Midface fractures; what the radiologist should know.

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Learning objectives

• To demonstrate the findings in different types of facial fractures and the information that a radiologist's report should contain in order to guide the maxillofacial surgeon.

Background

• Facial traumas are frequent results from traffic or working accidents, aggressions or accidental drops.

• The imaging technique of choice is the TCMD due to its high resolution in terms of space, velocity, easy collocation of the patient, small dependency on its collaboration and the possibility to realize multi planar reconstructions in 2D or 3D. It is important to create coronal slices and 3D models which permits the surgeon to define the range of the fracture lines.

• We divide the face into five anatomic areas (figure 1): nasal, orbital, zygomatic, maxillar and mandibular. These regions are connected by four vertical and four horizontal buttresses or sustaining arcs which are anchored either directly or via another buttress to the skull base, supporting the face. The thickness of these sustaining arcs, that permit the collocation of screws, determine the localization of osteosyntesis in the surgical treatment of facial

Images for this section:
Fig. 1: Facial regions and facial buttresses
Imaging findings OR Procedure details

PATTERNS OF FRACTURES

Nasal fractures: evaluate the involvement of the nasal septum

Classification:

1. Simple fractures: unilateral or bilateral, involving exclusively the nasal bones, with possible deviation of the nasal septum
2. Comminuted fractures: Unilateral or bilateral, can include the anterior maxillary spine
3. Complex nasal fractures: Fracture or dislocation of the bony or cartilaginous nasal septum

(Figure 2)

Naso-orbital-ethmoid fractures: Involved are the medial vertical buttresses and the upper transverse maxillary buttress. We have to pay especial attention to the grade of fragmentation in the middle maxillary buttress, where the medial palpebral ligament inserts in the lacrimal fossa. If the fracture includes the ethmoid sinus and the medial orbit wall, we must also examine the nasofrontal duct, since it drains the frontal sinus.

Manson classify these fractures in three principal groups:

1. Type I: Considerably huge fragment, the insertion of the palpebral ligament is intact
2. Type II: Comminuted fracture, the insertion of the ligament is united to a small bone fragment
3. Type III: Avulsion of the ligament, it is a clinical diagnosis.

(Figure 3)

Orbital fractures:

- Evaluate the bony socket (medial and lateral vertical buttress, superior transverse maxillary buttress): Localization and extension of the fractures, herniation of the orbital content, possible involvement of the canals (infraorbital, nasolacrimal, nasofrontal) and the apex.
• Evaluate the orbital content: Position and form of the globe, (enophthalmos or exophthalmos), anterior chamber (density and depth), posterior segment of the globe (collections of liquid, foreign bodies) and the position of the lens, ophthalmic veins and the optic nerve (Figure 4).

Any radiographic sign suggesting potential damage to the globe or to the optic nerve (retrobulbar hematoma or fragmentation of the bones that can result in entrapment of structures) has to be communicated immediately to the surgeon.

They can be found isolated or associated with other complex fractures (NOE, Maxillozygomatic complex, Le Fort II).

Isolated orbital fractures:

• **Blow out fractures**: due to the direct impact to the orbit by an object that is of bigger volume than the orbit itself, which produces a fracture of the orbital floor with displacement of the orbital content towards the maxillary sinus. There has to be excluded the entrapment of the inferior rectus muscle and/or the orbital fat. (Figure 5 and 6). In children the inferior rectus muscle can herniate into the maxillary sinus with apparent integrity of the orbital floor. This happens when it is a greenstick fracture, where one of the fragments is still united to the intact part of the orbital floor and acts as a "trap door" that allows the muscle or fat to pass, but as soon as they regain their original position, they get caught in the superior part of the sinus.

• **Blow in fractures**: produced by an object that produces a fracture with displacement of a fragment into the orbital cavity. When this happens to the orbital roof it can enclose the superior rectus or superior oblique muscle.

• **Fractures of the medial wall**: very frequent due to the ethmoid's fragility. They can be invisible but be suggested by the presence of emphysema outside of the nasal concha.(Figure 7)

• **Fractures of the apex**: Is a surgical emergency when it is accompanied by clinical or radiologic signs of optical nerve damage. (Figure 13)

**Zygomaticomaxillary complex fractures:**

Tripod, trimalar or tetrapod fractures involve the superior and the lateral transverse maxillary buttresses.

To evaluate: the grade of backwards shift of the cheekbone, rotational deformation, fracture of the zygomatic arch (single, comminuted, or displaced) and the involvement of the infaorbital foramen because these findings indicate surgery.
Classification:

1. Type A: Fracture of only one of the pillars, zygomatic arch, lateral or inferior orbital socket
2. Type B: Fracture that includes the four articulations with displacement (Figure 8 and 9)
3. Type C: Comminuted fractures.

Maxillary Fractures:

The nasal, orbital or malar bone fractures can include the maxilla. There are maxillary fractures only involving the alveolar arch or hard palate.

