries (neurological/abdomen/long bones/chest).

It is always wise to initiate assessment of a head injury or polytrauma patient using the ATLS (Advanced Trauma Life Support) protocol. A detailed record of all maxillofacial injuries should be made. Diagrams and representations of fracture patterns and soft tissue injuries make it easy for the understanding and execution of treatment. It is important to document the whereabouts, mechanism and time of injury accurately, to minimise medico-legal problems at a later date. Photographs are a good medium of educating the patients with their attenders and recording the preoperative soft tissue injuries.

Table 60.1 Immediate management of a polytrauma patient

Management	Option 1	Option 2
Airway	Suction, recovery position, Intubation	Tracheostomy. More so with C spine injury
Hemorrhage	Pressure	Ligation
	Grouping cross-matching	Fluids 1–2 liters in adults and 20ml/kg for children
IV	Peripheral with 16 G intra-cath	Central
Catheterization	Nasogastric tube insertion; caution when FNOE fractures	Foley's catheter for input - output chart
Immunisation	Anti gas gangrene	Tetanus
Laboratory	Routine	ABG
Imaging	CT scan: HFN, Chest, Pelvis	Chest X-ray, USG abdomen
Assessment	Circulatory	Neurological

60.5.5 Definitive Treatment

Paul Manson's quote "you never get a second chance" has to be kept in mind, i.e. the time frame [5] regarded appropriate for primary fracture treatment is limited to 2 weeks. After 2 weeks, the treatment is regarded as delayed and may necessitate secondary post-traumatic reconstruction (see Chap. 60 on residual deformities of the maxillofacial region).

60.6 Preoperative Documentation and Planning

Preoperative treatment planning is essential for successful outcomes. One must gather enough information and documentation to help in formulating an accurate treatment plan.

This can include:
1. The topography and extent of fracture involvement
2. Loss of hard and soft tissues with their residual defects
3. Involvement of teeth and teeth-bearing segments
4. Assessment of important structures like parotid and submandibular glands, nasolacrimal duct, trigeminal nerve, facial nerve, muscles of eye and most importantly vision

A proper evaluation by ophthalmologist, ENT surgeon and Neuro Surgeon is mandatory before proceeding with panfacial fracture fixation, and these allied specialities may be part of the surgical team for comprehensive management of the panfacial injuries.

Large bony defects with loss of soft tissue are best treated immediately or secondarily with local, pedicled non-vascularised or vascularised-free flaps provided the wound is clean and non-infected. Tissue shrinkage should be avoided as much as possible in these special situations by using techniques of maxillomandibular fixation (MMF) and internal or external fixation devices or splints. Immediate reconstruction can be planned in clean wounds. Need for transmylohyoid/submental endotracheal intubation as an alternative to tracheostomy should be explored in discussion with the anaesthesia team [6], especially in panfacial trauma involving nasal bones and skull base fractures needing fixation of maxilla and mandible.

60.7 Intra-operative Details

The essential in treating panfacial fractures is obtaining adequate fixation at key buttresses (Fig. 60.9a, b, Fig 55.2). Its description was first given by Cryer in 1916 [7]. This helps in creating the outer framework for fixation of other fractures.

60.7.1 Buttresses of the Facial Skeleton

These are the regions of thick bones which neutralise the forces applied onto them.

Outcome of maxillofacial reconstruction in terms of restoration of facial height, width and projection in addition to restoring the occlusion depends on proper reduction and fixation of these buttresses [8, 9] (Table 60.2).

They are important to:
1. Maintain projection and protection of airway
2. Anchor suspension of musculo-aponeurotic system
3. Protection of skull base and structures above like brain and eye with their adjoining structures from masticatory forces

60.7.2 Key Contributors to Facial Architecture

- Central facial width: fronto-naso-orbital-ethmoid (FNOE) complex, palate and the mandibular arch
- Lateral facial width: Frontal bar, zygomatic arches, malar eminences and mandibular angles
- Projection: frontal bone, frontonasomaxillary buttresses, zygomatic arches and mandible from angle to symphysis
- Facial height: frontal bone, midface buttresses, mandibular angles and condyles

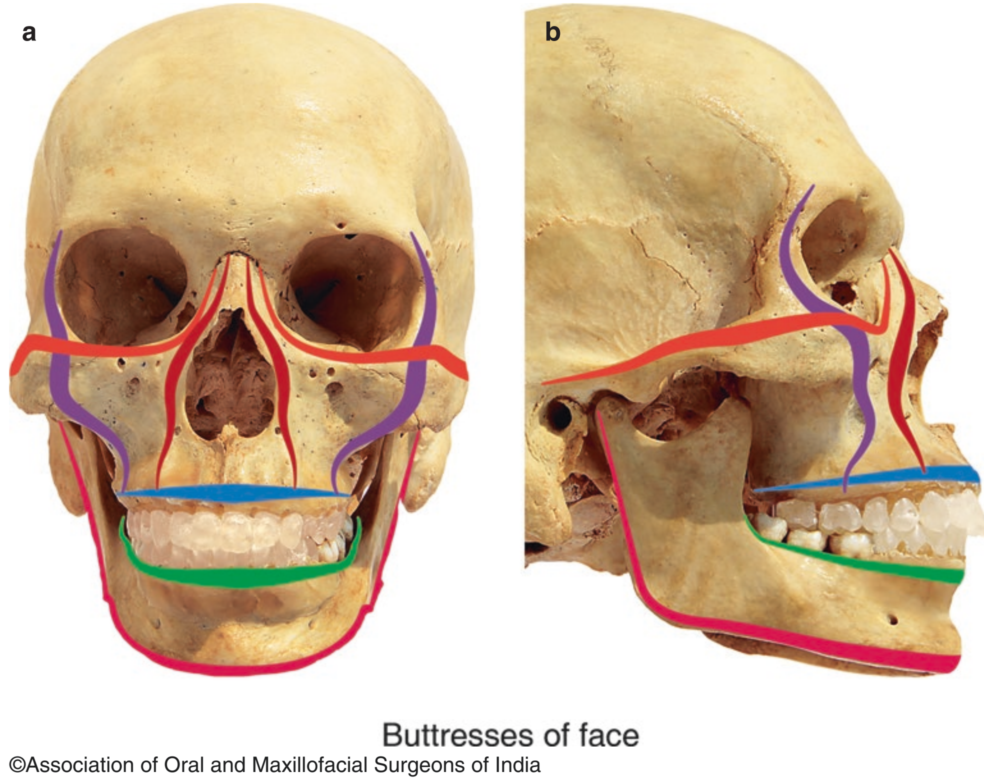

Fig. 60.9 (**a**, **b**) Schematic markings of facial buttresses (Correlate with Table 60.2) (Also see Fig. 55.2)

Table 60.2 Buttress of facial skeleton (colour codes of Fig. 60.9 marked)

Vertical buttresses	Horizontal buttresses
Nasomaxillary (red)	Frontal (orange)
Zygomaticomaxillary (purple)	Zygomatic (orange)
Pterygomaxillary	Maxillary (blue)
Condyle and posterior mandible (pink)	Mandibular (green)

60.7.3 Various Approaches to Facial Skeleton

Approaches to individual facial bones are discussed in the respective sections of the book. They are enumerated here for quick reference and revision.

