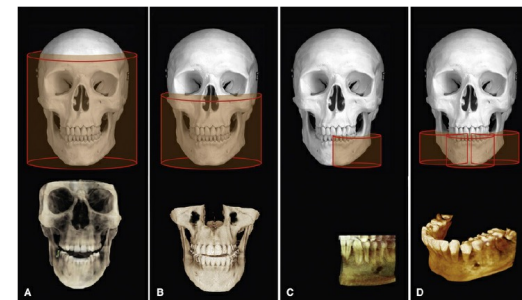


# Trauma Imaging

Dr Dayea Oh  
Oral & Maxillofacial  
Radiologist



# Objectives

- Understand imaging goals in facial trauma
- Review relevant maxillofacial anatomy on imaging
- Compare CT, CBCT, and I/O radiographs

# Contents

## Dento-alveolar trauma

- Injuries to dental structures
- Injuries to supporting structures

## When to use Cone Beam CT

## Facial Trauma & Multislice CT

# Dento-alveolar trauma

---

- ~5% of all bodily injuries (all ages)
- **15.5%** of patients aged between 7 and 20 had at least one traumatic dental injury to permanent dentition (Eilert-Petersson, 1997)
- Primary dentition injury prevalence **22.7%** (Petti, Glendor and Andersson, 2018)
- If trauma occurs at an age below 9 years, there is **8x risk for new trauma** (Glendor, 2007)



# Risk Factors

---

- Increased overjet with protrusion of upper incisors
- Insufficient lip closure
- Behaviour
  - Risk-taking
  - Peer relationship problems
  - Attention-deficit hyperactivity disorder (ADHD)
  - Stress



# Classifications

---

- More than 50 classifications (Andersson 2022)
- **Modified Andreasen's (by WHO) in 1994**
  - Most frequently used
  - Applies to both primary and permanent dentitions
- International Association of Dental Traumatology (IADT)
- American Association of Endodontists (AAE)



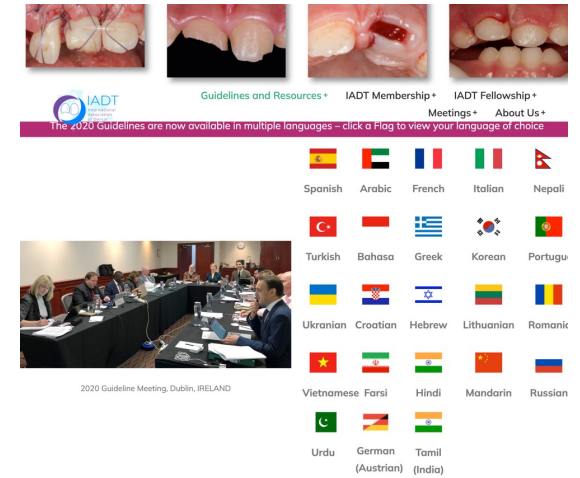
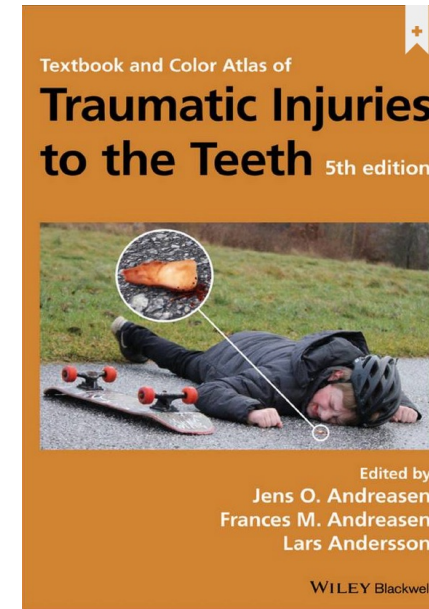
**International Association  
of Dental Traumatology**

# WHO (Andreasen's)

- I. Injuries to the hard dental tissues and the pulp
- II. Injuries to the periodontal tissues
- III. Injuries to the supporting bone
- IV. Injuries to gingiva or oral mucosa

NOW:

- I. Hard tissues and Pulp Injuries
- II. Periodontal Injuries



## Dental Traumatology

SHORT COMMUNICATION | [Open Access](#) | [CC BY](#)

### NAOD – The new Traumatic Dental Injury classification of the World Health Organization

[Stefano Petti](#) ✉, [Jens Ove Andreasen](#), [Ulf Glendor](#), [Lars Andersson](#)

First published: 28 April 2022 | <https://doi.org/10.1111/edt.12753> |

[VIEW METRICS](#)

# I. Injuries to the hard dental tissues and the pulp



**Infraction**



**Enamel fracture**



**Enamel-dentin fracture**



**Enamel-dentin-pulp fracture**



**Crown-root fracture without pulp involvement**



**Crown-root fracture with pulp involvement**

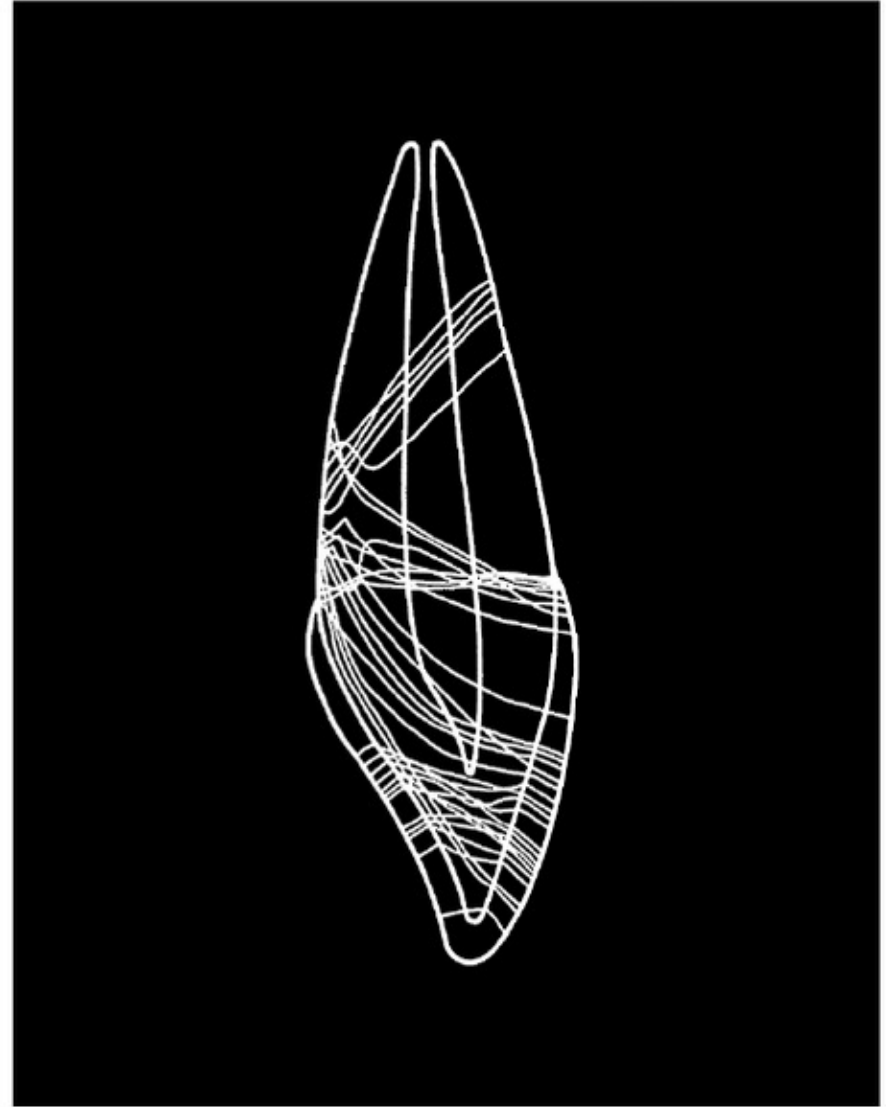


**Root fracture**

# Tooth fracture patterns

---

- Analysis of 33 fracture lines (of anterior teeth under direct frontal impacts)
- Four common fracture patterns:
  - Horizontal crown fracture
  - Horizontal fracture at the neck of the tooth
  - Oblique crown-root fracture
  - Oblique root fracture



## II. Injuries to the periodontal tissues



**Concussion**



**Subluxation**



**Extrusion**



**Lateral luxation**



**Intrusion**



**Avulsion**

*“Radiographs are necessary to make a **thorough diagnosis** of dental injuries. Tooth root and bone fractures, for instance, may occur without any clinical signs or symptoms and are frequently undetected when only one radiographic view is used.” (IADT, 2020)*



**International Association  
of Dental Traumatology**

# Dental Traumatology

COMPREHENSIVE REVIEW | [Open Access](#) | 

## International Association of Dental Traumatology guidelines for the management of traumatic dental injuries: 1. Fractures and luxations

Cecilia Bourguignon, Nestor Cohenca, Eva Lauridsen, Marie Therese Flores, Anne C. O'Connell, Peter F. Day, Georgios Tsilingaridis, Paul V. Abbott, Ashraf F. Fouad, Lamar Hicks ... [See all authors](#) ▾

First published: 31 May 2020 | <https://doi.org/10.1111/edt.12578>

Since maxillary central incisors are the most frequently affected teeth, the radiographs listed below are recommended to thoroughly examine the injured area:

1. One parallel periapical radiograph aimed through the midline to show the two maxillary central incisors.
2. One parallel periapical radiograph aimed at the maxillary right lateral incisors (should also show the right canine and central incisor).
3. One parallel periapical radiograph aimed at the maxillary left lateral incisor (should also show the left canine and central incisor).
4. One maxillary occlusal radiograph.
5. At least one parallel periapical radiograph of the lower incisors centered on the two mandibular centrals. However, other radiographs may be indicated if there are obvious injuries of the mandibular teeth (eg, similar periapical radiographs as above for the maxillary teeth, mandibular occlusal radiograph).



|                                                         | CROWN FRACTURE                                                                                                                                                                                                                                                     |                                                                                                                                                                                                                                                                      | CROWN/ROOT FRACTURE                                                                                                                                                                                                                                       | ROOT FRACTURE                                                                                                                                                                                                                                                                                                                                                                                                     | ALVEOLAR FRACTURE                                                                                                                                                                                                                                                                                                                           |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|---------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
|                                                         | UNCOMPLICATED                                                                                                                                                                                                                                                      | COMPLICATED                                                                                                                                                                                                                                                          |                                                                                                                                                                                                                                                           |                                                                                                                                                                                                                                                                                                                                                                                                                   |                                                                                                                                                                                                                                                                                                                                             |
| <b>DEFINITION AND DIAGNOSIS</b>                         | Enamel and dentin fracture without pulp exposure.                                                                                                                                                                                                                  | Enamel and dentin fracture with pulp exposure.                                                                                                                                                                                                                       | A fracture involving enamel, dentin, and cementum with loss of tooth structure.<br><br>Crown fracture extends below gingival margin.<br><br>The pulp may or may not be exposed.                                                                           | A fracture involving the root structure. It can be localized at the apical, middle or cervical third.                                                                                                                                                                                                                                                                                                             | The bone segment containing the involved tooth/teeth is fractured and mobile.                                                                                                                                                                                                                                                               |
| <b>CLINICAL ASSESMENT AND FINDINGS</b>                  | Sensitivity tests and vitality tests are likely to give positive results.<br><br>Normal mobility.<br><br>Percussion test: not tender. If tenderness is observed, evaluate the tooth for possible luxation or root fracture.                                        | Sensitivity tests and vitality tests are likely to give positive results.<br><br>Exposed pulp sensitive to stimuli.<br><br>Normal mobility.<br><br>Percussion test: not tender. If tenderness is observed, evaluate the tooth for possible luxation or root fracture | Sensitivity tests and vitality tests are likely to give positive results.<br><br>Tender to percussion.<br><br>Coronal fragment is mobile.                                                                                                                 | The coronal fragment is usually mobile and sometimes displaced.<br><br>The apical segment is usually not displaced.<br><br>Tender to percussion.<br><br>Sensitivity tests may be initially negative indicating transient pulpal damage.                                                                                                                                                                           | Fracture lines may be located at any level, from the marginal bone to the root apex.<br><br>Mobility of the teeth may be segmental if the fracture involves more than one alveolar socket.<br><br>Occlusal interference is often present due to misalignment of the fractured alveolar segment.<br><br>Displacement of an alveolar segment. |
| <b>IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS</b> | One occlusal and two periapical radiographs from mesial and distal are recommended in order to rule out displacement or the possible presence of a root fracture.<br><br>Radiograph of lip or cheek lacerations to search for tooth fragments or foreign material. | One occlusal and two periapical radiographs from mesial and distal are recommended in order to rule out displacement or the possible presence of a root fracture.<br><br>Radiograph of lip or cheek lacerations to search for tooth fragments or foreign material    | One occlusal and two periapical radiographs from mesial and distal are recommended in order to rule out displacement or the possible presence of a root fracture.<br><br>CBCT should be considered to reveal the extension and direction of the fracture. | One occlusal radiograph to determine the level of the root fracture at the apical and middle third.<br><br>Two periapical radiographs with varying horizontal angles are needed to locate the fractures in the cervical third of the root.<br><br>For a root fracture in the middle third, CBCT may rule out or confirm an oblique course of fracture involving the cervical third in the labiolingual dimension. | In addition to the three angulations and occlusal film, additional views such as a panoramic radiograph can be helpful in determining the course and position of the fracture lines.<br><br>CBCT may be useful for diagnosis of alveolar fractures, especially when they involve the palatal or both cortical plates.                       |

|                                                         | CONCUSSION                                                                                                                                                                                                             | SUBLUXATION                                                                                                                                                                                                            | EXTRUSIVE LUXATION                                                                                                                                                                                                                              | LATERAL LUXATION                                                                                                                                                                                                                   | INTRUSIVE LUXATION                                                                                                                                                                                                                                                                                                                                                                                                                                                |
|---------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>DEFINITION AND DIAGNOSIS</b>                         | Tooth is tender to touch and/or percussion but without displacement or abnormal mobility.                                                                                                                              | Tooth is tender to touch and/or percussion and mobile, but not displaced.                                                                                                                                              | Displacement of the tooth outward or incisally.                                                                                                                                                                                                 | Displacement of the tooth in any lateral direction except axially; usually associated with a fracture of the facial cortical bone.                                                                                                 | Displacement of the tooth inward and into the alveolar bone.                                                                                                                                                                                                                                                                                                                                                                                                      |
| <b>CLINICAL ASSESSMENT AND FINDINGS</b>                 | Sensitivity and vitality tests are likely to give positive results.<br><br>Tender to percussion.                                                                                                                       | Sensitivity tests may be initially negative, indicating transient pulpal damage.<br><br>Vitality tests are likely to give positive results.<br><br>Tender to percussion.                                               | The tooth appears elongated and is excessively mobile.<br><br>Sensitivity and vitality tests are likely to give negative results<br><br>Tender to percussion.                                                                                   | The tooth appears immobile or locked.<br><br>Fracture of the alveolar process may be palpable.<br><br>Sensitivity and vitality tests are likely to give negative results.<br><br>Tender to percussion.                             | The tooth appears partially or totally infra-occluded, immobile and locked.<br><br>Fracture of the alveolar process may be palpable.<br><br>Sensitivity and vitality tests are likely to give negative results.<br><br>Tender to percussion.                                                                                                                                                                                                                      |
| <b>IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS</b> | Two periapical radiographs from mesial and distal to exclude displacement.<br><br>No radiographic abnormalities are expected.<br><br>CBCT should be considered if available and based on the severity of the injuries. | Two periapical radiographs from mesial and distal to exclude displacement.<br><br>No radiographic abnormalities are expected.<br><br>CBCT should be considered if available and based on the severity of the injuries. | One occlusal and two periapical radiographs from mesial and distal.<br><br>PDL space appears enlarged.<br><br>CBCT: evidence of increased PDL space and confirmation of the integrity of the socket, mainly on the sagittal and coronal planes. | One occlusal and two periapical radiographs from mesial and distal.<br><br>PDL space appears enlarged.<br><br>CBCT: evidence of increased PDL space and diagnosis of alveolar fracture, mainly on the sagittal and coronal planes. | One occlusal and two periapical radiographs from mesial and distal.<br><br>The periodontal ligament space may be absent from all or part of the root.<br><br>The cement-enamel junction is located more apically than the adjacent, non-injured teeth.<br><br>If the tooth is totally intruded, a lateral should be considered to evaluate the penetration into the nasal cavity.<br><br>CBCT: PDL space may be absent, mainly on the sagittal and coronal planes |

