BACK TO BASICS:

DIGITAL RADIOGRAPHY OF THE FACIAL BONES

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DIGITAL RADIOGRAPHY OF THE FACIAL BONES

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ABSTRACT

Historically, digital radiographic images of the facial bones and related anatomical structures are performed when it is necessary for a clinician to view and assess these regions after a patient sustains trauma to the face or to examine a possible pathology. Prior to the advent of computed tomography (CT), routine facial bone digital radiography (DR) was the mainstay of most emergency department protocols until the early-to-mid-1980s. Today, it is still essential for radiologic technologists (RTs) to be able to perform various projections and views of this area in order to assist clinicians with diagnosis when the need arises. To that end, this course will discuss facial bone DR, patient injury and possibly pathologies, and provide a detailed review of the anatomical regions that make up the facial bones, specifically the nasal bones, mandible, orbits and zygomatic arches. Detailed information for patient, central ray, and image receptor angling and positioning will also be provided as well as the anatomy that's best depicted in each image/view, and image quality criteria the nasal bones, mandible, orbital bones, and zygomatic arches. Instructional videos will review the anatomical landmarks, body planes, and positioning lines, for proper positioning for this DR series. These videos will also include image reviews, analyzation, and correction strategies in order to obtain high-quality DR images of the Caldwell, Waters, and lateral DR views.

> *Editorial Note: Throughout this course, when referring to facial bone radiography (FBR) in concept and imaging techniques, it should be assumed that this also pertains to the mandible, nasal bones, orbits, and zygomatic arches. It should further be noted that it covers only topics of trauma of these regions and not pathology. References to conventional radiography pertains to digital radiography (DR) of the anatomical regions being imaged, which includes both direct digital radiography (DDR) and computed radiography (CR). Additionally, the term projection/view will be indicative of the radiographic positioning method or process used to obtain the final diagnostic image.*

Introduction

Overview, Statistics, and Epidemiology

Historically, facial bone radiography (FBR) and the surrounding anatomical regions of the face have been used as a standard radiologic procedure in the evaluation of patients with a trauma-related injury. Once computed tomography (CT) was developed and became widely available, the necessity for this type of radiographic examination began to decrease; however, it still plays an important role in diagnostic trauma protocols or regions where CT may not be readily accessible due to the rural location or the size of a particular healthcare facility.

The face is the most exposed region of the body and is susceptible to injuries that can range from superficial abrasions, to complex fractures of the facial skeleton, as well as foreign body penetration.[1] Facial bone trauma patients are a subset of patients that present to emergency departments (EDs) in the United States (US) that account for approximately 500 000 visits and nearly 1 billion dollars in healthcare costs in the US annually. Representing 5% to 15% of all facial fractures, frontal bone fractures are often the result of high-energy blunt trauma, such as motor vehicle accidents (MVAs), assaults, and significant falls. Specifically, in descending order, assaults, MVAs, falls, sporting activities, gunshot wounds, and occupational accidents account for most facial fractures. Of these, MVAs and gunshot wounds typically cause higher-severity facial injuries.[2]

Patients with facial bone fractures and/or injuries likely sustained them to the frontal sinus, which is often the result of either a direct blow or an extension of a skull fracture to the sinus.[3] Since the bones that make up the nasal pyramid are thin and notably project from the midface, this region is a common site for trauma. Data from epidemiologic studies suggest that nasal fractures make up more than half of all facial fractures and are the most frequently fractured bone of the face.[4] Like the nasal bones, the zygoma is a prominent facial anatomical region, which also makes it susceptible to injury. Overall, the most common structures involved in facial fractures, in order of frequency, are the nasal bones, orbital floor, zygomaticomaxillary complex (ZMC), maxillary sinuses, and mandibular ramus, all of which will be covered in this course.[2]

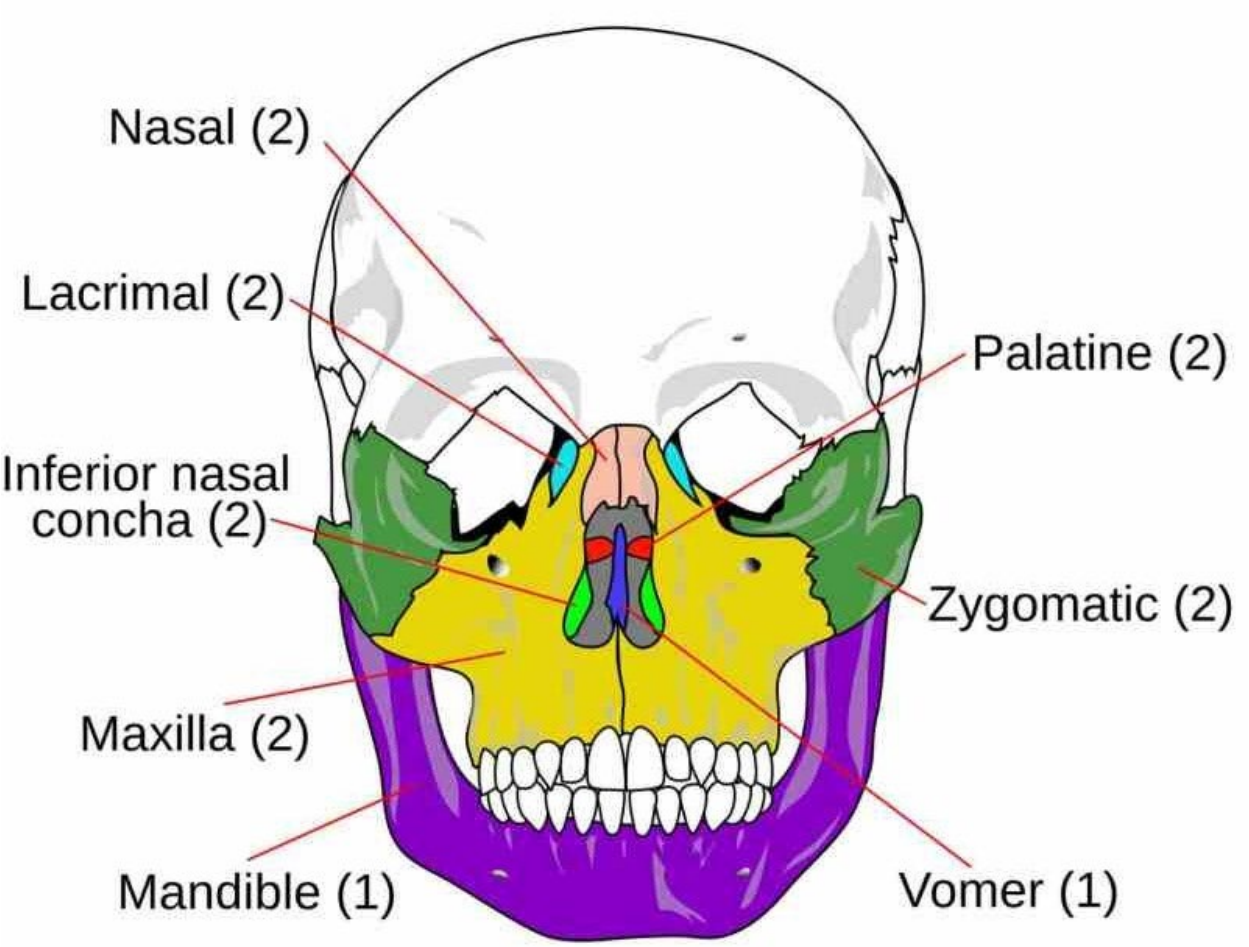
Facial Bone Anatomy

Facial Bones of the Skull

The facial bones of the skull form the upper and lower jaws, nose, nasal cavity, septum, and orbits.[5] The facial bones include 14 bones with 6 paired bones and 2 unpaired bones (Figure 1).[6] The paired

facial bones are the maxilla, palatine, zygomatic, nasal, lacrimal, and inferior nasal conchae bones. The unpaired bones are the vomer and mandible bones. Although the ethmoid bone is classified as a cranial bone, it does contribute to the nasal septum, the walls of the nasal cavity, and orbit.[5]

Figure 1. Facial Bones



A labelled diagram of the 14 facial bones, which include the mandible, vomer, maxilla, zygomatic, inferior nasal concha, palatine, lacrimal, and nasal bones. The number of bones of each bone type appear in parenthesis.

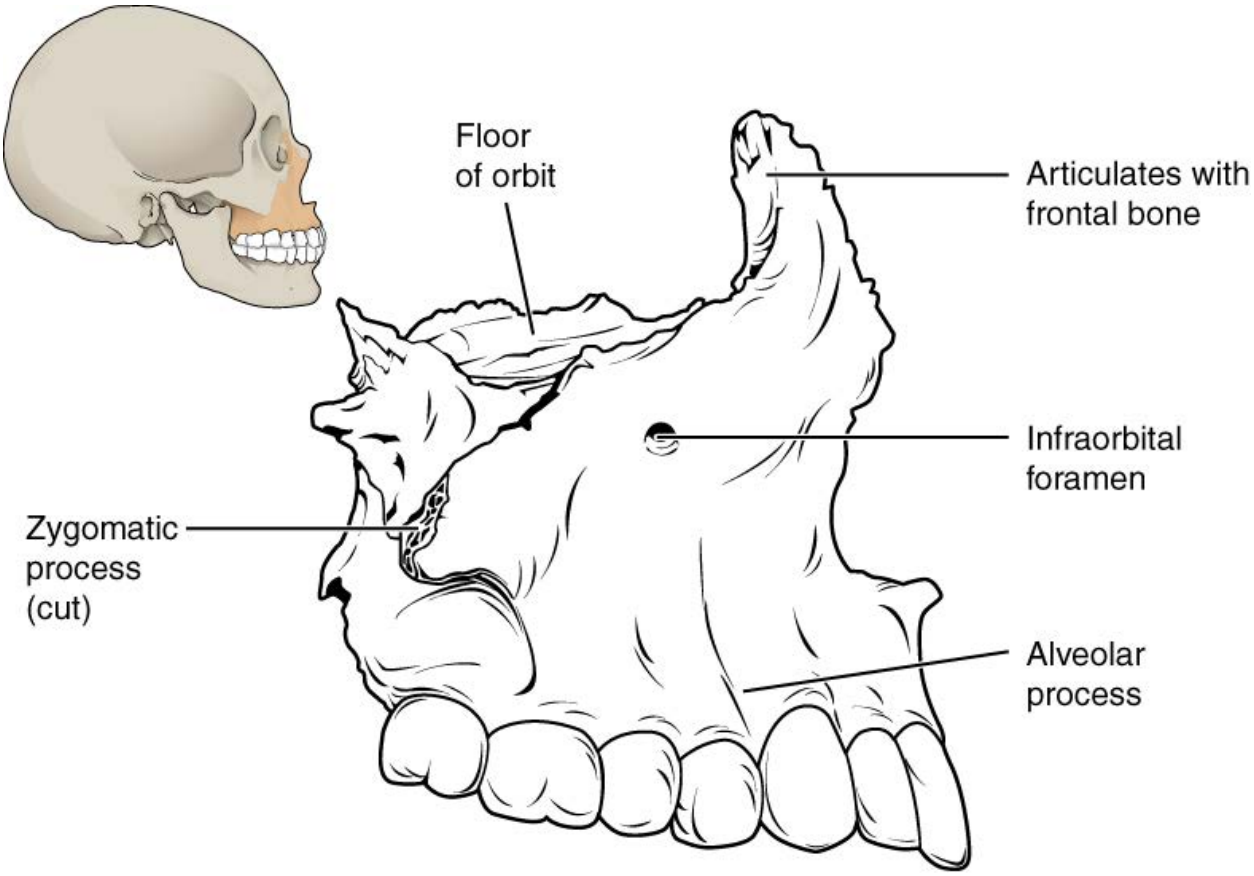
Nguyen et al. In: *StatPearls* [Internet]. Treasure Island, FL: StatPearls Publishing; 2023.[6] For educational purposes only.

The Maxillary Bone

The maxillary bone, often referred to simply as the maxilla, is one of a pair of bones that combine to form the upper jaw, much of the hard palate, the medial floor of the orbit, as well as the lateral base

of the nose (Figure 2).[5] The curved, inferior margin of the maxillary bone, which forms the upper jaw, contains the upper teeth. This region is referred to as the alveolar process of the maxilla. Each tooth is anchored into a deep socket called an alveolus. The infraorbital foramen is located on the anterior maxilla, just below the orbit. This is the anatomical point of exit for a sensory nerve that supplies the nose, upper lip, and anterior cheek. While on the inferior skull, the palatine process from each maxillary bone can be seen joining together at the midline to form the anterior three-quarters of the hard palate. The hard palate is a bony plate that creates the roof of the mouth and floor of the nasal cavity, separating the oral and nasal cavities.[5]

Figure 2. The Maxillary Bone



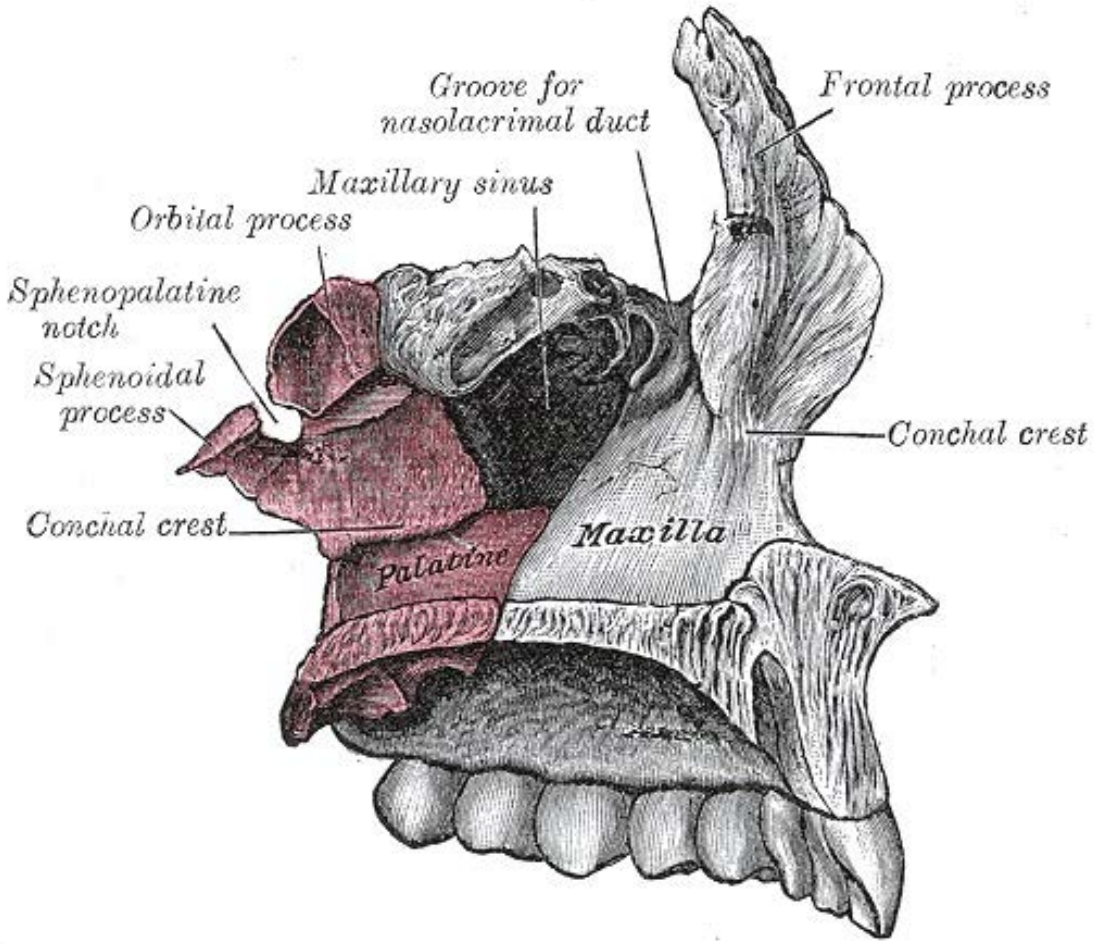
An illustration of a right lateral view of the maxillary bone.

Biga et al. *Anatomy & Physiology 2e*. OpenStax/Oregon State University; 2025.[5] For educational purposes only.

The Palatine Bone

The palatine bone is one of a pair of irregularly shaped bones that make up small regions of the lateral walls of the nasal cavity and the medial wall of each orbit. The largest region of each palatine bone is known as the horizontal plate.[5] The plates from the right and left palatine bones join at the midline to form the posterior quarter of the hard palate (Figure 3).[7]

Figure 3. The Palatine Bone



An illustration of a medial view of the palatine bone.

Gray. *Anatomy of the Human Body*. Lea & Febiger; 1918.[7] For educational purposes only.

Because of this complex interrelated anatomy, it is more useful for radiologists to describe how facial fractures relate to actual surrounding structures like orbits or sinuses. Quality diagnostic imaging studies composed of DR and/or three-dimensional (3D)-CT reconstructions are critical for

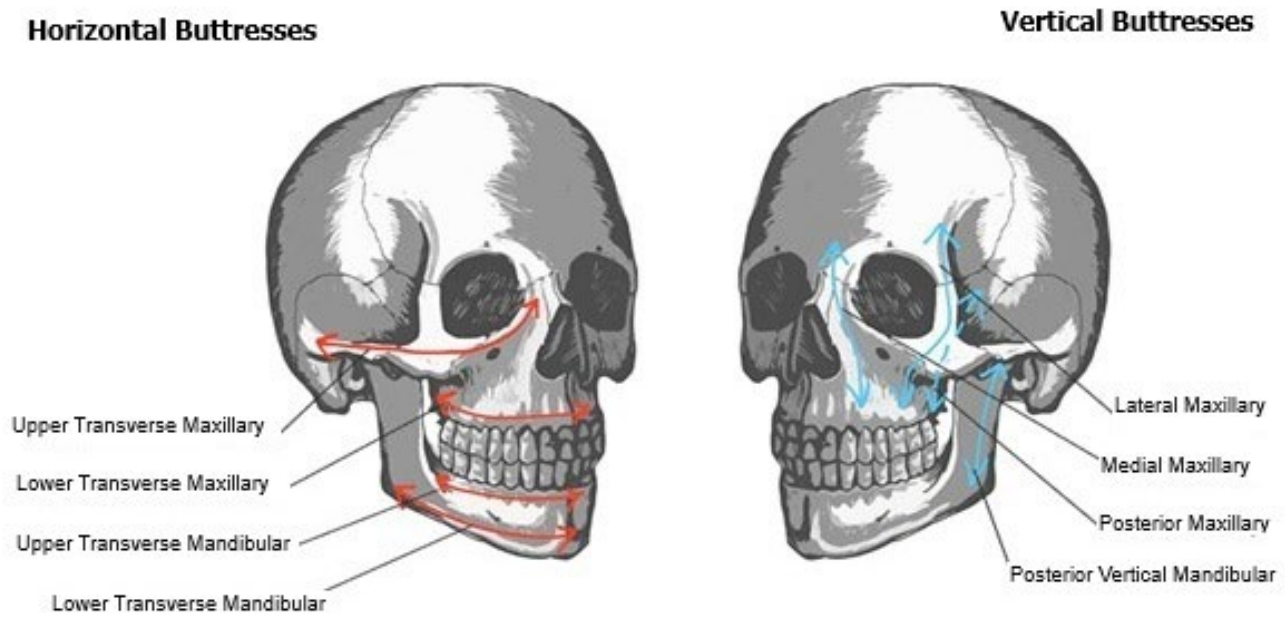
surgeons to understand which anatomical structures are involved so they can plan for an accurate surgical approach and intraoperative technique(s).[8]

Facial Bone Buttresses and Anatomy

Facial bone buttresses represent areas of relative increased bone thickness that support the functional units of the face (including the muscles, eyes, dental occlusion, airway, etc). They define the form of the face and have sufficient bone thickness to accommodate metal screw fixations, if they are needed.[10] Because facial buttress bones are thicker than the bones of the rest of the face, these structures form a strong framework that protects the teeth, nasal cavity, sinuses, and contents of the orbits.[8] Radiologists should know anatomical classifications expressed as struts/buttresses (ie, structurally significant skeletal components that, as one formed structure, play a role in the form and function of the facial bones) and thirds as is the nomenclature used by many surgeons and otolaryngologists for proper and accurate report interpretation.[8-9]

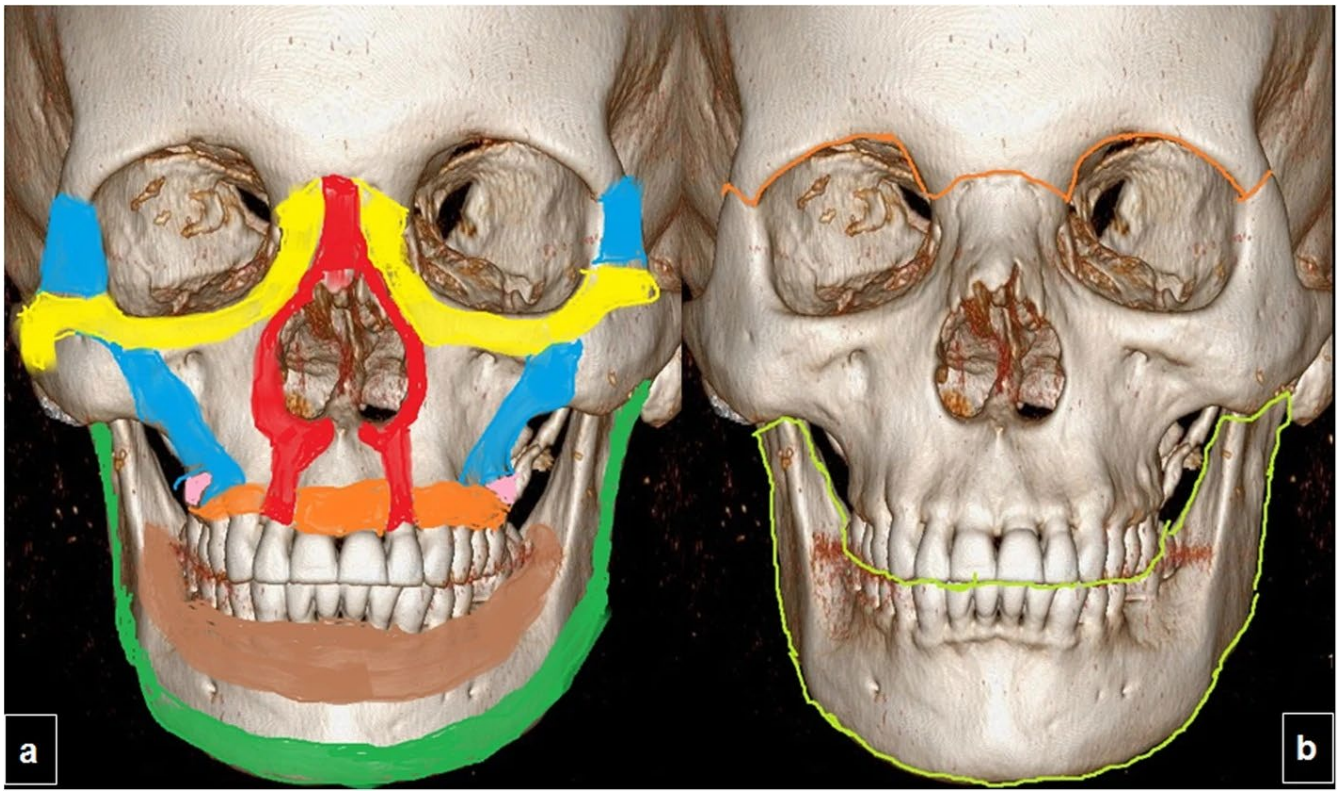
The vertically oriented buttresses connect the bones of the face to the base of the skull.[8] The facial skeleton contains 4 paired vertical buttresses: the lateral, medial, and posterior maxillary, and posterior vertical mandibular buttresses and four paired vertical buttresses: the upper maxillary, lower transverse maxillary, upper mandibular, and lower transverse mandibular buttresses (Figure 4).[11] A more detailed view of these buttresses are depicted on 3D-CT in Figure 5.[8]

Figure 4. Vertical and Transverse Facial Buttresses



Phillips et al. *Bull Emerg Trauma*. 2017.[11] For educational purposes only.

Figure 5. Facial Buttresses on 3D-CT



A system of facial struts/buttresses of an adult skull outlined in color on 3D-CT (A). The horizontal buttresses include the upper transverse maxillary (yellow lines in A), the lower transverse maxillary (orange lines in A), the upper transverse mandibular (brown lines in A), and the lower transverse mandibular (green lines in A) buttresses. The vertical buttresses include the medial maxillary (red lines in A), the lateral maxillary (blue lines in A), the posterior maxillary (pink lines in A), and the posterior mandibular (green lines in A) buttresses. A system of facial partitions is detailed in (B.). Specifically, a 3D-CT image of an adult skull with color overlays shows partitions of facial anatomy split into the upper (orange outline in B), middle, and lower (green outline in B) thirds, which is used by otolaryngologists to describe the location(s) of facial fractures.