Facial lacerations overlying fractures should be used for access when possible (Fig. 60.10a–d). In situations without any such lacerations, appropriate incisions for respective fractures should be used as described in other sections of this book.

Subciliary or transconjunctival incisions are commonly used to provide access to infraorbital rim and orbital floor; lateral brow or upper blepharoplasty incisions provide access to frontozygomatic suture and lateral wall of orbit; intraoral vestibular incision provides access to maxilla and zygomatic buttress; and coronal incision provides access to frontal, fronto-naso-ethmoid complex, zygomatic arches and roof of orbit.

Mandible symphysis, parasymphysis, can be approached through intraoral vestibular or crevicular incisions. Mandibular angle is approached intraorally through an extended 3rd molar incision alone or in combination with a transbuccal approach using a trochar and cannula. The condylar head will need to be approached through preauricular or bicoronal incision, whereas the mandibular subcondyle and ramus can be approached through retromandibular or peri-angular incision. Endoscopic approach to the mandibular condyle is been popularised in a few units (see Chap. 54 for details on endoscopic approach to condylar fractures).

Sequencing of fixation in panfacial fractures is a challenging task. The sequencing will alter slightly depending on clinical and radiological evaluation.

60.8 Sequencing Options

There are two options for sequencing:

1. *Bottom to top* [10, 11]: This involves restoring the maxillomandibular unit using occlusion as guide and fixing maxilla and mandible using semi-rigid or rigid fixation techniques. Thereon reduction and fixation proceeds in caudal direction starting from calvarium. The other fractures are then restored in a build-out fashion with maxilla and mandible being a stable base
2. *Top to bottom*: This involves starting with the reduction and fixation at the level of the calvarium. Then the operator proceeds in a caudal direction with reduction and fixation. In this top to bottom sequencing technique, establishing proper occlusion with MMF is no less

Fig. 60.10 (**a**–**d**) Use of existing laceration to achieve optimal results

important,and is surely done prior to rigid fixation of Leforte I and mandibular fractures.

Although author's preference is "bottom to top" approach, as establishing functional occlusion is of prime importance, a combination of both the approaches might be necessary in many situations (Fig. 60.11).

60.8.1 Bottom to Top Approach

1. When using this approach one is committed to using the mandible as guide for establishing the height, width and projection of face. Hence after occlusion is established, the mandible is rigidly fixed from one condyle to the other. This makes it necessary to plate minimum one condyle in case bilateral condylar fracture. It is necessary to ensure proper seating of mandibular condyle into the glenoid fossa.
2. Further sequencing will depend on presence or absence of palatal fracture and its nature (comminuted or not). In any case it is very important to establish width of midface correctly so as to achieve optimal functional and aesthetic results.
3. Use of splints made on dental models after model surgery serves an ideal and desirable method to establish correct width of middle and lower face particularly when there is comminution of maxilla and mandible. Use of conventional acrylic splints is the easiest and least time consuming. 3D splint has led to more accurate and predictable results but adds on to the time and cost.

Fig. 60.11 Use of combination techniques to achieve stable fixation schematic diagram

4. The next step is to begin the reduction and fixation of the remainder of the midface starting from the calvarium and working in a caudal direction similar to "top to down" sequencing.

60.8.2 Top to Bottom Approach

1. The reconstruction sequence to re-establish midfacial pillars (buttresses) and dimensions starts with the most reliable and stable point on calvarium and on the side with the least comminution.
2. The calvarial, frontal sinus and orbital roof fractures are addressed first using stable point/region on calvarium as reference point for reconstruction of midface.
3. The zygoma is positioned into its proper three-dimensional position, almost as a flat structure and confirming that lateral wall of orbit is in alignment with the greater wing of sphenoid. This helps proper establishment of width and anterior-posterior projection of face. Approximation of the sphenozygomatic suture in the lateral wall of the orbit should be a guide to reduction in cases of comminuted zygomatic fractures [12]
   Fixing the zygomatic arch increases the accuracy of multidimensional reconstruction (frontozygomatic suture, infraorbital rim, zygomaticomaxillary buttress, zygomatic arch) of fractured and comminuted zygoma [13, 14].
4. The infraorbital rims and NOE complex are properly aligned to complete the reconstruction of the periorbital area.
5. Where reconstruction of the medial canthal tendon is necessary, it can be addressed towards the end of the procedure.
6. The next step in midface reconstruction is fixation across the Le-Fort I and II level. Maxillomandibular fixation may be done at this stage. If everything has been perfectly aligned, these fractures should also align adequately. Splints play a significant role in determining the facial width at Le-fort I level. Malalignment at this level signifies need for reassessment and realignment of previously fixed fractures.
   The midface, because of weak bone structure and comminuted fracture pattern, must be considered a dependent and less stable structure.
7. From an aesthetic standpoint, a minimal malalignment at the Le-Fort I level is not as noticeable as a malalignment of the orbits.
8. Fractures of the inferior orbital rim and orbital floor can be now addressed as the true volume of the orbital defect can be seen once other fractures are aligned.
9. The mandibular fractures are then fixed. Condyle fractures may be addressed with separate incisions or managed conservatively depending on the displacement and influence on the vertical height of the mandible, as discussed previously.
   Tulio etal advocated fixation of condylar fractures as the first step in fixation of pan facial fractures. In their study there was no evidence of dental or skeletal alterations and measurement of the mandibular ramus and radiographic examination show that posterior facial height as well as projection and width of the inferior lower third of the face, was restored. The correct timing of surgical intervention and the use of rigid fixation allows the restoration of the morphological and functional nature of the face after pan facial fractures [15].
10. The occlusion should be rechecked, and rigid or elastic maxillomandibular fixation may be considered as necessary for 4–6 weeks. The occlusal splints may be fixed using wires for the period of MMF as a guide to maintaining the occlusion.
    The sequencing for pan-facial fractures depends more on the clinical situation, than on predefined algorithms as the patterns of clinical presentation may be diverse. However, the general consensus in current literature emphasizes that the the dental units are given priority for providing guidance. The dental arches are first stabilised to form a