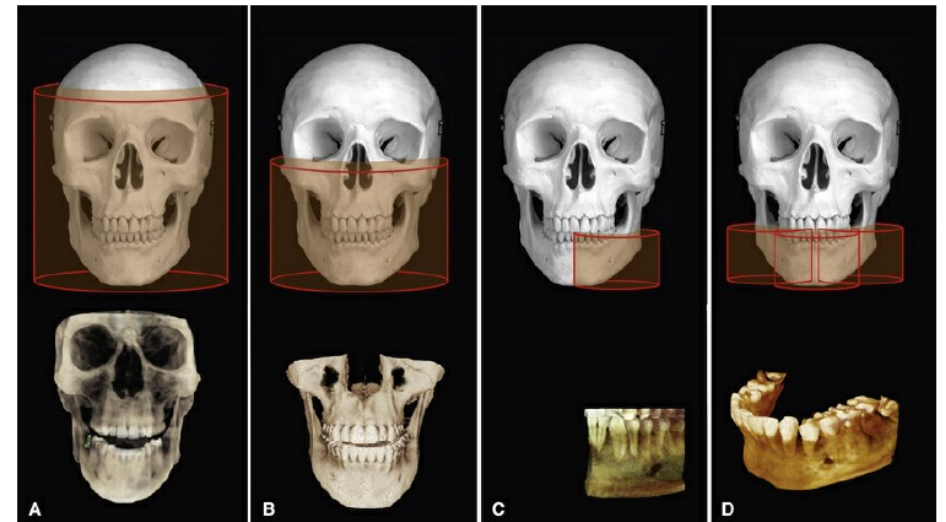
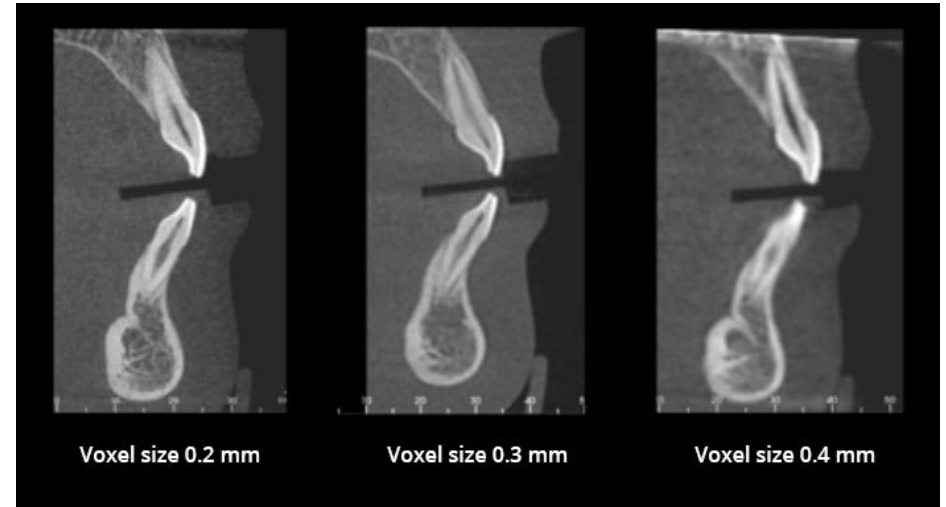
## Avulsion

|                                                         |                                                                                                                                                                    |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>IMAGING AND RADIOGRAPHIC ASSESSMENT AND FINDINGS</b> | Two periapical radiographs from mesial and distal.<br><br>CBCT should be considered to confirm the reposition of the tooth and rule out alveolar bone fracture(s). |
|---------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------|



# Advantages of CBCT

- No superimposition of anatomical structures
- Dimensionally accurate (isotropic voxel)
- Excellent spatial resolution
  - Small FOV + Voxel size (less than 0.1mm ideally)
- Intraoral imaging has poor sensitivity in detecting minimal tooth displacement and root & alveolar fractures, especially:
  - **Labial / palatal tooth displacement (lateral luxation injuries)**
  - **Oblique & vertical root fractures**



# CBCT vs PA in Horizontal Root Fractures?

[Dose Response](#). 2018 Jul-Sep; 16(3): 1559325818789837.  
Published online 2018 Aug 23. doi: [10.1177/1559325818789837](#)

PMCID: PMC6108019  
PMID: [30150907](#)



Hashemnia, et al., Dentistry 2018, 8:9  
DOI: [10.4172/2161-1122.1000513](#)

Role of Computed Tomography Scan in Dental Trauma: A Cross-Sectional Study

[Feng Li](#),<sup>1,\*</sup> [Jun Li](#),<sup>1,\*</sup> [Deming Zhang](#),<sup>2</sup> and [Feng Wu](#)<sup>1</sup>

Cone Beam Computed Tomography and Digital Periapical Radiography in Determining Horizontal Root Fractures: An In-vitro Comparative Study

Seyed Mohsen Hashemnia<sup>1</sup>, Sanaz Jahadi<sup>2</sup>, Shiva Shaygannia<sup>3</sup>, Ehsan Hekmatian<sup>4</sup>, Amirhosein Habibollahi<sup>5</sup>, Maryam Ghazizadeh<sup>5</sup>

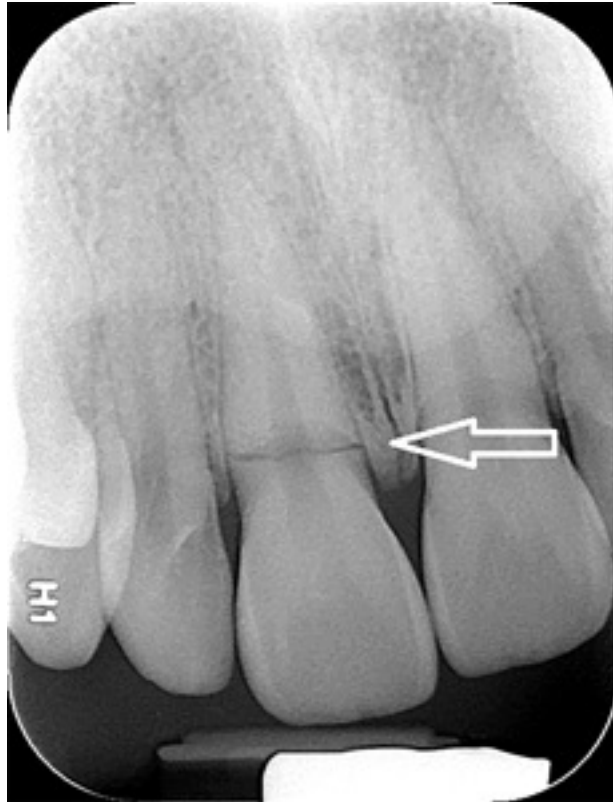
- in vivo study #1 → CBCT has 98.8% sensitivity & 95.6% specificity (100 microns) & PA has 97.2% sensitivity & 78.5% specificity
  - Author states CBCT should be used for detection of **horizontal root fractures**
- In vitro study #2 → CBCT (100microns) vs PA
  - “The sensitivity and specificity of CBCT radiography was **0.97 and 0.93**, and periapical was **0.83 and 0.885** respectively, indicating that the CBCT technique was preferred to the periapical to detect the **horizontal fracture** of the root”
  - “Although CBCT is an accurate imaging modality for detection of root fractures but based on ALARA (as low as reasonably achievable) it must be **used only for symptomatic patients that periapical images did not show any fractures**”

# PA vs CBCT

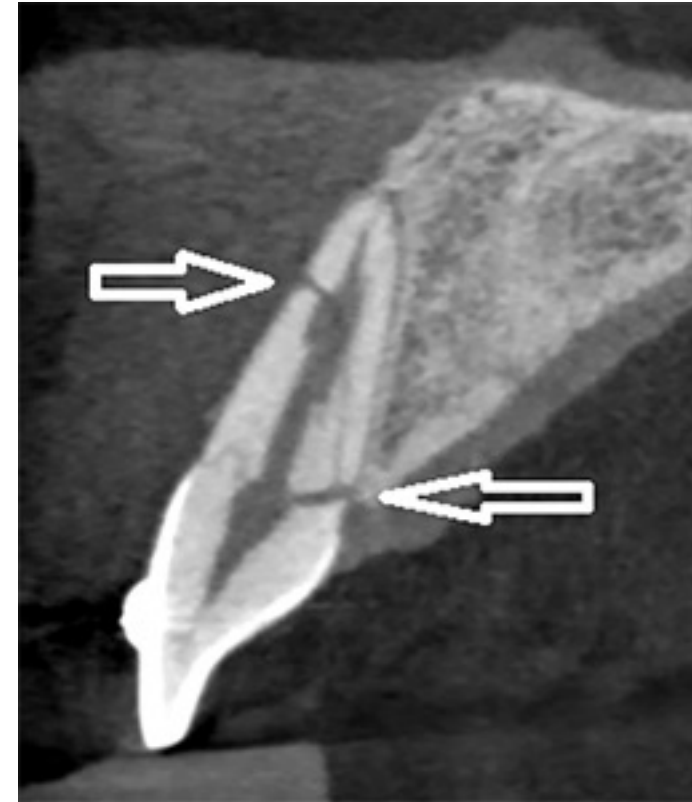
## CBCT Application in Dentoalveolar Trauma

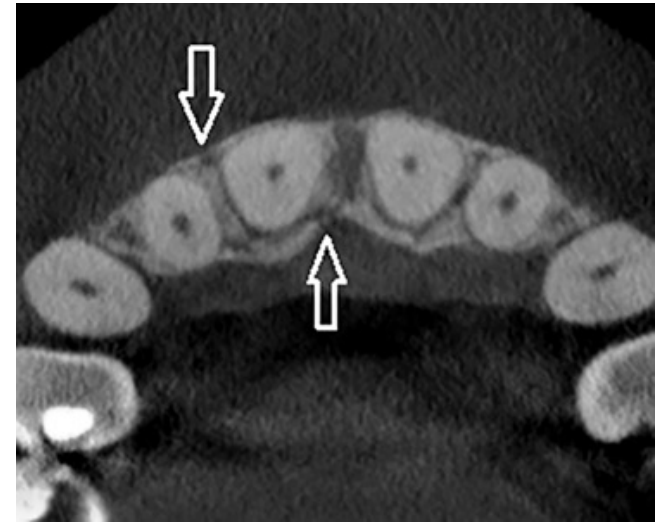
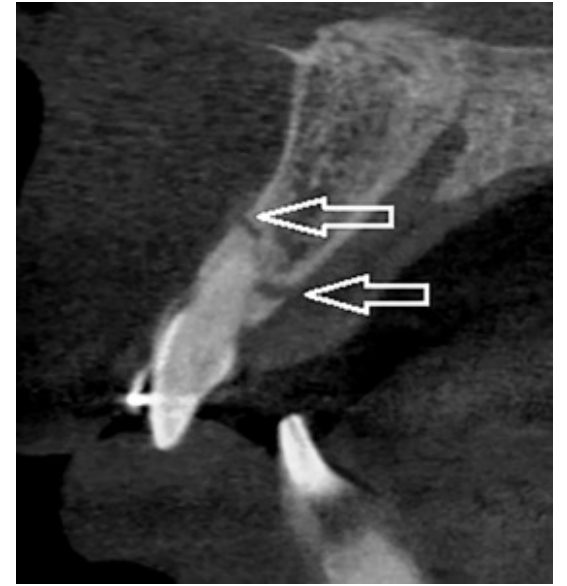
February 14, 2018

by Yosef Nahmias, DDS, MSc; Ali Fatemi, DDS, MSc, FRCD(C)



**Oblique fracture undetected**





# Summary: When to Take CBCT?

- Acute Stage (compliant patient only)
  - **Symptomatic patients that periapical images did not show any fractures**
  - **Accurate assessment of root fractures & luxation injuries**
- Late Stage
  - Review healing
    - “clinical and 2D radiographic examinations may not be sufficient to determine the presence or absence of pulp and periodontium healing”
  - Necrotic Pulp
  - Root resorption

COMPREHENSIVE REVIEW | [Free Access](#)

**Contemporary imaging for the diagnosis and treatment of traumatic dental injuries: A review**

Nestor Cohenca , Adrian Silberman

First published: 20 March 2017 | <https://doi.org/10.1111/edt.12339> | Citations: 16

# Responses of the pulp, periradicular and soft tissues following trauma to the permanent teeth

CY Yu,\* PV Abbott\*

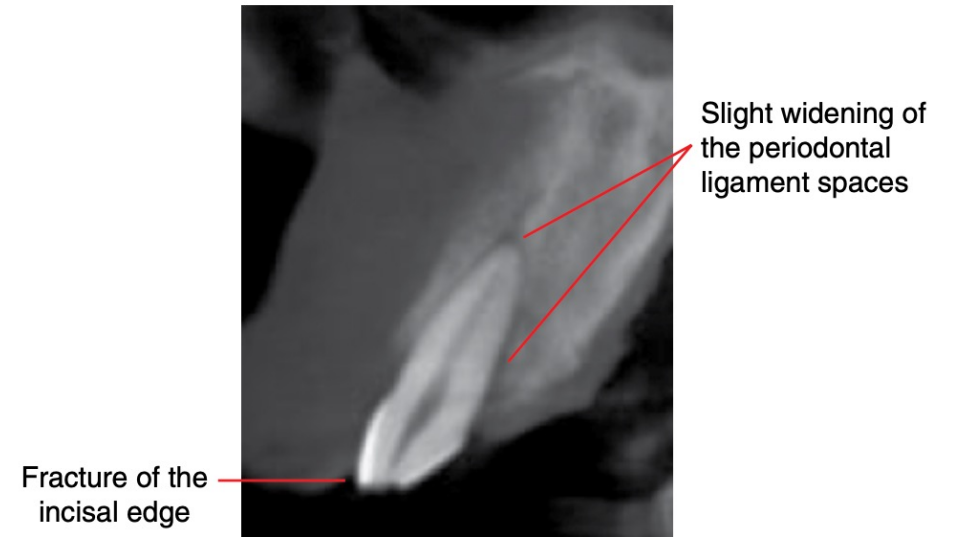
\*School of Dentistry, The University of Western Australia, Western Australia, Australia.

