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CASE SERIES

Serial Case of CT Scan Imaging in Fracture of Midface Region

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ABSTRACT

Background: Fractures in the face region are frequently seen in motor vehicle accidents, as the face is highly exposed during such incidents. Motor vehicle accidents are common in Bali, with fracture of the face region is the 2nd most common injury found in radiologic examination. Computed tomography (CT) scans are crucial for assessing these fractures, allowing for an accurate evaluation of severity to plan the patient treatment. **Case:** We present serial cases CT scan images of complex midface fractures such as Le Fort, tripod, NOE and orbital wall fracture and its characteristic imaging on CT-imaging. **Conclusions:** CT scan may guide treatment plans aimed at minimizing disability and enhancing the patient's quality of life. Understanding the imaging characteristics of midface fractures is thus essential for effective diagnosis and management.

Keywords: Midface, trauma, fracture, CT-scan.

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INTRODUCTION

Bali, Indonesia, is known for its tourism, however motor vehicle accidents are also common in the area, involving locals and also tourist. Riasa et al. (2020) founds, fracture of the face region is the 2nd most common injury found in radiologic examination in tourist that had motor vehicle accidents after intracranial bleeding, with fracture of the mid-face region is the most common fracture after nasal fracture.[1]

Other than aesthetic features, midface region also has crucial function due to the amount of nerve system and muscle in the midface region. Disruption of the bone, muscle and nerve system may cause disability to the patient and may cause morbidity. Computed tomography scan (CT-Scan) is the most important imaging examination that can provide image of the bone, soft tissue features and offers multi-planar and 3 dimensions (3D) image reconstruction while can be performed faster and easier patient positioning than conventional study. We reviewed case of CT-scan imaging in complex fracture of the midface also its critical imaging features needs to be reported.

CASE SERIES

Anatomy of the Midface

Restoring alignment of the face is the main target of surgical therapy. Face is a complex structure which is constructed by 6 pairs of bones (palatine, nasal, lacrimal, inferior nasal concha, zygoma and maxilla) and 2 un-paired bones (vomer and mandibula). Due to the proximity with vulnerable soft tissue, and its function, it is important to describe fracture that happens to these bones. However, facial buttress (Fig. 1) is an area of the face that has thicker bone is also important to evaluate. Disruption in the facial buttress will cause deformation of the face and disrupt functions such as masticator function or the orbital

structure and function thus needing surgical intervention.[2]

The conceptual of buttress system of the face, simplifies the skeletal structure into four pairs each of horizontal and vertical struts (**Figure 1**). The horizontal buttresses are the upper transverse maxillary, lower transverse maxillary, upper transverse mandibular, and lower transverse mandibular buttresses. The vertical buttresses are the medial maxillary, lateral maxillary, posterior maxillary, and posterior vertical mandibular buttresses.[2] One example of the importance function of the buttress system is on Le Fort fractures (craniofacial dissociation) where there is a disruption on the posterior maxillary buttress (pterygoid plates) which may cause the separation of midface with the cranium.[2]

