CT Facial Trauma Made Easy (ish)

Gary Holdsworth – Clinical Specialist Radiographer (Neuro CT) – Mid Yorkshire Hospitals NHST.
Facial fractures are commonly caused by blunt or penetrating trauma sustained during RTC, assaults, and falls.
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Right 28%, Left 36%, Midline 36%
Bilateral fractures 19%
One fracture pattern 52%
Panfacial injury 1%

*Mundinger et al. J Craniomaxillofac Surg 2014 (n=8127)*
Facial Fractures

**Upper Face:** frontal, superior orbit

Mundinger et al. *J Craniomaxillofac Surg* 2014
Facial Fractures

**Upper Face**: frontal, superior orbit

**Mid Face**: rest of orbit, nasal, zygoma, Le Fort, maxillary sinus, dentoalveolar, NOE, ZMC

Mundinger et al. *J Craniomaxillofac Surg* 2014
Facial Fractures

**Upper Face**: frontal, superior orbit

**Mid Face**: rest of orbit, nasal, zygoma, Le Fort, maxillary sinus, dentoalveolar, NOE, ZMC

**Lower Face**: mandible

*Mundinger et al. J Craniomaxillofac Surg 2014*
Plain x-rays are relatively insensitive to facial fractures.

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**CT = Gold Standard:** Detection of soft-tissue and bony injuries; characterisation of soft-tissue and bony injuries; surgical planning.

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With the high definition of CT even small fractures of the facial skeleton can be visualized. In complex midface injuries, it can be difficult to know which fractures are important to point out to the surgeon.

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With the high definition of CT even small fractures of the facial skeleton can be visualized. In complex midface injuries, it can be difficult to know which fractures are important to point out to the surgeon.

An understanding of the anatomically relevant and surgically accessible craniofacial buttresses is critical for management of these injuries.

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The "facial buttress" concept elucidates the structurally meaningful skeletal struts that play a role in facial form and function and helps identify the regions that are likely to require surgical reconstruction (it does not replace traditional anatomic terms).
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The buttress system of the midface is formed by strong frontal, maxillary, zygomatic and sphenoid bones and their attachments to one another.
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The buttress system of the midface is formed by strong frontal, maxillary, zygomatic and sphenoid bones and their attachments to one another.

Buttresses represent areas of relative increased bone thickness that support the functional units of the face (muscles, eyes, dental occlusion, airway) in an optimal relation; they define the form of the face and have sufficient bone thickness to accommodate metal screw fixation.
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4 Vertical Buttresses (3 face; 1 mandible)
5* Horizontal Buttresses (3 face; 2 mandible)
The vertical facial buttresses
The horizontal facial buttresses

1. Superior orbital rim
2. Inferior orbital rim
3. Maxillary alveolar rim
4. Mandibular alveolar rim
5. Inferior border of mandible
IMPORTANT!
Do not get distracted by facial injuries when reporting cranial trauma:
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- airway can be compromised
- concomitant skull-base fracture in 8% of cases
- concomitant c-spine fracture in 7%
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Airway OK?
Focus upon Brain & Skull first.
Check craniocervical junction.
IMPORTANT!
Do not get distracted by facial injuries when reporting cranial trauma:
- Airway can be compromised
- Concomitant skull-base fracture in 8% of cases
- Concomitant c-spine fracture in 7%

Airway OK?
Focus upon Brain & Skull first.
Check craniocervical junction.

Then move to the face ...
CT ‘Clear Sinus Sign’: “Absence of paranasal sinus fluid after facial trauma is a highly reliable criterion to exclude acute fractures involving the paranasal sinus walls”

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Critical Facial Injuries.

Airway compromise: Flail Mandible
Nasal septal haematoma
CT ‘Clear Sinus Sign’: “Absence of paranasal sinus fluid after facial trauma is a highly reliable criterion to exclude acute fractures involving the paranasal sinus walls”


Critical Facial Injuries.

**Airway compromise:** Flail Mandible
Nasal septal haematoma

**Vision:** Retro-bulbar haemorrhage
Orbital apex fracture
Globe injuries
Airway compromise: Flail Mandible.

Fractures of the symphysis + bilateral condyles, rami or angles.
Airway compromise: Flail Mandible.

Fractures of the symphysis + bilateral condyles, rami or angles. Can potentially compromise airway; concomitant pharyngeal haematoma. **Tongue position not maintained.**
Airway compromise: Nasal Septal Haematoma.

Potentially compromise nasal airway; life-threatening epistaxis.
Airway compromise: Nasal Septal Haematoma.