**Table 1. Possible responses of the pulp and root canal system, the periradicular tissues, and the soft tissues following trauma to a tooth**

|                               | Pulp/root canal system                                                                                                                                                                                                                                                                                                  | Periradicular tissues                                                                                                                                                                                                                                                                                                                            | Soft tissues                                                                                                                                                |
|-------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|--------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|-------------------------------------------------------------------------------------------------------------------------------------------------------------|
| <b>Favourable responses</b>   | Recovery and return to normal<br>Tertiary dentine formation<br>Pulp revascularization<br>Pulp fibrosis<br>Pulp canal calcification                                                                                                                                                                                      | Recovery and return to normal<br>Fibrous healing<br>Transient apical breakdown                                                                                                                                                                                                                                                                   | Recovery and return to normal<br>Transient marginal breakdown<br>Fibrous healing (scar)                                                                     |
| <b>Unfavourable responses</b> | Chronic pulp inflammation (pulpitis)<br>Pulp necrobiosis with<br>Pulp necrosis<br>without infection, with infection<br>Infection of the root canal system<br>Internal root resorption<br>surface, inflammatory, and/or replacement<br>Combinations of the above:<br><i>simultaneously and/or sequentially over time</i> | Cessation of root development<br>Disturbances to root development<br>Bone resorption<br>crestal, apical, and/or lateral<br>External root resorption<br>surface, inflammatory, replacement, and/or invasive<br>Ankylosis:<br>with or without root resorption<br>Combinations of the above:<br><i>simultaneously and/or sequentially over time</i> | Loss of attachment/ permanent marginal breakdown<br>Gingival recession<br>Combinations of the above:<br><i>simultaneously and/or sequentially over time</i> |

# CBCT CASES

Identify crown/root #s &  
injuries to periodontal  
structures

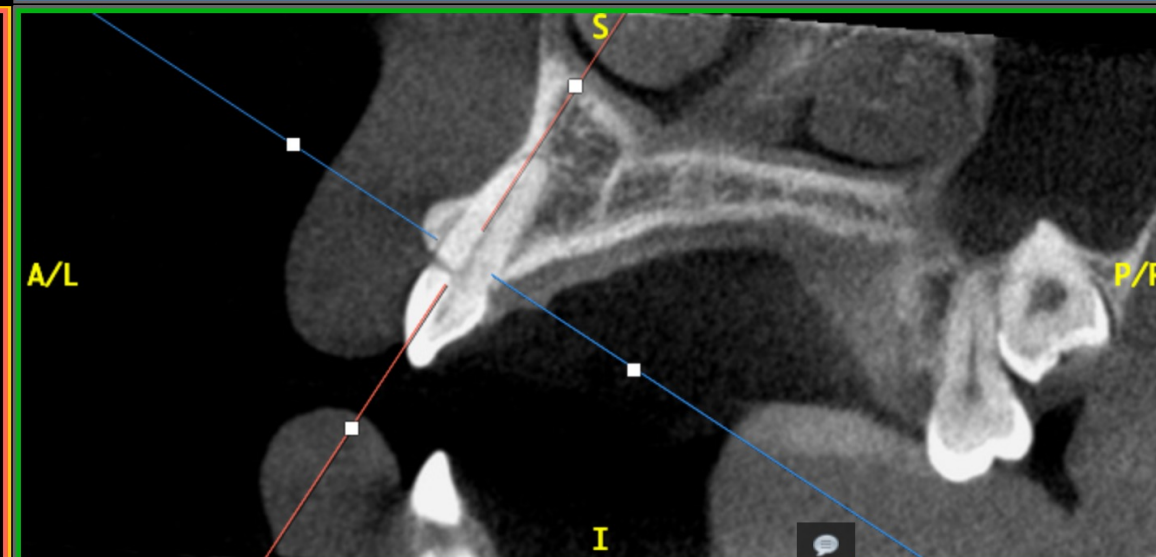
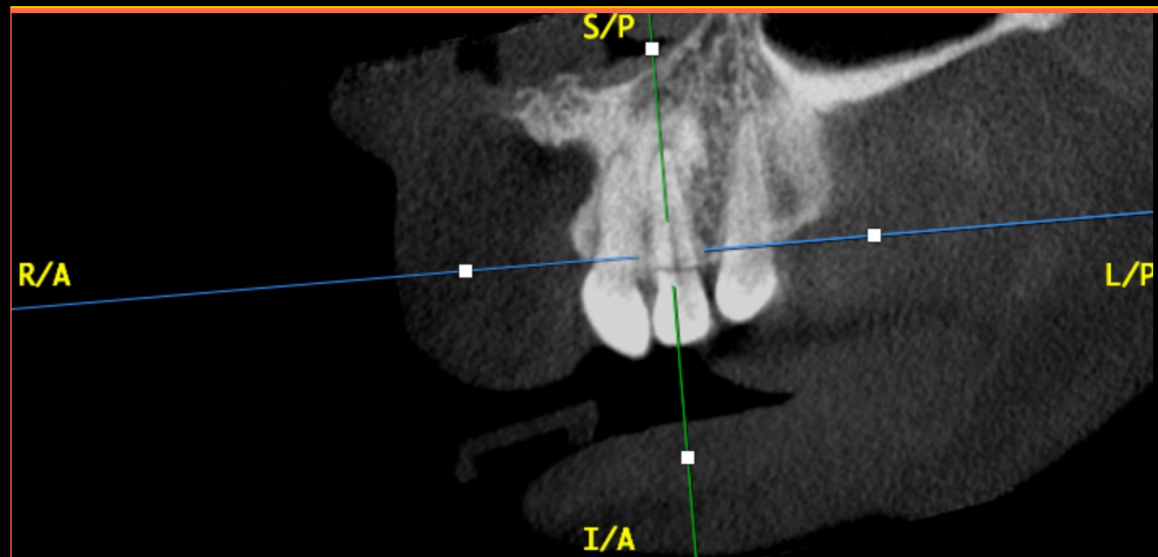
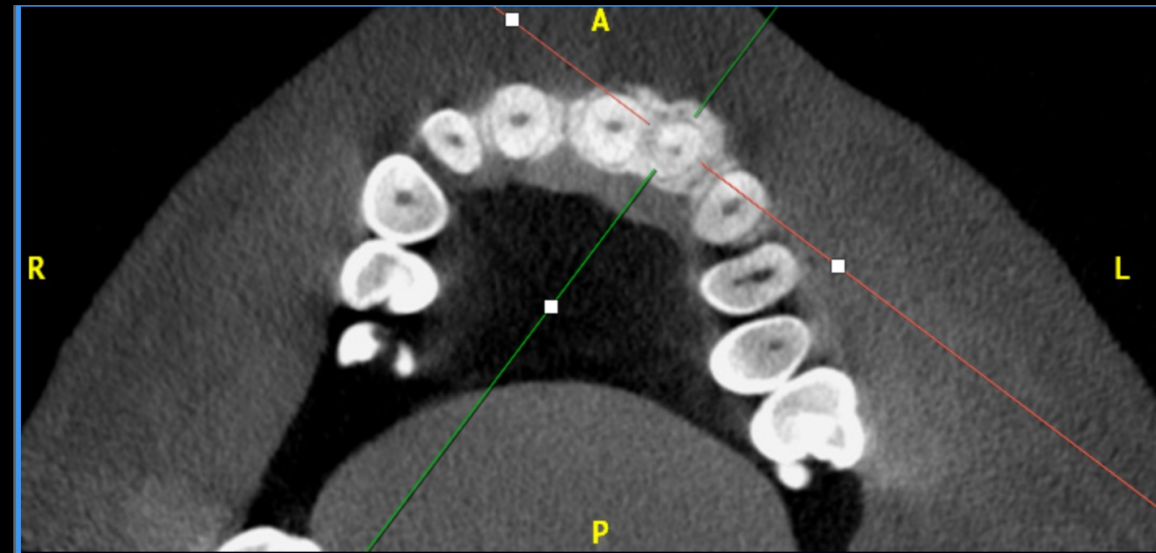
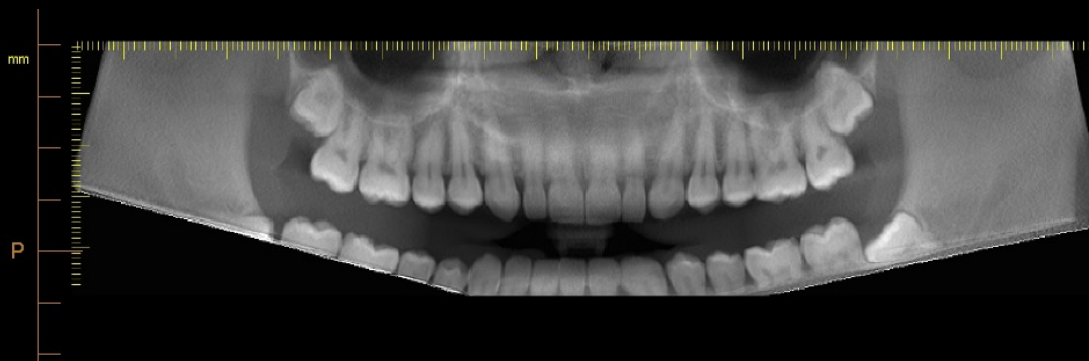


**Figure 17.6** Acute traumatic crown fracture with subluxation, 13: corrected sagittal CBCT image.

*Ref: Atlas of Oral and Maxillofacial Radiology By Bernard Koong*

# MPR

Trauma to 22



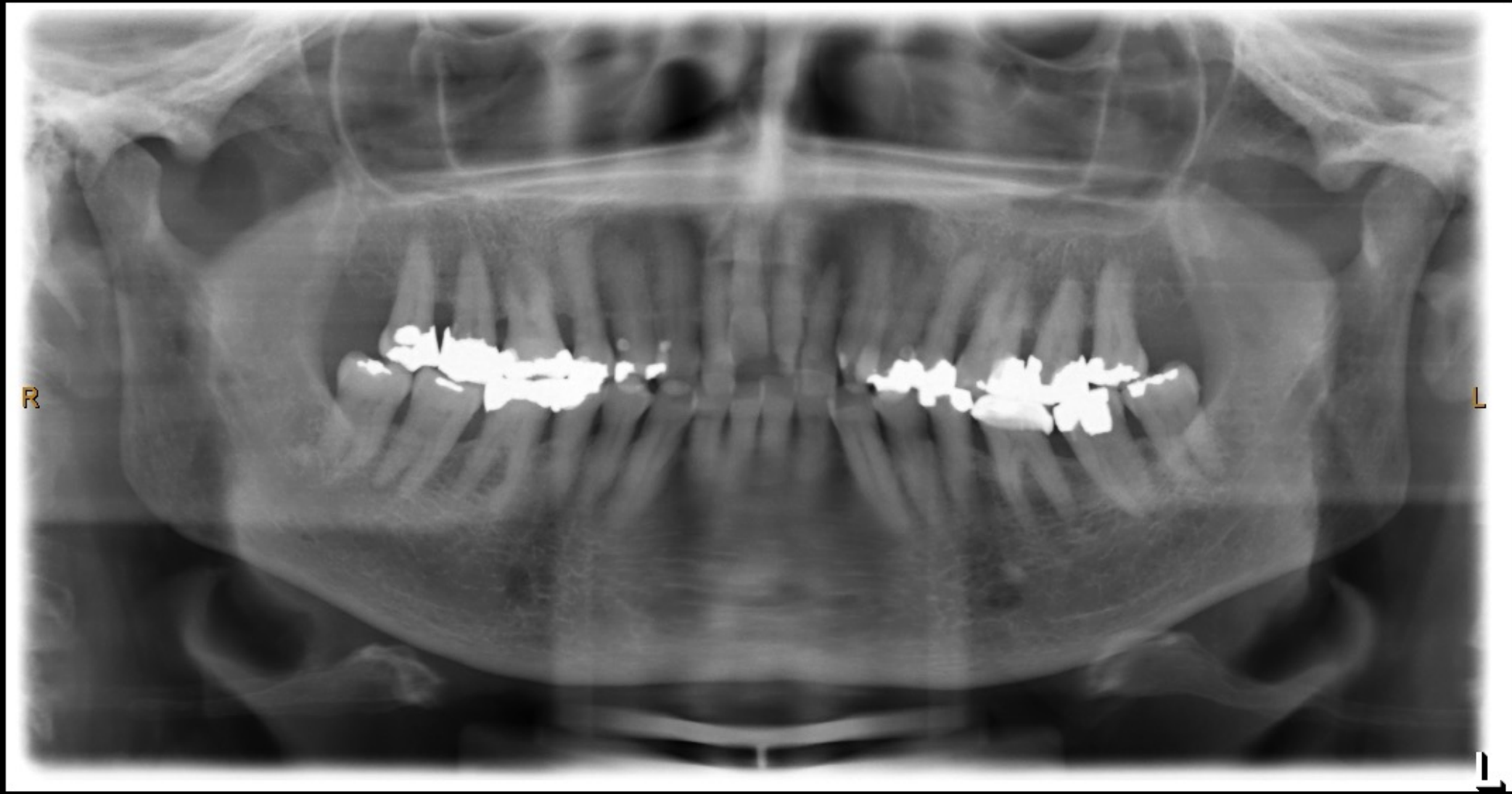
### ***Crown/Root Fracture ?***

- Horizontal / Oblique / Vertical?***
- Extension?***
- Complicated or Uncomplicated?***