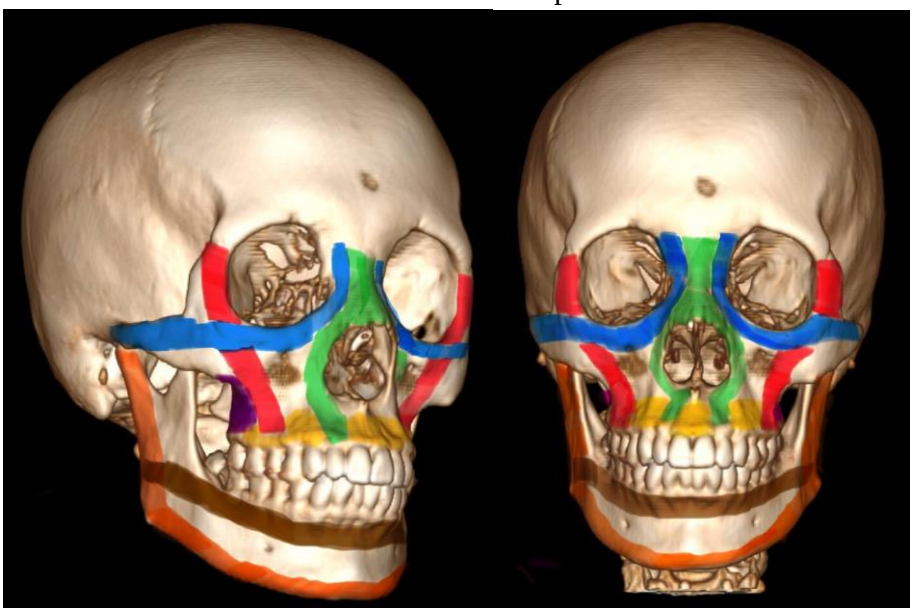

Figure 1. The buttress system of an adult skull in 3D CT images in frontal (a) and lateral oblique orientations (b). The horizontal buttresses are the upper transverse maxillary (blue), lower transverse maxillary (yellow), upper transverse mandibular (brown), and lower transverse mandibular (orange) buttresses. Vertical buttresses are the medial maxillary (green), lateral maxillary (red), posterior maxillary (purple), and posterior vertical mandibular (orange) buttresses.

A few notes to be taken, (a) the concept of evaluating facial buttress is to evaluate the integrity of the facial structure. (b) Buttress has enough thickness to accommodate metal screw internal fixation. (c) Facial buttress itself is a structural unit, therefore it had to be attached and intact to the base of the skull and cranium to be a stable structure. (d) The transverse buttress system makes of the width and profile of the face while the vertical buttress system makes the height profile of the face. (e) The facial buttress system had support function to its surrounding soft tissue organ such as upper transverse maxillary buttress and upper part of the lateral maxillary buttress has the function to support the eye ball structure, while the lower transverse maxillary and upper transverse mandibular support teeth structure.

Role of CT-Scan

Nowadays, CT-Scan are widely available examination. CT-scan is the golden standard examination for facial imaging.[3] CT-scan is more sensitive and specific to detect facial fractures than conventional study while also evaluates whether there are injuries to brain.[4] We can utilize not just axial image from CT, but also multi planar (MPR), maximum intensity projection (MIP) and also 3D render model from CT-scan examination. Surgeons can also utilize the three dimensional (3D)

images to plan operations approach to correct the alignment and to restore cosmetic.[4]

Fracture of the midface

Fracture on the midface regions can be classified into 2 types, simple fracture such as nasal fracture or mandibular fractures and complex fracture (**Table 1**) which involves multiple structure of the midface such as Le Fort fractures, zygomatico-maxillary complex fractures.[4]

Table 1. Complex fracture of midface classification and its distinct feature.

Le Fort Fracture	Type I: floating palatum Type II: Floating maxilla Type III: Craniofacial disassociation
Naso-orbito-ethmoidal (NOE) complex fracture (Markowitz and Manson Classifications)	Type I: Involve fracture of NOE with large intact bone fragment fracture with intact medial canthal tendon and its insertion in the bone Type II: Fracture of the NOE with comminuted (multi-fragmented) fracture, intact medial canthal tendon Type III: Comminuted fracture of NOE with avulsion of the medial canthal tendon from its insertion
Orbital wall fractures (blowout)	Comminuted/unhinged (open), hinged, trapdoor and linear fracture (non-displaced)
Zygomaticomaxillary complex fracture	Complete/comminuted fracture of zygomaticofrontal, zygomaticosphenoid, zygomaticomaxillary and zygomaticotemporal

Le Fort Fractures

Le Fort fractures is a complex fracture of the face that involves multiple structure of the face. It is usually caused by a high impact force. The specific imaging sign is when we found a craniofacial disassociation with multiple defects in the facial buttress which causes multiple degree of fractures. Le Fort fracture is classified into 3 groups based on its fracture pattern (**Figure 2**). Each Le Fort types can be conceptualized as a floating palatum (Le Fort type I), floating maxilla (Le Fort type II) and craniofacial disassociation (Le Fort type III).[4,6] However, the base of Le Fort fracture is when there is a complete nor comminuted fracture on the pterygoid plate, with each type is characterized further by separation of maxilla or craniofacial disassociation (**Table 2**). Keep in mind that combination of Le Fort fracture can happen and Le Fort fractures also can be unilateral when there is a complete displaced sagittal/parasagittal fracture of the palatum.[6] It is also important to report about the distance of malocclusion that occurs for surgeons to estimate the correction that needs to be done.

