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Review

Maxillofacial trauma—Developments, innovations and controversies

Michael Perry *

Consultant Oral and Maxillofacial Surgeon, Ulster Hospital, Dundonald, Belfast, Northern Ireland, UK

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ABSTRACT

Despite seat belt and alcohol legislation, craniofacial trauma still remains a common health problem and significant workload in many maxillofacial units. Although management has evolved considerably from "wiring teeth together", complex fractures can still result in cosmetic and functional deformity. Today's challenge is to consistently restore patients back to their pre-injury form and function—but this is not always possible. Greater understanding and developments have significantly improved outcomes, although controversy still exists in some areas. This review outlines some of these topics.

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Introduction

Despite seat belt and alcohol legislation,[59,78] craniofacial trauma[122] still remains a common health problem and significant workload in many maxillofacial units.[141] Although management has evolved considerably from "wiring teeth together", complex fractures can still result in cosmetic and functional deformity. Today's challenge is to consistently restore patients back to their pre-injury form and function—but this is not always possible. Greater understanding and developments have significantly improved outcomes, although controversy still exists in some areas. This review outlines some of these topics, namely;

Applied biomechanics, mechanisms of injuries and pathophysiology applicable to the face.
Soft tissues.
Advanced Trauma Life Support (ATLS) and the face.
Imaging.

* Tel.: +44 2890 484 511.
E-mail address: mikepmaxfax@yahoo.com.

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Surgical approaches and repair.
Endoscopic repair.
Controversial areas—Timing, plate removal, condyle and frontal sinus.
Biomaterials and secondary correction.

This is not an exhaustive list, but focuses on current topics and key papers, which have shaped the management of the facial trauma over the last 10–20 years.

Applied biomechanics

Why do we have sinuses? One controversial theory[104] is that the facial skeleton has evolved into a "crumple zone", preventing impact energy being transferred to the brain. Condylar fractures, for example following a blow to the chin, protect the brain stem. The midface can be conceptualised as a number of paired vertical and transverse buttresses, between which the sinuses lay, covered by paper thin bone. The thicker vertical buttresses resist functional forces (biting), while the horizontal buttresses house the organs (e.g. eyes) and define facial shape, but are relatively weak and collapse on impact. Anatomical reduction of these buttresses is essential for the reestablishment of occlusion, facial height, width and projection. The nasal septum is important for midface growth.

Mechanisms of injury and pathophysiology

Understanding mechanisms of injury can provide clues to occult injuries,[23,45] which can be initially overlooked.[31,32,36,131] With regards to facial injuries;

1. Specific injuries may occur following facial impacts (cf the "bell-clanger effect" in the mediastinum). Hippocrates noted the association between forehead trauma and blindness[74] around 400BC.[39] Cervical spine injuries have also been described—with upper midface injuries, cervical fractures tend to be at a lower level, while mandibular fractures are related more to upper fractures.[94]
2. Fractures from altercations are simpler to reduce and treat, with limited or no exposure and simple fixation. Conversely, high-energy injuries often require extensive procedures with open reduction and rigid fixation.
3. "Panfacial" fractures are associated with bleeding, swelling and airway compromise. These complications can also occur in the *absence* of any fractures, in patients taking anticoagulants or with clotting abnormalities.[52] Retropharyngeal haematoma (high cervical injuries), can result in delayed obstruction.[92] Swelling worsens when supine, from elevated venous pressures and reduced lymphatic drainage.
4. Although laminated windscreens and airbags have reduced mortality, injuries to the periorbital region,[35] globes,[53] soft tissues, temporomandibular (TMJ) joints[64] and fracture of the posterior arches of C1 and C2 are reported associations.[28]
5. Bone is plastic. Localised impacts can temporarily deform the facial skeleton. Optic nerve injury can occur following forehead and midface trauma, in the absence of fractures. Orbital apex disruption[18] can injure the tethered nerves and vessels and resulting in blindness. Similarly blows to the cheek can result in isolated orbital floor "blowout" fractures.
6. Loss of sight usually occurs immediately, but can be delayed.[68] It can also occur following apparently minor injuries, with minimal signs of injury.[14,46]
7. Severe hypotension has resulted in loss of sight (ischaemic neuropathy[43,118,135])—in the *absence* of craniofacial trauma.[12,17,41] Conversely hypertension during resuscitation may precipitate intraocular bleeding. In the elderly a dilated pupil may *precipitate* ocular problems. Acute angle closure glaucoma can be precipitated by drugs[13,73] and general anaesthesia—this should be considered in any tense, painful, red eye.

Soft tissues and fracture management

The excellent blood supply to the face has facilitated the development of procedures not possible elsewhere in the body. Degloved, contaminated and infected fractures often heal uneventfully following fixation,[71] a situation rarely seen in the limbs after comparable soft tissue injuries. "Free-grafting" [48] is possible—bone can be detached totally from its soft tissues, manipulated and replaced,[83,88] with little risk of infection or resorption. This has enabled development of extracorporal repair and access orbitotomies.[33] Bone can harvested from a choice of donor sites[70] (commonly calvarium, iliac crest, or rib). Conversely care is required in comminuted fractures where severe soft tissue damage impairs healing. Soft tissue contraction can occur and aftercare is especially important. Careful resuspension of soft tissues following degloving incisions is crucial for good aesthetics. In some areas, over reduction is desirable as a degree of contraction is inevitable.

ATLS and facial trauma—can one size fit all?

ATLS[6,38,138] is generally accepted as a gold standard in trauma.[30] Unfortunately the coexistence of facial injuries and injuries below the clavicles can pose a number of clinical problems[110,111] as each may affect the management of the other.[4,37] Even potential injuries (notably spinal), can affect maxillofacial intervention. Conversely, facial injuries may hinder the assessment of other body regions.[11] Therefore maxillofacial surgeons should ideally be an integral part of the trauma team when facial injuries are evident. Facial injuries can be broadly placed into four groups, based on clinical urgency.

1. Immediate life or sight-preserving interventions required.
2. Treatment required within a few hours—heavily contaminated wounds in a stabilised patient.
3. Treatment can wait 24 h if necessary.
4. Treatment can wait over 24 h if necessary.

Primary survey pitfalls include.

1. Airway assessment[113]—Direct inspection is essential. Compromise may arise from loose teeth, dentures, oropharyngeal bleeding,[132] tissue displacement, and swelling. Maintenance techniques may be difficult with mandibular fractures. Unexpected vomiting can occur. Senior clinical input is usually necessary.[7,51]
2. Rigid collars restrict mouth opening and with mandibular fractures can precipitate airway problems.[90] They can also raise the ICP[47,76] (clinical significance unknown).
3. Life-threatening blood loss can occasionally occur. Bleeding may continue unrecognised over a prolonged period (e.g. scalp lacerations or in supine, awake patients who swallow their blood). Anecdotally, even "minor" fractures (nasal and mandibular) have resulted in significant blood loss requiring fluid resuscitation. Midface bleeding can be difficult to control due to the extensive collateral supply.[93]
4. Damage control principles[126,130] may be useful as immediate definitive repair is not essential.[112] This avoids prolonged anaesthesia and surgery in a sick patient and facilitates resuscitation. Sequencing is important[77]—packing the nasal cavity displaces unsupported midface fractures. Stabilisation