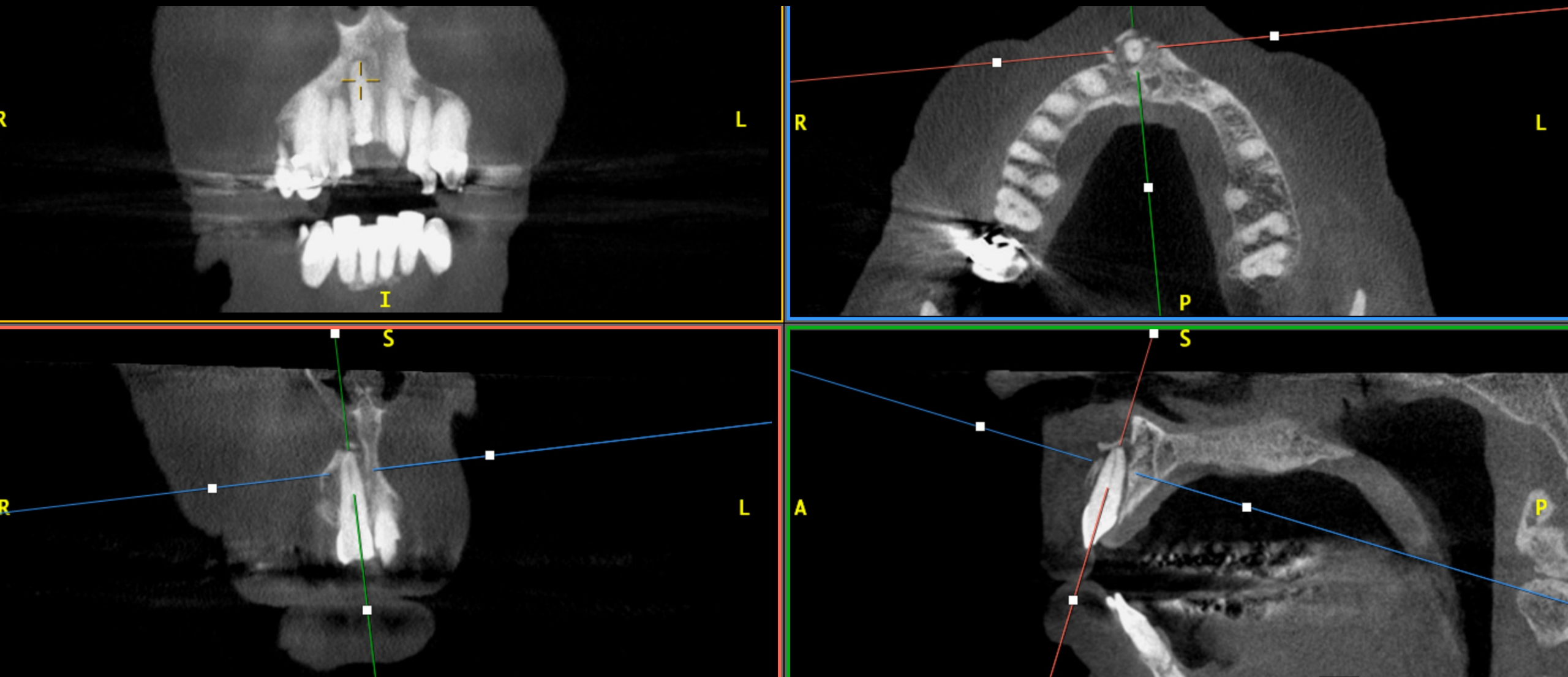
***Changes to the PDL space? Bony fracture?***



Anterior Mx Trauma (11 Injured)

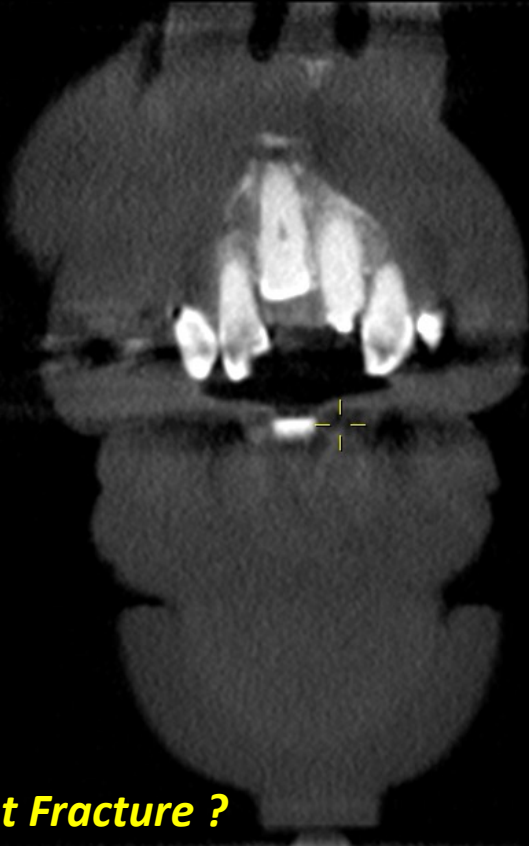


# MPR



Intrusion (Intrusive Luxation injury) & Comminuted fracture of Labial Cortex

11 vs 21



***Crown/Root Fracture ?***

***Changes to the PDL space?***

***Bony fracture?***

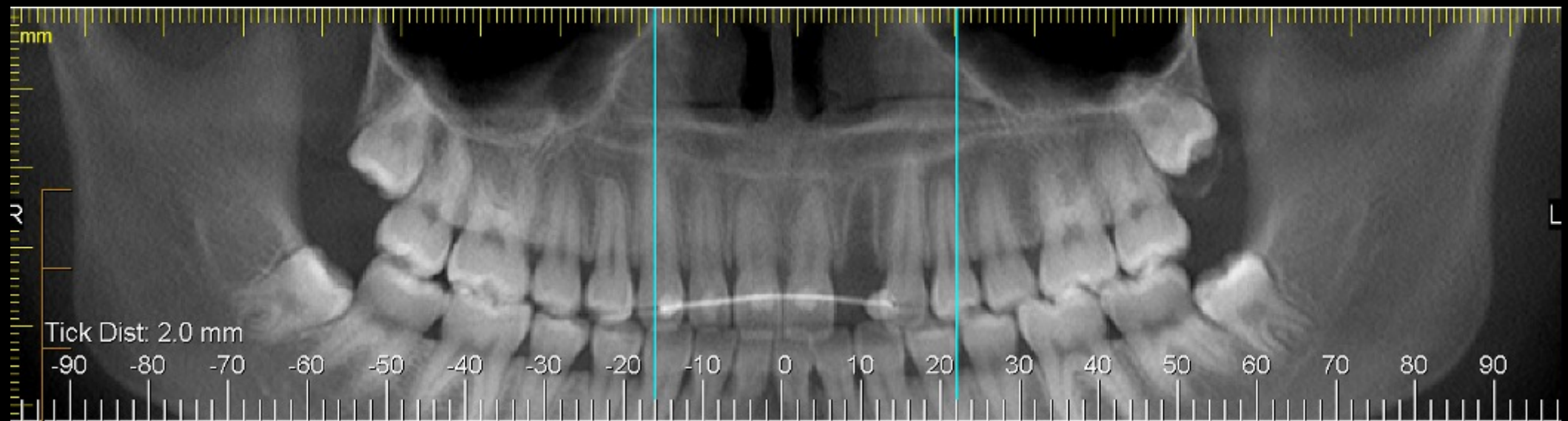


L



A

## Anterior Mx Trauma (22 site)



Assess tooth by tooth.

11?

21?

22?