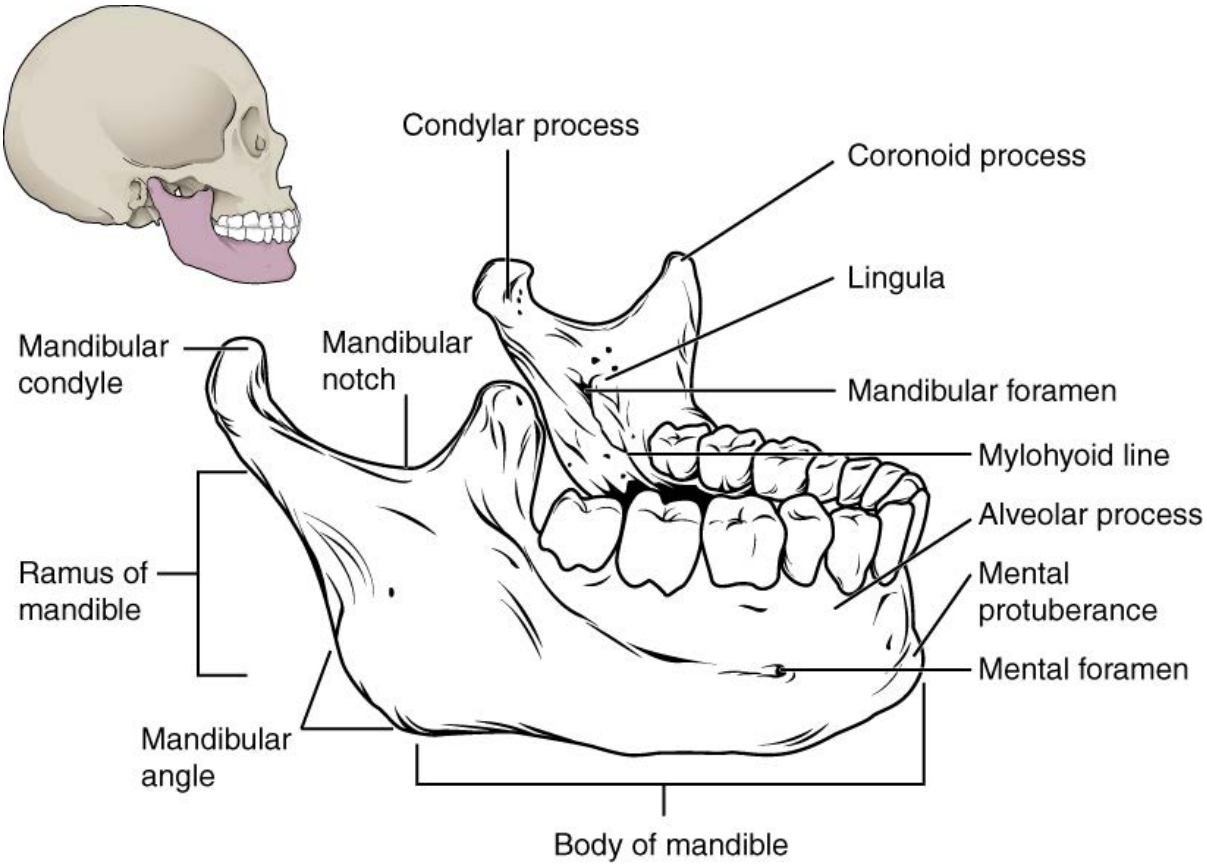
3D = three-dimensional; CT = computed tomography.

Gómez Roselló et al. *Insights Imaging*. 2020.[8] For educational purposes only.

Mandibular Anatomy

The mandible forms the lower jaw and is the only moveable bone of the skull (Figure 6).[5] Each side of the mandible consists of a horizontal body and posteriorly, a vertically oriented ramus of the mandible. The outside margin of the mandible, where the body and ramus come together, is called the angle of the mandible. The ramus on each side of the mandible has 2 upward-facing bony projections. The more anterior projection is the flattened coronoid process of the mandible, which provides attachment for one of the biting muscles. The posterior projection is the mandibular condyles, which are topped by the oval-shaped condyle. The condyle of the mandible is joined to the mandibular fossa and articular tubercle of the temporal bone. Together, these articulations form the temporomandibular joint, which allows for opening and closing of the mouth. The broad U-shaped curve located between the coronoid and condylar processes is referred to as the mandibular notch.[5]

Figure 6. The Mandible



A labelled illustration of the mandible in the right lateral view.

Biga et al. *Anatomy & Physiology 2e*. OpenStax/Oregon State University; 2025.[5] For educational purposes only.

Important landmarks of the mandible include[5]:

- Alveolar Process: This is the upper border of the mandibular body, which anchors the lower teeth.
- Mental Protuberance: The forward projection from the inferior margin of the anterior mandible that forms the chin (mental = "chin").
- Mental Foramen: The opening on each side of the anterior-lateral mandible, which is the exit site for a sensory nerve that supplies the chin.
- Mylohyoid Line*:* This bony ridge extends along the inner aspect of the mandibular body.
- Mandibular Foramen: This opening is located on the medial side of the ramus of the mandible. The opening leads into a tunnel that runs down the length of the mandibular

body. The sensory nerve and blood vessels that supply the lower teeth enter the mandibular foramen and then follow this tunnel.

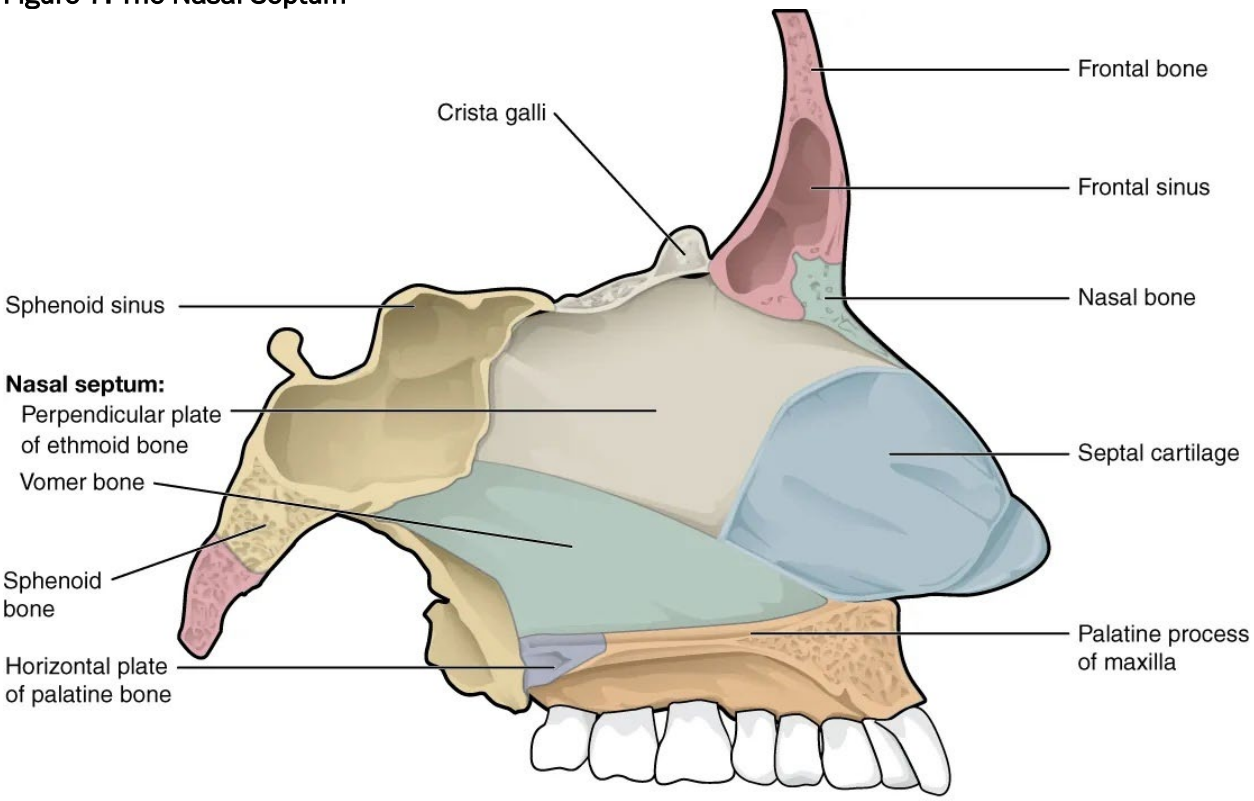
- Lingula: This small flap of bone is named for its shape (lingula = "little tongue"). It is located immediately next to the mandibular foramen on the medial side of the ramus.

Septum, Nasal Bones, and Conchae

Septum

The nasal septum consists of both bone and cartilage (Figure 7).[5] The upper component of the septum is formed by the perpendicular plate of the ethmoid bone. The lower and posterior components of the septum are formed by the triangular-shaped vomer bone. The anterior nasal septum is formed by the septal cartilage, which is a flexible plate that fills the gap between the perpendicular plate of the ethmoid and vomer bones. This cartilage also extends outward into the nose where it separates the right and left nostrils.[5]

Figure 7. The Nasal Septum



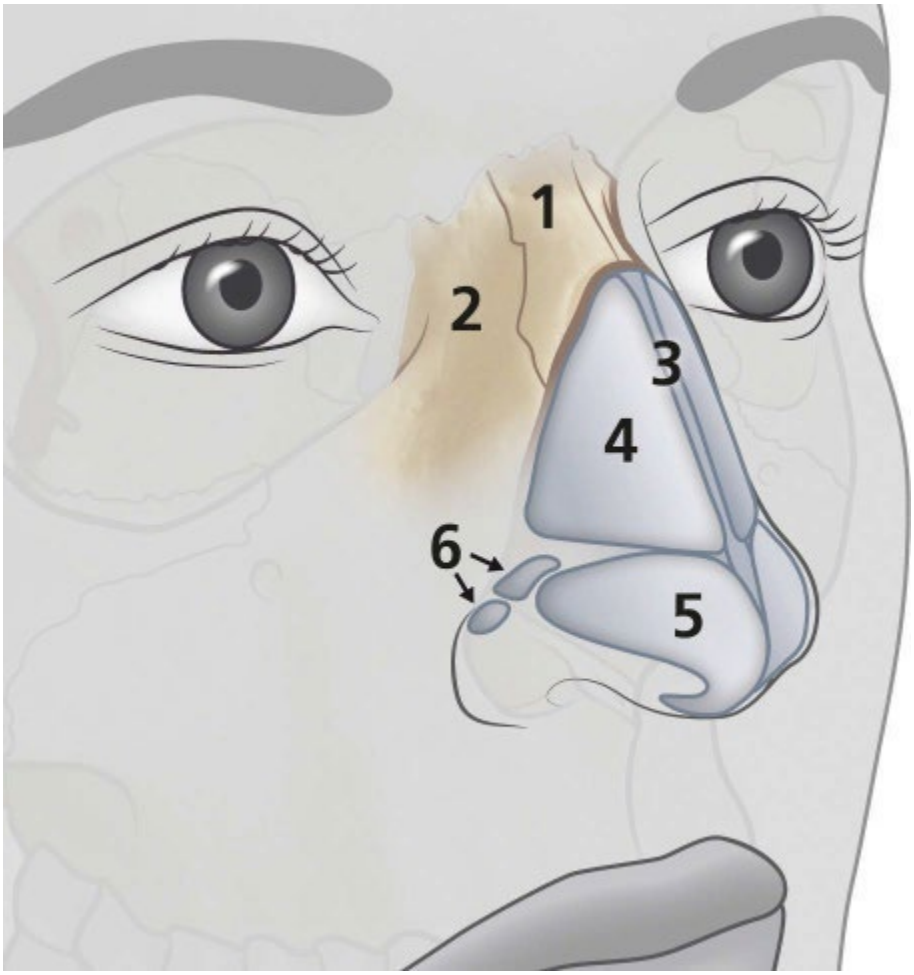
A labelled illustration of the sagittal section of the nasal septum.

Biga et al. *Anatomy & Physiology 2e*. OpenStax/Oregon State University; 2025.[5] For educational purposes only.

Nasal Bones

The cartilaginous and bony components of the nasal bones are both vulnerable to fracture.[4] The nasal bone cartilaginous structure includes the paired immobile bony pyramid, the semirigid attached upper lateral cartilages, and the nasal septum (Figure 8).[4,12] These components provide support to the nose and assist in maintaining airway patency.[4] The vomer bone is triangular-shaped and forms the posterior-inferior part of the nasal septum and is best visualized when looking from behind into the posterior openings of the nasal cavity.[5]

Figure 8. Nasal Bone and Cartilage



Osseous and cartilaginous components of the nose: 1 = nasal bone; 2 = nasofrontal process of os maxilla; 3 = superior margin of nasal septum; 4 = upper lateral cartilage; 5 = lower lateral cartilage; 6 = minor alar cartilages.

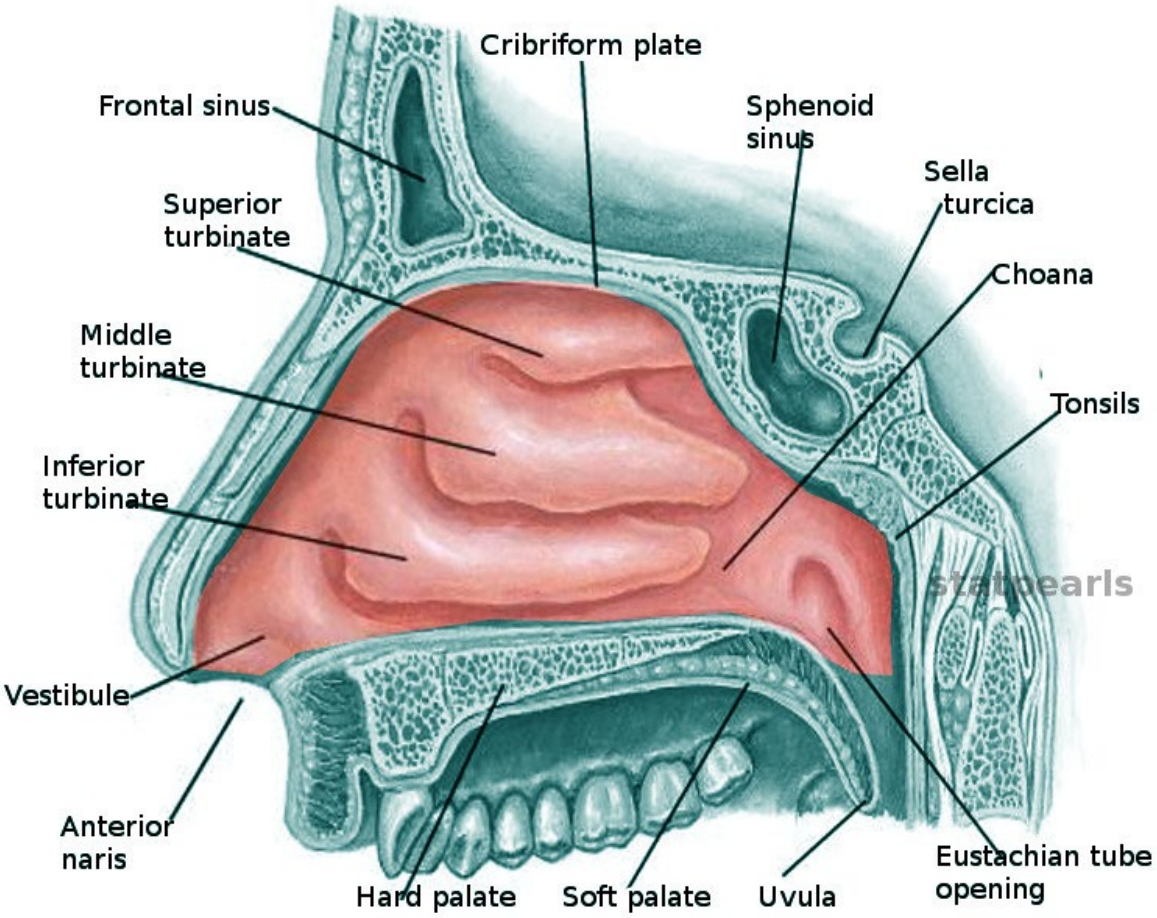
von Arx et al. *Swiss Dent J*. 2018.[12] For educational purposes only.

The nasal bone is 1 of 2 small bones that articulate with each other to form the bony base (bridge) of the nose. They also support the cartilage that forms the lateral walls of the nose. These are the bones that are damaged when the nose is fractured.[5]

Nasal Conchae/Turbinates

Nasal conchae are also known as nasal turbinates. Three pairs of turbinates are commonly described along the lateral walls of the nasal cavity: the superior, middle, and inferior (Figure 9).[13] The inferior turbinate is the largest and is located in the lower part of the lateral nasal wall. The inferior turbinate is a separate bone that articulates with the maxillary, palatine, and ethmoid bones. The middle turbinate is positioned above the inferior turbinate and is attached to the lateral wall of the nasal cavity. The middle turbinate is part of the ethmoid bone and has a thin, curved bony structure. The superior turbinate is the smallest of the 3 main turbinates and is located above the middle turbinate. This turbinate is also part of the ethmoid bone and has a similar thin, curved shape.[13]

Figure 9. The Nasal Cavity and Conchae/Turbinates



This illustration shows the nasal cavity and the anatomic relationships between the structures in the region, which include the superior, middle, and inferior turbinates, vestibule, anterior naris, frontal sinus, cribriform plate, sphenoid sinus, Sella turcica, choana, tonsils, Eustachian tube opening, uvula, and hard and soft palate.

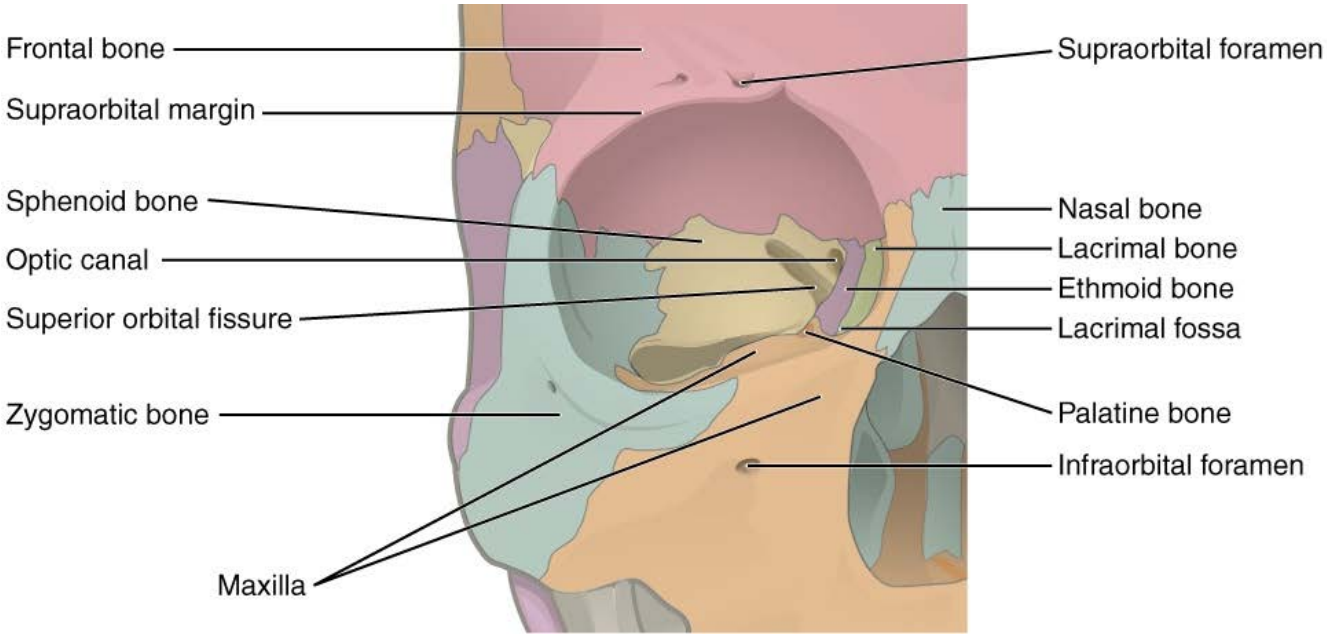
Fakoya AO, Hohman MH, Georgakopoulos B, et al. Anatomy, Head and neck, nasal concha. In: *StatPearls* [Internet]. Treasure Island, FL: StatPearls Publishing; 2024.[13] Contributed by O Chaigasame, MD. For educational purposes only.

The Orbits

The orbits are bilateral bony sockets that house the eyeball and contain the muscles that move the eyeball or open the upper eyelid (Figure 10).[5] Each orbit is cone-shaped, with a narrow posterior region that widens toward the large anterior opening. To help protect the eye, the bony margins of the anterior opening are thick and somewhat constricted. The medial walls of the 2 orbits are

parallel to each other, but each lateral wall diverges away from the midline at a 45° angle. This divergence allows for better lateral peripheral vision.[5]

Figure 10. Bones of the Orbit



Seven skull bones contribute to the walls of the orbit. Opening into the posterior orbit from the cranial cavity are the optic canal and superior orbital fissure.

Biga et al. *Anatomy & Physiology 2e*. OpenStax/Oregon State University; 2025.[5] For educational purposes only.