Table 60.3 Bottom-up inside-out and top-down outside-in, comparison of sequencing

Bottom-up	Top-down
Maxillomandibular fixation (MMF), splints for palate and mandibular lingual in case of gross comminution	Fix calvarium, frontal sinus and orbital roof fractures sequentially
Fix mandibular fractures (symphysis/body/ramus)	Fix zygomaticomaxillary complex (including arch) fractures, with proper alignment of infraorbital rims
Fix condylar fractures, at least one when fracture is bilateral	Fix naso-orbito-ethmoid complex, and nasal fractures
Fix maxilla at LeFort I level	Maxillomandibular fixation (MMF), splints for palate and mandibular lingual in case of gross comminution
Fix calvarium, frontal sinus and orbital roof fractures sequentially	Fix maxilla at Lefort I level
Fix zygomaticomaxillary complex (including arch) fractures, with proper alignment of infraorbital rims	Fix condylar fractures, at least one when fracture is bilateral
Fix naso-orbito-ethmoid complex, and nasal fractures	Repair of Mandibular fractures

cohesive unit, followed by the mandible in its horizontal and vertical dimensions (10, 19) (also see Manson 2012 in additional reading). The mid face is then managed using a top-down or a bottom-up method depending on the presence or absence of bony defects in the calvarium.

60.8.3 Essentials in Either Approach

1. Soft tissue repair and closure of wounds/incisions of intraoral and pharyngeal areas should be done prior to maxillomandibular fixation. In some cases it might be essential to temporarily release MMF to close lacerations and redo MMF later.
2. Laceration which would be concealed under the splint should be closed prior to fixation of splints.
3. Thoroughly debride perforating wounds before closure.
4. Extraoral incisions and lacerations communicating with the oral cavity should be closed from deep (mucosal) to superficial (skin) in multiple layers.

The sequence of the above approaches are compared in Table 60.3.

Author follows the *"Wire before you plate"* principle.

It is author's preference to use initial wire osteosynthesis stainless steel (SS) for better alignment and anatomical reduction at multiple sites before plating. This technique also does away with the requirement of holding fragments together, and with less of instrumentation in the surgical field, there is an obvious ease of plating more precisely. Wire osteosynthesis should be removed following fixation of the fractures to avoid or prevent reaction between dissimilar metals, namely, SS (stainless steel) and Ti (titanium).

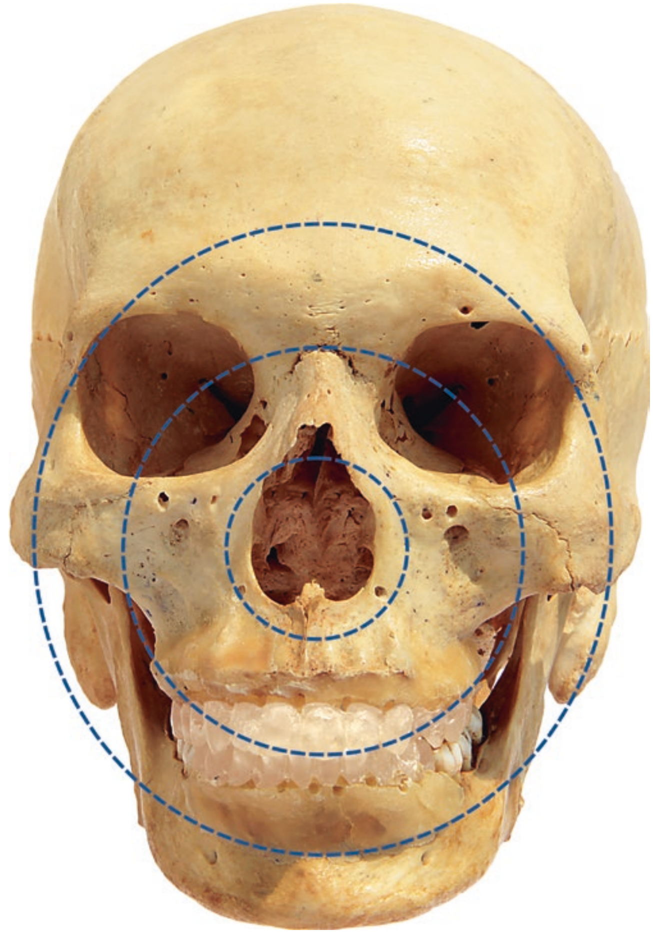

Fig. 60.12 Three concentric circles used as a guide to the reduction of panfacial fractures (Adapted from: H.C Killey. Fractures of Middle-third of facial Skeleton, Issue 3 of Dental Practitioners Handbook, No.3)

There are other sequencing methodologies and philosophies as suggested by other authors.

Manson et al. put forward a highly conceptualised treatment protocol where face is divided into groups, units and sections, and each section is assembled in three dimensions. Soft tissue is considered the "fourth dimension" of facial reconstruction. They advised bone reconstruction to be completed as early as possible to minimise soft tissue shrinkage, stiffness and scarring of soft tissues in non-anatomic position [1, 16].

Killey and Kay demonstrated the fixation of panfacial fractures first in the outer ring followed by the middle ring and lastly the nasal complex in the inner ring (Fig. 60.12).

Inside-out sequence was also found to show good results by Kim et al. [17].

The occlusion first approach, with initial reduction of larger segments, enables effective reconstruction of multiple segments. Smaller segments can then be oriented to fixation of these fractures [18].

Role of bone grafts in very comminuted fractures or missing bone demands immediate bone grafting to produce a stable outcome. Commonly used areas of bone and cartilage grafts are rib, calvarium, iliac crest and conchal cartilage [19]. Recipient site requirements determine the ideal donor site for replacing bone. Revascularisation potential and mechanical needs of the donor site are two factors known to influence this [20].

60.9 Paediatric Panfacial Fractures

They are rare and different as the cranium to face ratio is 8:1, and also differential growth in eyes, brain and face makes a difference in pattern and incidence of fractures. Children should not be treated as small adults as its not only important to restore them to normal form and function, but the growth potential also should be taken into consideration. One must remember that both injury and treatment can lead to growth disturbances, and hence many times conservative management is preferred. Splints are the mainstay in treatment of paediatric fractures (Figs. 52.50 and 52.51). Panfacial fractures are preferably treated with resorbable plates to prevent growth disturbances and damage to tooth buds. This also avoids second surgery for plate removal. Furher, it must be kept in mind that minor occlusal discrepancies are self-corrective during transitional dentition phase or can be treated easily with orthodontics at later date. Major emphasis should be on preventing deformities in central midface. Paediatric patients have to be followed up till growth has completed. In developing countries wire/resorbable suture osteosynthesis can be utilised for economic reasons and availability [21].