René Le Fort has described the maxillary fractures with destruction of the anchor with the skull base. They can be seen after a direct force injury in the midface (upper lip, central facial or frontonasal region). There is no Le Fort fracture without the rupture of the pterygomaxillary sustaining arch, which includes pterygoid fracturing. Isolated fractures of the pterygoids without Le Fort fracture are rare. Look for the main component that specifies the type of Le Fort fracture and make sure that there are present the rest of Le Fort defining fractures:

- Le Fort I: Scan the anterolateral nasal area, the absence of a fracture in this region exclude a Le Fort I fracture. A fractured inferior maxillary buttress on the other hand confirms the existence of such type of fracture. (Figure 10)
- Le Fort II: Examine the inferior rim of the orbital socket, the absence of a fracture in this area exclude a Le Fort II fracture. There are also lesions in the lateral maxillary buttress, orbital floor and nasofrontal union. (Figure 11)
- Le Fort III: Inspect the zygomatic arch, the absence of a fracture in this area exclude a Le Fort III fracture. Involvement of frontozygomatic and sphenozygomatic sutures, orbital floor and nasofrontal union is also present in Le Fort III. (Figure 11)

Consider the possibility of more than one type of Le Fort fracture in the same patient, not necessarily being bilateral and symmetric, such as the coexistence of other facial fractures.

Mandibular fractures:

Can be classified by the localization, pattern of the fracture and biomechanical factors.

Localization:

- Corpus
- Condyle
Mechanism: coup and contra-coup leave some loose segments in the mandible. The most common are:

- Angle and contralateral corpus
- Bilateral angles
- Angle and contralateral condyle
- Bilateral Symphysis with destabilization of the tongue and the respiratory tract due to the loss of anchor with the genioglossal muscle.

The biomechanics: is beneficial if the vectors of the masticatory muscle’s force tend to reduce the fracture and unfavorable when it tends to displacement of the fragments. (Figure 12)

**Frontal sinus fractures**

Though in terms of definition it does not form part of the face, it is often involved in facial fractures (Figure 13)

Types:

- Isolated fractures of the extern table (no need for reparation)
- Fractures of the posterior table: (antibiotic therapy) except of cases that present liquorrea which requires surgery
- Fractures affecting the draining conduct: Occlusion of the sinus is required to prevent the formation of mucocele.

**Fractures in pediatrics:**

- Most common are nasal fractures
- In pediatric patients due to the lack of pneumatisation of the sinus and the distribution of the bony mass fractures of the mandible condyles are more frequent than in adults and midface fractures are rare.
- Condyle fractures are the injuries that most require hospitalization and treatment.
- Facial fractures in pediatric patients do not follow the Le Fort pattern, but have oblique fracture lines.
- Tend to present greenstick fractures for the incomplete ossification. (Figure 12 and 13)
Fig. 1: Facial regions and facial buttresses
Fig. 2: (a) Simple nasal fracture (b) Complex nasal fracture, note the fracture of the nasal septum
**Fig. 3:** NOE fracture type I, coronal reconstruction and volume rendering images.

**Fig. 4:** Orbital medial wall fracture with right lens luxation, you can see the lens in the posterior pole of the globe,
Fig. 5: Orbital floor fracture with entrapment of the inferior rectus muscle.
Fig. 6: Blow out orbital fracture, the orbital floor is collapsed without entrapment of the inferior rectus muscle. Note the adjacent hematoma.
Fig. 7: NOE fracture with medial orbital wall fracture
Fig. 8: Zygomaticomaxillary complex fracture type B, quadripode fracture (a) volume rendering image (b) coronal view. Red arrows point to zygomaticomaxillary suture, zygomaticofrontal suture and zygomatic arch.
**Fig. 9:** Volume rendering image of the same case as figure 8, note the fracture of the suture connecting the zygoma with the esphenoid major wing
**Fig. 10:** Le Fort I fracture, volume rendering and coronal view images.

**Fig. 11:** Severe head injury and complex facial fracture, including bilateral Le Fort II (red lines) and right Le Fort III (blue line), volume rendering image and coronal view. The red arrow point the zygomatic arch fracture that is the hallmark of Le Fort III fracture.
Fig. 12: Four year old boy with bilateral mandibular condyle fracture, volume rendering posterior view.

Fig. 13: Twelve year old girl with head injury and left frontal bone fracture with extension to anterior cranial fossa, orbital apex (blue arrow) and vertical oblique fracture line in left maxilar bone (inferior red arrow)
Conclusion

The MDCT is the fundamental technique to detect and characterize facial traumas. It is necessary to realize multi-planar reconstructions, especially in coronal section and 3D reconstruction in order to perform a correct classification. The radiologist has to know the facial buttresses and the most frequent patterns of facial fractures. It is important that he looks for those fractures that require surgical treatment in order to inform and guide the surgeon, instead of simple listing of radiologic findings.

References


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