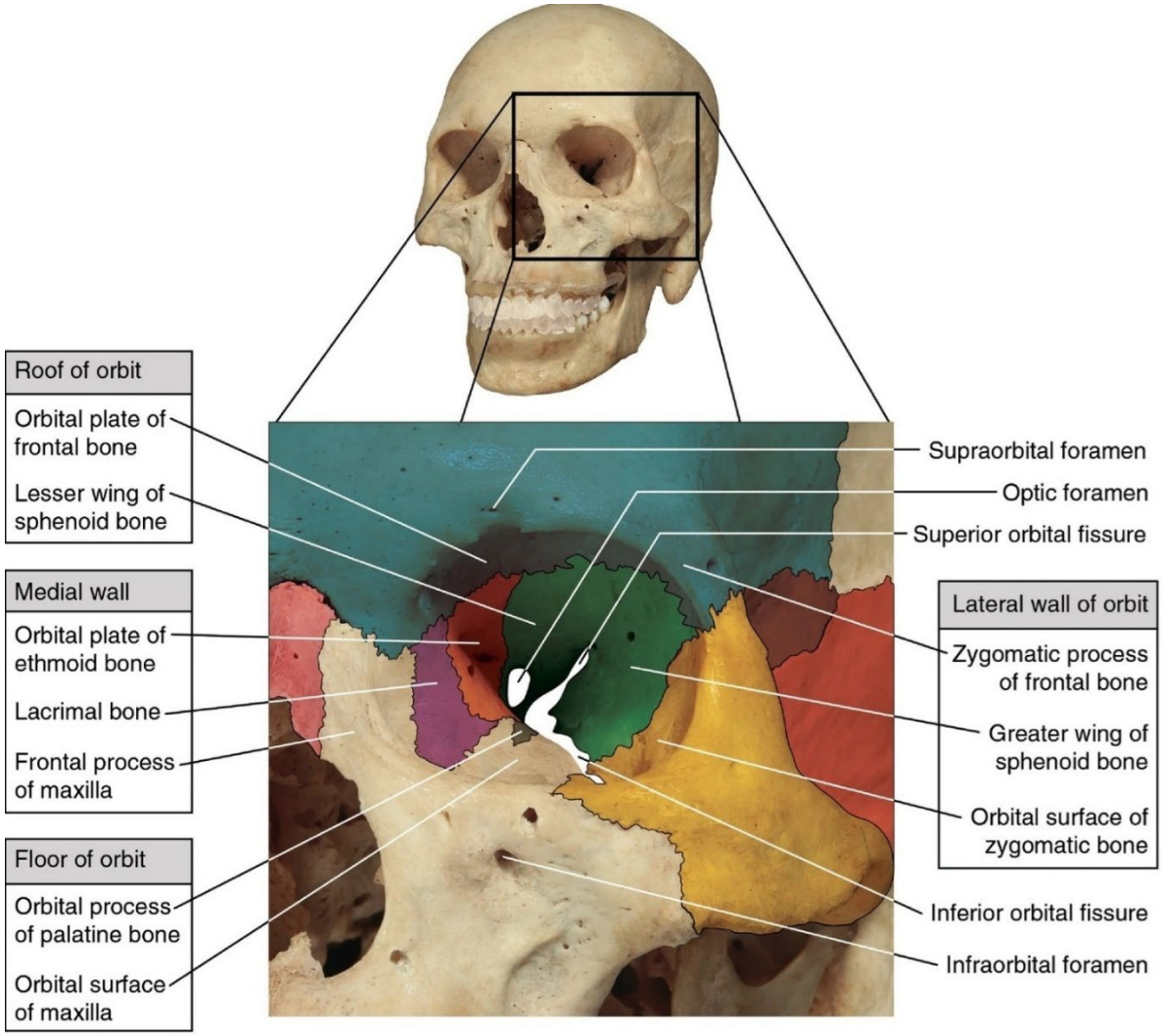
The walls of each orbit include contributions from 7 skull bones. The frontal bone forms the roof, and the zygomatic bone forms the lateral wall and lateral floor. The medial floor is primarily formed by the maxilla with a small piece from the palatine bone. The ethmoid bone and lacrimal bone make up much of the medial wall, and the sphenoid bone forms the posterior orbit.[5]

At the posterior peak of the orbit is the opening of the optic canal, which allows for passage of the optic nerve from the retina to the brain. The optic foramen is an opening located in the sphenoid bone. Lateral to this is the elongated and irregularly shaped superior orbital fissure, which provides passage for the artery that supplies the eyeball, sensory nerves, and the nerves that supply the muscles involved in eye movements.[5]

The Orbital Floor and Rims

The orbital floor is comprised of the maxillary bone, the orbital plate of the zygomatic bone, and the palatine bone (Figure 11).[14-15] The orbital rim refers to the bony edge of the eye socket, while the orbital floor is the bony surface that forms the bottom of the eye socket, essentially the "floor," of the orbital cavity. The rims are superior, inferior, medial, and lateral. The width of the rims is greater than its height, which forms a rectangular. The orbital cavity is bound by the orbital roof, lateral and medial walls, and orbital floor. The orbital floor forms the roof of the maxillary sinus. The presence of the maxillary sinus and the insertion of the inferior oblique muscle make this region more prone to fracture and comminution.[16]

Figure 11. Major Structures of the Orbital Cavity

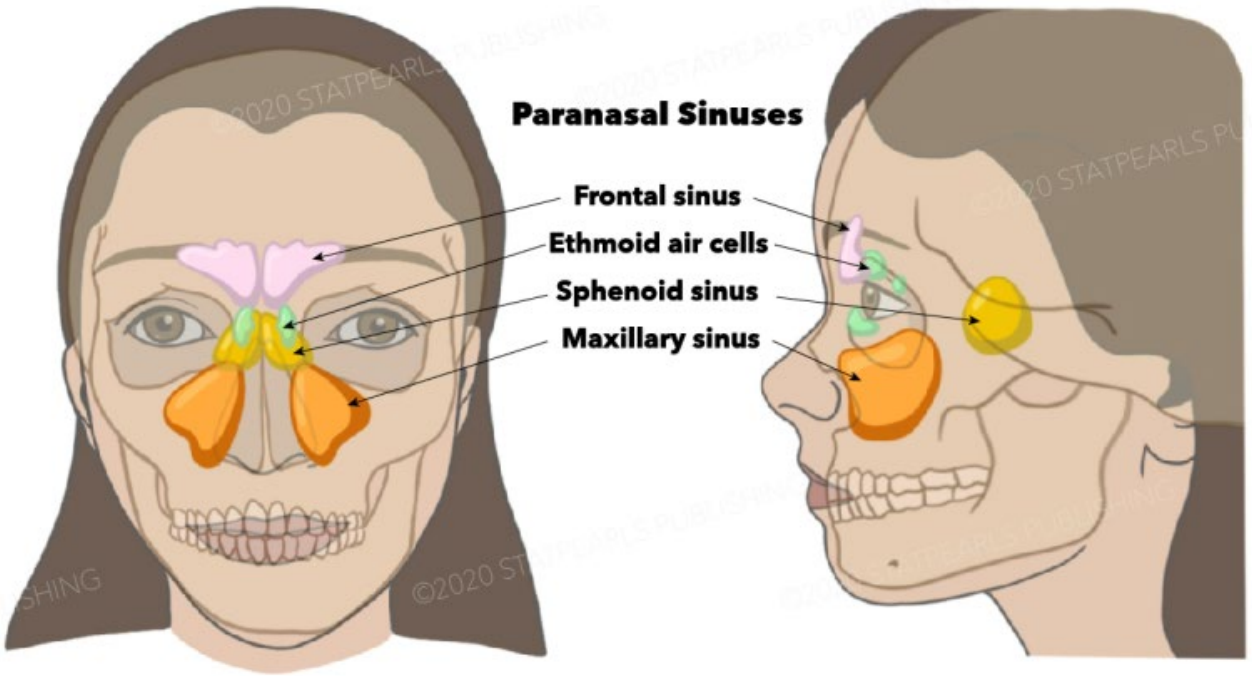


Bonanthaya et al, eds. *Oral and Maxillofacial Surgery for the Clinician*. Springer Nature Singapore Pte Ltd; 2021.[14] For educational purposes only.

Paranasal Sinuses

Since injuries to the facial bones and related surrounding structures also can affect the paranasal sinuses, it is also important to review that anatomy. The paranasal sinuses are hollow, air-filled spaces located within certain bones of the skull.[5] The paranasal sinuses are named for the skull bone that each occupies (Figure 12).[17] The frontal sinus is located just above the eyebrows, within the frontal bone, and is the most anterior of the paranasal sinuses. The largest sinus is the maxillary sinus. It is paired and located within the right and left maxillary bones, where they occupy the area just below the orbits. The sphenoid sinus is a single, midline sinus. It is located within the body of the sphenoid bone, just anterior and inferior to the Sella turcica, thus making it the most posterior of the paranasal sinuses. The lateral aspects of the ethmoid bone contain multiple small spaces separated by very thin bony walls, each of which is called an ethmoid air cell. These air cells are located on both sides of the ethmoid bone, between the upper nasal cavity and medial orbit, just behind the superior nasal conchae.[5]

Figure 12. The Paranasal Sinuses



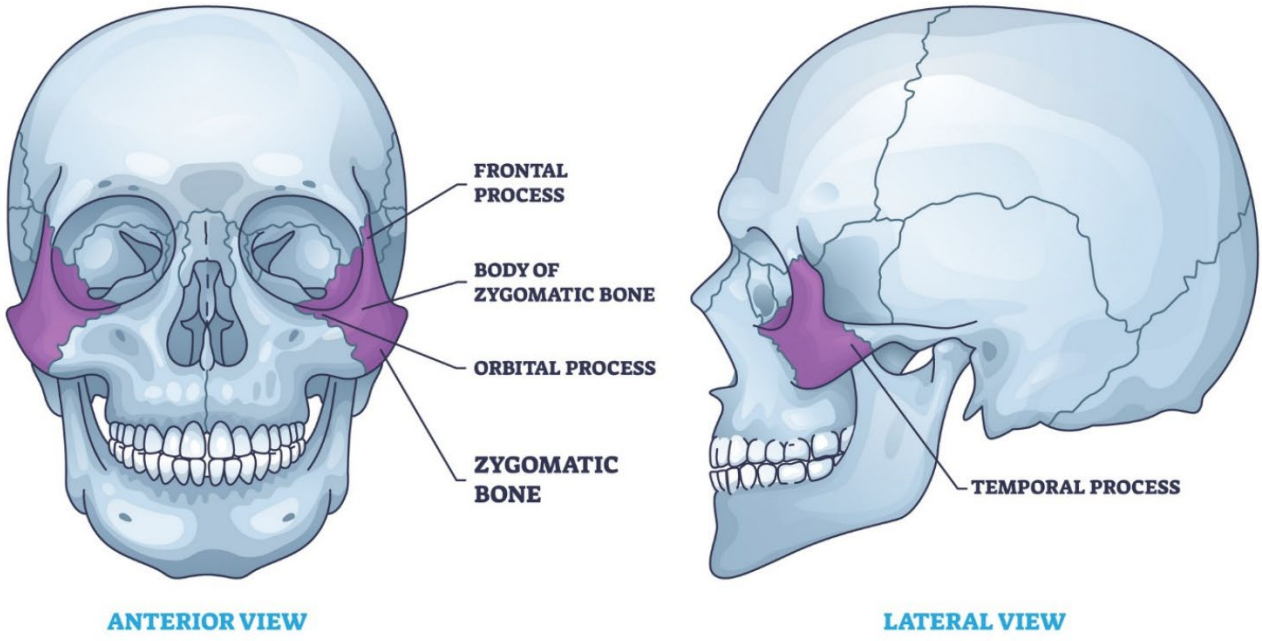
Cappello ZJ, Minutello K, Dublin AB. Anatomy, head and neck: Nose paranasal sinuses. In: *StatPearl*s [Internet]. Treasure Island, FL: StatPearls Publishing; 2023.[17] For educational purposes only.

Zygomatic Bone and Arches

The zygomatic bone is also referred to as the cheekbone, and it occupies a prominent and important position in the facial skeleton.[5] Each of the paired zygomatic bones forms much of the lateral wall of the orbit and the lateral-inferior margins of the anterior orbital opening. The zygoma forms a significant portion of the floor and lateral wall of the orbit and forms a portion of the zygomatic arch, otherwise known as the malar eminence.[18] The short temporal process (ie, an outgrowth or protrusion of bone or tissue from a larger body) of the zygomatic bone projects posteriorly, where it forms the anterior portion of the zygomatic arch.[5]

The zygomatic arch is the most lateral projection of the midface; this structure plays a key role because it absorbs and dissipates traumatic forces away from the cranial base.[19] It is the bony arch on the side of skull that spans from the area of the cheek to just above the ear canal. It is formed by the junction of 2 bony processes: a short anterior component, the temporal process of the zygomatic bone (the cheekbone), and a longer posterior portion, the zygomatic process of the temporal bone, extending forward from the temporal bone (Figure 13). Thus, the temporal process (anteriorly) and the zygomatic process (posteriorly) join together, like the 2 ends of a drawbridge, to form the zygomatic arch.[5]

Figure 13. Zygomatic Process



A labelled illustration of anterior and lateral views of the zygomatic process.

Zygomatic Sutures

The zygoma has 4 articulations, referred to as the ZMC complex; where these articulations meet and are held together by strong, fibrous bands of tissue are called sutures (Figure 14)[19-20]:

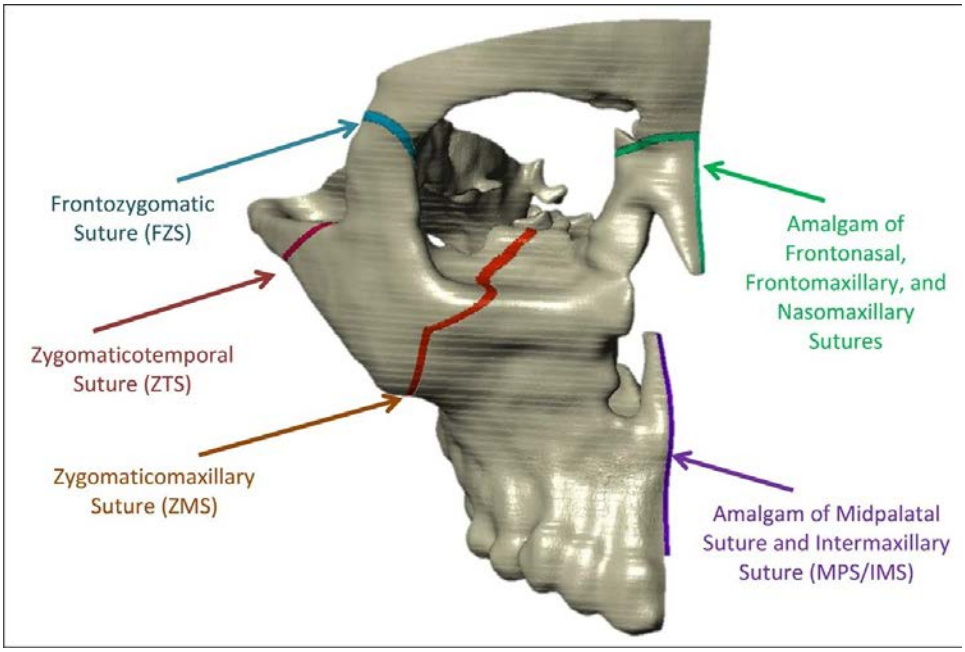
1. Zygomaticotemporal Suture: This is the temporal process of the zygoma, which articulates with the zygomatic process of the temporal bone to form the zygomatic arch.

2. Zygomaticomaxillary (ZM) Suture: This suture line crosses the inferior orbital rim, resulting in frequent simultaneous orbital floor and ZMC fractures. The ZM suture lies within the ZM buttress, a key vertical support structure in the midface. The other 2 vertical midface buttresses are the nasomaxillary and the pterygomaxillary buttresses.

3. Zygomaticofrontal (ZF) Suture: This is lateral to the brow and is a small suture line easily accessed via a short lateral brow incision.

4. Zygomaticosphenoidal Suture: The alignment of this suture is critical when reducing a fracture to re-establish pretraumatic orbital volume, even though this suture line is not typically fixated after reduction.

Figure 14. Cranial Sutures



Partial skull geometry illustrating relevant cranial sutures and their approximate anatomical locations.

Fuhrer et al. *Sci Rep*. 2019.[20] For educational purposes only.

Common Fracture Types

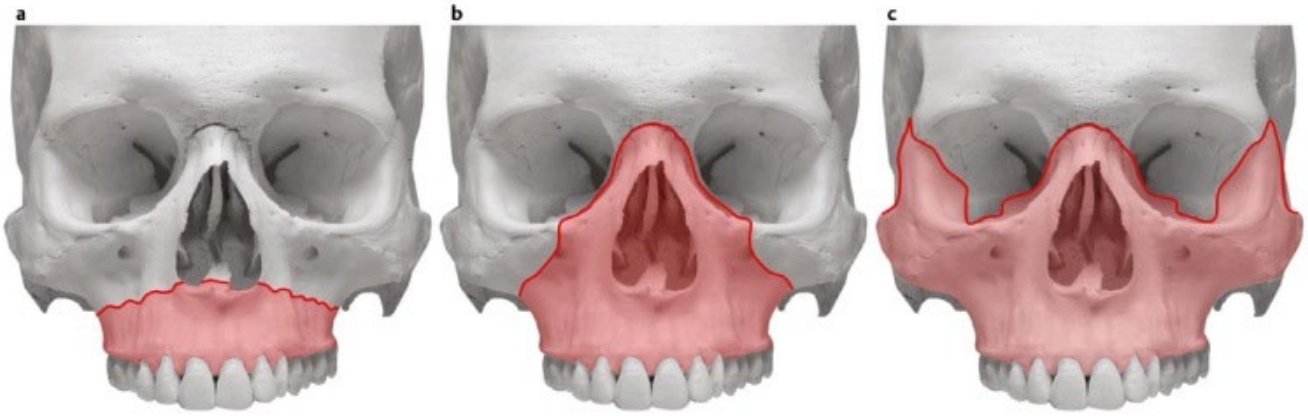
Facial Bone Fractures

Facial bone fractures are commonly caused by blunt or penetrating trauma sustained during MVAs, assaults, sports, industrial accidents, gunshot wounds, and falls.[10,21] The complexity of the facial bones makes the characterization of facial fractures based on the involved bones very difficult and challenging for proper radiographic interpretation. In addition, given the proximity of vulnerable soft-tissue regions, it may be more clinically useful to describe facial fractures according to their location in relation to functionally relevant anatomic structures (eg, a fracture of the medial orbital wall, or a fracture of the anterior maxillary sinus wall, etc) to provide clarity for the clinician or surgeon.[22]

Facial Fracture Types and Le Fort Classifications

Facial bone fractures can be characterized as limited, transfacial, and smash fractures.[23] Transfacial fractures are typically known as Le Fort fractures (Figure 15).[24-25] One of the most common fractures of the facial bones is a tripod fracture complex. This fracture refers to a specific type of zygomatic (cheekbone) fracture where the bone is separated at its 3 main attachment points from the rest of the face, essentially creating a tripod-type shape. A LeFort Type II fracture is a more of a complex facial fracture, which is classified as a pyramidal fracture, where the midface is separated from the skull base; typically, there are also fractures along the nasal bridge, orbital floor, and maxillary sinus walls.[26]

Figure 15. Le Fort Fractures



Outlines over images of a skull show the location on the face of a Le Fort Type I fracture (A.), Type II fracture (B.), and Type III fracture (C.).

Kühnel et al. *GMS Curr Top Otorhinolaryngol Head Neck Surg*. 2015.[24] For educational purposes only.

More detailed descriptions of Le Fort facial facture classifications are outlined below.[3,25]

- LE FORT TYPE I
    - A horizontal maxillary fracture, separating the teeth from the upper face
    - The fracture line passes through the alveolar ridge, lateral nose, and inferior wall of the maxillary sinus
    - It is also known as a Guerin fracture.

- LE FORT TYPE II
    - A pyramidal-type fracture with the teeth at the pyramid base and the nasofrontal suture at its apex
    - The fracture arch passes through the posterior alveolar ridge, the lateral walls of maxillary sinuses, the inferior orbital rim, and the nasal bones.
    - The uppermost fracture line can pass through the nasofrontal junction or the frontal process of the maxilla.

- LE FORT TYPE III
    - Craniofacial disjunction
    - The transverse fracture line passes through nasofrontal suture, the maxillo-frontal suture, the orbital walls, and the zygomatic arch/ZF suture.

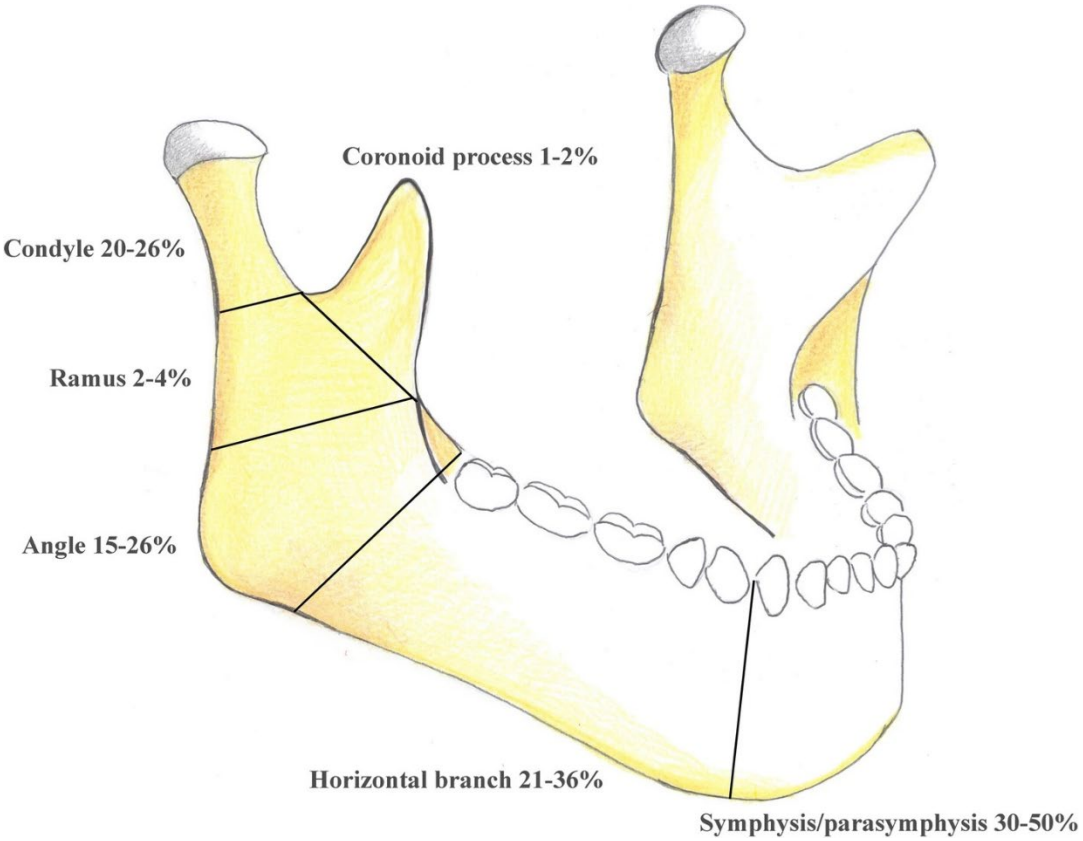
- Due to the involvement of the zygomatic arch, there is a risk of temporalis muscle impingement.
- Le Fort Type III fractures have the highest rate of cerebrospinal fluid leaks.

Smash fractures are comminuted fractures that do not follow the classical facial fracture patterns.[23]

Mandibular Fractures

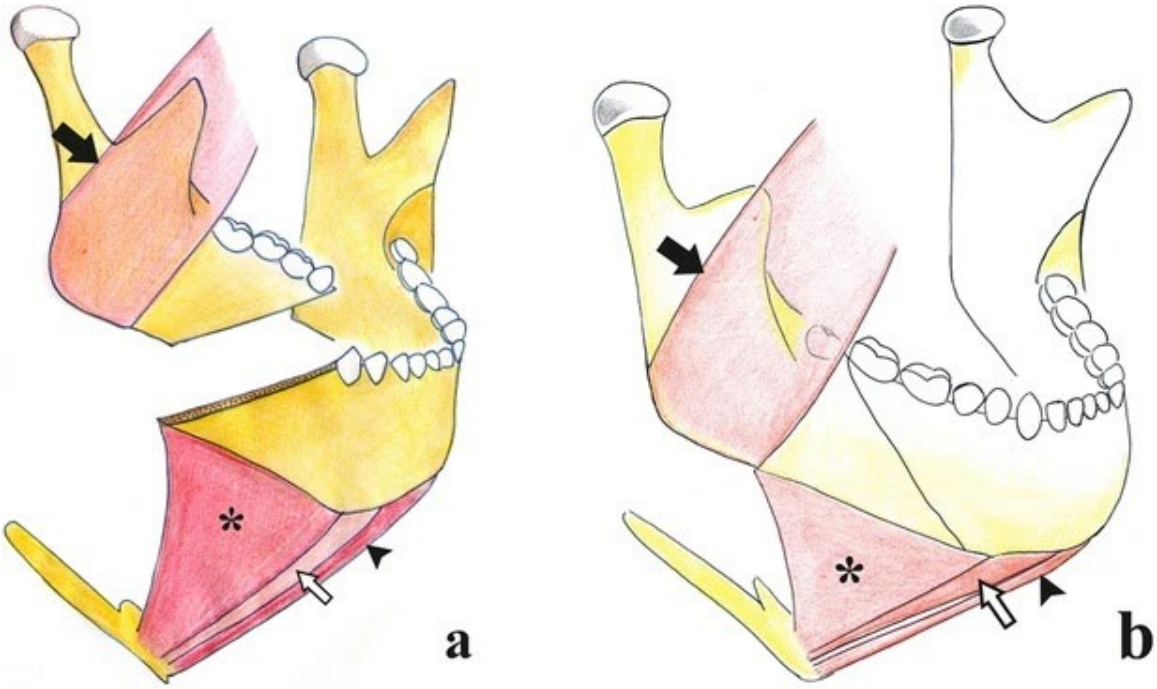
Mandibular fractures are among the most common maxillofacial fractures (60%–70%) observed in EDs; more than 2500 people sustain a mandibular fracture in the US annually. The most common causes of maxillofacial fractures are MVAs (40%–42%), falls, assaults, sports-related injuries, and work-related injuries. Mandibular fractures can be classified in relation to their anatomic location (Figure 16) as follows: symphysis/parasymphysis fractures (30%–50%), horizontal branch fractures (21%–36%) (Figure 17), angle fractures (15%–26%) (Figure 18), ramus fractures (2%–4%) (Figure 19), condyle fractures (20%–26%), and coronoid process fractures (1%–2%) (Figure 20).[27]

Figure 16. Anatomic Areas of Mandibular Fractures



Nardi et al. *Insights Imaging*. 2020;11:30.[27] For educational purposes only.