-6.00



-4.00



-2.00



0.00



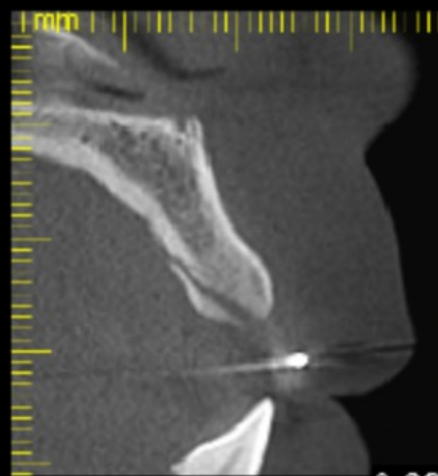
2.00



4.00



6.00



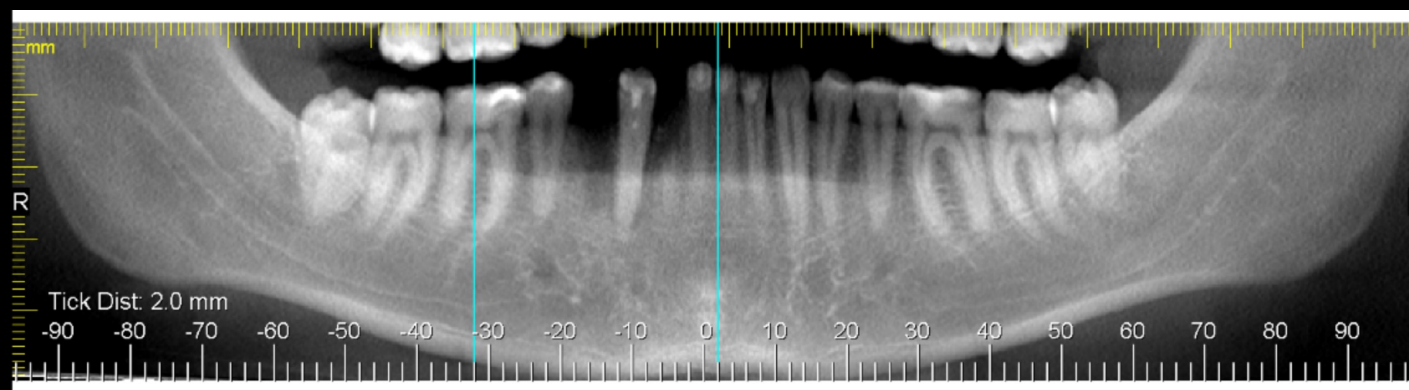
8.00



10.00



12.00



### Anterior Md Trauma (Q4)



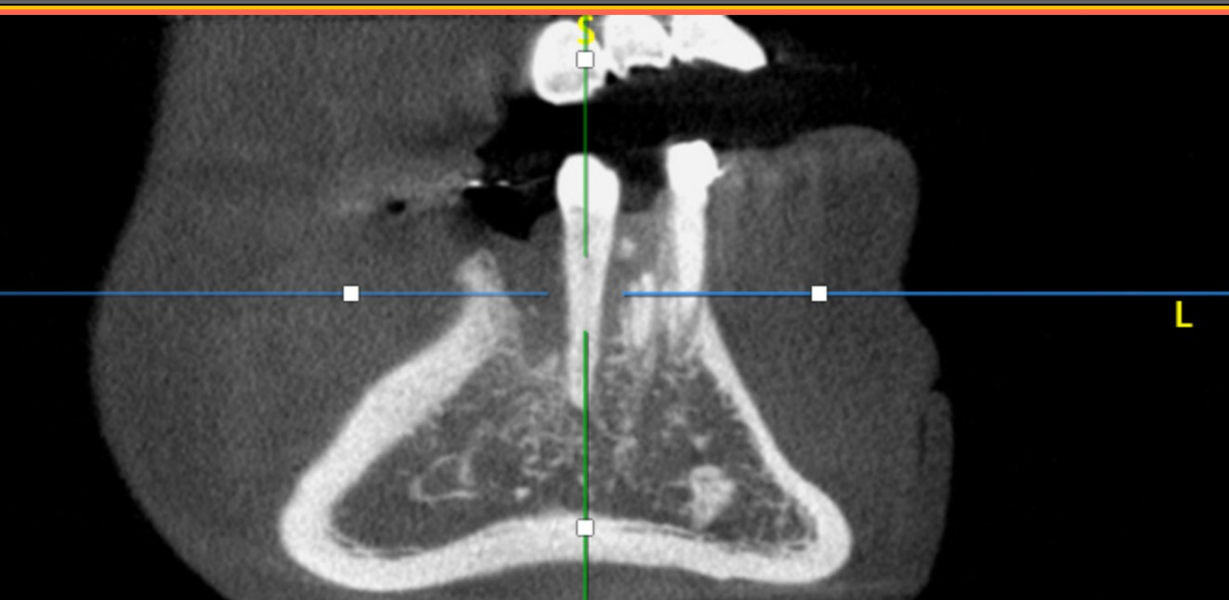
# MPR



L

R

I



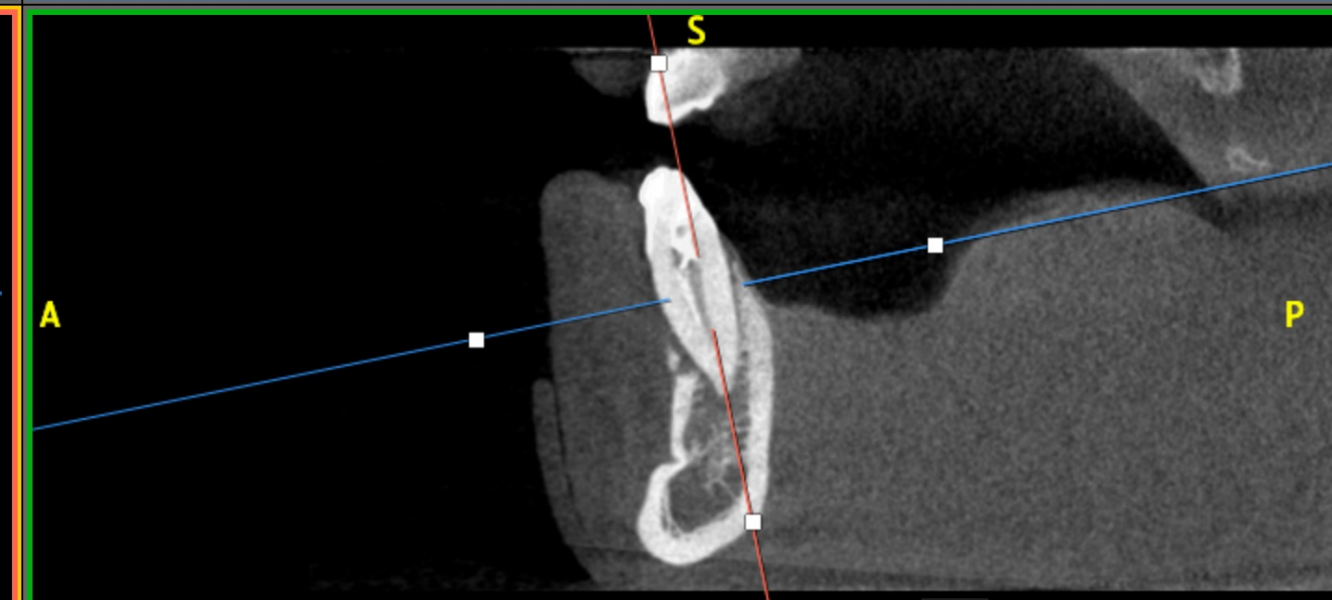
L

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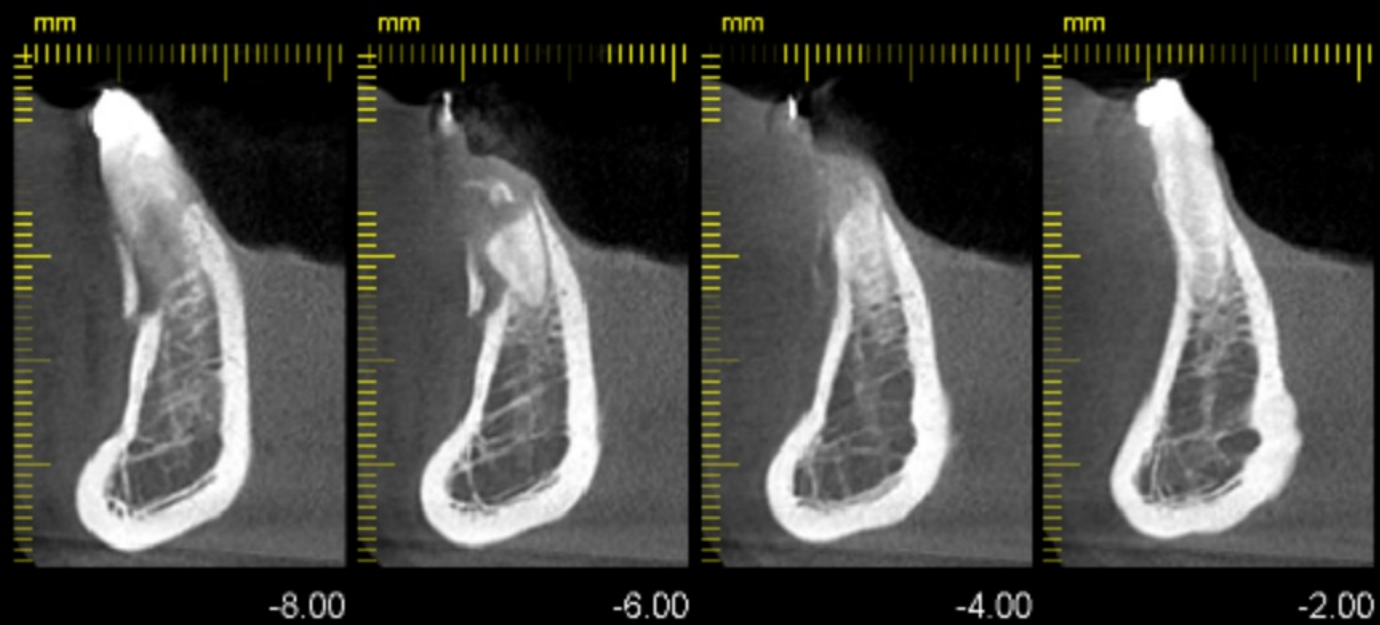
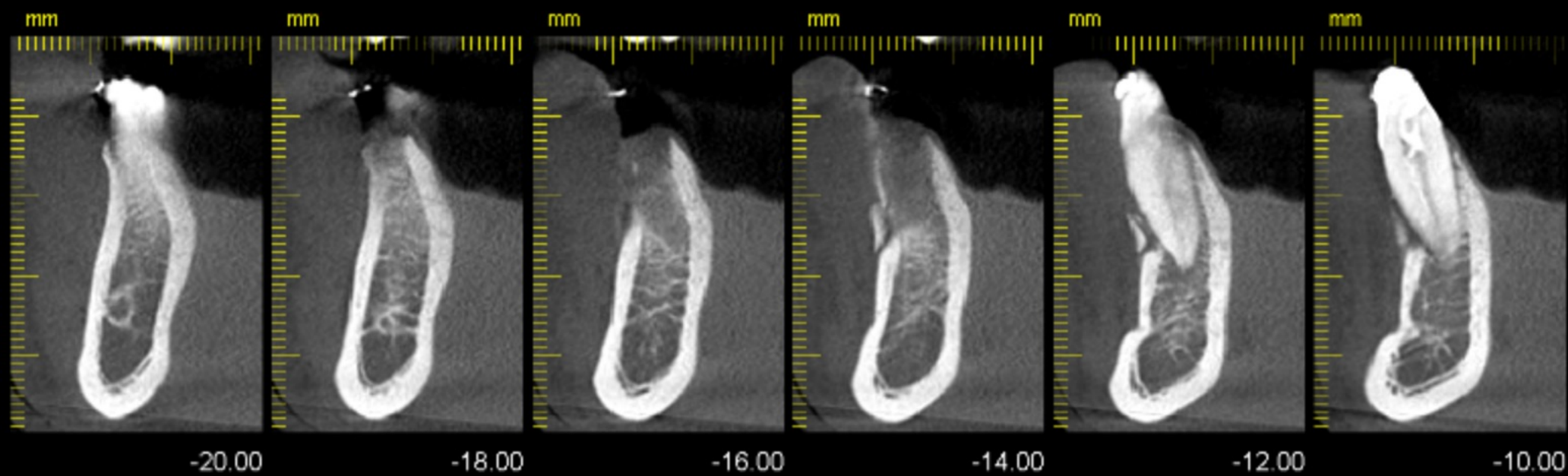


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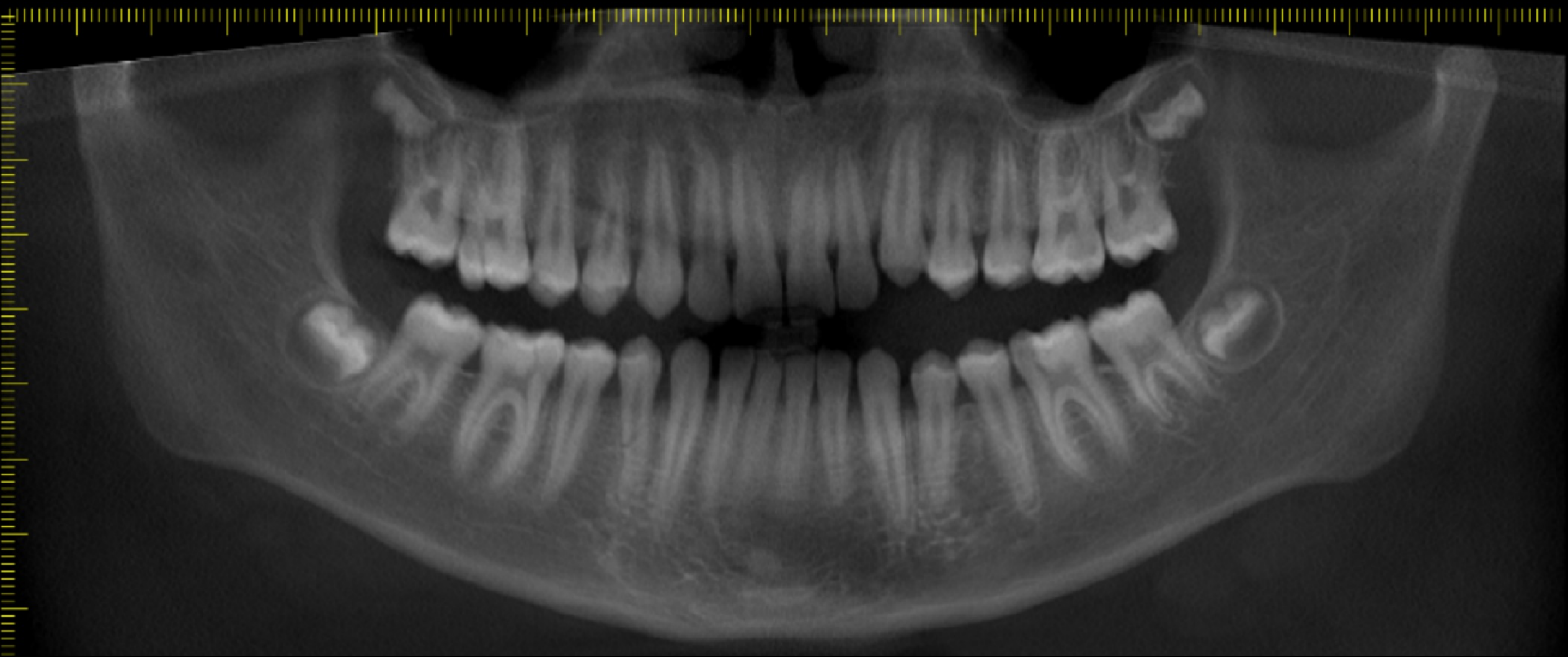
P