60.10 Complications

Complications associated with panfacial injuries include those associated with individual fractures of frontal sinus, nasal and fronto-naso-ethmoid, zygomatic, maxillary and mandibular fractures.

- Motor and sensory deficits of motor and sensory nerves like anaesthesia, paresthesia and weakness
- Reduction in posterior facial height
- Anterior open bite
- Increase in facial width secondary to reduction of anterior-posterior facial projection
- Traumatic telecanthus
- Orbital deformities
- Lacrimal apparatus injuries/dacryocystitis
- Malocclusion
- Nasal obstruction and external nasal deformity
- Cerebrospinal fluid leak
- Anosmia
- Blindness
- Temporomandibular joints dysfunction
- Oro nasal fistula from wide palatal fractures (Fig. 55.25)

60.11 Tips and Tricks

1. Panfacial fractures do not follow specific patterns but occur in variety of combinations involving all facial subunits.
2. Discuss with patients' relatives about realistic outcomes of surgery. Use of patient photographs prior to injury may act as a guide for the surgeon to establish treatment goals. This may be challenging to assess with the oedema and disfigurement following trauma. Making a record of intra-operative and post-operative photographs is a good practice for comparison and documentation.
3. In patients with displaced midface fractures and bilaterally displaced mandibular condyles, it is important to fix at least one condyle anatomically by open method in order to obtain adequate mandibular positioning and posterior facial height.
4. In either approaches to panfacial fractures seating of condyle into glenoid fossa is absolutely mandatory.
5. If prolonged ventilation is anticipated tracheostomy, percutaneous endoscopic gastrostomy (PEG) should be considered.
6. Vertical and horizontal buttresses should be established and fixed (to attain correct facial width and height) before orbital walls and rim correction.
7. Special attention should be paid to soft tissue repair and need for suspension, more particularly to fractures involving FNOE region.
8. Bicoronal exposure allows simultaneous harvesting of calvarial bone graft for bony augmentation and reconstruction like in blow-out orbital fractures.
9. Establish zygomatic arch as linear structure to get perfect facial projection and width.
10. Inadequate and delayed FNOE complex fractures treatment is usually a disaster and at most times is only partially correctable by secondary surgeries.

11. Preoperative arch impressions and splints fabrication have a major role to play in preventing oro-nasal communication and establishing facial width.
12. MMF is mandatory for proper occlusion intra-operatively. Elastics may be needed during follow-up.
13. Most common residual deformity associated with panfacial fractures is lack of projection, increased facial width, malocclusion, enophthalmos and lacrimal dysfunction.
14. Complete removal of all mucosa and blockage/sealing of fronto-nasal duct should be done before cranialisation or obliteration of frontal sinus.
15. Documentation of details of injury is essential of medico-legal reasons, more so of the mechanism and time of injury; these details if necessary can be noted from other observers. Photographs can serve as legal documentation. These should be taken following a valid patient consent.
16. Close soft tissues from deep to superficial and from intraoral to extraoral. Complete intraoral closure prior to securing the MMF. Debride contaminated wounds thoroughly before closure.
17. Forced duction test is essential before and during surgery in fractures involving orbital walls (Fig. 56.21).
18. Caution: removal of throat pack is a joint responsibility of the anaesthetist and surgeon.

60.12 Case Scenario

Case 1:

(Figs. 60.13a–d, 60.14a–f, and 60.15a–c) Shows Management of a Case of Pan Facial Fracture

Figure 60.13 shows the pre operative CT scans, Fig. 60.14 show the various surgical approaches used for internal fixation and Fig. 60.14 shows the post operative radiographs showing the fixation.

Fig. 60.13 (**a**–**d**) Panfacial trauma preoperative CT scan. (**a**) Right condylar fracture. (**b**) Naso-ethmoid complex fracture, left zygomatic buttress and infraorbital rim fracture. (**c**) Mandibular symphysis fracture. (**d**) Left condylar fracture