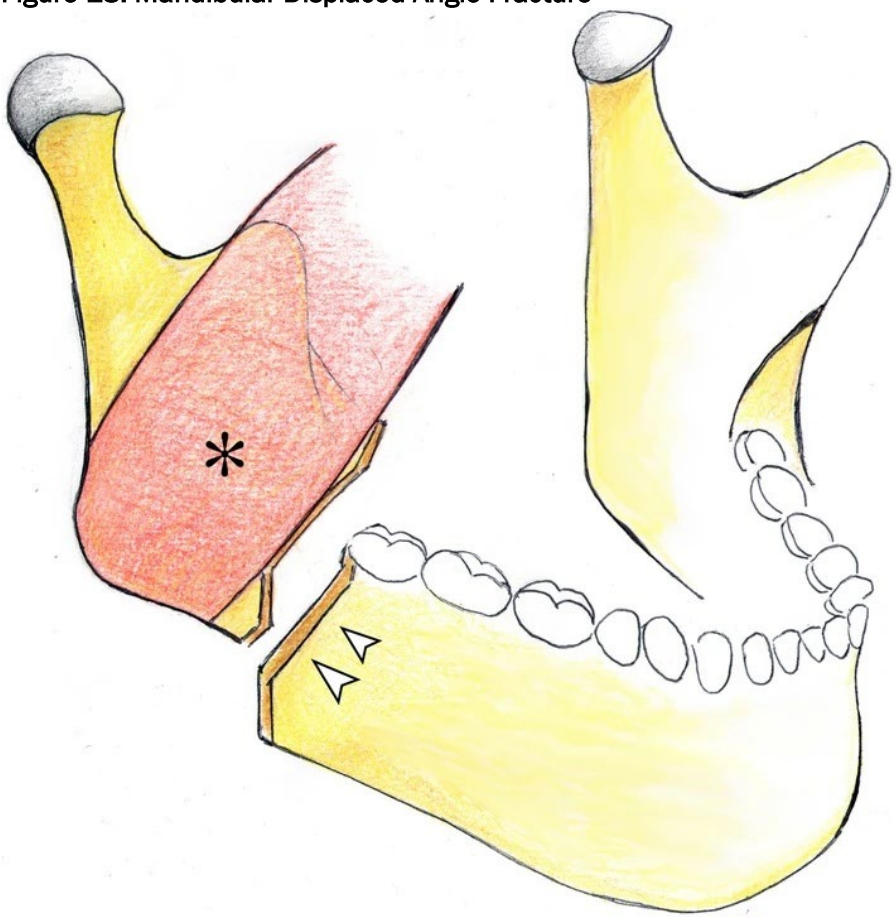
Figure 17. Mandibular Horizontal Branch Fractures



Labelled illustrations of horizontal branch fractures. An unfavorable fracture is pictured in (A.) showing a fracture in a downward and posterior direction. The bone fragments are misaligned by the action of the masseter muscle (black arrow in A.) that pulls the distal bone fragment upwards, and the mylohyoid (asterisk in A.), geniohyoid (white arrow in A.), and anterior belly of digastric (black arrowhead in A.) muscles that pull the mesial bone fragment downwards. A favorable fracture is pictured in (B.) showing a fracture in a downward and anterior direction. The bone fragments impact each other with no displacement.

Nardi et al. *Insights Imaging*. 2020;11:30.[27] For educational purposes only.

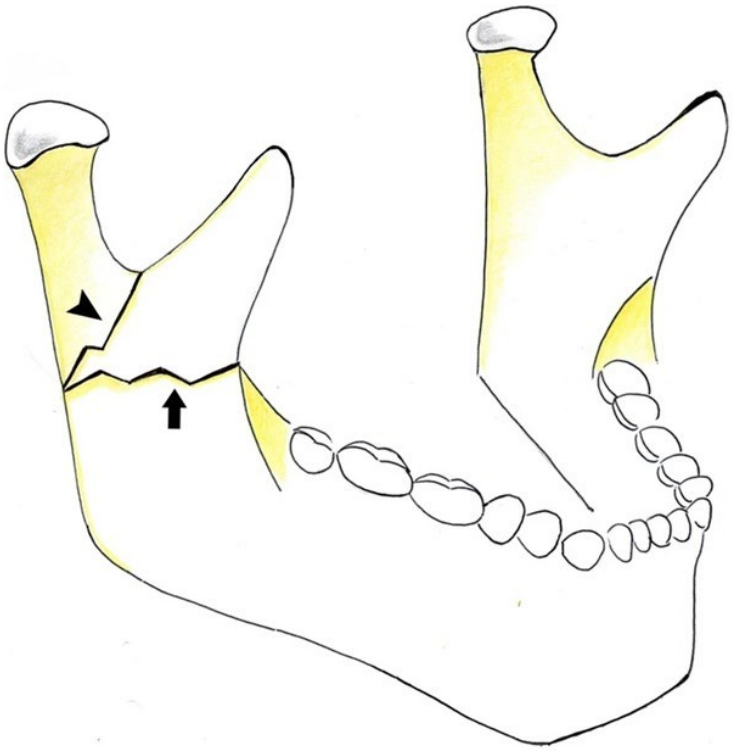
Figure 18. Mandibular Displaced Angle Fracture



A labelled illustration of a displaced angle fracture. The vertical fracture runs distally to the third molar (arrowheads). It is displaced since the masseter muscle (asterisk) pulls the distal bone fragment upwards and medially.

Nardi et al. *Insights Imaging*. 2020;11:30.[27] For educational purposes only.

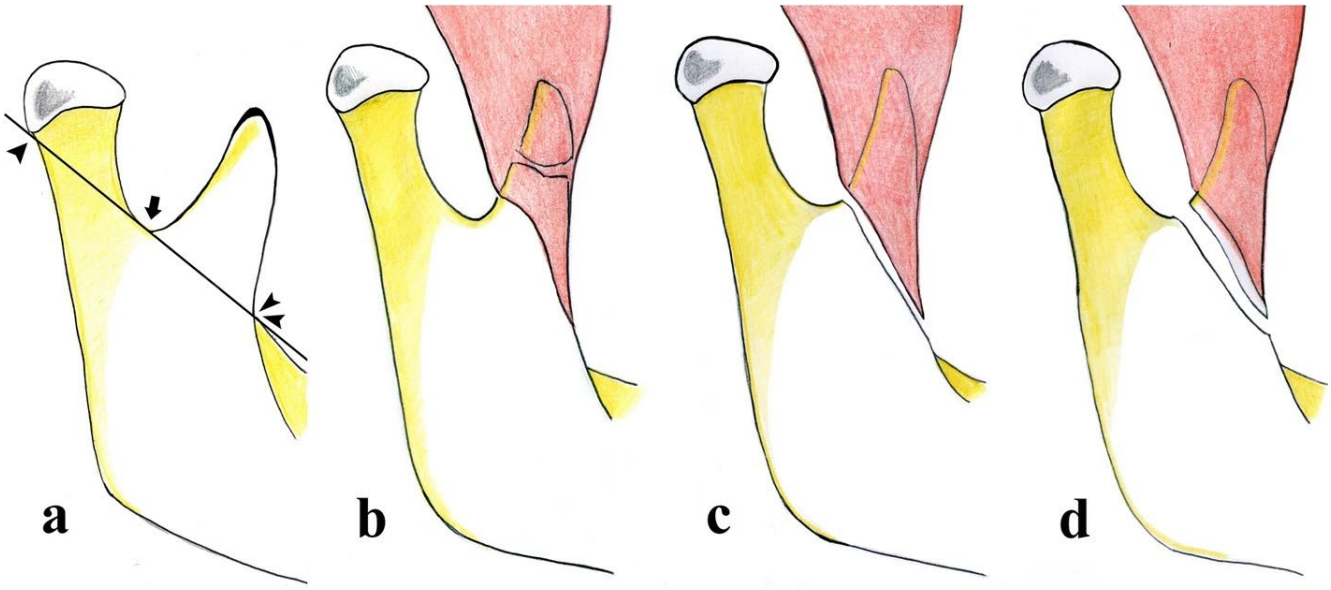
Figure 19. Mandibular Ramus Fracture



This type of fracture can be vertical (arrowhead) or horizontal (arrow), depending on the direction of the fracture rhyme.

Nardi et al. *Insights Imaging*. 2020;11:30.[27] For educational purposes only.

Figure 20. Mandibular Coronoid Process Fractures

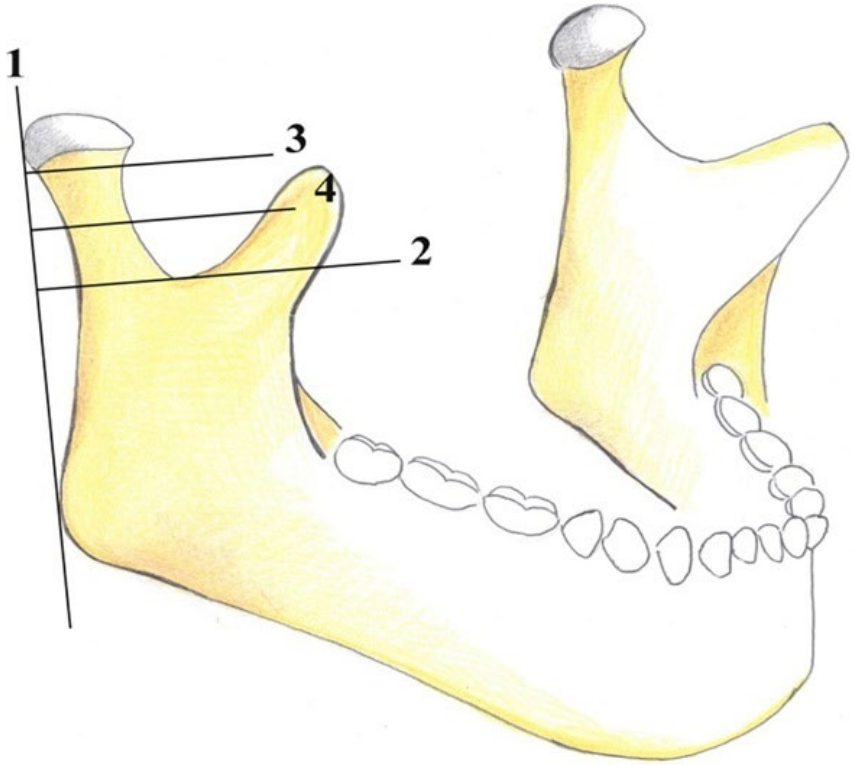


Labelled illustrations of coronoid process fractures. A straight line passing through the deepest central point of the sigmoid notch (arrow in A.) can be traced from the lower posterior portion of the condylar head (single arrowhead in A.) to the anterior edge of the mandibular ramus (double arrowhead in A.). The bone portion included between the arrow and double arrowhead represents the coronoid process. A coronoid process apex fracture is depicted in (B.), which is fully included in the temporal muscle. Bone fragment displacement is minimal. A coronoid process fracture is illustrated in (C.), which is medial to the deepest central point of the sigmoid notch. The fracture originates close to the correspondence of the temporal muscle attachment points. A coronoid process fracture corresponding to the deepest central point of the sigmoid notch is illustrated in (D.). The fracture originates below the temporal muscular attachment.

Nardi et al. *Insights Imaging*. 2020;11:30.[27] For educational purposes only.

There are also classification systems for different types of mandible fractures, specifically, the AO Foundation's classification of condyle fractures of the mandible (Figure 21) as well as Dingman and Natvig's classification of favorable and unfavorable mandibular fractures (Figure 22).[27-28]

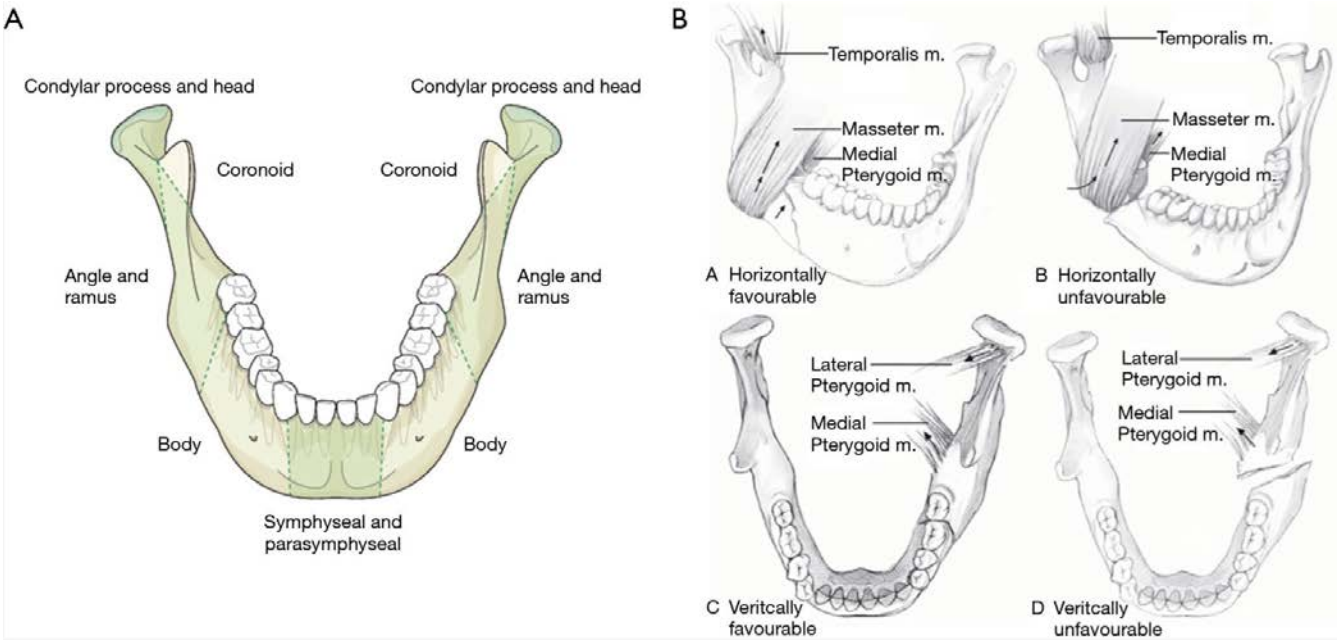
Figure 21. Mandibular Condyle Fracture Classification



A labelled illustration depicting mandibular condyle fractures as classified by the AO Foundation, which is divided into 3 groups: head fractures, "high-neck" fractures, and "low-neck" fractures. The distinction between high- and low-neck fractures can be achieved by drawing imaginary lines (labels 2.–4.) on the DR image while reviewing both simultaneously.

Nardi et al. *Insights Imaging*. 2020;11:30.[27] For educational purposes only.

Figure 22. Dingman and Natvig Mandibular Fracture Classification



Illustrations of mandibular fracture classifications by Dingman and Natvig who classify fractures of the mandible to the symphysis, parasymphysis, body, angle, ramus, condylar process, coronoid process and alveolar process (A.). Based on the location, fractures are classifications as either horizontally or vertically favorable or unfavorable (B.).

Naeem et al. *Quant Imaging Med Surg*. 2017.[28] For educational purposes only.

Nasal Bone Fractures

As described, the nasal bones consist of 2 fused bones that form the bridge of the nose and develop into various sizes as an individual reaches adulthood (Figure 8).[4,12,22] The nasal bones can be easily fractured because they're broad and flat. Proximal nasal bone fracture may be accompanied by fractures of adjacent bones, which may lead to additional complications.[29] The degree of force required to fracture the nasal bones is relatively small (25 lbs–75 lbs of pressure) compared to other regional midfacial structures.[22] Nasal bone fractures can be diagnosed by physical examination (examining for crepitation, septal deviation from the midline, and dislocated type of fracture) and patient history in addition to conventional radiography (Figure 23).[23,30] The most common cause of nasal bone fracture is blunt trauma to the midface. Nasal bone fractures are usually transverse, depressed, or displaced with also the potential of dislocation and are typically categorized using the modified Murray classification system as[22,25,31]:

Type I: Injury restricted to soft tissue

Type II: Simple displacement without telescoping

Type IIa: Simple, unilateral nondisplaced fracture

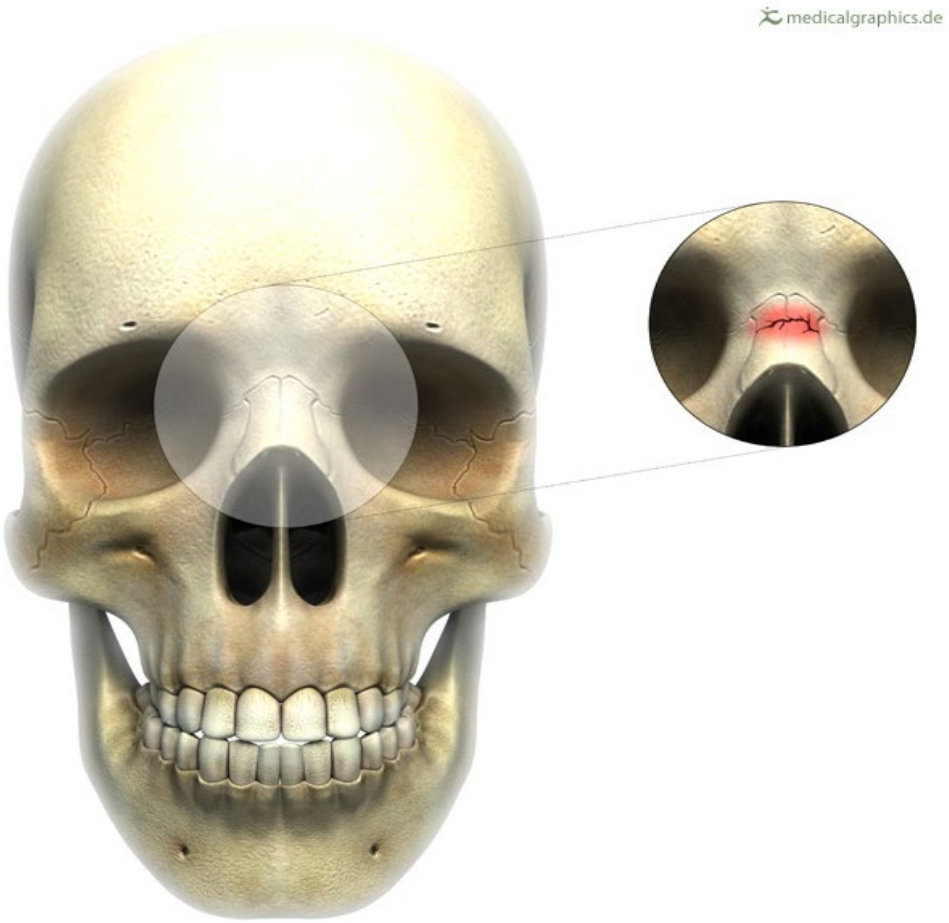
Type IIb: Simple, bilateral nondisplaced fracture

Type III: Simple, displaced fracture

Type IV: Closed comminuted fracture

Type V: Open comminuted fracture or complicated fracture

Figure 23. Transverse Nasal Bone Fracture



Medical Graphics. Nasal Fracture. MedicalGraphics.de. Available at: https://www.medicalgraphics.de/en/product/nasal-fracture/. Accessed November 25, 2024.[30] For educational purposes only. (Creative Commons License: CC BY-ND 4.0)

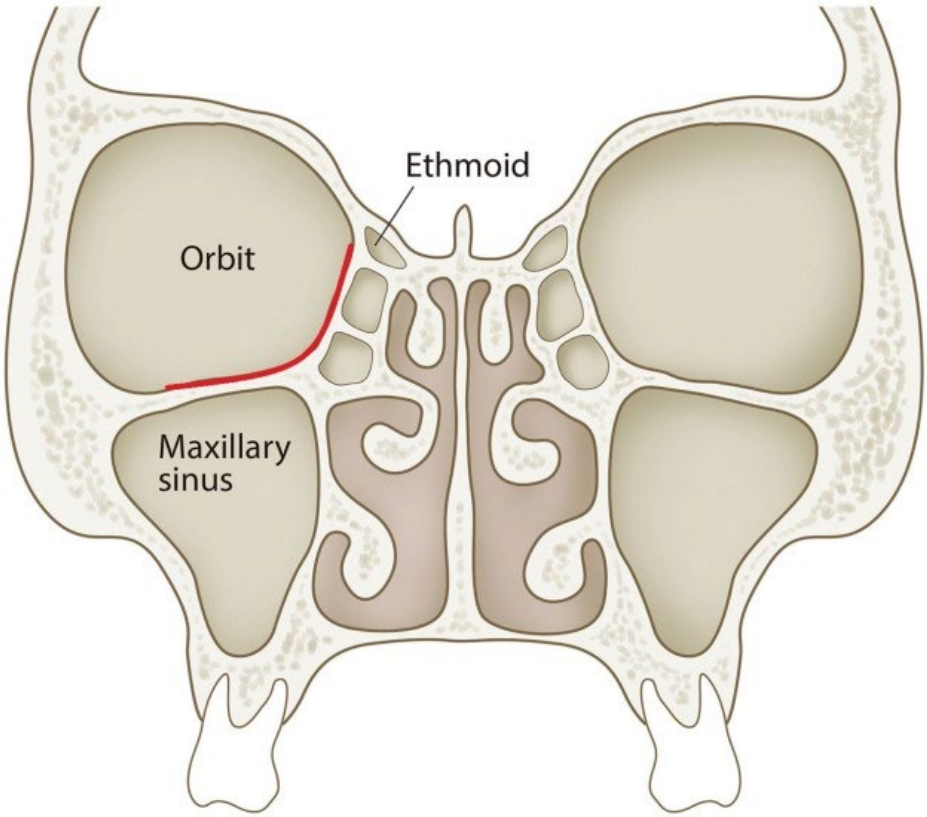
Fractures of the Orbits

Orbital fractures can be isolated but are more commonly associated with other midface-related fractures, such as posterior distribution of naso-orbito-ethmoid fractures (medial orbital wall) and ZMC fractures (orbital floor, lateral orbital wall). Fractures of the orbital bones may also occur in the Le Fort II complex (medial wall and floor) and the Le Fort III complex (medial wall, posterior orbital floor, lateral wall).[32]

Blow-Out, Blow-Up, and Blow-In Fractures

Isolated fractures to the orbital floor and orbital wall are often referred to as "blow-out" fractures (Figure 24).[16] This mainly involves the medial and/or inferior walls of the orbit and results in displacement of the fracture fragments into the ethmoid sinus, nasal cavity, or maxillary sinus. "Blow-up" fractures are a rare type of orbital fracture that involve the orbital roof and are associated with traumatic intracranial injury.[33]

Figure 24. Orbital Blow-Out Fracture



Common fracture sites of blowout fracture of the orbit (red line). Most thin portions of the orbit are medial to the infraorbital groove.

Kim et al. *Arch Craniofac Surg*. 2016.[16] For educational purposes only.

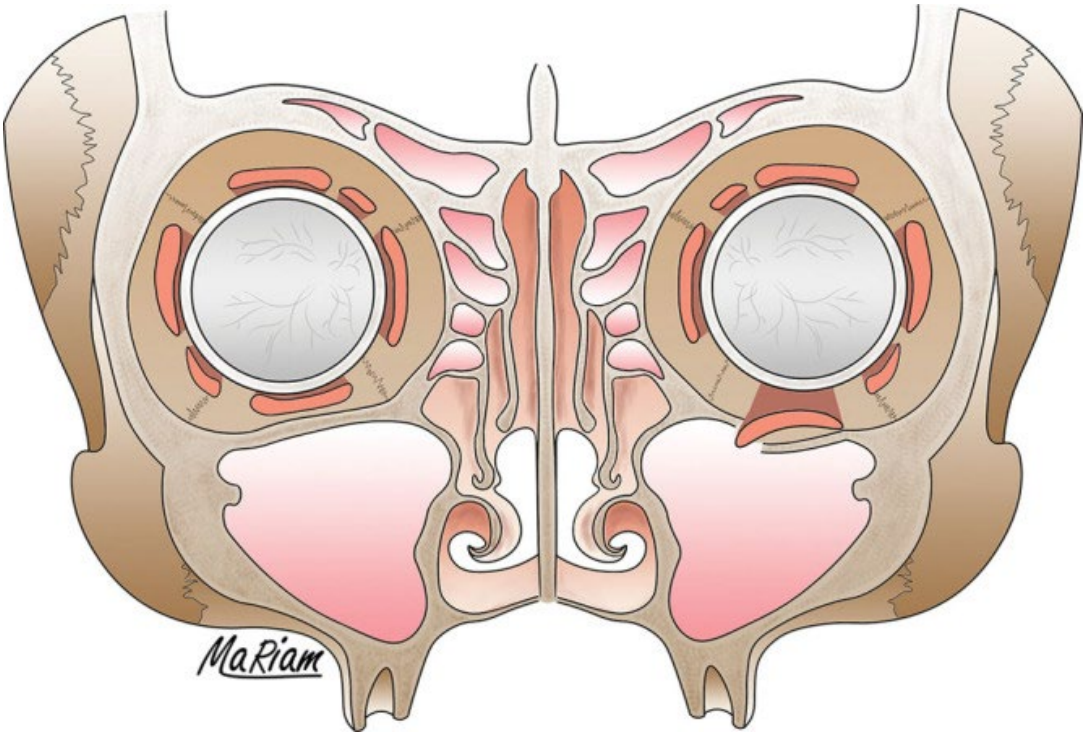
With “blow-in” fractures, the frontal bone is displaced inferiorly, resulting in decreased orbital volume. When the orbital walls are fractured, review of the bony structures by the radiologist should address the displaced fragments, the involvement of the orbital apex, as well as the infraorbital and the optic canal.[32]

Trapdoor Fractures

A "trapdoor fracture" is a specific type of blowout fracture that occurs primarily in children and young adults, where the fractured orbital floor spontaneously returns to its original position, potentially entrapping soft tissues. Younger patients tend to sustain this type of fracture, as opposed to adults or elderly patients, because of the distensibility of the immature facial bones. The inferior orbital wall, and less often, the medial wall of the face, are injured.[34]

Trapdoor fractures are categorized into 2 types: linear and hinged trapdoor fractures. With a linear trapdoor fracture, a break occurs in the bones of the orbital floor that permits orbital tissue (the inferior rectus muscle or the inferior periorbital fat) to prolapse into the fracture site during fracture formation. The bony fragments of the fracture then return to their original position, entrapping the prolapsed orbital tissue and creating what is known as the tear drop sign, which is visible on CT. With a hinged trapdoor fracture, the fractured part of the orbital floor is minimally displaced and acts as the hinge of a swinging door entrapping the orbital tissue (Figure 25).[34]

Figure 25. Hinged Trapdoor Fracture of the Orbits



A coronal cut in the orbit showing the entrapment by a hinged fracture. There is a gap, but no defect in the orbital floor.