P



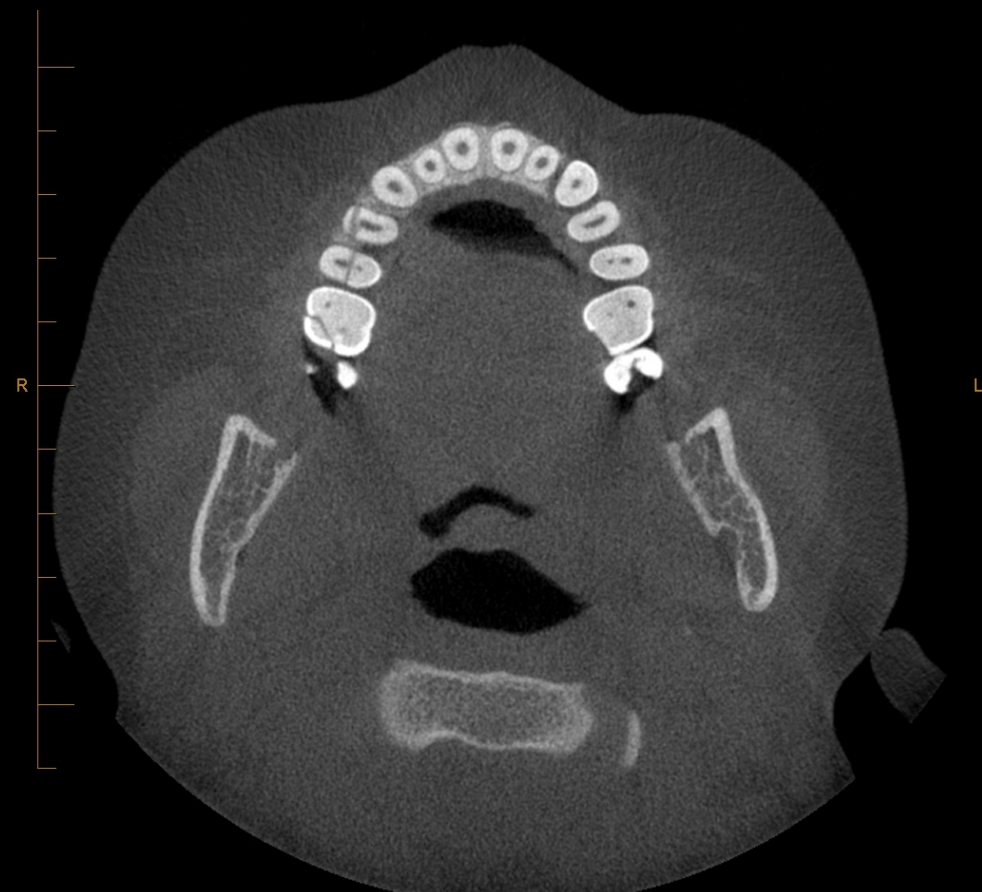
Complex, multiple dentoalveolar trauma





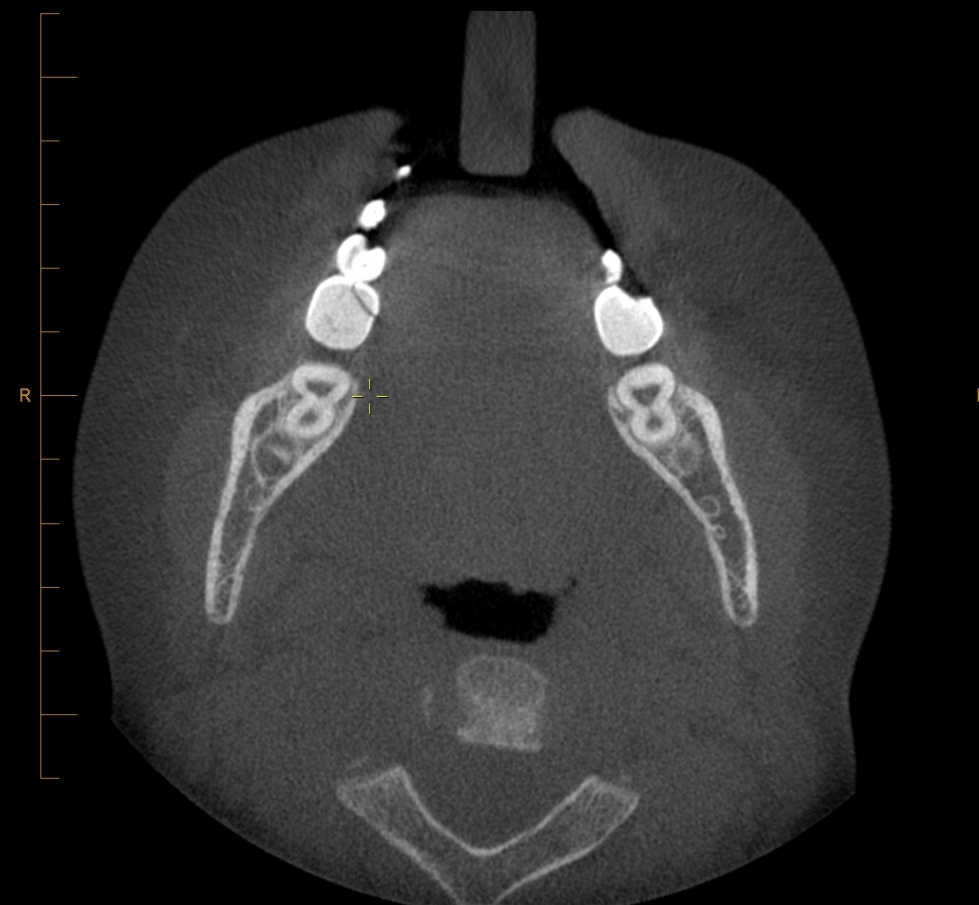
16, 15, 14, 44, 46

Mx



16, 15, 14, 26

Md



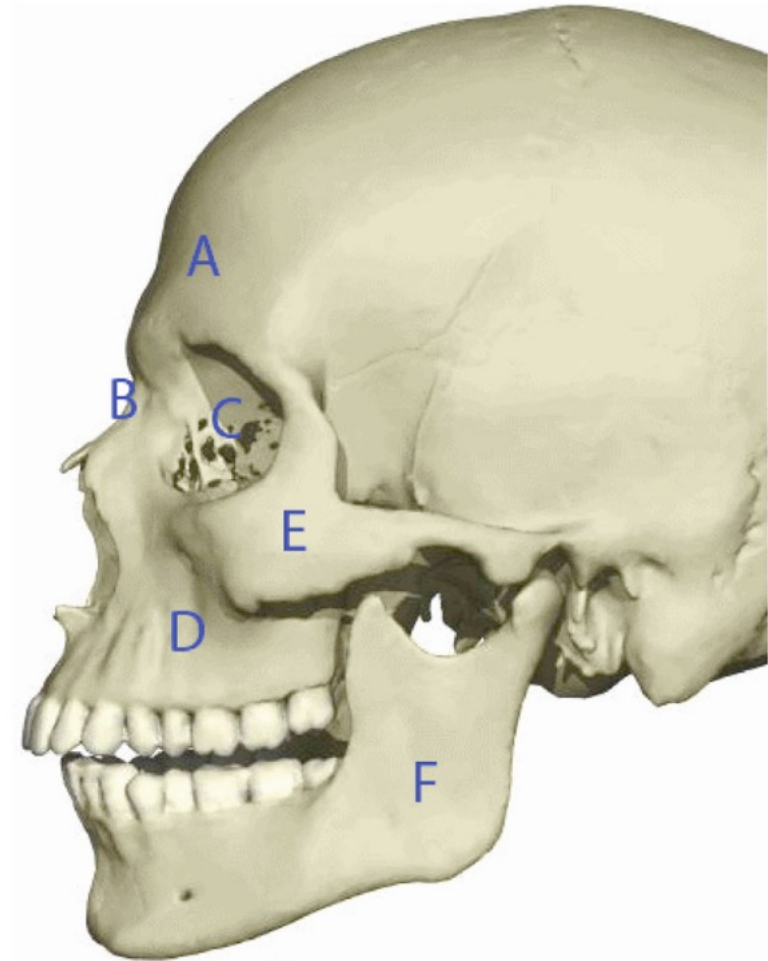
# Facial Bone Trauma

CT is Gold Standard

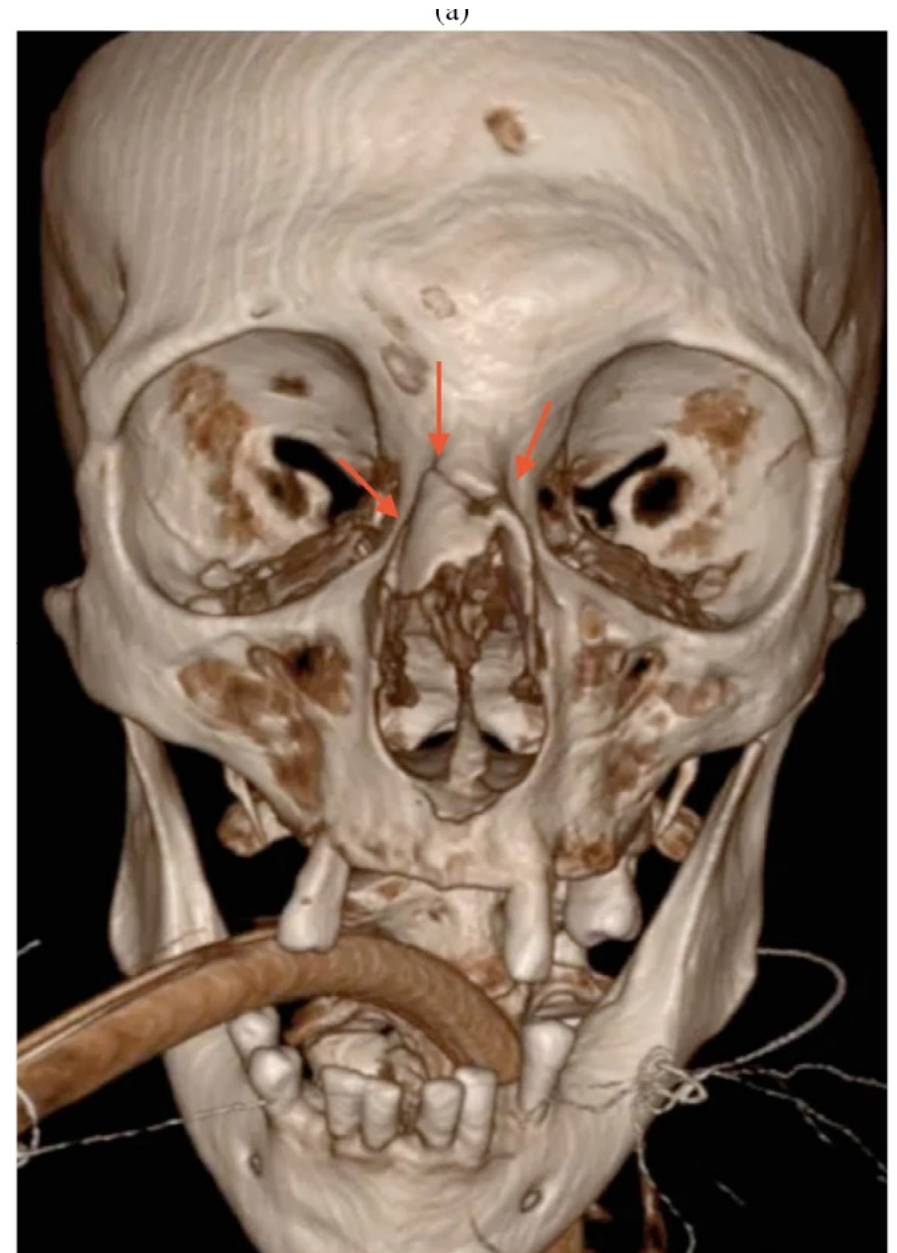
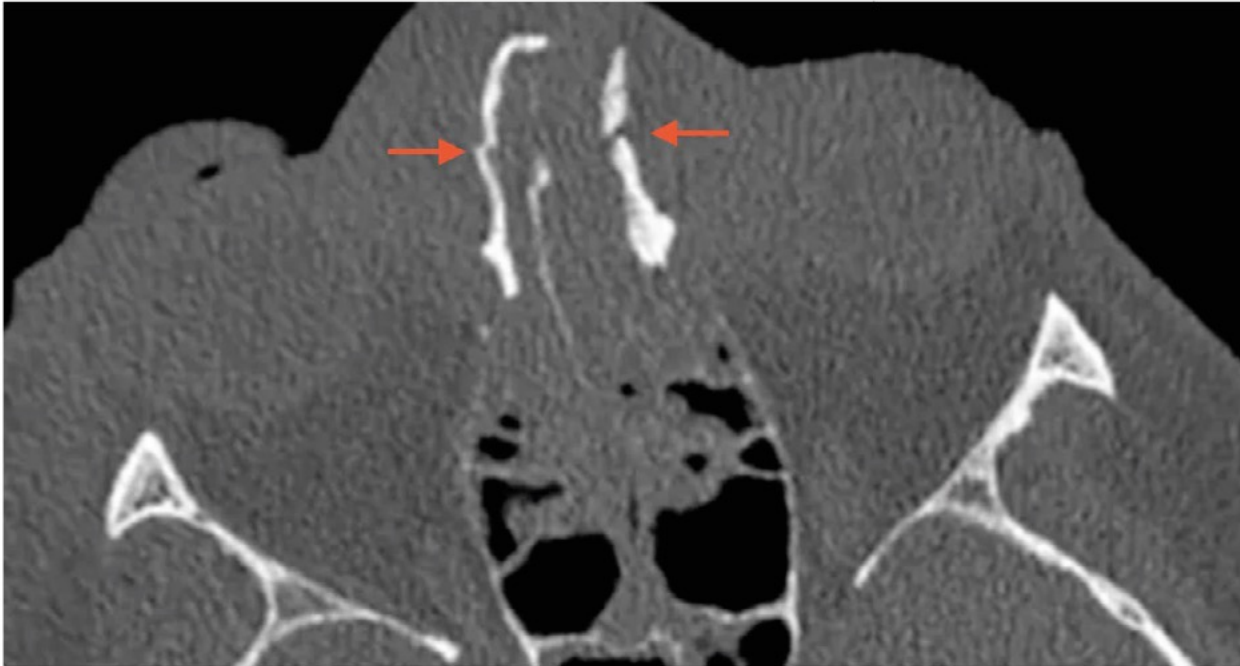
# Classification of Cranio-Maxillofacial Fractures

**Table 5.1** Classification of Cranio-Maxillofacial fractures

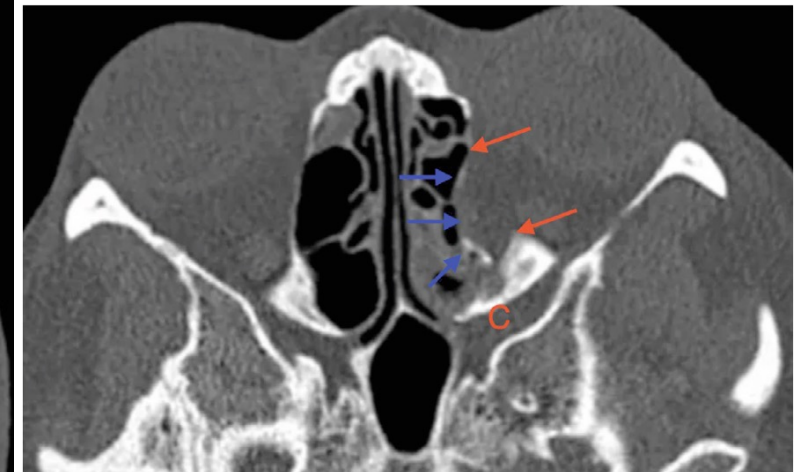
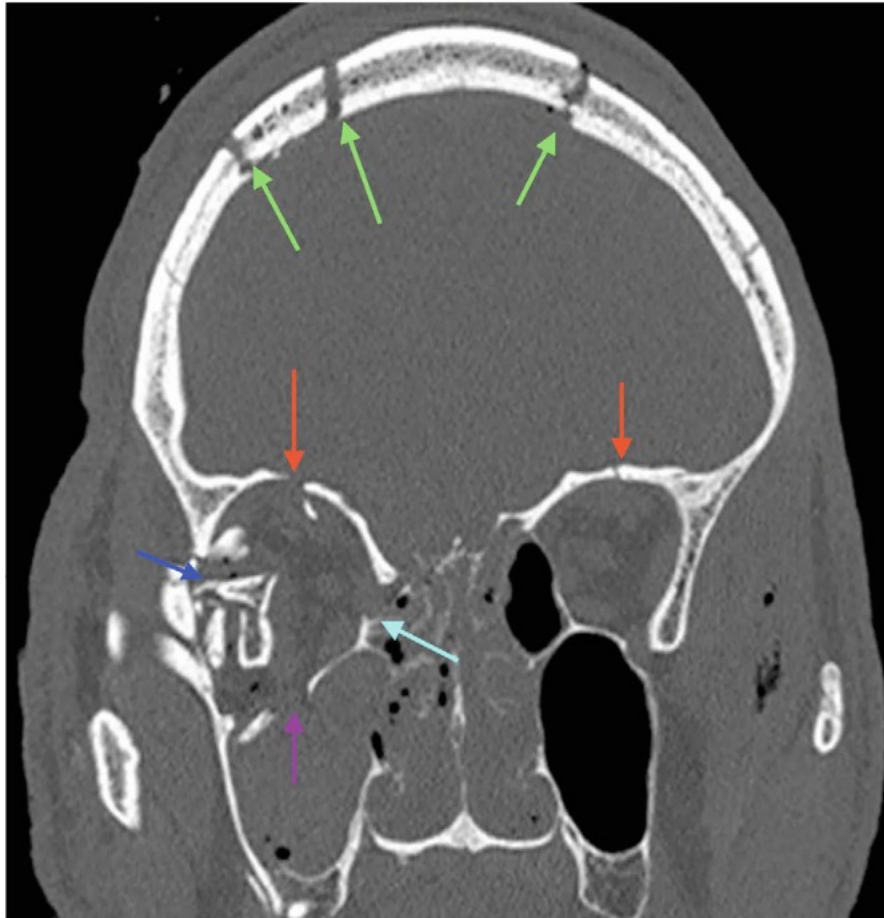
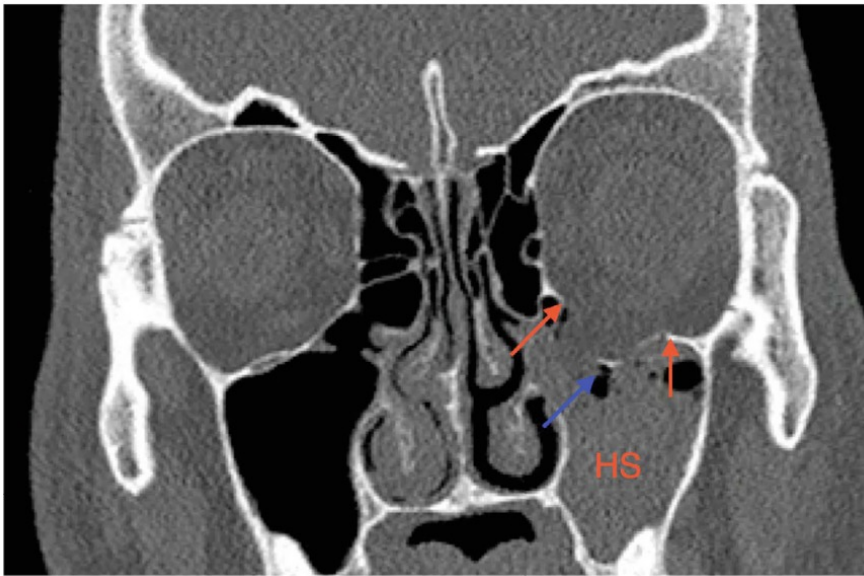
| Category                                        | Types of fractures                                                                                                                                                                                                                                                                                                                                                                                        |
|-------------------------------------------------|-----------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Facial bone fractures                           | <ul style="list-style-type: none"> <li>–Nasal bone fracture</li> <li>–Orbital fractures:                             <ul style="list-style-type: none"> <li>* Orbital floor (“blowout”) fracture</li> <li>* Orbital roof (“blow-in”) fracture</li> <li>* Medial or lateral orbital wall fractures</li> </ul> </li> <li>–Zygomaticomaxillary complex fracture</li> <li>–Zygomatic arch fracture</li> </ul> |
| Maxillary fractures<br>(Le Fort classification) | <ul style="list-style-type: none"> <li>–Le Fort I: Horizontal fracture of the maxilla</li> <li>–Le Fort II: Pyramidal fracture involving the nasal bridge, maxilla, and orbital floor</li> <li>–Le Fort III: Craniofacial disjunction involving the zygomatic arches and orbital walls</li> </ul>                                                                                                         |
| Mandibular fractures                            | <ul style="list-style-type: none"> <li>–Condylar fracture</li> <li>–Coronoid process fracture</li> <li>–Ramus fracture</li> <li>–Angle of mandible fracture</li> <li>–Body of mandible fracture</li> <li>–Symphysis and parasymphysis fracture</li> <li>–Alveolar process fracture</li> </ul>                                                                                                             |
| Frontal bone and Sinus fractures                | <ul style="list-style-type: none"> <li>–Frontal sinus anterior wall fracture</li> <li>–Frontal sinus posterior wall fracture</li> </ul>                                                                                                                                                                                                                                                                   |
| NOE fractures                                   | Fractures involving the nasal bridge, ethmoid bone, and medial orbital rim                                                                                                                                                                                                                                                                                                                                |
| Cranial vault and Skull base fractures          | <ul style="list-style-type: none"> <li>–Linear skull fractures</li> <li>–Basilar skull fractures</li> </ul>                                                                                                                                                                                                                                                                                               |