Naso-Orbito-Ethmoid (NOE) fracture

NOE fracture usually happens due to high velocity blunt trauma on lateral midface which causes defect on the NOE region which include 5 cardinal line which is: (a). lateral nose and aperture piriform, (b) nasomaxillary buttress, (c) floor dan inferior orbital rim, (d) medial orbital wall and (e) frontomaxillary suture.[7]

NOE fracture is categorized into 3 categories according to Markowitz-Manson classification which can be seen on table 1. However, on type III in which there is avulsion of the medial canthal ligament from its osseus insertion, it cannot be diagnosed with CT-imaging, therefore physical exam is also needed for reporting.

It is also important to report the degree of fracture that happens on the fossa lacrimal region and also the distance of the left and right lacrimal fossa on coronal plane to give

data for the surgeon in medial canthopexy procedure.

Pure NOE fractures are rare, almost around 60% of case are associated with ZMC fracture nor other panfacial fractures, which is also important to report to the surgeon for treatment planning.[7]

Table 2. Criteria of Le Fort fracture classification on CT image site confirmation.

Site of fracture	CT Plane evaluation	Le Fort Type	Site of fracture confirmation
Inferior medial maxillary buttress (piriform aperture)	Coronal	I	Inferior lateral maxillary buttress
Upper transverse maxillary buttress (inferior orbital rim)	Coronal, axial	II	Lateral maxillary buttress, orbital floor, nasofrontal junction
Upper transverse maxillary buttress (zygomatic arch)	Coronal, axial	III	Zygomaticofrontal suture, zygomaticosphenoid, orbital floor and nasofrontal junction

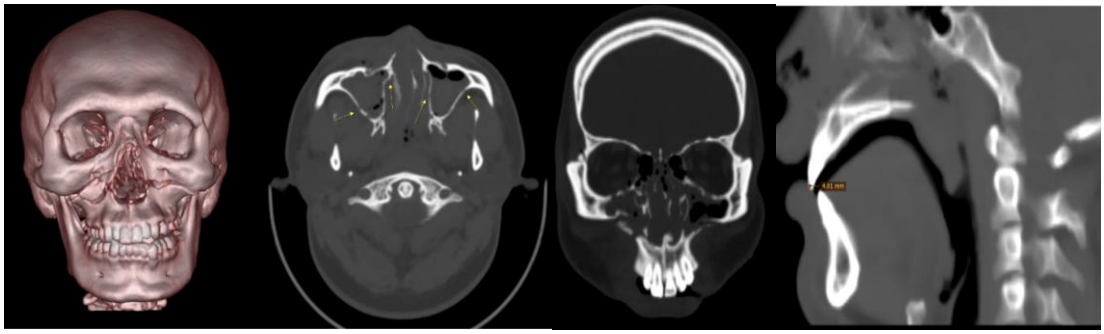

Figure 2. Head CT scan of a 26 years old male involved in motorcycle accident showed fracture on bilateral pterygoid plate, lateral margin of nasal fossa and anterior-medial-lateral sinus wall (arrow) which causes a floating palatum shape which is a Le Fort fracture type I. Notice that malocclusion also happens to the patient.

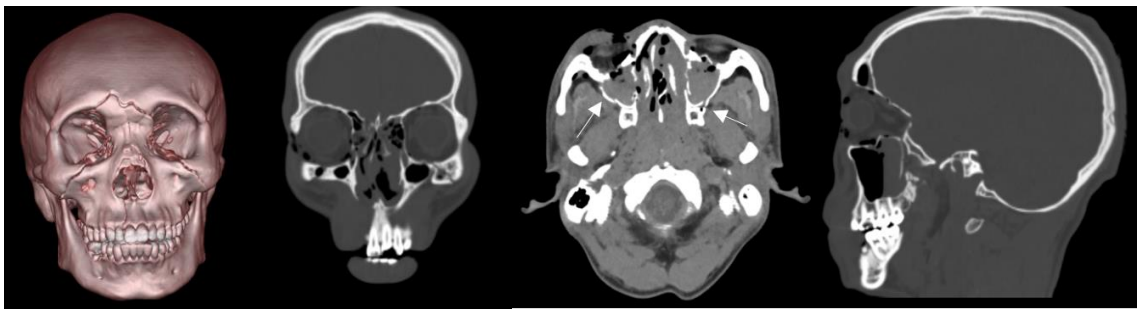

Figure 3. A 23 years old male involved in a motorcycle accident, on CT Scan exam, there are comminuted fracture on the bilateral pterygomaxillary (white arrow), anterior-medial-posterolateral maxillary sinus wall, inferior orbital rim and the nasofrontal junction. On 3D reconstruction image, we can see the pyramid like fracture line, which gives the appearance of floating maxilla or Le Fort fracture type II.