Al-Qattan et al. *Plast Reconstr Surg Glob Open*. 2021.[34] For educational purposes only.

Zygomatic Arch Fractures

Because the structure of the zygomatic arch is a cylindrical, thin, and long bridge-like bone that is structurally vulnerable to local trauma, fractures commonly result from both high- and low-velocity forces such as MVAs, assaults, and sports-related trauma. As described, the zygoma is attached to the frontal bone (via the frontozygomatic suture), the maxilla (via the ZM suture), the squamous part of the temporal bone (via the zygomaticotemporal suture) and the sphenoid bone (via the zygomaticosphenoid suture) (Figure 14).[20,35]

Types of Fractures and Classification Systems

The zygomatic arch is the third-most commonly fractured facial bone for which patients often seek urgent treatment in the ED.[36] A zygomatic arch fracture commonly presents as a visible depression on the involved side of the face.[37] Clinically, a depressed fracture of the zygoma can be missed due to the soft tissue swelling that can obscure the anatomic region of the bony defect.[2] Fractures of the ZMC are often referred to as "tetrapod fractures" due to the 4 bony articulations that make up the

zygoma.[19] Furthermore, the zygoma is connected to the maxilla and sphenoid bone as part of the inferior orbital floor and forms the lateral orbital margin with the frontal bone. As a result, fractures of the zygomatic complex inevitability lead to a certain degree of orbital defect.[38]

Various classification systems have been used to categorize ZMC fractures. Below is a system proposed by Zingg et al in 1992[18]:

TYPE A: An incomplete zygomatic fracture that involves one articulation of the zygoma

- A1: Zygomatic arch fracture
- A2: Lateral orbital wall fracture
- A3: Infraorbital rim fracture

TYPE B: All 4 articulations are fractured (a complete tetrapod fracture) with the zygomatic bone itself remaining intact

TYPE C: A multifragment zygomatic fracture, where all 4 articulations are fractured, and the body of the zygoma is fractured as well.

In 2007, Yamamoto et al proposed another classification system which is primarily based on displacement (Figure 26)[14]:

TYPE I: No displacement

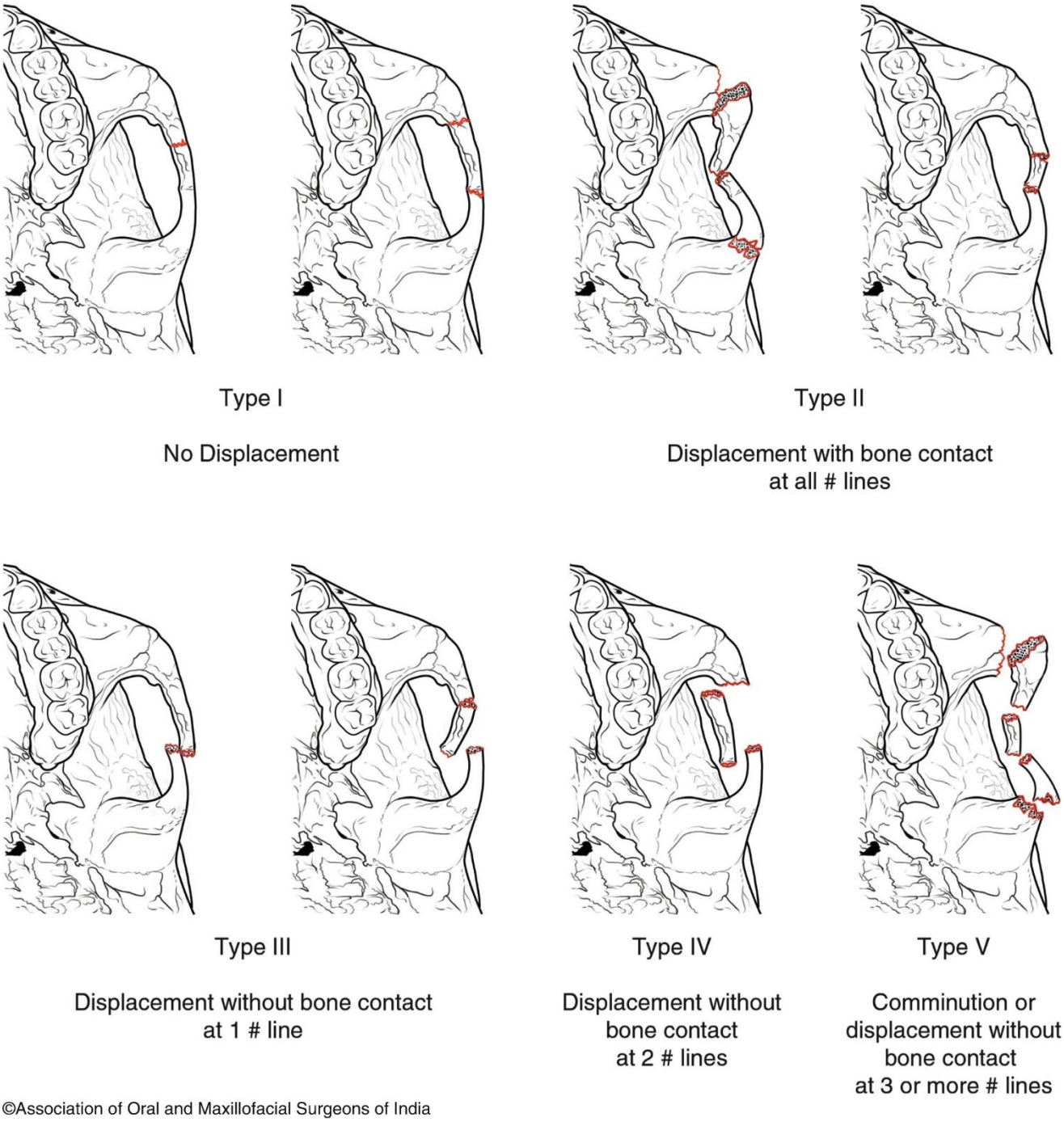
TYPE II: Displacement with bone contact at all fracture lines

TYPE III: Displacement without bone contact at 1 fracture line

TYPE IV: Displacement without bone contact at 2 fracture lines

TYPE V: Comminution or displacement without bone contact at 3 or more fracture lines.

Figure 26. Yamamoto et al. Classification of Zygomatic Arch Fractures



Bonanthaya et al, eds. *Oral and Maxillofacial Surgery for the Clinician*. Springer Nature Singapore Pte Ltd; 2021.[14] For educational purposes only.

Clinical Indications for Facial Bone DR

Patient Stabilization and Evaluation

Before evaluating a patient with facial trauma, an emergency, trauma, facial-plastics, or otolaryngologist physician must perform a primary survey keeping in mind that "airway, breathing, and circulation" should be the primary concern for patient stabilization. Maxillofacial trauma can yield a compromised airway, secondary to hemorrhage, soft-tissue edema, and loss of facial architecture due to fractures. Depending on the cause of injury and severity of the fractures, associated injuries to the patient's brain, cervical spine, and cerebrovascular structures may also be present and should be evaluated. Once any life-threatening injuries to the patient have been evaluated and treated, and the patient stabilized, a secondary survey of the face should include palpation, visual inspection, full visual acuity interrogation, cranial nerve evaluation, detection of a CSF leak, and dental occlusion assessment.[38]

DR Versus CT

In healthcare facilities where it is available on an emergency basis, multidetector CT (MDCT) has supplanted FBR for patient evaluation. Even with the high-contrast resolution provided by DR, these studies cannot characterize the full extent of fractures, detect nasofrontal duct involvement, and ascertain intracranial pathology.[2] In the evaluation of the fracture fissures (especially in the lower orbital wall), multiplanar reconstructions increase the diagnostic effectiveness of CT imaging. In addition, 3D-CT reconstructions are a good complementary imaging technique that allows RTs and physicians to precisely locate any free bone fragments and assess the degree of their displacement.[32]

Even though imaging for these types of injuries has evolved, it is important that RTs are still knowledgeable and able to perform all aspects of skull and facial bone DR and their associated subsets. If a physician is concerned about an isolated injury to the jaw or teeth, DR can still play an important diagnostic role. Many rural, off-site, and smaller healthcare facilities in the US may not have immediate access to MDCT, and in those healthcare settings, DR still plays a key diagnostic role in imaging a patient with facial injuries.

Surface Topographic Landmarks and Positioning References

In order for the RT to ensure correct positioning of the patient's skull for each projection, it is key to have a complete understanding of topographic skull landmarks and positioning baselines. Various

planes, points, lines, protuberances, and locations most often used in FBR are outlined in Table 1 and depicted in Figure 27.[40-41]

Table 1. Radiographic Surface Anatomy and Reference Point Landmarks of the Skull

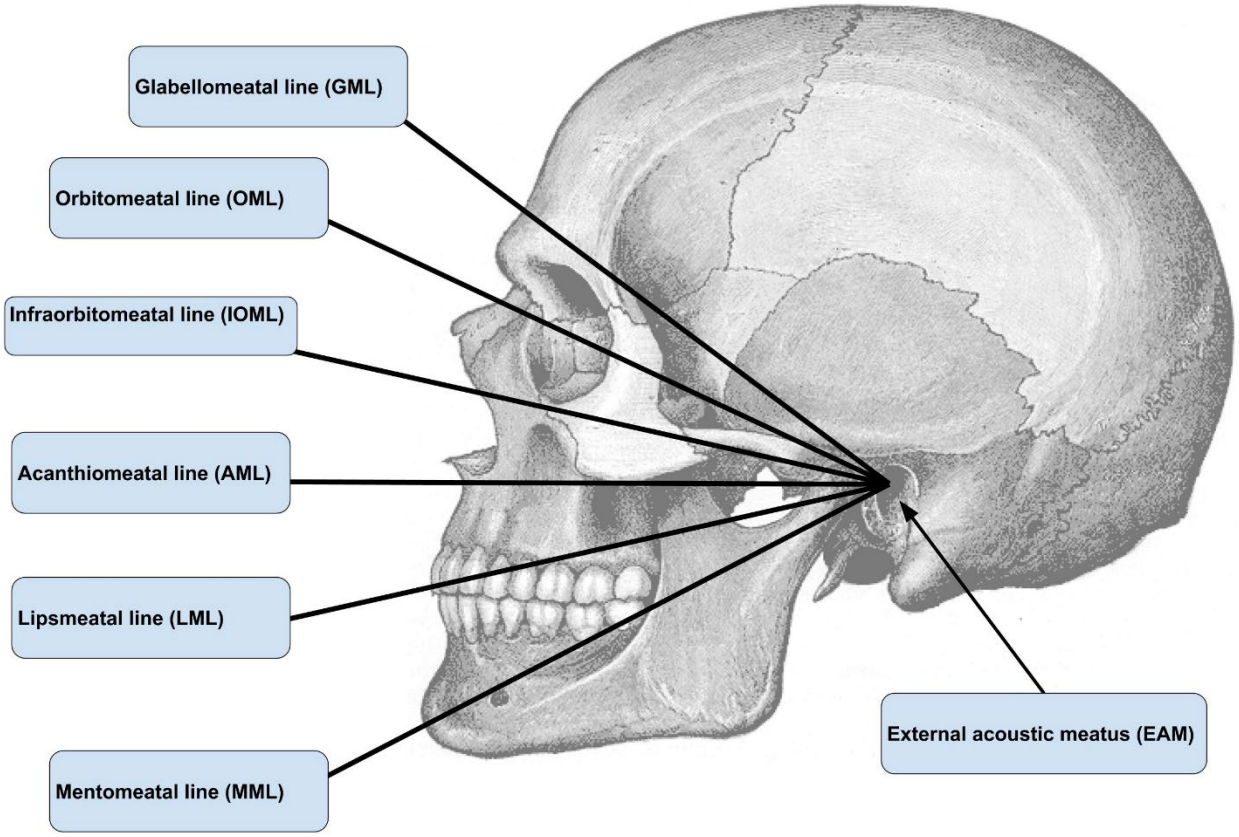
Landmark or Line	Description
Acanthion	The acanthion is the midline junction of the upper lip and auricle nose.
AML	The AML is a line from the acanthion to EAM.
Auricle or Pinna	The auricle or pinna is the ear or outer ear.
CML	The CML is a line drawn from the lateral canthus of the eye to the EAM.
EAM	The EAM is the external opening to the ear canal.
EOP; also known as the Inion	The EOP lies near the middle of the squamous part of occipital bone; it is the highest point, often referred to as the inion. The inion is the most prominent projection of the protuberance, which is located at the posteroinferior (lower rear) part of the human skull.
Glabella	The glabella is a smooth bony prominence on the frontal bone between the eyebrows.
GML; also known as the SOML	Most superior of the positioning lines; the GML refers to the line between the glabella and the EAM.
Gonion (Angle of Mandible)	The gonion is the lower posterior angle seen on each side of the jaw or mandible.
Inner Canthus	The inner canthus is the junction of the upper and lower eyelid near the nose.
IOML; also known as Reid's Baseline	The IOML is a line drawn from infraorbital margin to the EAM.
IPL	The IPL connects the pupils of the eyes; in a true lateral position, the IPL must be perpendicular to the IR.
LML	The LML is a line drawn from the lips to the EAM.
Mental Point	The mental point is located at the midpoint of the chin. It is in the center of the flat triangular region of the mandible.
MML	The MML is a line drawn from the mental point to the EAM.

Landmark or Line	Description *(Table 1 Cont'd)*
MSP	The MSP divides the body into equal right and left halves; cranial reference points are the EOP and the glabella.
Nasion	The nasion is the midline bony depression between the eyes where the frontal and 2 nasal bones meet, just below the glabella. It is also known as the bridge of the nose.
OML; also known as the Radiographic or Orbitomeatal Baseline	The OML is a line drawn from outer canthus of the eye to the EAM.
Outer Canthus	The outer canthus is the more lateral junction of the eyelids.
Superciliary Ridge; also known as the Superciliary Arch	The superciliary ridge is the ridge of the bone found over each eye and under each eyebrow.
SOML; also known as the GML	The SOML is a line drawn from the glabella to the EAM.
Tragus	The tragus is a small flack of cartilage over the EAM.
Vertex	The vertex is most superior portion of the head.

AML = acanthiomeatal line; CML = canthiomeatal line; EAM = external acoustic meatus; EOP = external occipital protuberance; GML = glabellomeatal line; IOML = infraorbitomeatal line; IPL = interpupillary line; IR = image receptor; LML = Lips-Meatal line; MML = mentomeatal line; MSP = midsagittal plane; OML = orbitomeatal line; SOML = supraorbital meatal line.

Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024.[40] For educational purposes only.

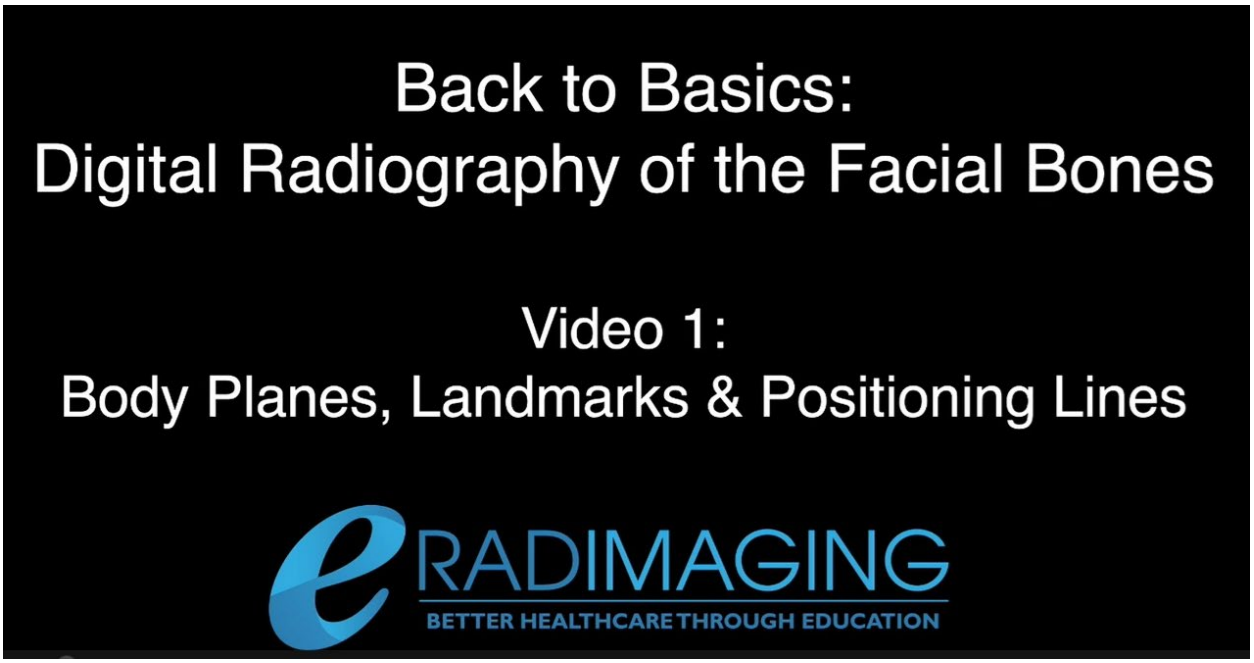
Figure 25. Skull Positioning Lines



Key radiographic positioning lines for performing all aspects of skull and facial bone DR.

Murphy A. Skull positioning lines (diagram) [Case study]. Radiopaedia.org. Available at: https://radiopaedia.org/cases/58734. Published March 3, 2018. Accessed November 29, 2024.[41] For educational purposes only.

There is a difference of 7° between the angles of the OML and IOM and a difference of 8° between the angles of the OML and the GML in a normal adult skull.[40]



This video defines relevant body planes, landmarks, and positioning lines RTs should be familiar with to ensure correct positioning and optimal images for facial bone radiography.*[42-47]

(Click on the image to view the video.)

**All images featured in this video are being used for educational purposes only.*
Specific credits appear in the Reference List.

Facial Bone CR and DR

Digital Radiographic Exposure Techniques and Concepts

As CR and DR of the facial bones are a very specialized and detailed sector of radiographic imaging, it's important for RTs to already be well-versed in the basic imaging concepts and terminology prior to performing this type of imaging study. As the scope of this CE course is specific to imaging the facial bones, higher-level terminology and concepts in CR and DR will be the primary focus of this section of the course.

When utilizing a DDR IR (also known as a DR plate or panel) or a CR imaging phosphor plate, the principles of patient positioning for routine facial bone radiography are the same. For the purposes of this CE course, both DDR and CR equipment will be referred to generally as DR. Some of the direct DR systems may have a built-in IR in their upright Bucky or in a U-arm configuration. With a

U-arm configuration, both the X-ray tube and the U-arm detector can be perfectly aligned, and the detector can be tilted easily for examinations of anatomical regions such as those needed for FBR.[40]

It is essential to use proper radiographic exposure techniques with DR technologies to provide quality diagnostic FBR images. The IRs that are used in DR are sensitive to both low and high levels of ionizing radiation. An image can be produced with very low milliamperage exposure time (mAs) or very high mAs. It is the image processing function that will produce an image with the correct preset brightness and contrast levels.[40] With DR, it is recommended practice to use the highest kilovolt peak (kVp) within the optimal range for the position and anatomy coupled with the lowest number of mAs needed to provide an adequate exposure to the IR, but not overexpose the patient.[48] The optimal kVp level is usually higher for imaging bone to soft-tissue contrast and for thicker objects; this concept is key for FBR. In Table 2, examples of some baseline radiographic exposure techniques are outlined.[43,49,50-52]

Table 2. Radiographic Exposure Techniques for FBR

Examination and Views	X-Ray Tube Voltage (kVp)	X-Ray Tube Current (mAs x Time) = mAs	Use of Grid (Yes or No) and Focal Spot Size
Facial Bones PA Caldwell projection, parietoacanthial (Waters view), lateral, and submentovertical	75–80	Use AEC with the center detector cell.	Yes/Small
Nasal Bones Parietoacanthial (Waters view), right and left lateral	• Waters View: 70–75 • For both lateral projections, the exposure technique used should be similar to that of a finger (ie, low kVp, low mAs)	Use AEC with the center detector cell for the Waters view; manual technique for the right and left lateral as noted in the kVp section.	Yes/Small (except for the right and left lateral views, which should be performed with no grid and “tabletop”)

Examination and Views	X-Ray Tube Voltage (kVp)	X-Ray Tube Current (mAs x Time) = mAs	Use of Grid (Yes or No) and Focal Spot Size
Mandible PA, axiolateral oblique-bilateral, submentovertical, reverse Towne (Clementisch)	70–75	Use AEC with the center detector cell.	Yes/Small
Orbits PA erect with 15° caudal angle (modified Caldwell), parietoacanthial (Waters), parieto-orbital oblique (Rhese method)	75–80	Use AEC with the center detector cell.	Yes/Small
Zygomatic Arch PA axial (modified Titterington), AP-axial modified Towne, oblique inferosuperior tangential projection, submentovertex	75–80	• Use AEC with the center detector cell. • Some literature recommends using a manual technique when performing the inferosuperior tangential projection of the zygomatic arch due to the lateral position of the anatomy being imaged.	Yes/Small

A selection of baseline radiographic exposure techniques for FBR.

AEC = automatic exposure control; AP = anteroposterior; DR = digital radiography; kVp = kilovoltage peak; mA = milliamperage; PA = posteroanterior; SID = source-to-image distance for the above values is based on 40 inches and the use of a grid.

Data from: Caroll. *Radiography in the Digital Age: Physics-Exposure-Radiation Biology*. Charles C. Thomas Publisher; 2011; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Hobbs et al. *Radiol Technol*. 2007; Mickelsen et al. *Radiol Technol*. 2013.[43,49,51-52] For educational purposes only.

Each radiography suite should have current technique charts that are customized for the room type, procedures performed, and IRs used (CR or DDR). AEC systems should be set up with safe "back up" exposure times for each study. There should be proper monitoring in place of exposure indicators of each digital IR to ensure proper exposure levels. There should be oversight from the appointed radiologist, consulting medical physicist, equipment manufacturer, biomedical department, and quality control/quality assurance manager on all final posted technique charts with necessary departmental approvals in place. Patient radiation exposure data (including exposure indices [EIs], mAs, kVp, etc) should be collected and analyzed and may be compared with published reference values.

Automatic Exposure Control

When considering the use of AEC DR of the facial bones, it is recommended that the center cell be utilized.[40] The exception to this is the right and lateral nasal bone projections for which a manual technique should be used and performed "tabletop."[48] The AEC should be calibrated to the type of IR utilized in the radiography suite in order to provide a consistent exposure for each anatomical region. The RT, quality assurance coordinator, and the radiation safety officer should be aware of the importance of using technique charts with AEC devices.[40] Firstly, using an AEC technique chart ensures the lowest radiation dose to the patient.[50] Secondly, an AEC technique chart contains many important pieces of information needed to ensure a quality diagnostic image. AEC controls radiographic exposure time, so the RT should still set the kVp and SID, along with determining the correct focal spot size and tube-to-part-to-IR angles. In addition, the shortest possible exposures time that can be set (AEC programing) should be used for every FBR view. Of note, AEC should not be used in the following circumstances: when the anatomical region being radiographed is too small, especially in pediatric patients, and when there is a large metal artifact (or implant-type

medical or mechanical device) in the imaging plane, and there is no well-collimated field. In the latter scenario, the AEC will terminate the exposure prematurely, causing excess scatter radiation from the table and patient and making it necessary to repeat the view. Lastly, the manufacturer should set up the appropriate "back-up" exposure time with the AEC component to make sure the exposure terminates in case of system malfunction.[40]

Exposure Index

In DR, EI provides valuable information about exposure to the IR and is used to determine whether adequate exposure has reached the IR. Specific terminology regarding EI in DR is outlined in Table 3.[48] When evaluated along with image quality, EI assists the RT in determining whether the digital image meets departmental standards. RTs or radiology department or facility administrators should check directly with the equipment manufacturer to verify how their system's EI works as it relates to dose and classic "speed settings" while remaining within the recommended parameters for each anatomical region being imaged (Table 4).[40,48] With some DR devices, the EI number should be low for less exposure, and with other devices, lower values may indicate higher exposure. As such, it is important to note and understand that EI is not representative of an individual patient dose metric.[40]

Table 3. EI Terminology

Term/Abbreviation	Definition
EI	Amount of exposure received by the IR. The EI is dependent upon the type of imaging study, image processing, and exposure.
Target Exposure Index (EI_T)	The reference exposure when an image is optimally exposed. This value will be determined based on the anatomy being imaged, the view, procedure, and the IR.
Deviation Index	Quantifies how much the actual EI varies from the EI_T. It provides immediate feedback about the adequacy of the exposure.