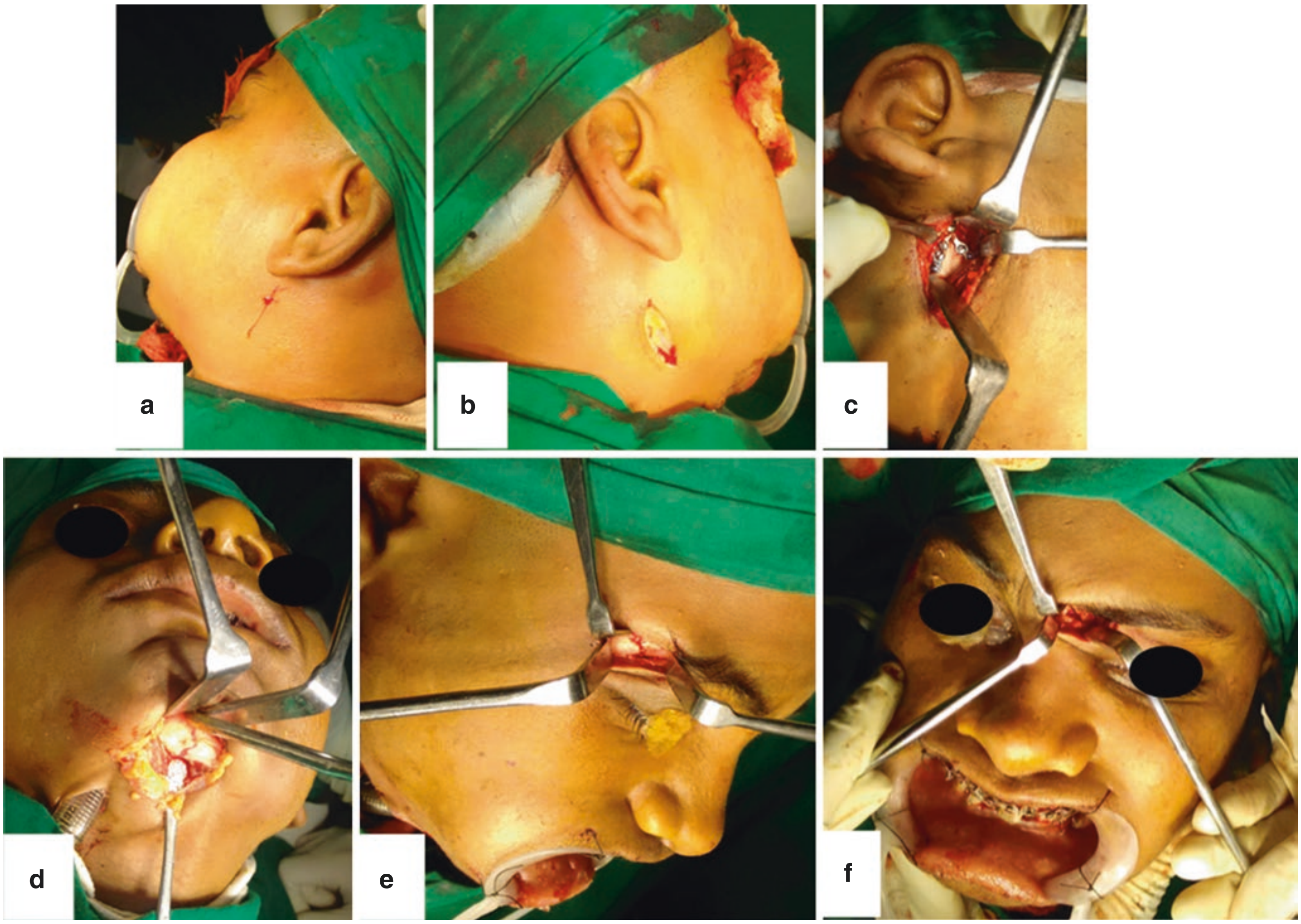

Fig. 60.14 (**a**–**f**) Panfacial trauma intra-operative images of case shown in Fig. 60.14. (**a**) Left retromandibular approach (**b**) Right retromandibular approach. (**c**) Right condyle plating. (**d**) Symphysis exposure. (**e**) Right frontozygomatic fracture. (**f**) Naso-ethmoid fracture exposure

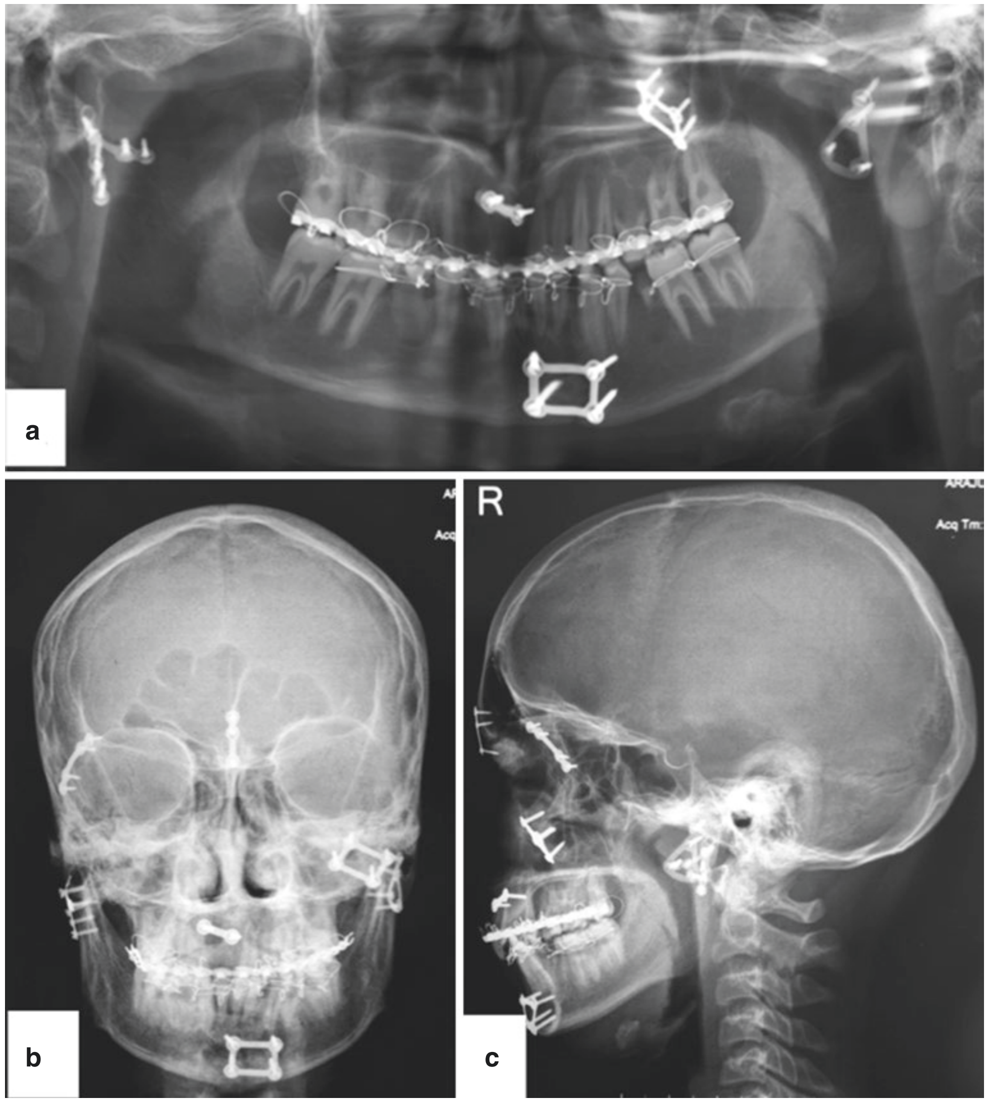

Fig. 60.15 (**a**–**c**) Panfacial trauma post-operative radiographs of case shown in Fig. 60.14. (**a**) OPG. (**b**) PA cephalogram. (**c**) Lateral cephalogram