Potentially compromise nasal airway; life-threatening epistaxis.
Vision: Retrobulbar Haemorrhage.

Proptosis, ‘tented’ posterior sclera, stretched optic-nerve. Bleeding from infraorbital or ethmoidal arteries.
Vision: Orbital Apex Fracture

Impingement on optic nerve; traumatic optic neuropathy and vision loss.
Vision: Orbital Apex Fracture

Impingement on optic nerve; traumatic optic neuropathy and vision loss.
Vision: Globe Rupture

Full thickness tear of sclera or cornea. Anterior surface common, but posterior occult on clinical exam.
Vision: Globe Rupture

Full thickness tear of sclera or cornea. Anterior surface common, but posterior occult on clinical exam.

'Flat-tire' sign
Scleral discontinuity
Vision: Globe Rupture

Full thickness tear of sclera or cornea. Anterior surface common, but posterior occult on clinical exam.

Intra-ocular FB’s?

‘Flat-tire’ sign
Scleral discontinuity
Intra-ocular air
Vision: Globe Rupture

Full thickness tear of sclera or cornea. Anterior surface common, but posterior occult on clinical exam.

Intra-ocular FB’s?

‘Flat-tire’ sign
Scleral discontinuity
Intra-ocular air

Lens dislocation.
Acute lens oedema
(30 HU lower than normal side) = Traumatic Cataract
Vision: Detachments

Retinal detachment (separated from choroid) – ‘V-shaped’, apex at optic disc
Vision: Detachments

Retinal detachment (separated from choroid) – ‘V-shaped’, apex at optic disc
Choroidal detachment (separated from sclera) – ‘lens-shaped’
Suggested approach ... the search for CRITICAL FINDINGS!

Is the Airway seen and open?

Clear paranasal sinus?

No

Pterygomaxillary disruption?

Yes

Le Fort I, II, III

No

ZMC, Frontal maxillary, Orbit, NOE

Yes

Nasal Zygomatic arch Mandible Dento-alveolar
Suggested approach ... the search for CRITICAL FINDINGS!

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ZMC, Frontal maxillary, Orbit, NOE

Yes

Nasal
Zygomatic arch
Mandible
Dento-alveolar
Nasal Fracture
Unilateral vs bilateral, simple vs comminuted; if comminuted, telescoping or depression?
Septum involved?
Haematoma?
Nasal Fracture
Unilateral vs bilateral, simple vs comminuted; if comminuted, telescoping or depression?
Septum involved?
Haematoma?

Frontal Process of Maxilla Fracture
Part of a more complex fracture?
Nasal Fracture
Unilateral vs bilateral, simple vs comminuted; if comminuted, telescoping or depression? Septum involved? Haematoma?

Frontal Process of Maxilla Fracture
Part of a more complex fracture?

Zygomatic Arch Fracture
Three fracture lines, depressed middle fragment. Limit motion of mandible by impinging on coronoid process or masseter origins
Dento-alveolar Fracture
Any portion of the alveolar process.
Malaligned and displaced tooth.
Tooth injuries: luxation, subluxation, avulsion, and fracture.
Suggested approach ... the search for CRITICAL FINDINGS!

Is the Airway seen and open?
- No
- Yes

Clear paranasal sinus?
- Yes
- No

Pterygomaxillary disruption?
- Yes
  - Le Fort I, II, III
- No
  - ZMC, Frontal maxillary, Orbit, NOE

Nasal
Zygomatic arch
Mandible
Dento-alveolar
Suggested approach ... the search for CRITICAL FINDINGS!

Is the Airway seen and open?

- No
  - Pterygomaxillary disruption?
    - Yes: Le Fort I, II, III
    - No: ZMC, Frontal maxillary, Orbit, NOE
  - Clear paranasal sinus?
    - Yes: Nasal, Zygomatic arch, Mandible, Dento-alveolar
    - No: ZMC, Frontal maxillary, Orbit, NOE
Le Fort fractures involve the midface, which results in separation of all, or a portion, of the midface from the skull base.
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The Le Fort classification system attempts to distinguish according to the plane of injury. Isolated pterygoid plate fracture is diminishingly rare; the absence of pterygomaxillary disruption rules out a Le Fort.
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Among the most severe facial fractures. Progressively severe category from I to III.
Modified Le Fort classifications by Marciani RD 1993

Le Fort I  - Low Maxillary Fractures
   Ia  - Low maxillary fracture/multiple segments

Le Fort II  - Pyramidal
   IIa  - Pyramidal and nasal fractures
   IIb  - Pyramidal and naso-orbito-ethmoidal (NOE) Fracture