International Electrotechnical Commission standardized terminology for digital radiography exposure indexes.

EI = exposure index; EI_T = target exposure index; IR = image receptor.

Tsoukatos G. Back to Basics: A Review of Chest Digital Radiography. eRADIMAGING. Available at: https://www.eradimaging.com/course/1026. Published June 26, 2024. Accessed December 1, 2024.[48] For educational purposes only.

Table 4. EI Parameters

Equipment Manufacturer	EI Name	Symbol
Agfa*	Log of median of histogram	lgM
Canon†	Reached exposure value	REX
Carestream Health‡	Exposure indicator	EI
Fuji§	S Value	S
Konica Minolta, Inc¶	Sensitivity Number	S

A selection of proprietary manufacturer EI parameters used in DR systems. EI terminology and symbols vary by equipment manufacturer.

*Mortsel, Belgium; †Ota-ku,Tokyo, Japan; ‡Rochester, NY; §Minato City, Tokyo, Japan; ¶Chiyoda City, Tokyo, Japan.

Data from Tsoukatos G. Back to Basics: A Review of Chest Digital Radiography. eRADIMAGING. Available at: https://www.eradimaging.com/course/1026. Published June 26, 2024. Accessed December 1, 2024; Seibert et al. *Pediatr Radiol.* 2011.[48,54] For educational purposes only.

The EI_T should be configured with due consideration given to: the practice (eg, adult vs pediatric); the characteristics of the interpreting radiologists (eg, tolerance of image noise); body part being imaged and view; IR technology and performance characteristics; image processing algorithm used; and beam qualities used for clinical imaging.[53] Including exposure information and EI type date on every final digital radiograph will enable RTs to take note of and use that information to refine exposure technique selection and assist with the creation of technique charts for future reference. There must be a technique for each procedure that is performed with that unit, coupled with the type of digital detector (DDR and/or CR) that is used in that specific radiography suite.[40]

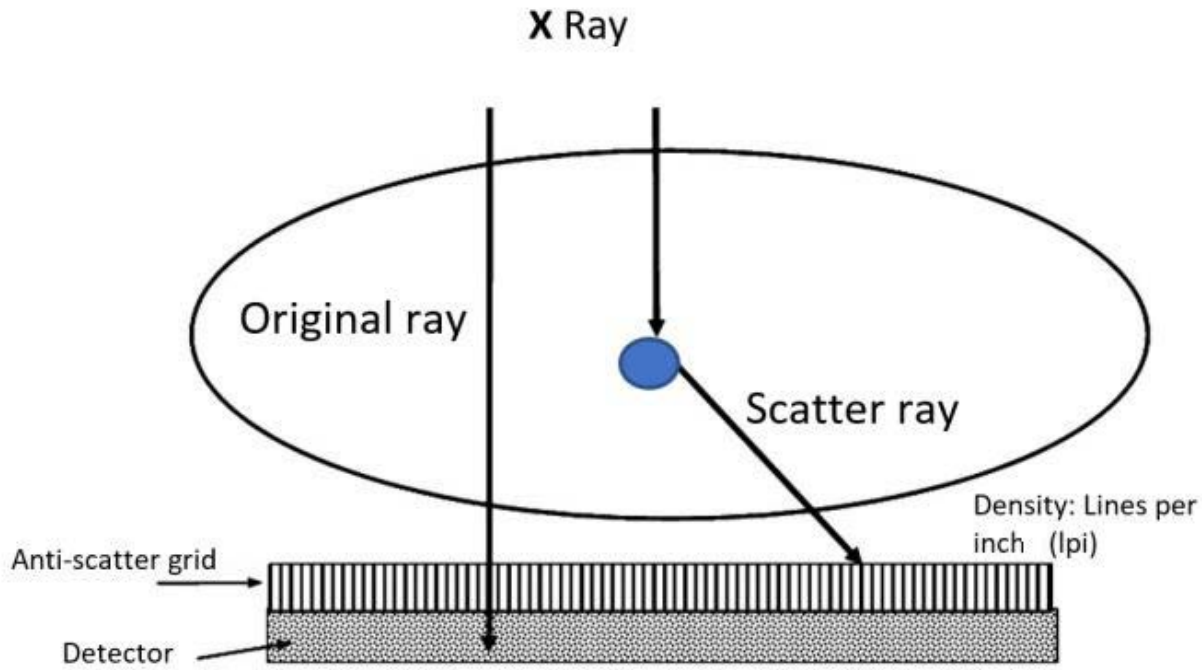
Conventional Radiographic Antiscatter Grids

The goal of any antiscatter grid is to minimize the amount of scatter radiation that reaches the IR while allowing the primary radiation to pass through it. Current DR practice utilizes grids when radiographic exposure exceeds 70 kVp, or the anatomy being imaged is more than 10 cm thick. In

pediatric DR applications, where typically the body measurements are less than 12 cm thick, grids are not recommended.[40]

A conventional grid device is built from a group of thin strips of material, such as lead, which are aligned to allow the transmission of the primary X-rays and to intercept scattered X-rays. The thin lead strip is separated by an interspace material, which is covered by a protective layer.[40] The strip frequency is defined as the number of strip lines per centimeter (or inch) (Figure 28).[40,55] The grid ratio is defined as the ratio of the lead strip's height to the width of the interspace material.

Figure 28. Antiscatter Grid



Acuna-García et al. *Int J Adv Res Comp Sci*. 2020.[55] For educational purposes only.

Contrast

Radiographic contrast is the difference in density between adjacent areas on a standard radiograph. To prevent a decrease of contrast in a particular radiograph due to scatter radiation, close collimation and grids can be utilized. Improvement in contrast through the use of grids is expressed through the contrast improvement factor; unfortunately, improved contrast comes at a cost of having to increase the mAs due to the attenuation of some of the primary radiation besides scatter.[48]

Grid Suppression Software

This software technique removes the stationary grid patterns, thus preventing moiré artifact-a summation artifact caused by the scanning laser beam overlapping with the grid line structure-from being generated on the resultant image. The moiré pattern occurs when the laser scan lines that read the digital image run parallel to the gridlines with a frequency approximately equal to the laser scanning frequency. This digital artifact is very intrusive on lateral FBR images and needs to be eliminated in order to yield quality diagnostic artifact-free images. Grid suppression algorithms can help eliminate the visibility of grid lines when utilizing a stationary grid (eg, performing a cross-table lateral projection of the facial bones for trauma). Otherwise, radiographic grid suppression software can remove the moiré lines from an image.[40]

When the software is in place, a standard 103 lines-per-inch (lpi) grid is sufficient and customary. In the absence of this software, a 152-lpi grid or higher is required. Grid pattern removal processing suppresses the display of moiré patterns associated with the use of nonoptimal stationary grids, such as those with a low number of grid lines per inch (80 lpi to 100 lpi) and radiographic grids with horizontal grid lines. Specific menu selections (or processing algorithms) must be considered for radiographic grid and nongrid examinations (lateral views of the nasal bones) to produce optimal results.[40] Specific menu selections (or processing algorithms) must be considered for both grid and non-grid examinations to produce optimal results.[48] Such technological advancements improve image quality by increasing the contrast and clarity of the image while using less radiation.

Positioning Concepts and Techniques

Overview

Routine projections performed in FBR are defined as projections commonly taken of patients who can cooperate fully during the study. This varies depending on radiologist and department protocols. Special projections are performed in addition to routine projections; special projections are defined as projections most taken to demonstrate better specific anatomic parts or certain pathological or trauma conditions performed on patients that may be necessary for patients who cannot fully cooperate. When positioning a patient for FBR, it is necessary to look at various facial features and locate topographic skull landmarks to place specific positioning lines precisely in relation to the IR. FBR can be performed with the patient in any of the following positions, depending on the patient's condition and the radiographic equipment being used[40]:

- Upright (seated or standing)

- Semiprone
- Supine
- Prone

Patient Preparation and Safety Protocols

The upright position allows the patient to be positioned quickly and easily and permits the use of a horizontal X-ray beam. A horizontal X-ray beam is necessary to visualize any existing air-fluid levels within the cranial or sinus cavities.[40] Prior to initiating the FBR, the RT should question and document any of the patient's past surgeries or implanted medical devices in the region to be imaged.[49] In addition to checking patient pregnancy risk, as per departmental or site protocol, and documenting any previous studies or pertinent clinical history, RTs should also ask the patient to safely remove any of the following items that may appear as radiographic artifacts and impede diagnostic image quality[40,]:

- Hearing aids or other removable, nonpermanent sound amplification devices
- Eyeglasses or removable contacts
- Dentures and removable partial plates
- Hairpins, hairpieces, ponytail holders, barrettes, and wigs
- Ocular prosthesis (that is removable and nonpermanent)
- Facial piercings and earrings (that are removable and nonpermanent)
- Temporary removable tattoos (if they can safely be removed)

Facial bone CR and DR often require the patient's face to come in direct contact with the RT's hands, the table, or other upright Bucky surfaces. It is important that proper handwashing techniques and surface disinfectants are used before and after the examination and that personal protective gear is used when applicable. All RTs should follow the radiation safety principles of **A**s **L**ow **A**s **R**easonably **A**chievable (ALARA) when performing FBT. This includes following the current regulatory guidelines on when to use appropriate shielding techniques.[40]

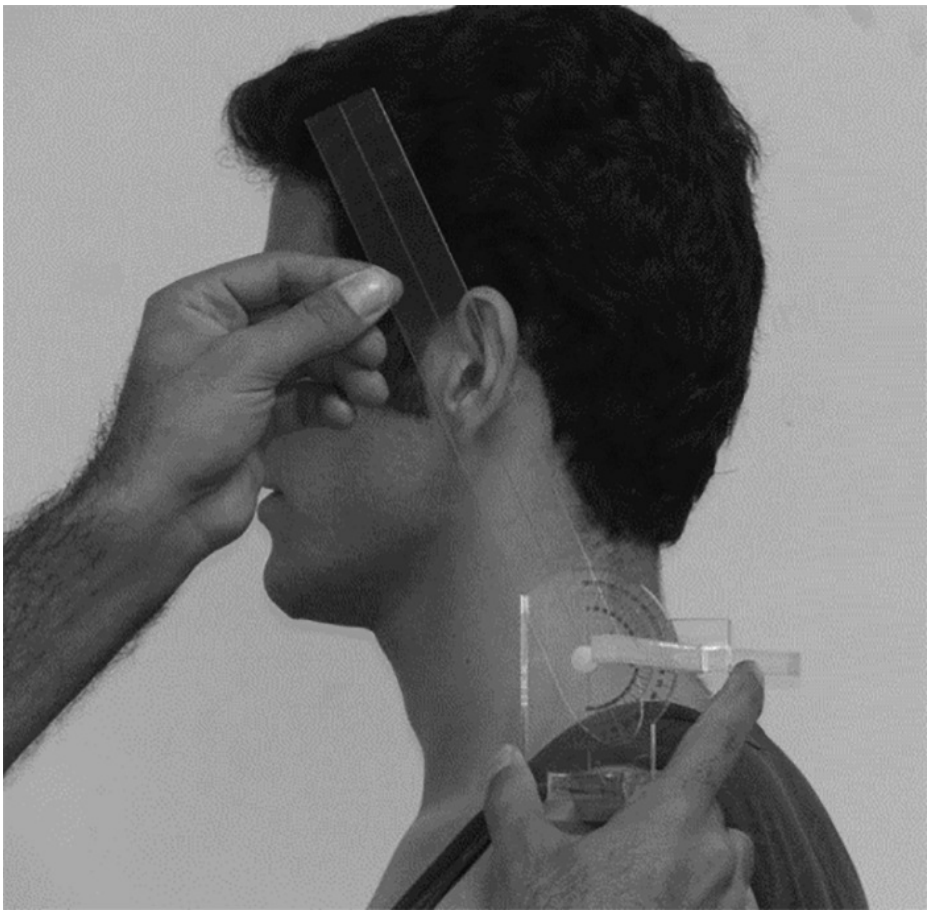
Angle Ruler (Goniometer) and Radiographic Markers

<u>Goniometers</u>

When performing FBR, it is important to have available either a table type or pocket (handheld) goniometer, which is a device used to measure angles. With FBR, a goniometer positioned either on

a tabletop or handheld can be useful for determining the proper FBR angles to use when positioning a patient's head for imaging the calvarium (Figure 29).[40,56] Prior to the widespread use of MDCT for imaging traumatic facial injuries, some equipment manufacturers also offered table-mounted goniometers that could measure angles for all projections used in all aspects of skull radiography.[40]

Figure 29. Goniometer for Positioning the Head



An example of how a goniometer may be used to measure the angle of a patient's head prior to completing FBR.

FBR = facial bone radiography.

Rajabi et al. *J Rehab Sci Res*. 2020.[56] For educational purposes only.

Radiographic Markers

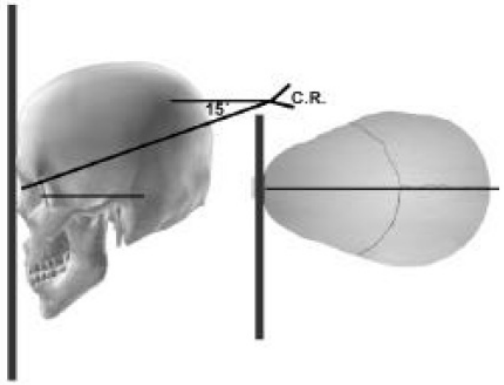
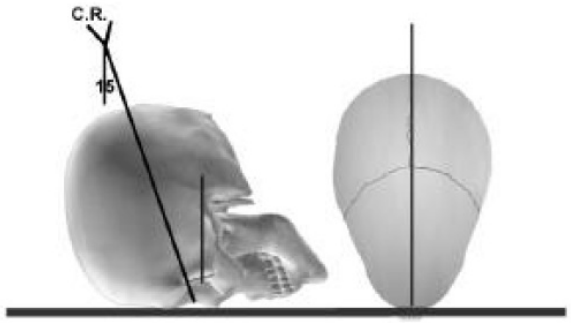
It is a globally accepted best practice that all radiographic images must display a correct anatomical side marker. Anatomical side markers are defined as annotations of "right" or "left" on diagnostic images. The gold standard in general radiography is to place a radiopaque anatomical side marker in the field-of-view for each radiographic image in the primary X-ray beam prior to completing the exposure. The advent of DR has allowed for anatomical side markers to be digitally added to films as part of postprocessing.[57]

Positioning Techniques for Facial Bone Imaging

When an RT is performing FBR, he or she must understand the effects of flexion, extension, or tilt upon vertical shift. On all routine frontal projections of skull-facial bone anatomy (including the PA, AP, Caldwell, Waters, and Towne projections), excessive extension of the patient's chin will cause posterior anatomy to shift down as anterior anatomy moves up, and vice versa. An example of how these anatomical changes affect the associated anatomy are as follows: raising the patient's chin will lower the petrous pyramids, which lie posterior. On all lateral projections of skull-facial bone anatomy, tilting of the head will cause the anatomy on that side to shift downwards, while the anatomy on the opposite side will shift upwards. This is why precise positioning and utilization of surface topographic landmarks are essential to providing a quality diagnostic image with the anatomy in proper perspective.[40,43]

Most standard radiographic imaging protocols for FBR include a modified Caldwell, right or left lateral (side of injury imaged closest to the IR), and parietoacanthial-Waters view. Tables 5 through 8 outline the positioning nuances of the PA/Caldwell method, the lateral view, the parietoacanthial-Waters method, and the acanthioparietal-reverse Waters Method.[40,49-50,58-59] Figures 30 through 35 demonstrate proper positioning of a patient's head for these views as well as select resulting X-ray images.[50,60] Video-based instructions and discussion of image evaluation criteria for a PA axial projection of the facial bones, Caldwell (Video 2) as well as the lateral method (Video 3) are also included. Relevant anatomy, patient positioning, CR placement and angle, motion, exposure factors, and anatomical marker are evaluated to determine if the image is optimal for submitting to the radiologist for interpretation or if there are repeatable errors present.[42-43,61]

Table 5. PA/Caldwell Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's health status. • The midsagittal line should be centered to the IR. • The patient's forehead and nose should be placed against the IR. • The OML should be perpendicular to the IR. • The lateral margins of the orbits should be adjusted so they are equidistant from the IR. • The CR should be horizontal and centered 1/2 inch below the external occipital protuberance and directed in a 15°–20° caudal angle, exiting at the nasion. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should made on suspended respiration; the patient should be instructed not to move. • NOTE: An alternative modified PA Caldwell projection can be performed using a 25° to 30° caudal angle for better visualization of the superior orbital fissures, foramen rotundum, and inferior orbital rim. Additionally, If the patient cannot be positioned for a PA projection, then an AP view may be performed with a 15° cephalic angle and the OML positioned perpendicular to the IR.

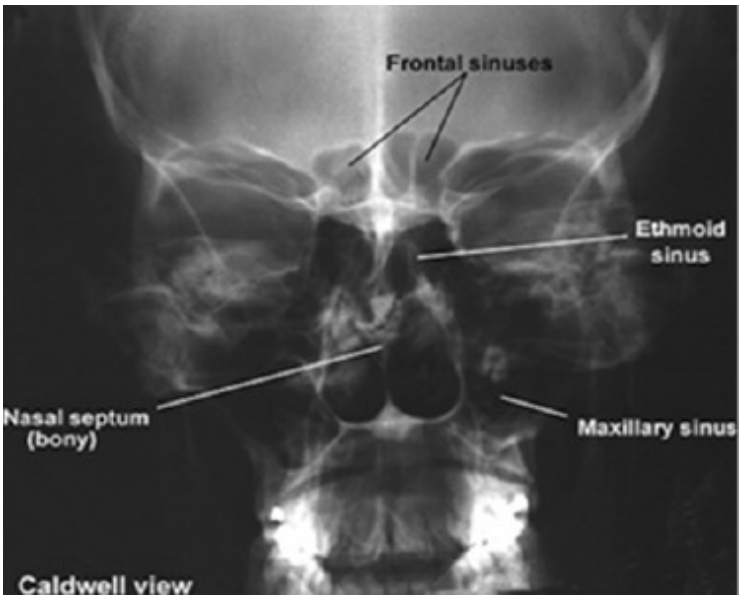
Patient Positioning Example	Figure 30. PA/Caldwell Method Postioning  A.  B. Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.

Anatomy Best Depicted	• The anatomic structures best visualized with this view are the orbits filled by the petrous pyramids, the posterior ethmoidal sinus, frontal bone, frontal sinus, and dorsum sellae. • The orbital rims, maxillae, nasal septum, zygomatic bones, and anterior nasal spine would also be well visualized (Figure 31).[60] • Furthermore, this view allows good visualization of the orbital rims, greater and lesser sphenoid wings, lacrimal gland fossa, medial orbital wall, and both the superior and inferior orbital fissures.
Image Quality Criteria	The petrous ridges of the temporal bone should be symmetrical and located in the lower 1/3 of the orbits. The entire cranial perimeter should be visible without rotation or tilt.

AP = anteroposterior; CR = central ray; IR = image receptor; OML = orbitomeatal line; PA = posteroanterior.

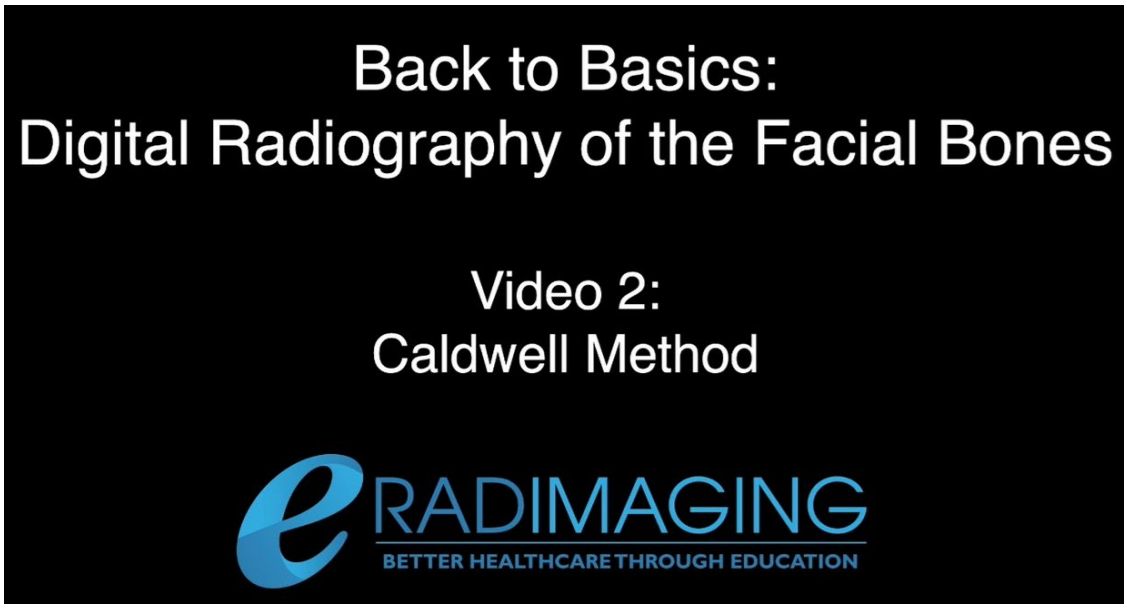
Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

Figure 31. Caldwell View



A radiographic example of a well-executed Caldwell view of the facial bones. This view is ideal for visualizing the frontal sinuses.

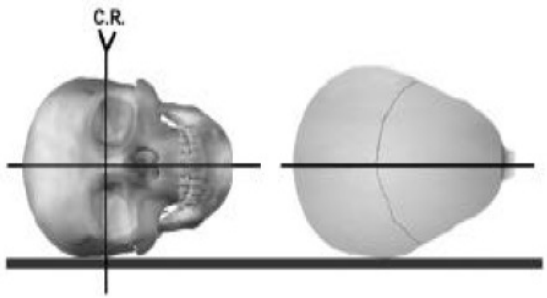
Laza et al. *Global J Otolaryngol.* 2017.[60] For educational purposes only.

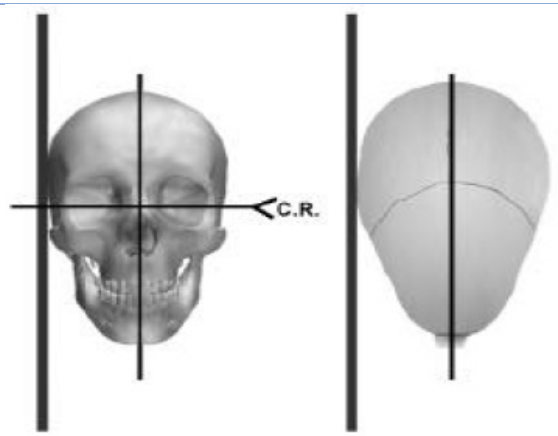


This video discusses image evaluation criteria for a PA axial projection of the facial bones, Caldwell method. Relevant anatomy, patient positioning, CR placement and angle, motion, exposure factors, and anatomical marker are evaluated to determine if the image is optimal for submitting to the radiologist for interpretation or if there are repeatable errors present.*[42-43]

(Click on the image above to view the video.)