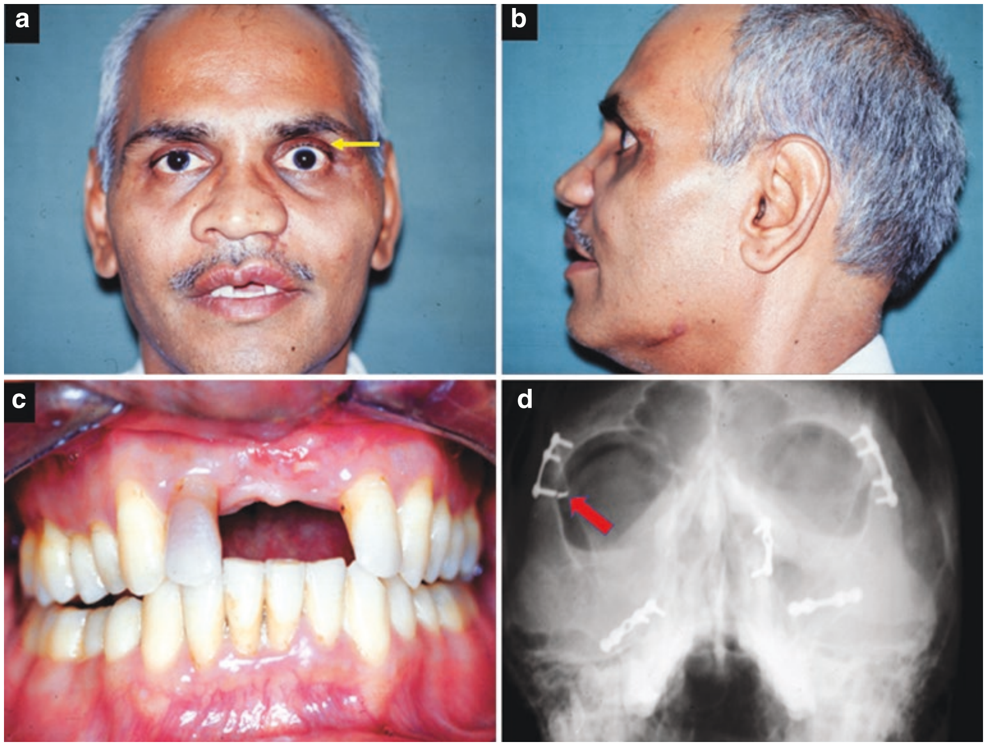

Fig. 60.16 (**a**–**d**) Pre-operative photographs. (**a**) Frontal view showing asymmetrical face, alar bases, lip and deepened supra tarsal fold (yellow arrow). (**b**) Lateral view showing upturned lip, increased vertical dimension, scar on left body of mandible. (**c**) Malocclusion with anterior open bite. (**d**) Pre-operative P.A. Waters view showing inadequate fixation of midfacial fractures and foreign body within right orbit (Red arrow)

Case 2 (Figs. 60.16a–d, 60.17a–e, and 60.18a–d)

Back ground:

This case was treated in 1997 by the first author, when CT scan was a novelty rather than necessity. Plating system used was stainless steel.

A 43 years male with no comorbidities was referred by dental surgeon for correction of malocclusion and asymmetrical face. Patient had a history of RTA with panfacial fractures, and head injury, cerebral oedema 3 months prior. He was treated conservatively for head injury and had no residual neurological deficit. He was treated by other specialist for panfacial fractures by ORIF and then referred to dentist for prosthetic correction of occlusion. Patient insisted upon simultaneous correction of occlusion and asymmetric face.

Patient reported with complaints of:

Inability to masticate, changed pattern of upper and lower teeth meeting , crooked nose with asymmetric nasal bases, sunken left eyeball, diplopia on superior gaze, and changed facial appearance compared to preinjury status.

Clinical Findings (Fig. 60.16a–d)

1. Significant change in facial appearance as compared to pre-trauma, pre-treatment appearance
2. Elongated face
3. Upturned upper lip and acute nasolabial angle
4. Deviated and depressed nose, with dissimilar alar bases
5. Enophthalmos with increased supratarsal fold left eye. (yellow arrow)
6. Changed pupillary levels, and excessive scleral show of left eye
7. Increased width of face more so on left side
8. Malocclusion, with anterior open bite, increased vertical dimension of face due to posterior and inferior displacement of maxilla with gagging.
9. Scars in Bilateral frontozygomatic, left infraorbital, left mandibular body region.
10. Left mandibular body fracture fixed adequately but patient had left marginal mandibular nerve paresis/ injury.
11. Total mobility of middle third of facial skeleton suggestive of non-union/malunion.