Le Fort III  - Craniofacial dysjunction
   IIIa  - Craniofacial dysjunction and nasal fractures
   IIIm  - Craniofacial dysjunction and NOE

Le Fort IV  - Le Fort II or III fracture and cranial base fracture
   IVa  - Supra-orbital fracture
   IVb  - Anterior cranial fossa and supra-orbital rim fracture
   IVc  - Anterior cranial fossa and orbital wall fracture
Modified Le Fort classifications by Marciani RD 1993

Le Fort I - Low Maxillary Fractures
  Ia - Low maxillary fracture/multiple segments

Le Fort II - Pyramidal
  IIA - Pyramidal and nasal fractures
  IIB - Pyramidal and naso-orbito-ethmoidal (NOE) Fracture

Le Fort III - Craniofacial dysjunction
  IIIA - Craniofacial dysjunction and nasal fractures
  IIIB - Craniofacial dysjunction and NOE

Le Fort IV - Le Fort II or III fracture and cranial base fracture
  IVa - Supra-orbital fracture
  IVb - Anterior cranial fossa and supra-orbital rim fracture
  IVc - Anterior cranial fossa and orbital wall fracture
Le Fort fractures

Le Fort I

Le Fort II

Le Fort III
Le Fort fractures

- a floating palate
- a floating maxilla
- a floating face

Le Fort I
Le Fort II
Le Fort III
Le Fort fractures

- a floating palate
- a floating maxilla
- a floating face

Le Fort I

Le Fort II

Le Fort III
Le Fort fractures

Le Fort I

Le Fort II

Le Fort III
Le Fort fractures

Le Fort I (left)  Le Fort I & II  Le Fort II & III
Le Fort fractures

The hard palate is an important posterior extension of the lower transverse buttress of the Maxilla (maxillary alveolar rim). A displaced unilateral Le Fort fracture is possible only if the palate is fractured sagittally or parasagittally.
Le Fort fractures

1. Le Fort I
2. Le Fort II
3. Le Fort III
Le Fort fractures

Multiplanar CT: axial, coronal and sagittal images – need to work on all 3!
Le Fort fractures

Multiplanar CT: axial, coronal and sagittal images – need to work on all 3!

Is there a fracture of the pterygomaxillary buttress? Yes — likely Le Fort
Le Fort fractures

Multiplanar CT: axial, coronal and sagittal images – need to work on all 3!

Is there a fracture of the pterygomaxillary buttress? Yes → likely Le Fort

Is the anterolateral margin of the nasal fossa fractured? Yes → Type 1 fracture
Le Fort fractures

Multiplanar CT: axial, coronal and sagittal images – need to work on all 3!

Is there a fracture of the pterygomaxillary buttress? Yes —> likely Le Fort

Is the anterolateral margin of the nasal fossa fractured? Yes —> Type 1 fracture

Is the infraorbital rim fractured? Yes —> Type 2 fracture
Le Fort fractures

Multiplanar CT: axial, coronal and sagittal images – need to work on all 3!

Is there a fracture of the pterygomaxillary buttress? Yes → likely Le Fort

Is the anterolateral margin of the nasal fossa fractured? Yes → Type 1 fracture

Is the infraorbital rim fractured? Yes → Type 2 fracture

Is the lateral orbital wall and zygomatic arch fractured? Yes → Type 3 fracture
Le Fort fractures

Multiplanar CT: axial, coronal and sagittal images – need to work on all 3!

Is there a fracture of the pterygomaxillary buttress? Yes → likely Le Fort

Is the anterolateral margin of the nasal fossa fractured? Yes → Type 1 fracture

Is the infraorbital rim fractured? Yes → Type 2 fracture

Is the lateral orbital wall and zygomatic arch fractured? Yes → Type 3 fracture

Remember: any combination is possible; for example, there may be type 2 on one side and type 3 on the other; a type 1 and type 2 on the same side etc
Le Fort I – transverse fracture of inferior maxillae (all walls of the maxillary sinus except the superior wall/roof), anterolateral margins of the nasal fossa, nasal septum.
Le Fort fractures

Le Fort II – Pyramid shaped. Fractures of maxillary sinuses (anterior, lateral wall), inferior orbital rim, orbital floor, nasofrontal suture
Le Fort fractures

Le Fort III – Fractures of the nasofrontal suture, maxillofrontal suture, lateral orbital wall and zygomatic arch/zygomaticofrontal suture
Le Fort fractures

Le Fort I, II & III
The hard palate is an important posterior extension of the lower transverse buttress of the Maxilla (maxillary alveolar rim). A displaced unilateral Le Fort fracture is possible only if the palate is fractured sagittally or parasagittally.
Suggested approach ... the search for CRITICAL FINDINGS!