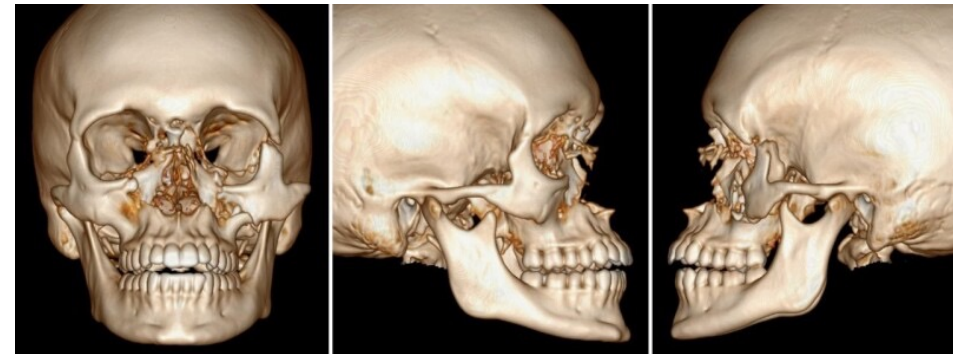
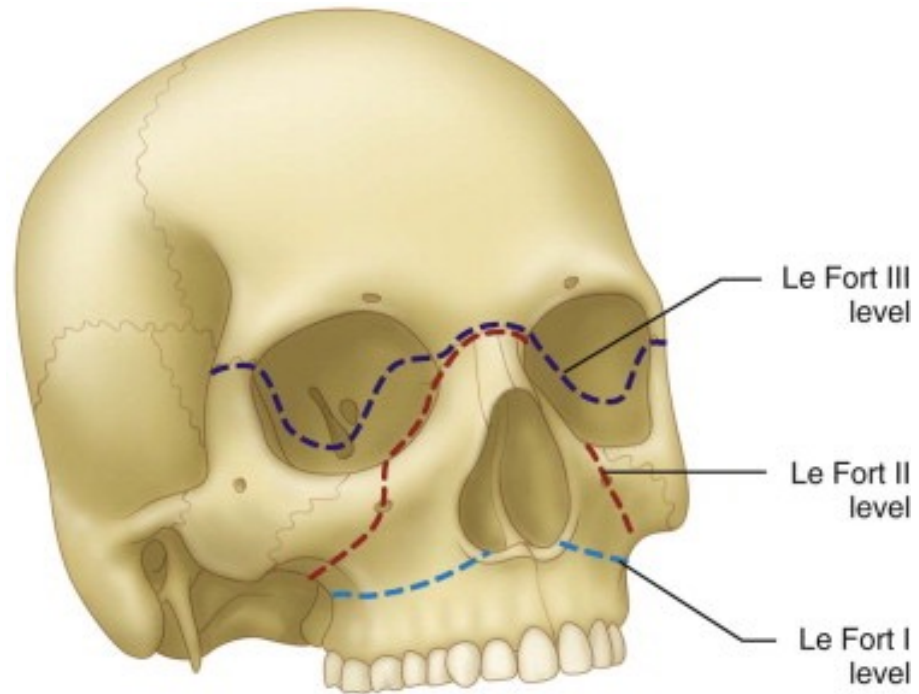
# Nasal Fractures



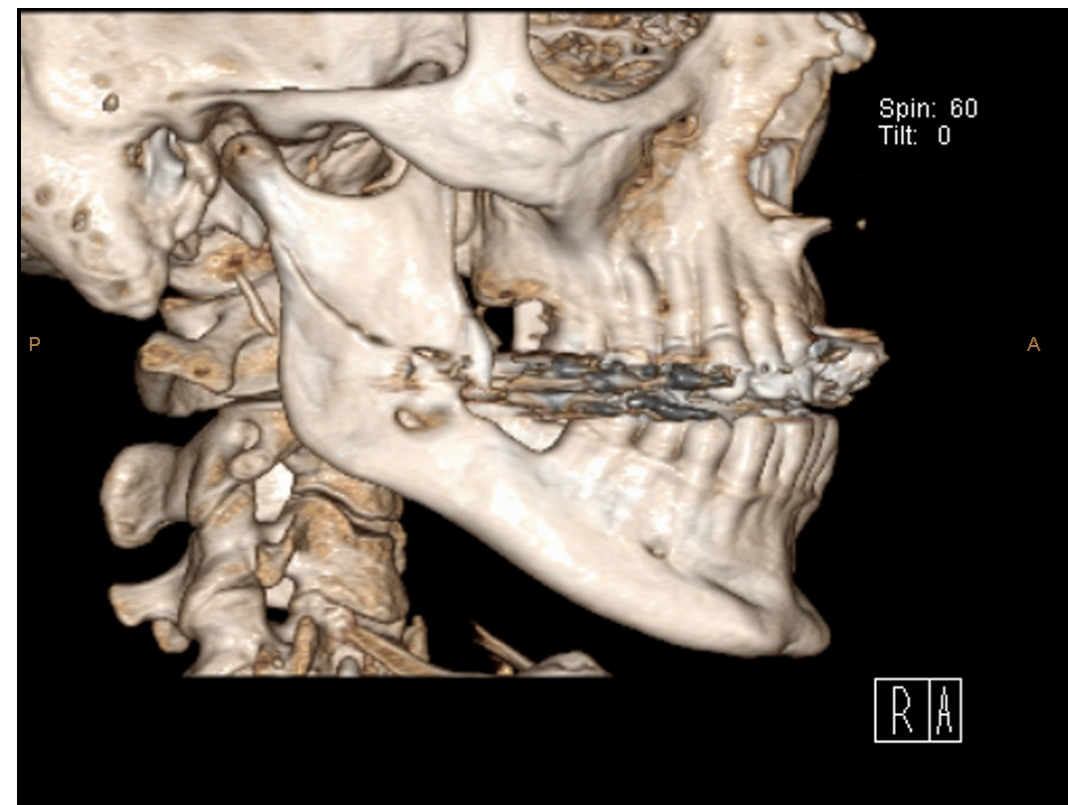
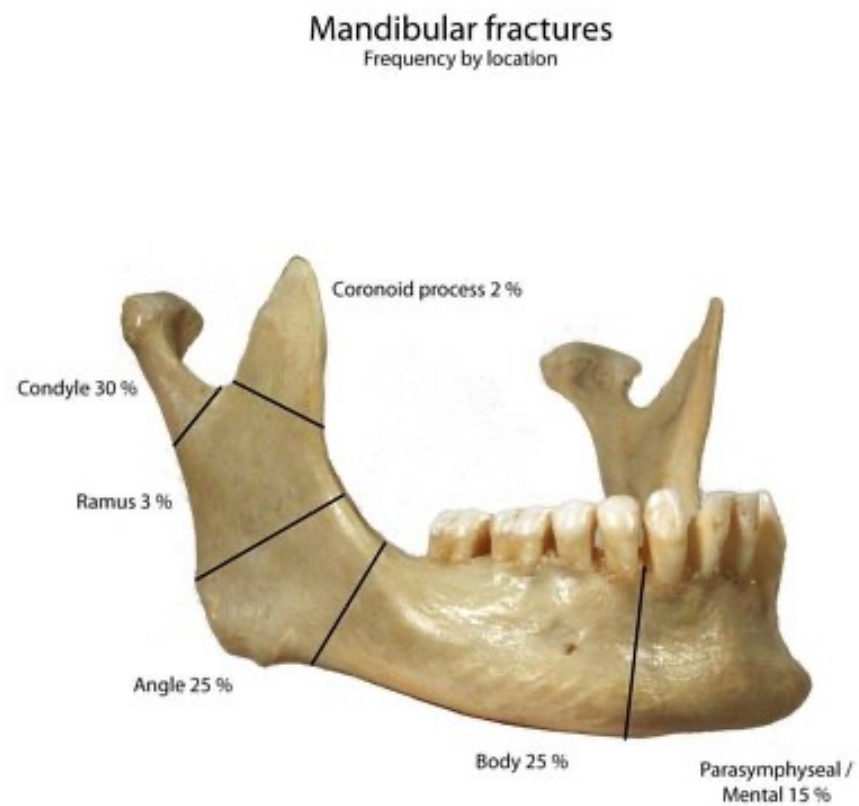
# Orbital

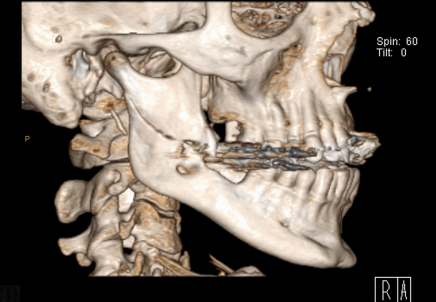


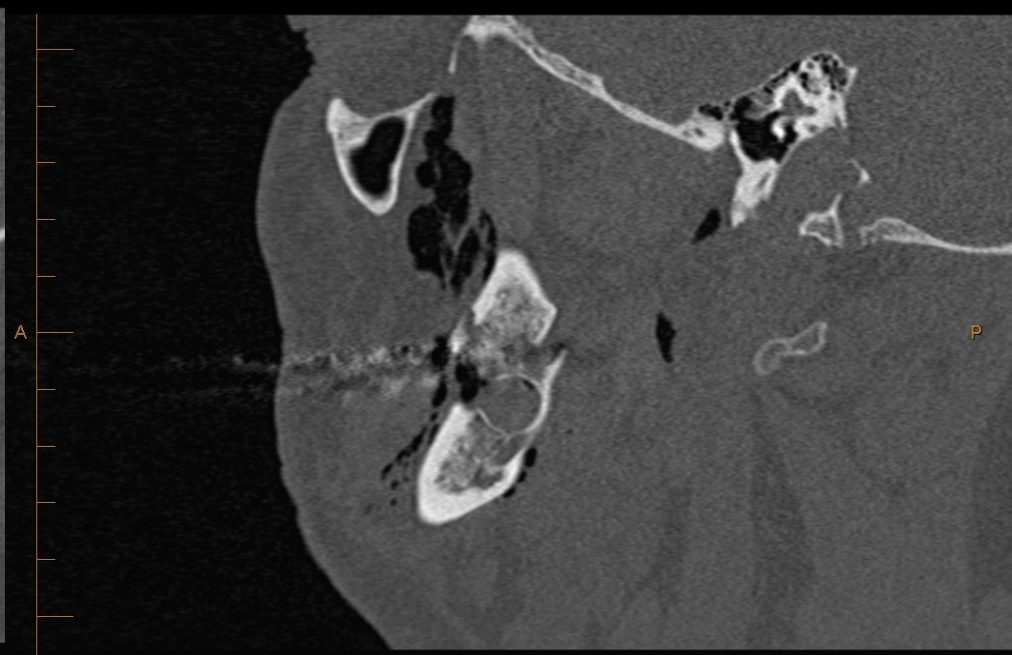
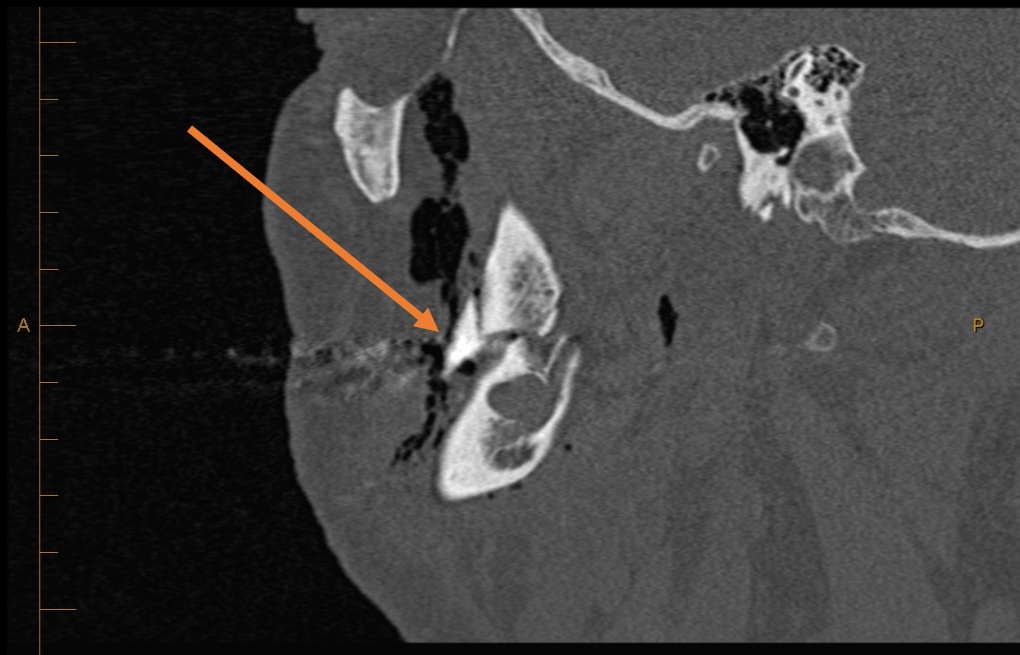
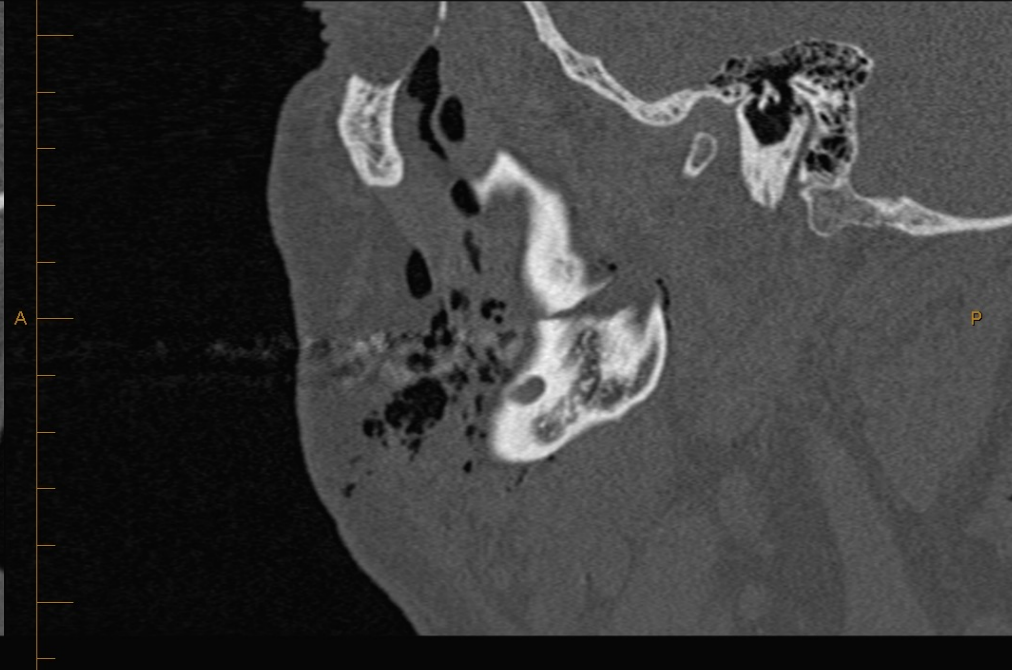
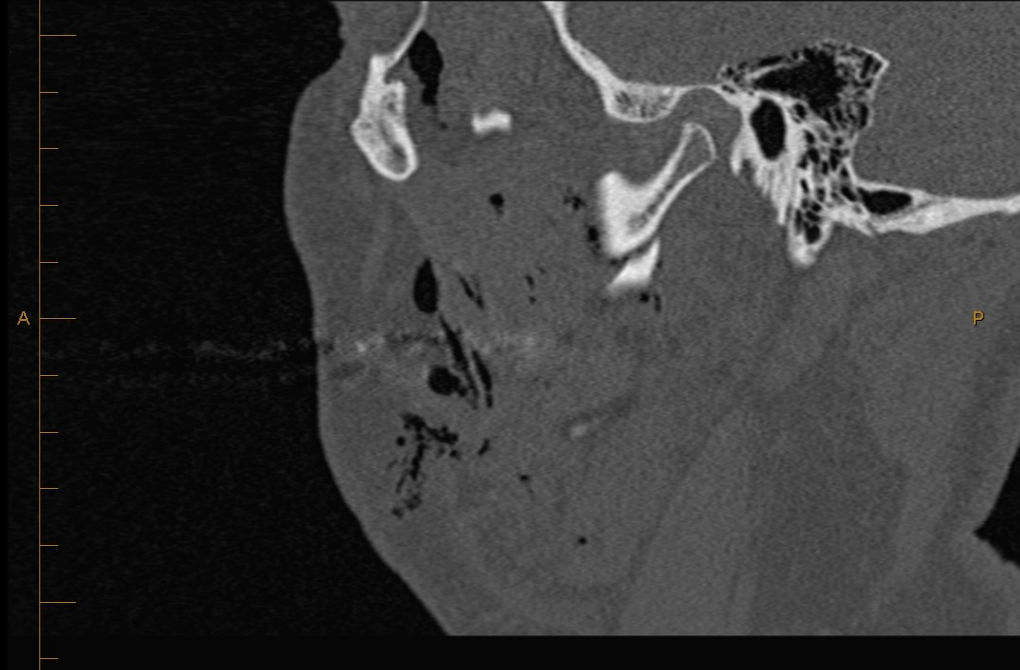
# Le Fort Fractures (Midface / Maxilla)