**All images featured in this video are being used for educational purposes only and were licensed by eRADIMAGING from iStock by Getty Images.*

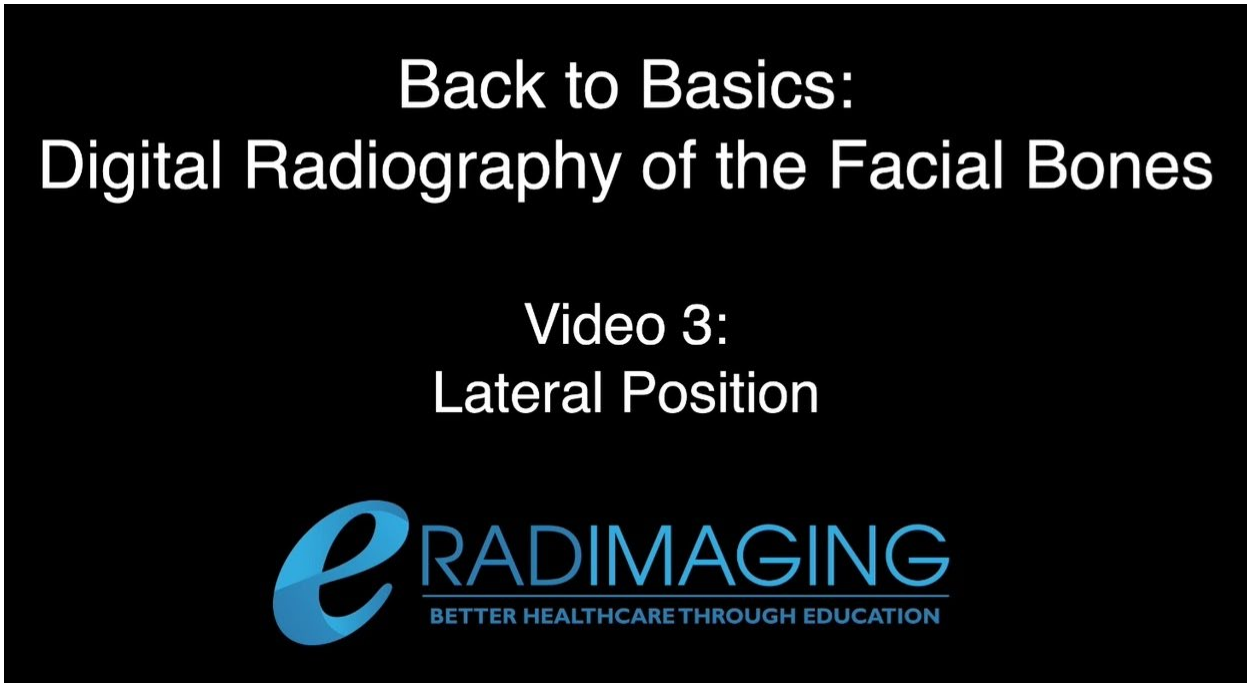
Table 6. Lateral View	
Patient Positioning Techniques	• The chosen lateral view (right or left) should be based on the location of the patient's injury. • This view is best performed with the patient in an upright, seated, or semiprone position on the table, which may depend on the patient's health status. • The clinical side of interest (right or left) is placed against the IR. • The midsagittal line is positioned parallel to the IR. • The IPL should be positioned perpendicular to the IR in a lateral skull type projection. • The CR of the X-ray beam should be perpendicular and centered to the zygoma. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 32. Lateral View Positioning**  **A.**

	 **B.** Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	• The anatomic structures best visualized with this view are the superimposed halves of the cranium, with greater detail of the side closest to the IR. • Additionally, the Sella turcica, anterior clinoid processes, dorsum sellae, and posterior clinoid processes, as well as the sphenoid, frontal, ethmoid, and maxillary sinuses would also be well visualized. • NOTE: Although not as useful as a frontal projection, the lateral projection provides diagnostic information concerning air-fluid levels in patients who present with trauma, when a horizontal X-ray projection is possible with the patient in an upright position.
Image Quality Criteria	• The images should demonstrate the entire cranium without rotation or tilt. The orbital roofs, sphenoid bone, and the temporomandibular joints should be superimposed with the Sella turcica in profile.

	• There should be no overlap of the spine and mandible. The zygomatic bones should be in the center of the radiograph.

CR = central ray; IPL = interpupillary line; IR = image receptor.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.



This video discusses image evaluation criteria for the lateral position for facial bone DR. Relevant anatomy, patient positioning, CR placement, motion, exposure factors, and anatomical marker are evaluated to determine if the image is optimal for submitting to the radiologist for interpretation or if there are repeatable errors present.*[42-43,61]

(Click on the image above to view the video.)

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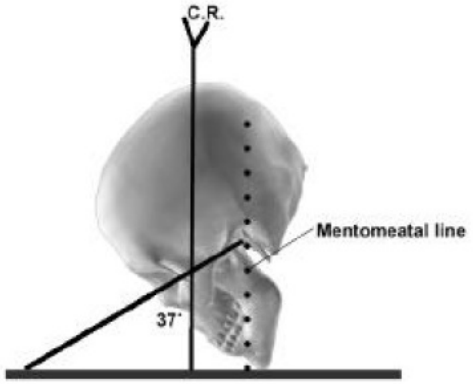
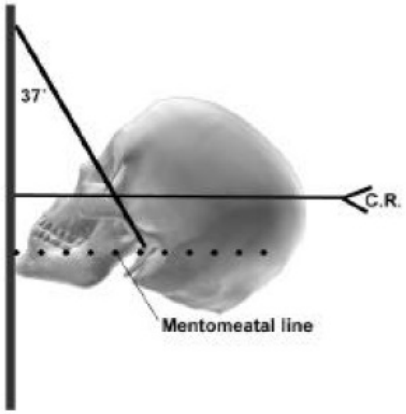
Table 7. Parietoacanthial-Waters Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's health status. • The patient should rest their chin on the IR. • The MML should be parallel to the CR of the X-ray beam and perpendicular to the IR. • The patient's neck should be gently hyperextended (if clinically safe) so that the OML forms a 37° angle to the IR. • The MML should be approximately 90° to the IR. • The midsagittal line and the IPL should be perpendicular to the IR. • The X-ray beam CR should be perpendicular to the IR exiting at the acanthion. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 33. Parietoacanthial-Waters View Positioning**

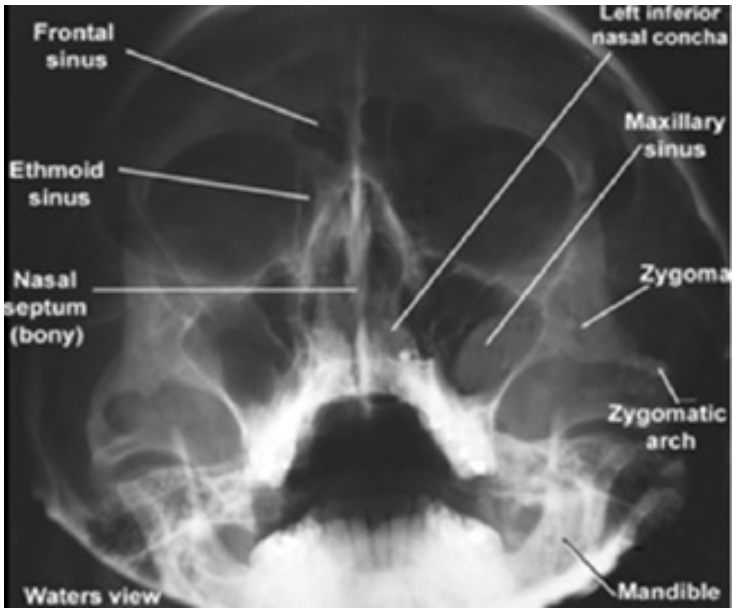
	 A.  B. Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography*. General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best	• The anatomic structures best visualized are the facial bones, maxillary sinus groups, orbits,

Depicted	maxilla, and zygomatic arches (Figure 34).[60] • This is also an ideal view for visualizing the orbital floors to rule out "blow-out" fractures of the orbits and if trauma in that region affects the maxillary sinus and surrounding structures.
Image Quality Criteria	The petrous ridges of the temporal bone should be projected below the maxillary sinuses. The distance between the lateral skull and the orbit should be equal on both sides.

CR = central ray; IPL = interpupillary line; IR = image receptor; MML = mentomeatal line; OML= orbitomeatal line.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

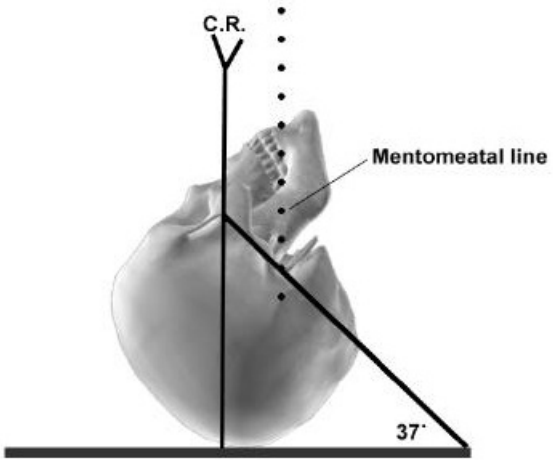
Figure 34. Waters View



Radiograph of the facial bones – Waters view.

Laza et al. *Global J Otolaryngol.* 2017.[60] For educational purposes only.

Table 8. Acanthioparietal-Reverse Waters Method	
Patient Positioning Techniques	• This is a supplemental trauma view if the patient is unable to be positioned for or tolerate a standard Waters view, depending on their health status. • This view is best performed with the patient in a supine position on the table. • The midsagittal line should be centered to the IR. • The patient's neck should be gently extended (if clinically safe), so that the OML forms a 37° angle with the IR. • The MML should be perpendicular to the IR. • Support the patient's shoulders and neck to relieve discomfort and decrease movement. • The X-ray beam CR should be perpendicular and entering the acanthion • The X-ray beam CR for trauma patients should be adjusted to enter the acanthion while remaining parallel with the MML, approximately 30° in a cranial direction. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.

Patient Positioning Example	**Figure 35. Acanthioparietal-Reverse Waters View Patient Positioning**  Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	The superior facial bones, which are magnified, in comparison to the Waters view.
Image Quality Criteria	The petrous ridges should be projected below the maxillary sinuses. Images should demonstrate an equal distance between the lateral aspect of the skull and the orbits.

CR = central ray; IR = image receptor; MML = mentomeatal line; OML = orbitomeatal line.

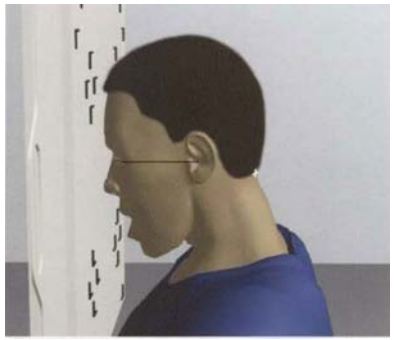
Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO*

Manual of Diagnostic Imaging: Radiographic Technique and Projections. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

Positioning Techniques for Imaging the Mandible

Most radiographic imaging protocols for mandible DR consist of bilateral axiolateral, posteroanterior (PA), PA-axial, AP-axial (Towne method), and submentovertex projections.[51] The PA view is generally used to image patients with angle and ramus fractures; the Towne view is used for patients with possible displaced condylar fragments; and the bilateral oblique views are used to evaluate the angle and horizontal branch of the mandible.[27]

Some imaging facilities may have access to panoramic DR equipment, which can be a helpful adjunct to conventional DR when performing imaging studies of patients with traumatic mandibular injuries, especially if the maxilla and teeth are involved.[51] In addition, cone-beam–CT can yield an excellent volumetric study of maxillofacial bone structures and accurately detect mandibular fractures. It also has a high spatial resolution that delivers relatively low radiation doses, compared to MDCT, and is only slightly affected by metal artefacts, which are often present in patients that may be stabilized by metallic-based immobilization techniques and/or devices.[27] Tables 9 through 13 outline the positioning nuances that make up mandibular DR imaging, specifically the PA view, the PA-axial Towne or AP Towne view, the axiolateral oblique-bilateral views, the submentovertex-Schüller Method, and the reverse Towne-Clementisch Method. Figures 36 through 45 depict examples of patient positioning for various views as well as select resultant DR images of the mandible with and without visible abnormalities.[40,49-51,58-59,62-67]

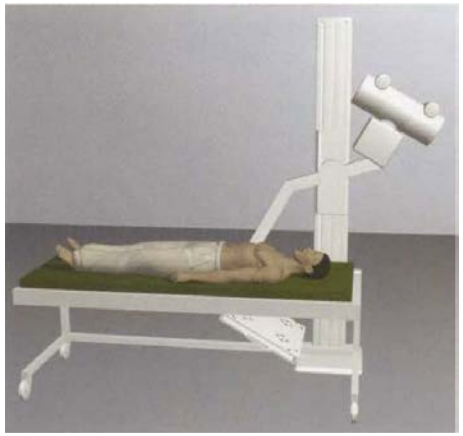
Table 9. Mandible – PA View	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's current health status. • The midsagittal line should be centered to the IR. • The patient's forehead and nose should be placed against the IR. • The OML should be perpendicular to the IR. • The X-ray beam CR should also be perpendicular and exit at the level of the acanthion. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: The patient should only be asked to open their mouth in this position to clearly see the TMJ space and the mandibular condyle if it is a safe and a clinically approved maneuver based on the patient's condition and the extent of their injuries.
Patient Positioning Example	**Figure 36. Patient Positioning for Mandibular PA View** 

	Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003.[58] For educational purposes only.
Anatomy Best Depicted	The mandibular body and rami
Image Quality Criteria	• The mandible should be visible in its entirety. • No rotation should be evident on the PA projection when the mandibular body is symmetrical and the midsagittal plane of the head is properly aligned with the long axis of the collimated X-ray field.

CR = central ray; IR = image receptor; OML = orbitomeatal line orbitomeatal line; PA = posteroanterior; TMJ = temporomandibular joint.

Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-51,58-59] For educational purposes only.

Table 10. Mandible – PA-Axial Towne or AP Towne View	
Patient Positioning Techniques	• This view is best performed with the patient on the table in an upright, seated, or prone position, which may depend on the patient's health status. If the patient presents with extensive trauma, it can be performed in an AP supine position on the table. • The midsagittal line should be centered to the IR. • The patient's forehead and nose should be gently placed against the IR. • The OML should be positioned perpendicular to the IR. • This projection requires the patient to not only tuck in their chin as far down as possible, but to also position their neck as far posterior as possible to prevent superimposition of their shoulders, especially for those patients who present with hyper-kyphosis. • The X-ray beam CR should be positioned at a 30° cephalic angle midway between the TMJ. • If performed on the table in an AP supine position, the X-ray beam CR should be positioned at a 30° caudal angle. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: The patient should only be asked to open their mouth to clearly see the TMJ space and the mandibular condyles if it is a safe and clinically approved maneuver based on the patient's condition and extent of their injuries.

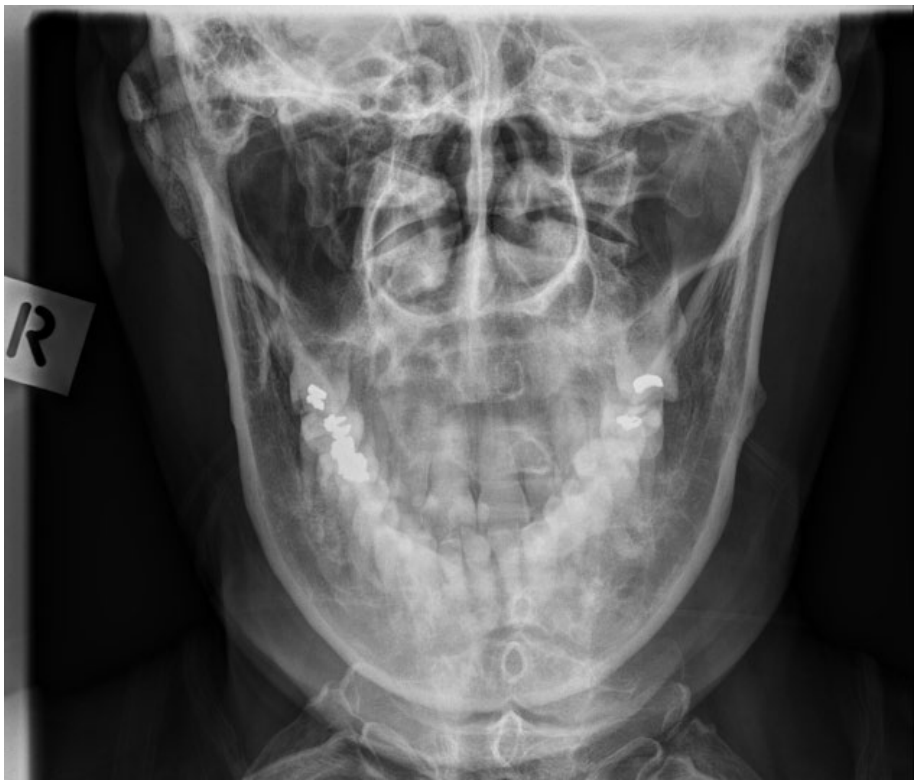
Patient Positioning Example	**Figure 37. Mandibular AP Patient Positioning**  Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003.[58] For educational purposes only.
Anatomy Best Depicted	The PA axial projection also will demonstrate the TMJs.
Image Quality Criteria	• The mandible should be visible in its entirety. No rotation should be evident on a PA projection when the mandibular body is symmetrical and the midsagittal plane of the head is properly aligned with the long axis of the collimated X-ray field (Figure 38).[62] • An example of a patient with a fractured mandible appears in Figure 39.[63]

AP = anteroposterior; CR = central ray; IR = image receptor; OML = orbitomeatal line; PA = posteroanterior; TMJ = temporomandibular joint.

Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health

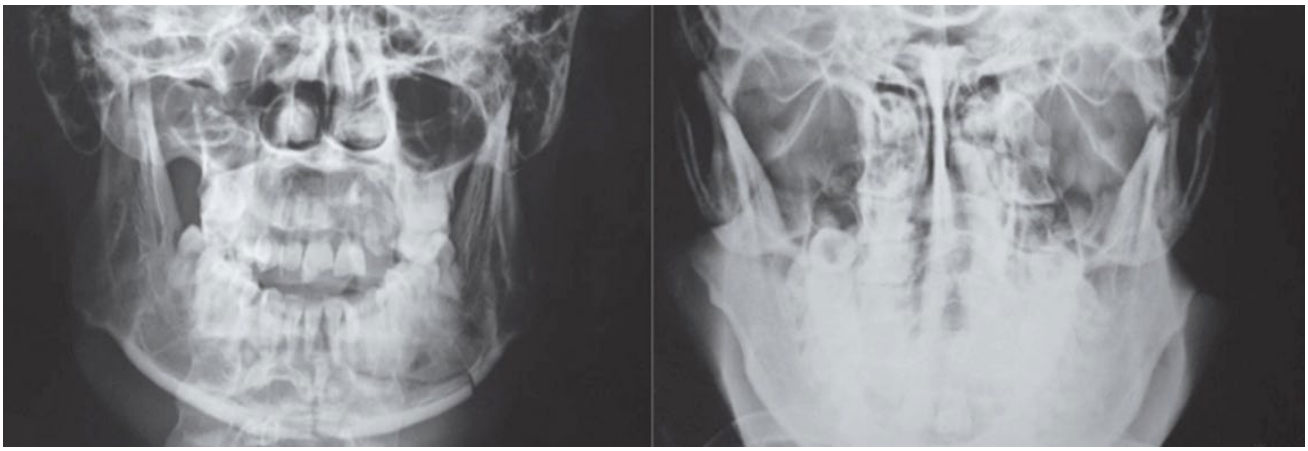
Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Er A. Normal mandible series [Case study]. Radiopaedia.org, Available at: https://radiopaedia.org/cases/150232. Published March 15, 2023. Accessed December 12, 2024.[40,49-51,58-59,62] For educational purposes only.

Figure 38. Normal AP Axial/Towne View of the Mandible



Er A. Normal mandible series [Case study]. Radiopaedia.org, Available at: https://radiopaedia.org/cases/150232. Published March 15, 2023. Accessed December 12, 2024.[62] For educational purposes only.

Figure 39. AP and Towne View – Mandibular Fracture



Right **Left** **Right** **Left**

An AP and Towne view of the mandible revealing a fracture in the right-side angle region, symphysis, parasymphysis, bilateral subcondylar, and comminuted fracture on the left side of the body of the mandible.

AP = anteroposterior.

Pita-Neto et al. *Int Arch Med.* 2015.[63] For educational purposes only.

Table 11. Mandible – Axiolateral Oblique-Bilateral (Right and Left Sides) View	
Patient Positioning Techniques	• This view is best performed with the patient in a seated-upright, semiprone, or semisupine position on the table. • The IPL should be perpendicular to the IR. • The patient's head should be gently adjusted into a true lateral position. • The patient should be instructed to keep their mouth closed and teeth together if their clinical condition safely allows. • The patient's head should be gently obliqued 30° towards the IR. • The X-ray beam CR should be angled 25° in a cephalic angle and should exit on the opposite side of the mandible. • Whether the examination is performed on the table or by upright IR, the entire mandible needs to be properly positioned and imaged. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTES: As depicted in Figure 40, some upright IRs could be tilted to allow the correct angle to be obtained.[58] If the patient being imaged is very muscular, the RT will need to take additional measures to avoid projecting the patient's shoulder over the mandibular area of interest. To do this, open the patient's body inferiorly by rotating his or her midsagittal plane about 15.° Apply a 10°cephalic angle to maintain a 25° CR to the anatomy being imaged.

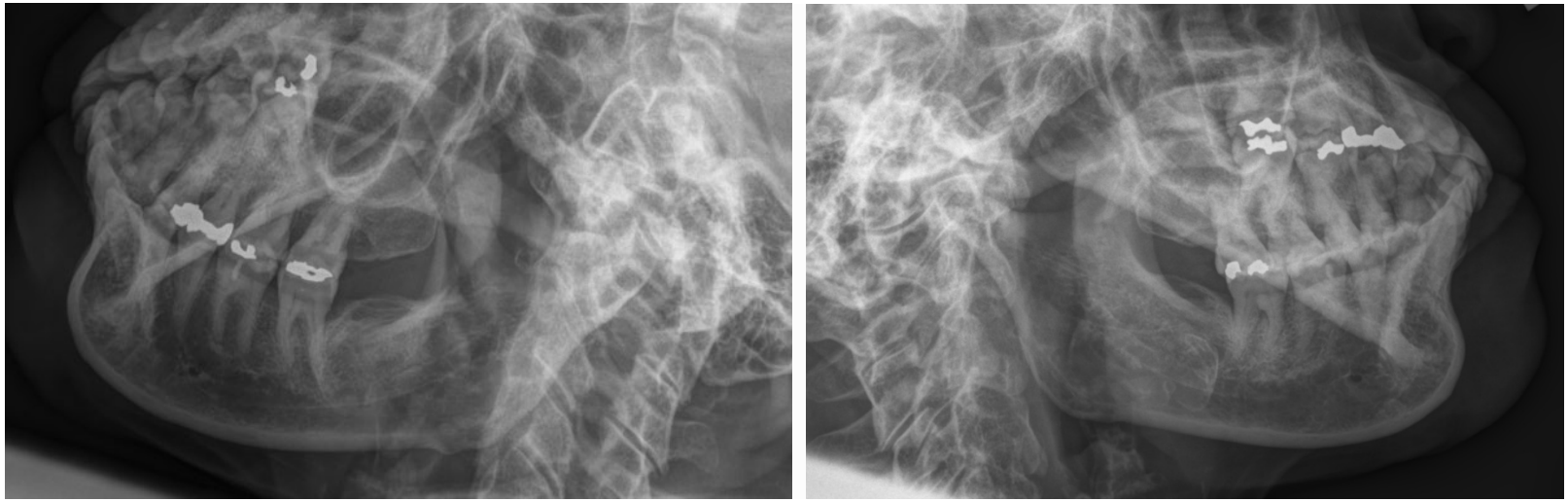
Patient Positioning Example	Figure 40. Mandibular Oblique Lateral Patient Positioning  A.  B.

	Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003.[58] For educational purposes only.
Anatomy Best Depicted	• This view is an oblique projection of the mandible of the affected side down. • The axiolateral oblique mandible view allows for visualization of the mandibular body, mandibular ramus, condylar process, and mentum.
Image Quality Criteria	• The images should not show any overlap by the opposite mandible side (side up) (Figure 41).[64] • The mandibular ramus should not be superimposed over the cervical spine or foreshortened.

CR = central ray; IPL = interpupillary line; IR = image receptor.

Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Er A, Murphy A. Mandible (axiolateral oblique view). Radiopaedia.org. Available at: https://radiopaedia.org/articles/156358. Published November 13, 2022. Accessed December 12, 2024.[40,49-51,58-59,64] For educational purposes only.

Figure 41. Normal Axiolateral Oblique Views of the Mandible

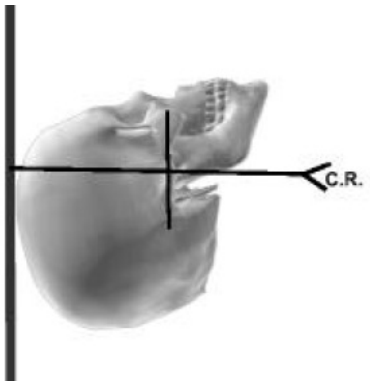


Right *Left*

Examples of normal right and left axiolateral oblique views of the mandible.