- Is the Airway seen and open?
  - No
  - Clear paranasal sinus?
    - No
      - Pterygomaxillary disruption?
        - Yes
        - Le Fort I, II, III
      - ZMC, NOE, Orbit, Frontal, Maxillary
    - Yes
      - Nasal Zygomatic arch Mandible Dento-alveolar
  - Yes
Zygomaticomaxillary Complex (ZMC) Fractures
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4 principle fracture lines: lateral orbital rim, zygomatic arch, zygomaticomaxillary buttress, inferior orbital rim.
Zygomaticomaxillary Complex (ZMC) Fractures

4 principle fracture lines: lateral orbital rim, zygomatic arch, zygomaticomaxillary buttress, inferior orbital rim. They are the 2nd most common facial bone fracture after the nasal bones, and are also known as a tripod, tetrapod, quadripod, malar or trimalar fracture.
Zygomaticomaxillary Complex (ZMC) Fractures

Results from a direct blow to the malar eminence with distinct fracture components that disrupt the anchoring of the zygoma.
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Zygomaticomaxillary Complex (ZMC) Fractures

Results from a direct blow to the malar eminence with distinct fracture components that disrupt the anchoring of the zygoma. Additionally, the fracture components may result in impingement of the temporalis muscle = trismus; may compromise the infraorbital foramen &/or nerve resulting in hypo-aesthesia within its sensory distribution.

Naso-orbitoethmoid (NOE) fractures

Comminution of both naso-maxillary buttresses results in fractures involving the nasal bones and septum, ethmoid sinuses, and medial orbital walls.
Naso-orbitoethmoid (NOE) fractures (also known as orbito-ethmoid or naso-ethmoidal complex fractures) are fractures which involve the central upper midface.
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NOE fractures are caused by a high-impact force applied anteriorly to the nose and transmitted posteriorly through the ethmoid bone.
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NOE fractures are caused by a high-impact force applied anteriorly to the nose and transmitted posteriorly through the ethmoid bone.

Telecanthus secondary to medial canthal tendon injury (Markowitz & Manson classification system = whether this tendon is disrupted or not) Reports should try to comment on the degree of comminution of the nasomaxillary buttress, specifically in the region of the lacrimal fossa, where the medial canthus attaches.
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Telecanthus secondary to medial canthal tendon injury (Markowitz & Manson classification system = whether this tendon is disrupted or not)

Nasofrontal duct disruption and subsequent frontal mucocoele formation
Nasofrontal duct injury is suggested if base of frontal sinus is fractured &/or the anterior ethmoid complex.

Ravinda VM et al. Surg Neurol Int 2015; 6:141
&
Harris L et al. Radiology 1987; 165:195
Nasofrontal duct injury is suggested if base of frontal sinus is fractured &/or the anterior ethmoid complex. Fragments in the nasofrontal outflow tract.

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Nasofrontal duct injury is suggested if base of frontal sinus is fractured &/or the anterior ethmoid complex.

Fragments in the nasofrontal outflow tract.

Surgical obliteration of the frontal sinus might be needed to prevent mucocele formation.

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Nasofrontal duct disruption and subsequent frontal mucocoele formation
Orbital injuries and exophthalmos due to reduced intra-orbital volume
CSF rhinorrhea due to fracture through the cribriform plate
Orbit fractures

Orbital blow-out fractures occur when there is a fracture of one of the walls of orbit but the orbital rim remains intact (‘pure’) (‘impure’ = if the orbital rim is fractured).
Orbit fractures

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Resulting from a sudden increase in the intra-orbital pressure which decompresses by fracturing one or more of the bounding walls of the orbit.
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Resulting from a sudden increase in the intra-orbital pressure which decompresses by fracturing one or more of the bounding walls of the orbit.

Blow-out fractures can occur through one or more of the walls of the orbit:

- **Common:** inferior (floor) > medial wall (lamina papyracea)
- **Rare:** superior (roof)
- **Never?:** lateral wall (?)
Orbit fractures

Inferior blow-out fractures are the most common. Orbital fat prolapses into the maxillary sinus and may be joined by prolapse of the inferior rectus muscle.
Orbit fractures

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In the young, the fracture may spring back into place (known as a ‘trapdoor fracture’).

**Orbit fractures**

Inferior blow-out fractures are the most common. Orbital fat prolapses into the maxillary sinus and may be joined by prolapse of the inferior rectus muscle.

In the young, the fracture may spring back into place (known as a ‘trapdoor fracture’).

Most fractures occur in the floor posterior and medial to the infraorbital groove.