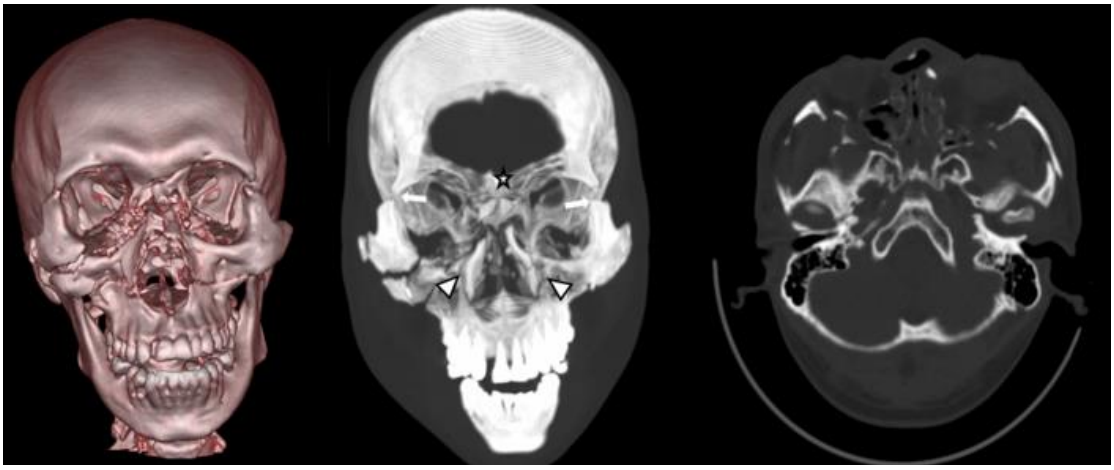

Figure 4. A 36 years old male hit by a falling tree on the face. On Head CT exam, there are fractures on the bilateral orbital lateral-inferior-medial wall, nasofrontal junction (star), zygomafrontalis suture (thick arrow), processus pterygoid medial and lateral which gives the impression of a floating face on 3D images, which is a characteristic for Le Fort fracture type III. On this patient, we can also see fracture of the right zygoma arch and also fracture that causes the separation of the right zygoma bone from the calvaria which is a right side zygomaticomaxillary complex fracture.