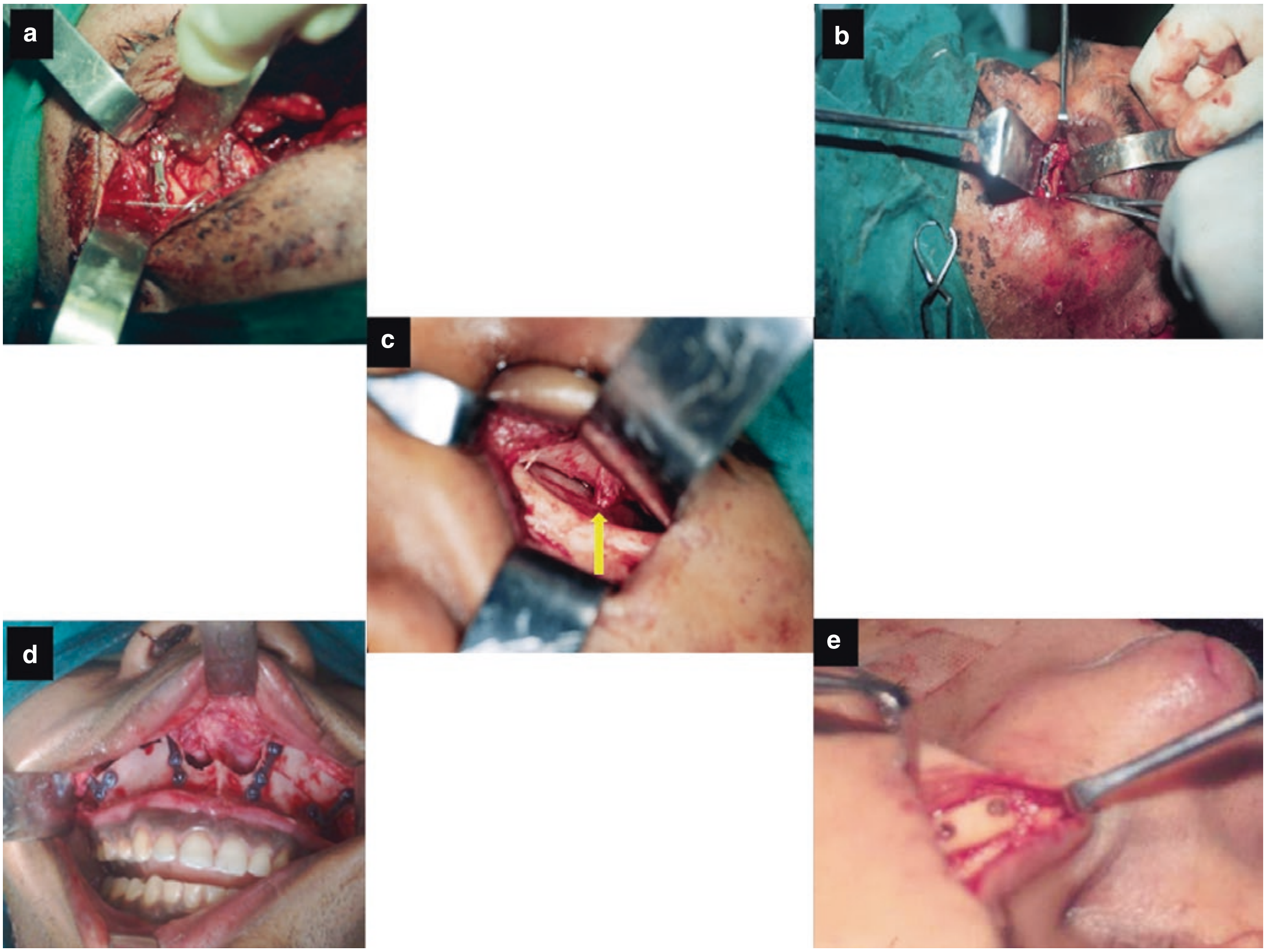

Fig. 60.17 (**a**–**d**) Intra-operative representative photos. (**a**) Fixation at FZ suture. (**b**) Fixation at inferior orbital rim. (**c**) Entrapment of inferior rectus, left orbital floor (yellow arrow). (**d**) Fixation of LeFort I fracture. (**e**) Fixation of bone graft to augment nasal bridge

Diagnosis:

1. Patient was counselled and asked to undergo X-rays to have 3 dimensional orientation. 1. PA Caldwell.
2. PA Water sinus (full face),
3. Base of skull for zygomatic arches and mandible.
4. Upper and lower occlusal topographic. CT scan of face with 3D reconstruction was not done for financial reasons. Remember CT scans were relatively expensive then.
5. Routine preoperative preparation.

Radiological Findings

Inadequate fixation seen at bilateral Fronto Zygomatic (FZ) suture, LeFort I,II,III level, and FNOE complex. A Foreign body (broken drill) was seen in Right orbit near FZ suture (red arrow). Mandible was fixed adequately both radiologically and clinically.

Plan of action/surgical approach (Fig. 60.17a–e)

1. Transmylohyoid intubation.
2. Mandible fracture being adequately fixed during previous surgery was not addressed
3. Mobilisation/osteotomy of midfacial skeleton to achieve adequate occlusion, projection of midface and reduce mid-facial width.
4. Approach midface fractures through existing scars at FZ suture, and left infraorbital region, subciliary approach to right infraorbital region.
5. Horizontal incision at nasal bridge for alignment of FNOE complex. (Fig 60.17e)
6. Intraoral sub labial approach for LeFort I fracture.
7. Iliac bone grafting at LeFort I level and nasal bridge to achieve prominence and augment the same.
8. Bone graft at left floor of orbit to correct enophthalmos and diplopia.
9. Alar cinch for flared left ala of nose.

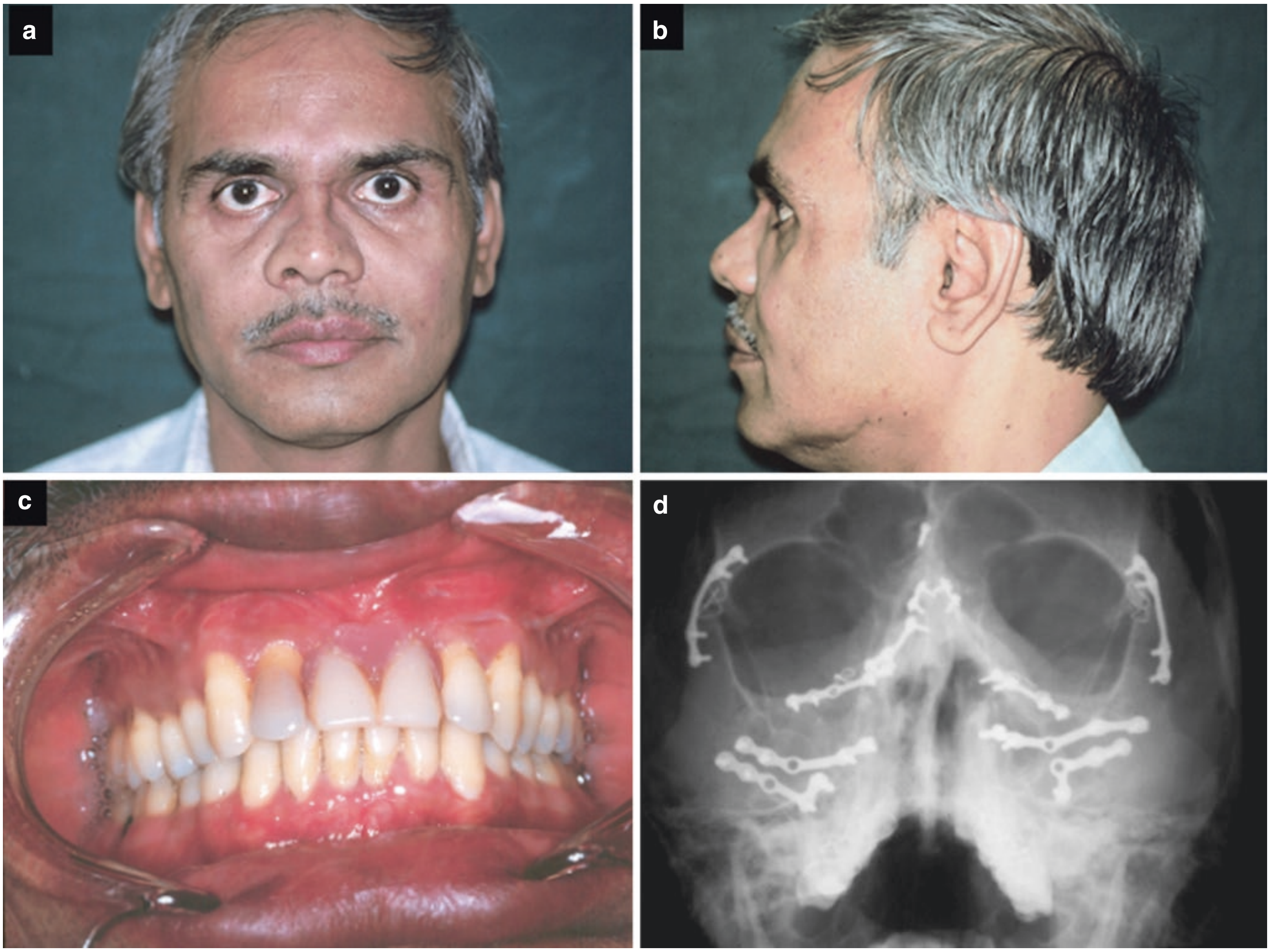

Fig. 60.18 (**a**–**d**) Ten years Post-operative photographs. (**a**) Frontal view showing restored symmetry. (**b**) Lateral view showing correct lip positioning, corrected vertical dimension, scar on left body of mandible. (**c**) Corrected occlusion. (**d**) Post-operative P.A. Waters view (Full face) showing adequate fixation of midfacial fractures at all the struts

10. Avoid MMF. Post-op X-ray (Fig. 60.18d) shows plating with wires, they were not removed as hardware used then was stainless steel so there was no issue of Eddy's current due to dissimilar metals.