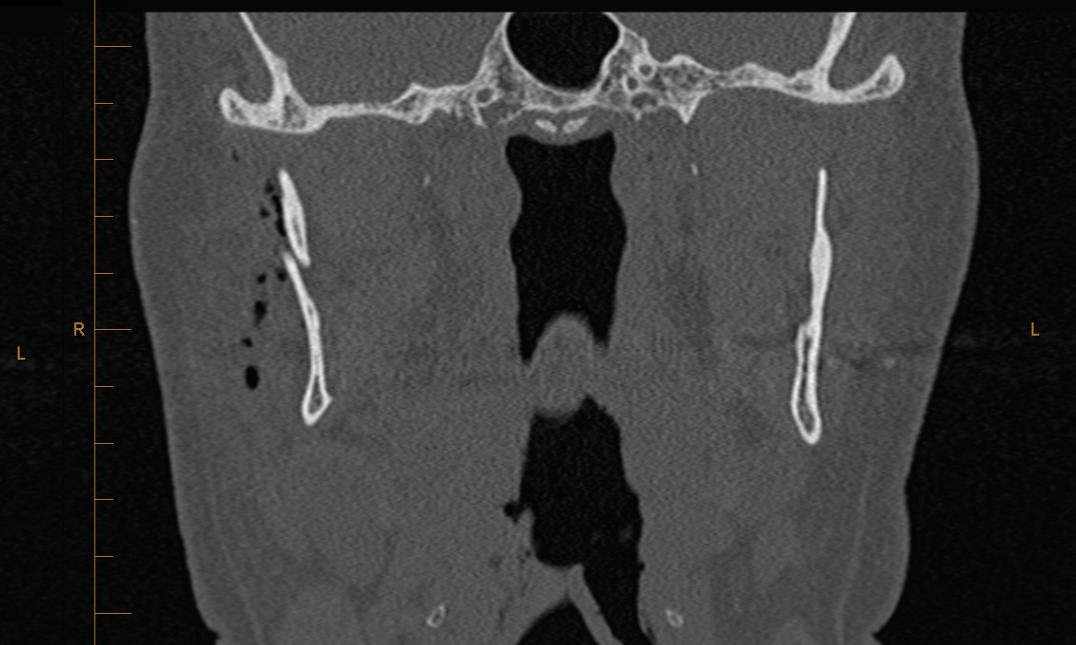
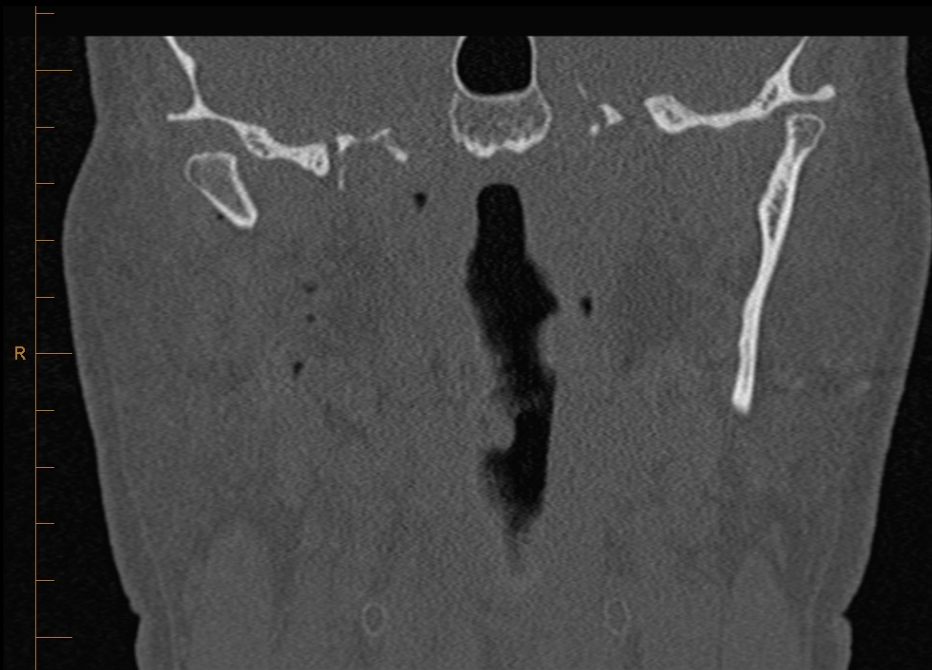


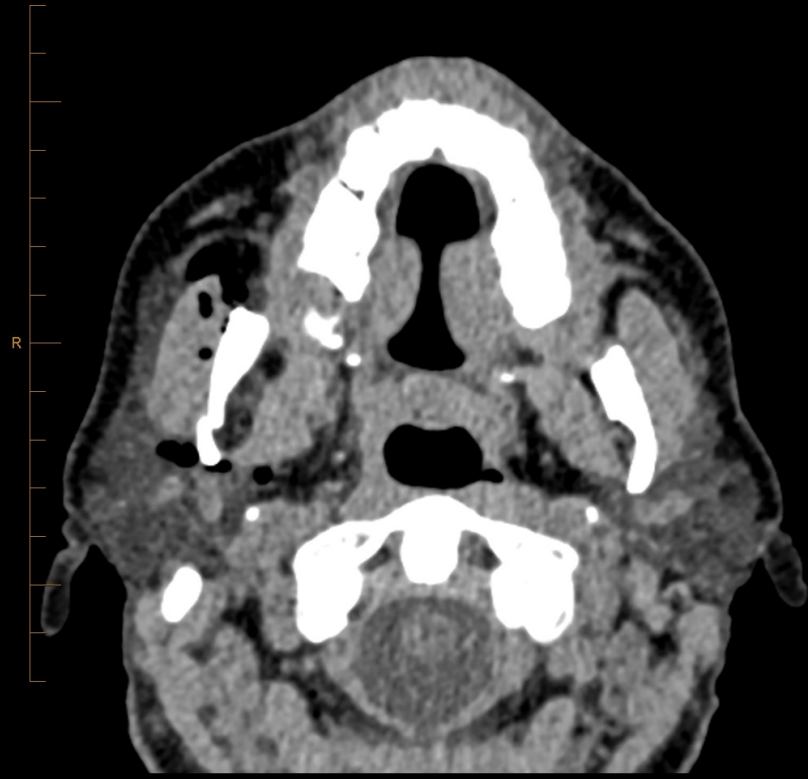
# Mandibular Fracture











16:33:39  
H:36s\3  
CT  
VR Mag: 1.05  
HFS

R

L

120.00 kV  
27.00 mA  
Tilt: 0.00  
FOV: 167.00  
Thickness: 0.60 mm



10.00mm/div



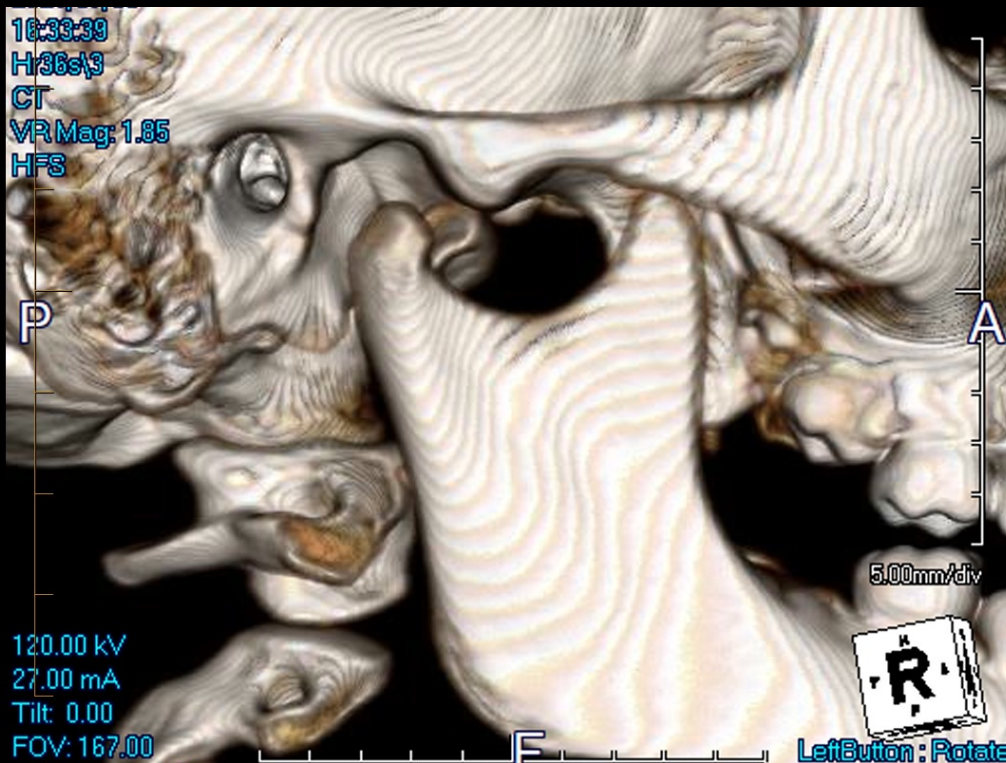
LeftButton : Rotate  
JPEGLossy:75

16:33:39  
H:36s\3  
CT  
VR Mag: 1.85  
HFS

P

A

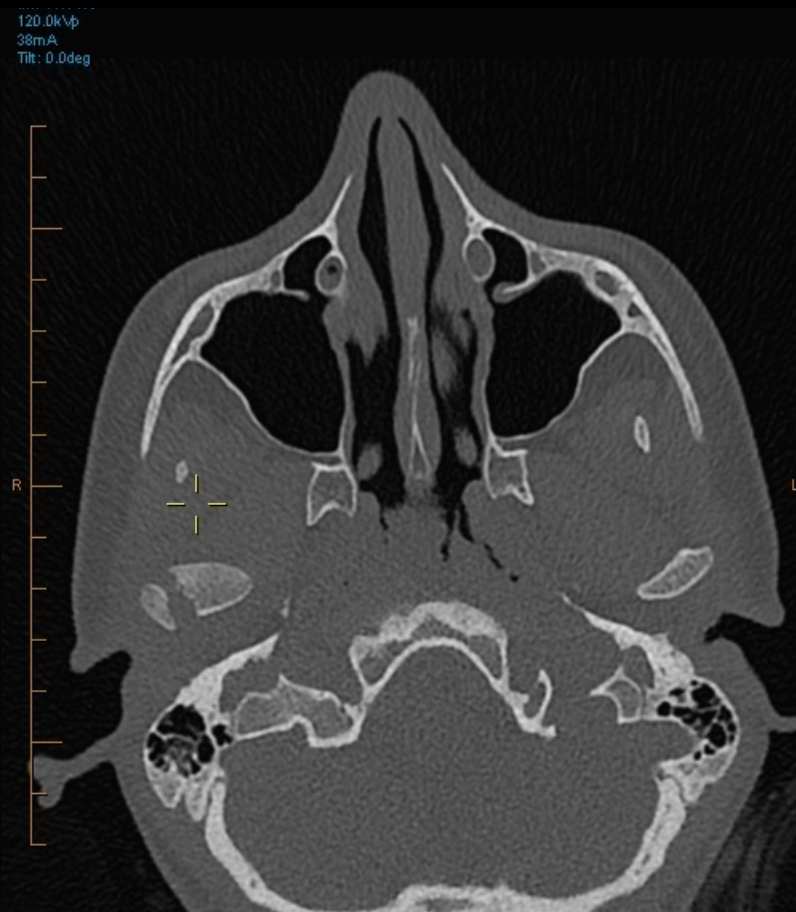
120.00 kV  
27.00 mA  
Tilt: 0.00  
FOV: 167.00  
Thickness: 0.60 mm



5.00mm/div



LeftButton : Rotate  
JPEGLossy:75



# AI in Trauma Imaging

- AI applications:
  - Automated fracture detection (mandible, midface)
  - Triage in emergency settings
  - 3D reconstruction assistance
- Deep learning (CNNs) improves detection accuracy
- Limitations:
  - Training dataset bias
  - Limited generalizability

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## A review on artificial intelligence for the diagnosis of fractures in facial trauma imaging



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END.