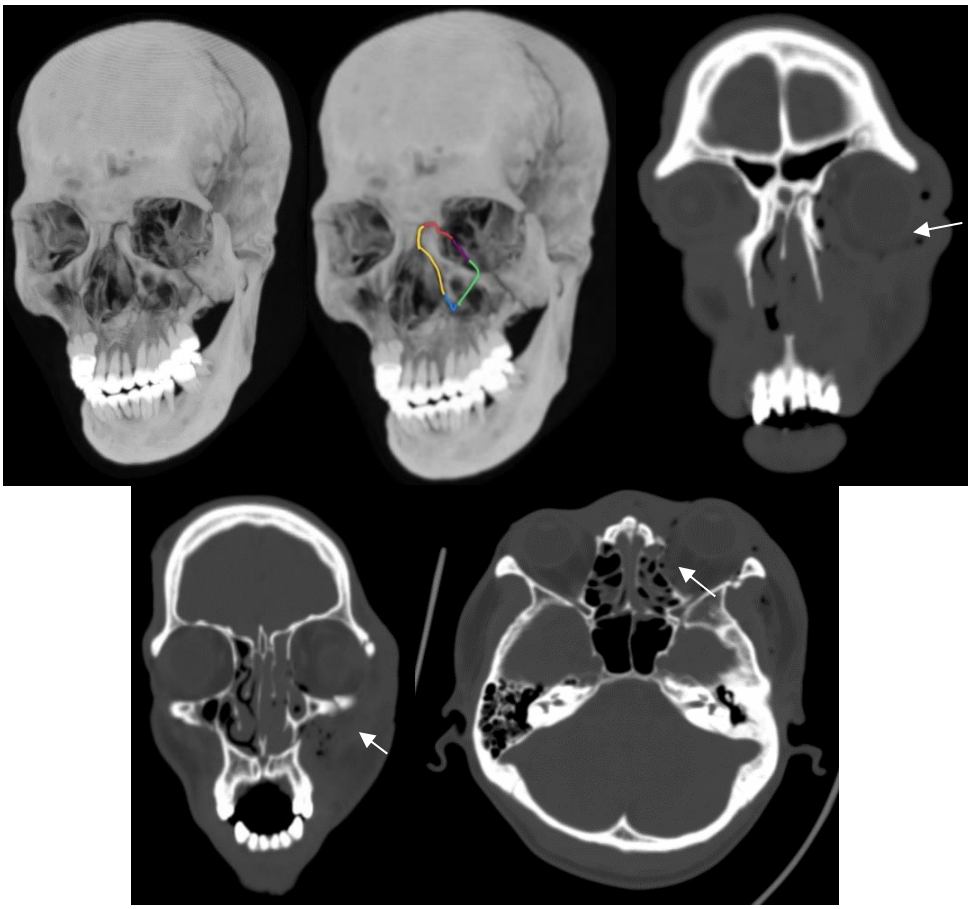

Figure 5. A 38 years old male involved in a motorcycle accident without using helmet with active bleeding from the medial side of the eye but the patient still able to move his left eye. On Axial CT-scan reformat coronal and MIP shows comminuted fracture along the 5-cardinal line: left lateral nose and aperture piriform (yellow line), nasomaxillary buttress (blue line), anterior maxillary wall through orbital floor (green line), medial wall orbital (purple line) and left frontomaxillary suture (red line) which is left side type II NOE fracture (Markowitz and Manson classification). We can also see there is a fracture on the left frontozygoma suture and left temporal and parietal bone.

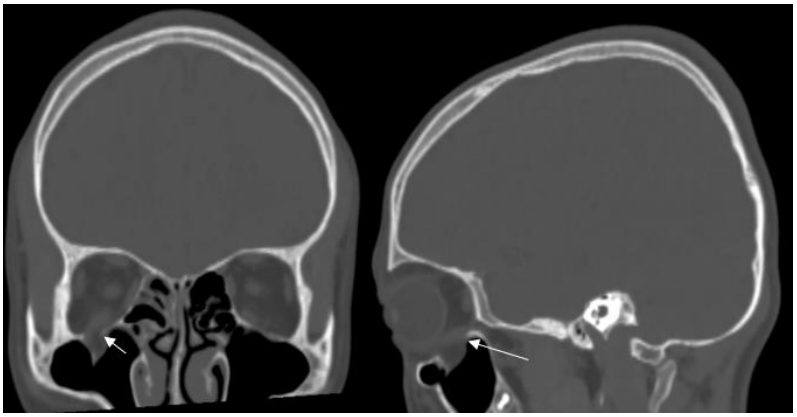

Figure 6. A 13 years old male patient with complaints of double vision on right eye post accidentally hitting the corner of the table. On CT scan coronal and sagittal view, there is a defect on the inferior orbital floor, with herniation of the orbital fat and partial of the inferior rectus muscle of the right eye (arrow). This is a case of orbital blow-out fracture, hinged type, without trapdoor appearance.