60.13 Conclusion

The increasing number of RTA and related CMF injuries suggests the need for immediate attention from the concerned authorities, to enforce strict laws like mandatory use of seat belts and total head and face guard (that suit climatic conditions) rather than the conventional helmets. Restricting the use of mobile phones and head phones while driving may lead to decrease in the incidence of RTA. If RTA is considered an epidemic of modern times, then prevention is its vaccine. Increasing public awareness towards voluntary use of safety measures for their own safety rather than merely obeying the rules can reduce most of the cranio-maxillofacial injuries.

Panfacial trauma can appear complex and challenging to treat but is actually the conglomeration of treating individual fractures that are a common place in maxillofacial injuries (it would be wise to "simplify" the fracture in the minds' eye view and formulating a treatment plan). Adhering to a treatment protocol and treating each fracture as a unit, with adequate fixation, enable the surgeon to obtain good results. Development of a sequential and methodical treatment plan prior to surgery and adherence to the basic principles of maxillofacial trauma is vital in treatment of these patients.

References

1. Kelly KJ, Manson PN, Vander Kolk CA, Markowitz BL, Dunham CM, Rumley TO, Crawley WA. Sequencing LeFort fracture treatment (Organization of treatment for a panfacial fracture). J Craniofac Surg. 1990;1(4):168–78.
2. Gadre KS, et al. Incidence and pattern of cranio-maxillofacial injuries: a 22 year retrospective analysis of cases operated at major trauma hospitals/centres in Pune, India. J Maxillofac Oral Surg. 2013;12(4):372–8.
3. Hazen A, Ehiri JE. Road traffic injuries: hidden epidemic in less developed countries. J Natl Med Assoc. 2006;98:73–82.
4. Gruss JS, Phillips JH. Complex facial trauma: the evolving role of rigid fixation and immediate bone graft reconstruction. Clin Plast Surg. 1989;16:93–104.
5. Manson PN, Crawley WA, Yaremchuk M, et al. Midface fractures: advantages of immediate extended open reduction and bone grafting. Plast Reconstr Surg. 1985;76:1–12.
6. Gadre KS, Waknis PP. Transmylohyoid/submental intubation: review, analysis, and refinements. J Craniofac Surg. 2010;21:516–9.
7. Cryer MH. The maxillae. In: The internal anatomy of the face. Philadelphia, PA: Lea & Febiger; 1916. p. 76–7.
8. Manson PN, Hoopes JE, Su CT. Structural pillars of the facial skeleton: an approach to the management of Le Fort fractures. Plast Reconstr Surg. 1980;66:54–62.
9. Manson PN, Clark N, Robertson B, Slezak S, Wheatly M, Vander Kolk C, Iliff N. Subunit principles in midface fractures: the importance of sagittal buttresses,soft-tissue reductions, and sequencing treatment of segmental fractures. Plast Reconstr Surg. 1999;103(4):1287–306.
10. Curtis W, Horswell BB. Panfacial fractures: an approach to management. Oral Maxillofac Surg Clin North Am. 2013;25(4):649–60.
11. Yang R, Zhang C, Liu Y, Li Z, Li Z. Why should we start from mandibular fractures in the treatment of panfacial fractures? J Oral Maxillofac Surg. 2012;70(6):1386–92.
12. Rohner D, Tay A, Meny CS, et al. The sphenozygomatic suture as a key site for osteosynthesis of the orbitozygomatic complex in panfacial fractures: a biomechanical study in human cadavers based on clinical practice. Plast Reconstr Surg. 2002;110:14630–71.
13. Stanley RB Jr. The zygomatic arch as a guide to reconstruction of comminuted malar fractures. Arch Otolaryngol Head Neck Surg. 1989;1150:1459–62.
14. Gruss JS, Van Wyck L, Phillips JH, Antonyshyn O. The importance of the zygomatic arch in complex midfacial fracture repair and correction of posttraumatic orbitozygomatic deformities. Plast Reconstr Surg. 1990;85(6):878–90.
15. Tullio A, Sesenna E. Role of surgical reduction of condylar fractures in the management of panfacial fractures. Br J Oral Maxillofac Surg. 2000;38(5):472–6.
16. Markowitz BL, Manson PN. Panfacial fractures: organization of treatment. Clin Plast Surg. 1989;16:105–14.
17. Kim J, Choi JH, Chung YK, Kim SW. Panfacial bone fracture and medial to lateral approach. Arch Craniofac Surg. 2016;17(4):181–5.
18. Choi JW, Kim MJ. Treatment of panfacial fractures and three-dimensional outcome analysis: the occlusion first approach. J Craniofac Surg. 2019;30(4):1255–8.
19. Gruss JS, Mackinnon SE, Kassel EE, et al. The role of primary bone grafting in complex craniomaxillofacial trauma. Plast Reconstr Surg. 1985;75:17–24.
20. Phillips JH, Forrest CR, Gruss JS. Current concepts in the use of bone grafts in facial fractures. Basic science considerations. Clin Plast Surg. 1992;19:41–58.
21. Iatrou I, et al. Surgical protocols and outcome for the treatment of maxillofacial fractures in children: 9 years' experience. J Craniomaxillofac Surg. 2010;38:511–6.

Additional Reading

Gruss JS, Bubak PJ, Egbert MA. Craniofacial fractures. An algorithm to optimize results. Clin Plast Surg. 1992 Jan;19(1):195–206.

Manson PN. Panfacial Fractures. In: Ehrenfeld M, Manson PN, Prein J, editors. Principles of Internal Fixation of the Craniomaxillofacial Skeleton, Trauma and Orthognathic Surgery. Thieme; 2012. p 292–305.