In approximately 50% of cases, inferior blow-out fractures are associated with fractures of the medial wall.

Orbit fractures

Inferior blow-out fractures
Orbit fractures

Medial blow-out fractures are the second most common type, occurring through the lamina papyracea. Orbital fat and the medial rectus muscle may prolapse into the ethmoid air cells.
Orbit fractures

Medial blow-out fractures are the second most common type, occurring through the lamina papyracea. Orbital fat and the medial rectus muscle may prolapse into the ethmoid air cells.
**Orbit fractures**

Pure superior blow-out fractures (i.e. those without an associated orbital rim fracture) are uncommon.
Orbit fractures

Pure superior blow-out fractures (i.e. those without an associated orbital rim fracture) are uncommon. They are usually seen in patients with pneumatisation of the orbital roof.
Orbit fractures

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Fractures may only involve the sinus, the anterior cranial fossa (less common), or both sinus and anterior cranial fossa. In the latter, CSF leaks and meningitis may occur.

Very easily missed on axial images
Orbit fractures
Orbit fractures

In addition to evaluating the location and extent of the fracture, other features that need to be assessed and commented on include:
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- presence of intra-orbital haemorrhage - may result in stretching or compression of the optic nerve
Orbit fractures

In addition to evaluating the location and extent of the fracture, other features that need to be assessed and commented on include:

- presence of intra-orbital haemorrhage - may result in stretching or compression of the optic nerve

- globe injury / rupture
Orbit fractures

In addition to evaluating the location and extent of the fracture, other features that need to be assessed and commented on include:

- presence of intra-orbital haemorrhage - may result in stretching or compression of the optic nerve
- globe injury / rupture
- prolapse of orbital fat
Orbit fractures

In addition to evaluating the location and extent of the fracture, other features that need to be assessed and commented on include:

- presence of intra-orbital haemorrhage - may result in stretching or compression of the optic nerve
- globe injury / rupture
- prolapse of orbital fat
- extraocular muscle entrapment - suspected if there is a change in the shape &/or angle of the muscle
Orbit fractures
Maxillary sinus fractures ... NOT!

**The posterior superior alveolar canal**
The alveolar canals are apertures in the centre of the infratemporal surface of the maxilla, these transmit the posterior superior alveolar vessels and nerves.
Maxillary sinus fractures ... NOT!

The posterior superior alveolar canal

The alveolar canals are apertures in the centre of the infratemporal surface of the maxilla, these transmit the posterior superior alveolar vessels and nerves.
Maxillary sinus fractures ... NOT!
Summary

Is the Airway seen and open?

Clear paranasal sinus?

No

Pterygomaxillary disruption?

Yes

No

Le Fort I, II, III

ZMC, NOE, Orbit, Frontal, Maxillary

Yes

Nasal
Zygomatic arch
Mandible
Dento-alveolar
Summary

ALWAYS check for intracranial & C-Spine injuries first.
2 critical facial findings – airway & vision

Is the Airway seen and open?

Clear paranasal sinus?

No

Pterygomaxillary disruption?

Yes

Le Fort I, II, III

No

ZMC, NOE, Orbit, Frontal, Maxillary

Yes

Nasal
Zygomatic arch
Mandible
Dento-alveolar
Summary

ALWAYS check for intracranial & C-Spine injuries first.
2 critical facial findings – airway & vision

Systematic evaluation:
Clear paranasal sinuses?
Pterygomaxillary disruption?

- Is the Airway seen and open?
  - Clear paranasal sinus?
    - Yes
      - Nasal Zygomatic arch Mandible Dento-alveolar
    - No
      - Pterygomaxillary disruption?
        - Yes
          - Le Fort I, II, III
        - No
          - ZMC, NOE, Orbit, Frontal, Maxillary
Summary

ALWAYS check for intracranial & C-Spine injuries first.  
2 critical facial findings – airway & vision

Systematic evaluation:  
Clear paranasal sinuses?  
Pterygomaxillary disruption?

Try to fit all fractures into  
1 or 2 patterns (but don’t worry if you can’t)
Summary

ALWAYS check for intracranial & C-Spine injuries first.
2 critical facial findings – airway & vision

Systematic evaluation:
Clear paranasal sinuses?
Pterygomaxillary disruption?

Try to fit all fractures into 1 or 2 patterns (but don’t worry if you can’t)

Look for potential soft-tissue complications.
The End?

Any Questions??
The End?

Any Questions??

Thank you for your attention.

Acknowledgements/References:

4) https://radiopaedia.org/articles/naso-orbitoethmoid-noe-complex-fracture;
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