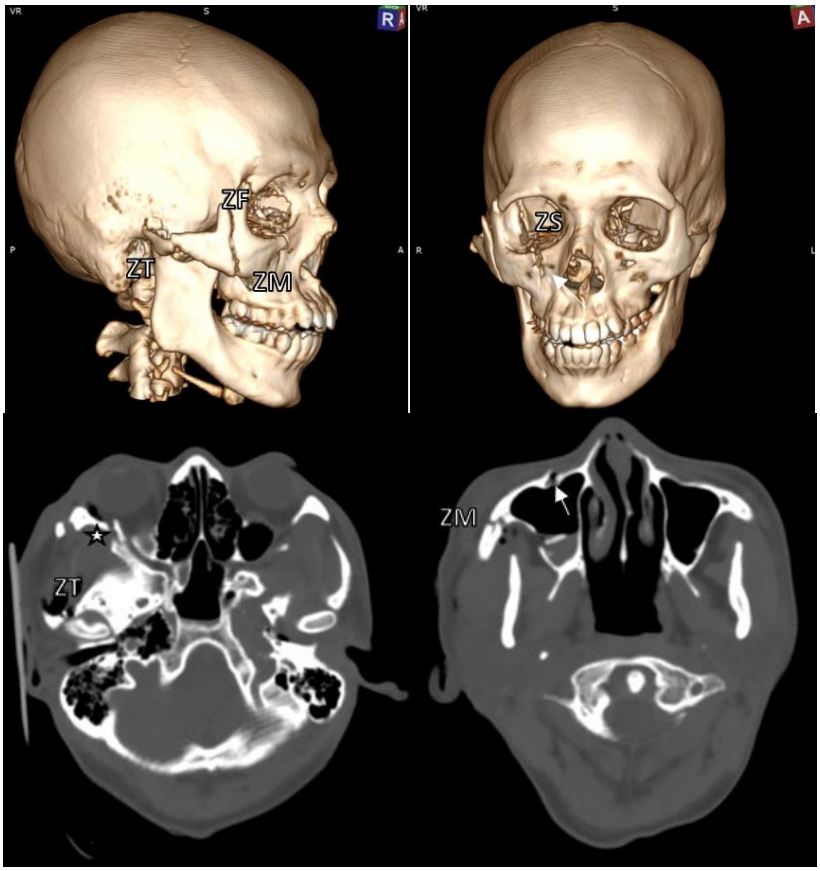

Figure 7. A 22 years old male post motorcycle accident. On Head CT-scan axial and 3D reconstruction, on 3D reconstruction we can see the disruption of zygomaticofrontal (ZF), zygomaticosphenoid (ZS), zygomaticomaxillary (ZM) and zygomaticotemporal (ZT) suture which shows a case of ZMC fracture. On axial view, we can also see fractures of the anterior maxillary sinus wall (arrow) and that the defect of the ZS suture is caused by comminuted fracture of the right lateral orbital wall (☆) with the fragments medially displaced which is a case of blow-in right orbital fracture.

Orbital wall fracture

Orbital wall fracture can be as an isolated fracture or associated with Le Fort, NOE and ZMC fractures.[8] Fracture of the orbital wall can cause a blow-out fracture or a blow-in fracture, which depends on whether the fragment of the orbital floor or walls displaced into the eye socket (blow-in

fracture) or into the maxillary sinus (blow-out fracture). Blow-out fracture itself is divided into comminuted/unhinged (open), hinged, trapdoor, and linear (non-displaced) fractures. They are defined by the degree of the displaced orbital floor window into the maxillary sinus. Usually, the point pivot of the hinge is located at the transition zone between the orbital floor and the medial wall of the orbit.[8]

It is important to report the characteristic of the fracture (comminuted/ hinged/unhinged) and the soft tissue (periorbital fat, muscle, bulb or optic nerve) herniation that occurs to evaluate the planning for surgery and also to predict the risk of chronic dipoplia even after surgery.[3] On CT exam, when an enophthalmos of more than 2mm is an indication for surgery, while a sign of muscle incarceration is an indication of urgent surgery, when there are no such conditions, the surgery can be postponed up to 2 weeks to allow reduction of orbital oedema, bleeding, and emphysema.[9]

Zygomaticomaxillary Complex (ZMC) Fracture

Fractures of the zygomatico-maxillary complex or tripod/tetrapod fracture are usually caused by direct impact to the malar eminence, resulting in separation of the zygomatic bone from the calvaria bone. In normal condition, there are 4 sutures that attaches to the skull and midface, they are: zygomaticofrontal (ZF), zygomaticosphenoid (ZS), zygomatico-maxillary (ZM), and zygomaticotemporal (ZT), disruption of all 4 sutures will cause separation of the zygoma bone or ZMC fracture.[4]

The zygoma bone itself has an important function, not just as cosmetically giving the height and width shape of the face, it also functions as a lateral side wall of the orbit, in which when fracture happens may cause disruption in the integrity of orbital structure, artery damage and also damages to cranial nerve II-VI which courses through the superior orbital fissure, therefore it is important to give detailed structural damage to the zygoma bone.[4]

CONCLUSION

The complications of fractures in the midface region are not only limited to aesthetics, but also involve the function of organs surrounding the fracture. Understanding the anatomy of bone structure, as well as facial buttresses and types of fractures in the midface region, is crucial in evaluating patients with post-traumatic facial injuries.

It is also important to remember that there can be multiple type of complex mid-face fracture that can happens on one site. It is important to recognize these signs since they greatly affect the patient's prognosis, especially for treatment planning and preventing long-term complications both from the trauma itself and post-treatment in the future.

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