Er A, Murphy A. Mandible (axiolateral oblique view). Radiopaedia.org. Available at: https://radiopaedia.org/articles/156358. Published November 13, 2022. Accessed December 12, 2024.[64] For educational purposes only.

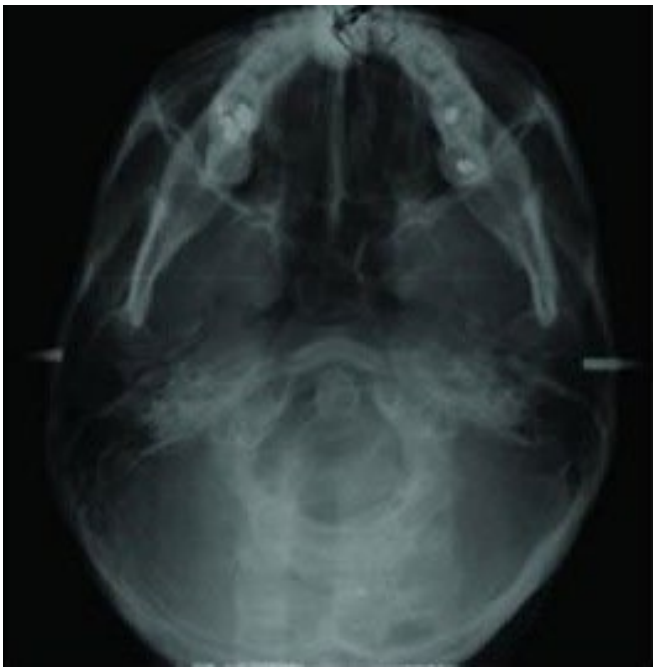
Table 12. Mandible – Submentovertex-Schüller Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or a supine position on the table, which may depend on the patient's health status. • To allow full extension of the neck in the supine position, the patient's shoulders should be elevated on firm pillows. To avoid strain on the neck muscles and to keep the abdominal muscles relaxed, have the patient flex their knees. This positioning should only be performed if clinically safe, on the patient's health status. • The midsagittal plane of the body should be centered to the midline of the IR. Full extension of the neck will position the head on its vertex. • The IOML should be as parallel as possible with the IR plane. If this is not possible, angle the IR (whether an upright device or DR plate) so that it is parallel to the IOML. • The X-ray beam CR should be directed midway between the angles of the mandible and perpendicular to the IOML. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: Do not leave the patient in this position for an extended amount of time; the increased cranial pressure that may result from positioning, patients may feel dizzy for a few minutes once they sit up.

Patient Positioning Example	**Figure 42. Submentovertex/Schüller Method Patient Positioning**  Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	The coronoid and condyloid processes of the mandible
Image Quality Criteria	The images should demonstrate the mandibular condyles anterior to the pars petrosa. The final image should be free of mandibular foreshortening or rotation (Figure 43).[65]

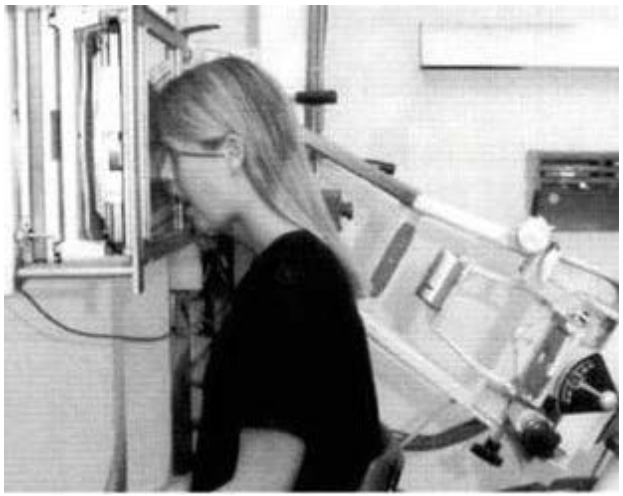
CR = central ray; DR = digital radiography; IOML = infraorbitomeatal line.

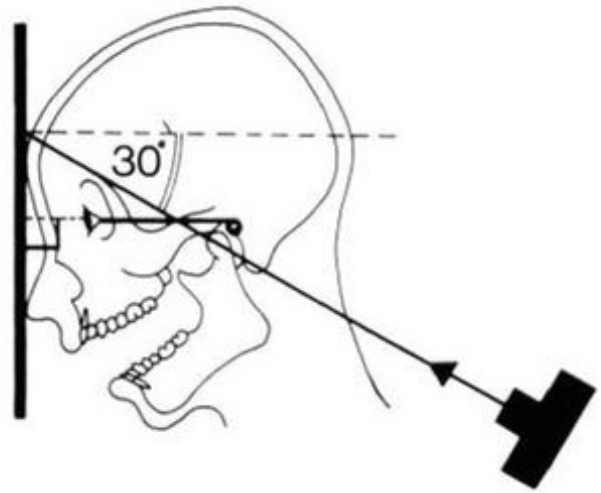
Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Maglione et al. *Int J Dent.* 2012.[40,49-51,58-59,65] For educational purposes only.

Figure 43. Submentovertex View of the Mandible



Maglione et al. *Int J Dent.* 2012.[65] For educational purposes only.

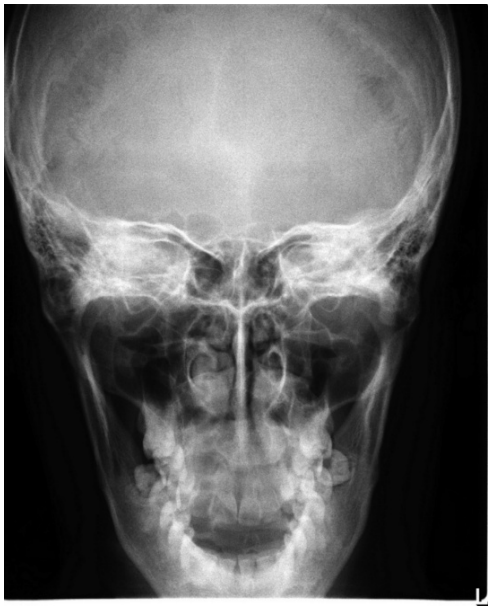
Table 13. Mandible – Reverse Towne-Clementisch Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's health status. • The radiographic baseline should be horizontal and perpendicular to the IR. • The patient should be in a forehead-nose position. The OML should be perpendicular to the IR. • The patient should be instructed to open their mouth (if clinically safe). • The X-ray beam CR should be aimed upwards at a 30° angle (Figure 44).[66] • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 44. Patient Positioning for Mandibular Reverse Towne View**  **A.**

	 **B.** Nainoor et al. In: *Diagnosing and Managing Temporomandibular Joint Conditions*. Machoň V, ed. IntechOpen; 2025.[66] For educational purposes only.
Anatomy Best Depicted	• The primary anatomical structures that are visualized are the bilateral condylar neck and head regions as well as the intracapsular TMJs. • It is also useful for evaluating the posterior aspect of the maxillary sinus, the nasal septum, the mandibular rami, and styloid processes.
Image Quality Criteria	The images should demonstrate the mandibular condylar neck and head region, rami, and styloid process in their entirety (Figure 45).[67]

CR = central ray; IR = image receptor OML = orbitomeatal line; TMJ = temporomandibular joints

Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Nainoor et al. In: *Diagnosing and Managing Temporomandibular Joint Conditions*. Machoň V, ed. IntechOpen; 2025; Uribe S. Normal anatomy reverse Towne view [Case study]. Radiopaedia.org. Available at: https://radiopaedia.org/cases/46475. Published July 5, 2016. Accessed December 12, 2024.[40,49-51,58-59,66-67] For educational purposes only.

Figure 45. Normal Reverse Towne View of the Mandible

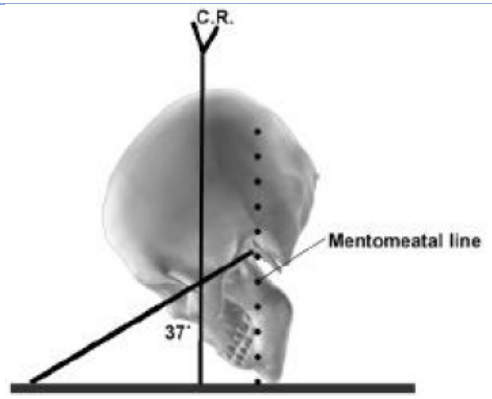


Uribe S. Normal anatomy reverse Towne view [Case study]. Radiopaedia.org. Available at: https://radiopaedia.org/cases/46475. Published July 5, 2016. Accessed December 12, 2024.[67] For educational purposes only.

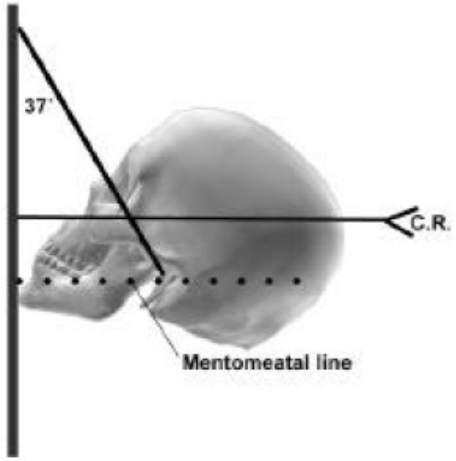
Positioning Techniques for Imaging the Nasal Bones

Most imaging protocols for DR imaging of the nasal bones include completing a parietoacanthial-Waters view with both right and left lateral projections. It should be noted that injuries to the cartilage cannot be detected radiologically. Clinical examination can determine the presence of edema or nasal deformity.[52,68-70] Imaging can be useful in the documentation, assessing the extent and associated facial fractures and/or complications, as well as consideration for additional imaging options such as MDCT.[70] Tables 14 and 15 outline the positioning nuances that make up nasal bone DR, specifically the parietoacanthial/Waters Method and right and left lateral views. Figures 46 through 50 depict examples of patient positioning for these views as well as select resultant DR images of the nasal bones with and without visible abnormalities.[40,49-52,58-59,68,71-72]

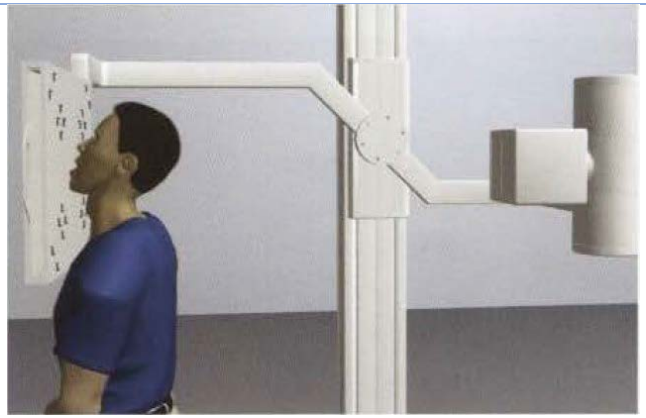
Table 14. Nasal Bones – Parietoacanthial/Waters Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's health status. • The patient should rest their chin on the IR. • The MML should be parallel to the X-ray beam CR and perpendicular to the IR. • The patient's neck should be gently hyperextended (if it's clinically safe to do so) so that the OML forms a 37° angle to the IR. • The X-ray beam CR should be perpendicular to the IR exiting at the acanthion. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: If this projection is performed with the patient's mouth open (if clinically safe), then the sphenoidal sinus will be visualized.
Patient Positioning Example	**Figure 46. Patient Positioning – Parietoacanthial/Waters Method**



A.



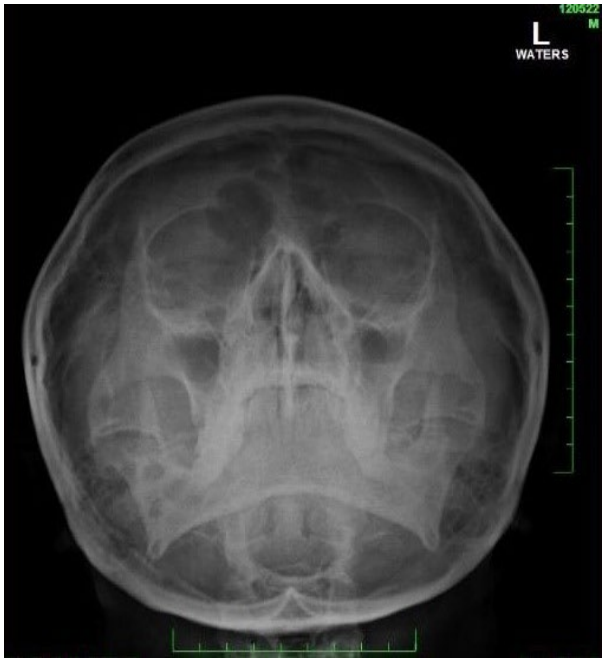
B.

	 **C.** Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[50,58] For educational purposes only.
Anatomy Best Depicted	• The outlines of the maxillary sinuses, some anterior ethmoid air cells, the orbital floors, and nasal bones • This is an ideal view to determine if there is displacement of the nasal septum or presence of depressed fractures of the nasal alae ("wings").
Image Quality Criteria	The petrous ridges of the temporal bone should be below the maxillary sinuses. The distance between the lateral skull and the orbit should be equal on both sides (Figure 47).[71]

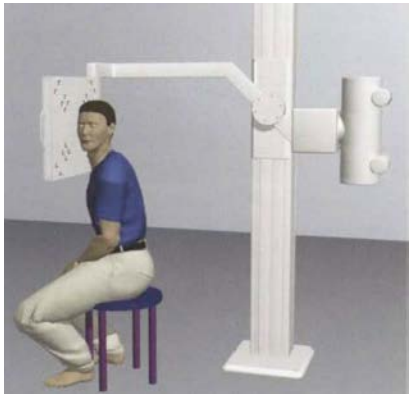
CR = central ray; IR = image receptor; MML = mentomeatal line; OML = orbitomeatal line.

Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Mickelsen et al. *Radiol Technol*. 2013; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Sidauruk et al. *Int J Multidisciplinary: Appl Business Educ Res.* 2022.[40,49-52,58-59,71] For educational purposes only.

Figure 47. Paranasal Sinus Radiography Parietoacanthial/Waters Projection



Sidauruk et al. *Int J Multidisciplinary: Appl Business Educ Res.* 2022.[71] For educational purposes only.

Table 15. Nasal Bones – Lateral (Right and Left)	
Patient Positioning Techniques	• The patient should be lying semiprone on the table with his or her head turned to either a left or right lateral position. However, for injured, elderly, or immobile patients, this position may be difficult. Alternatively, the patient may be seated against an upright IR. • The nasal bones should be positioned on the center of the IR; the patient's head should be adjusted to a true lateral position, ensuring that the IPL is perpendicular to the IR. • The X-ray beam CR should be centered ½ inch inferior to the nasion. • It is important to have tight collimation to the anatomical area of interest due not using antiscatter grids because the imaging is being performed on the tabletop. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 48. Nasal Bone Lateral Projection Patient Positioning**  **A.**

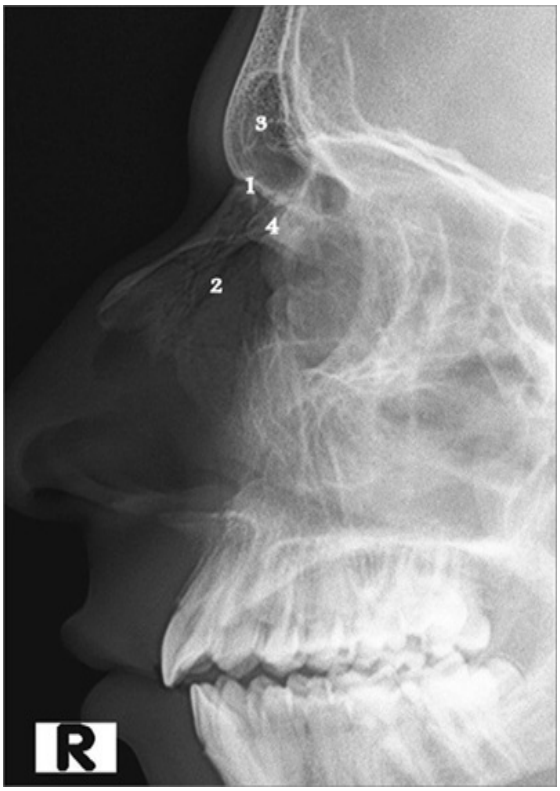
	 **B.** Sandström S.*The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology: 2003.[58] For educational purposes only.
Anatomy Best Depicted	• The nasal frontal suture, the groove for the anterior ethmoidal nerve, the frontal sinus, the nasal process of the frontal bones, and the nasal bones in profile (Figure 49).[72] • Other anatomical structures that should be visualized include the nasofrontal suture and the anterior nasal spine of the maxilla.
Image Quality Criteria	The right and left lateral views allow both sides of the nasal bones to be imaged.

CR = central ray; IPL = interpupillary line; IR = image receptor.

Data from: Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Hobbs et al. *Radiol Technol*. 2007; Mickelsen et al. *Radiol Technol*. 2013; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and*

Projections. 1st ed. The World Health Organization/International Society of Radiology: 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Radswiki T, Walizai T, Ashraf A, et al. Nasal bone fracture. Radiopaedia.org. Available at: https://radiopaedia.org/articles/12964. Published February 12, 2011. Accessed December 14, 2024; Er A, Bell D, Campos A, et al. Nasal bones (lateral view). Radiopaedia.org. Available at: https://radiopaedia.org/articles/85033. Published December 12, 2020. Accessed December 14, 2024.[40,49-52,58-59,68,72] For educational purposes only.

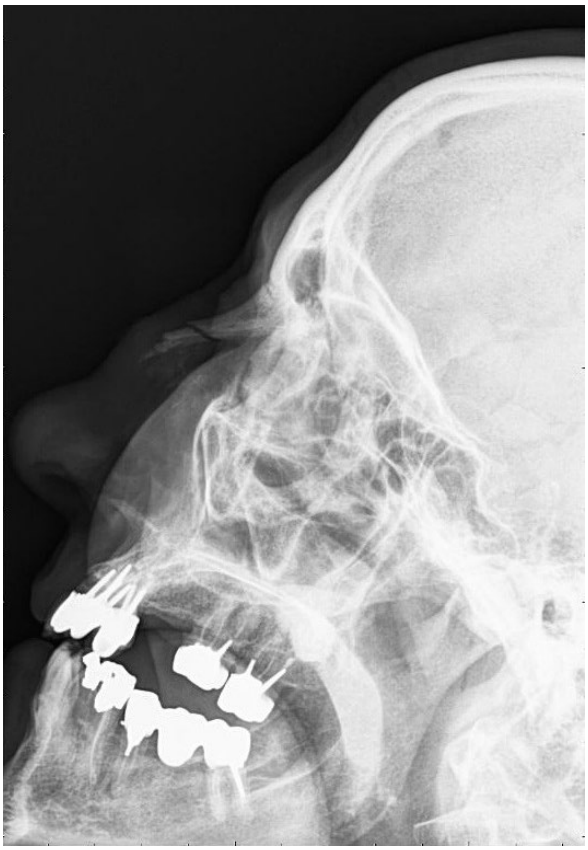
Figure 49. Right Lateral View of the Nasal Bones



An X-ray of normal a right lateral view of the nasal bones and associated anatomy, including (1) the nasofrontal suture; (2) the groove for anterior ethmoidal nerve; (3) frontal sinus; (4) the nasal process of the frontal bone.

Adapted from Er A, Bell D, Campos A, et al. Nasal bones (lateral view). Radiopaedia.org. Available at: https://radiopaedia.org/articles/85033. Published December 12, 2020. Accessed December 14, 2024.[72] For educational purposes only.

Figure 50. Nondisplaced Nasal Bone Fracture



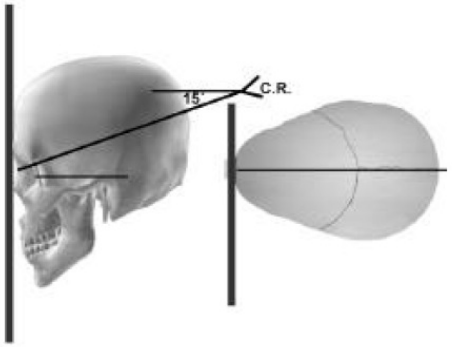
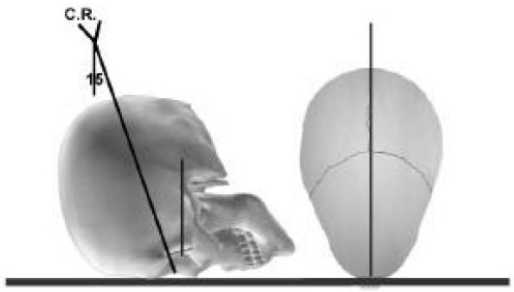
A right lateral radiograph of a patient with a nondisplaced nasal bone fracture with nasal deformity, which is visible in the soft tissue region.

Radswiki T, Walizai T, Ashraf A, et al. Nasal bone fracture. Radiopaedia.org. Available at: https://radiopaedia.org/articles/12964. Published February 12, 2011. Accessed December 14, 2024.[68] For educational purposes only.

Positioning Techniques for Imaging the Orbital Bones

Most radiographic imaging protocols for DR of the orbits include the following projections: the PA-Caldwell view, lateral (right or left depending on the injury site), parietoacanthial-Waters method, and the parieto-orbital oblique view/Rhese view of the orbits. Tables 16 through 19 outline the positioning nuances that make up radiography of the orbital bones, while Figures 30 through 33 and 51 through 53 depict examples of patient positioning for the PA/Caldwell view and select resultant DR images of the orbital bones with and without visible abnormalities.[40,49-50,58-59,73-74]

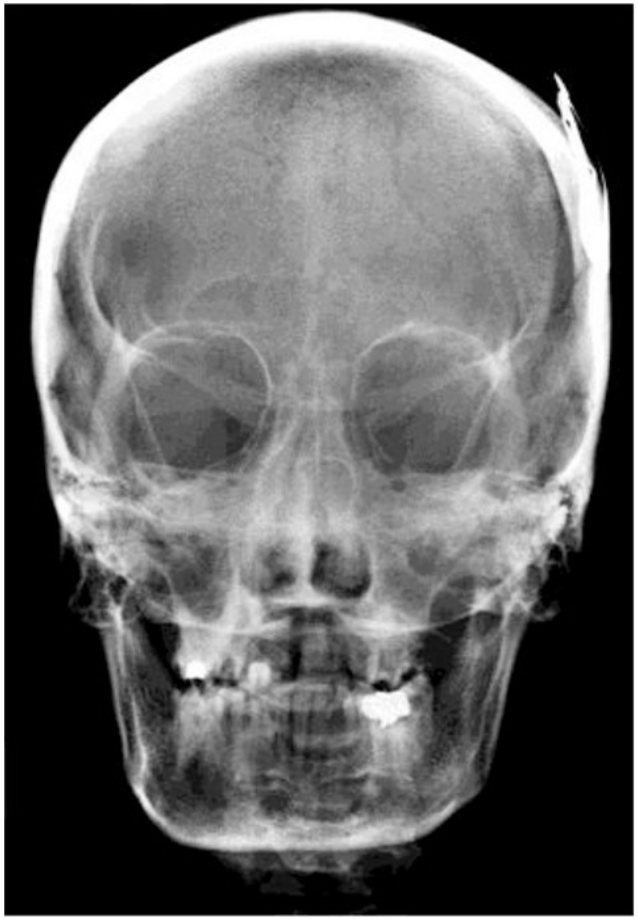
Table 16. Orbital Bones – PA-Caldwell Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the radiographic table, which may depend on the patient's health status. • The midsagittal line should be centered to the IR. • The patient's forehead and nose should be placed against the IR. • The OML should be perpendicular to the IR. • The lateral margins of the orbits should be adjusted so they are equidistant from the IR. • The X-ray beam CR should be horizontal and centered 1/2 inch below the external occipital protuberance It should also be directed in a 15°–20° caudal position and exit the nasion. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: An alternative modified PA Caldwell projection can be performed using a 25°–30° caudal angle for better visualization of the superior orbital fissures, foramen rotundum, and inferior orbital rim.
Patient Positioning Example	**Figure 30. PA/Caldwell Method Postioning**

	 **A.**  **B.** Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	The orbits filled by the petrous pyramids, the posterior ethmoidal sinus, frontal bone and sinus, and dorsum sellae (Figure 51).[73]
Image Quality Criteria	The petrous ridges of the temporal bone should be symmetrical and located in the lower 1/3 of the orbits. The entire cranial perimeter should be visible without rotation or tilt.

CR = central ray; IR = image receptor; OML = orbitomeatal line; PA = posteroanterior.

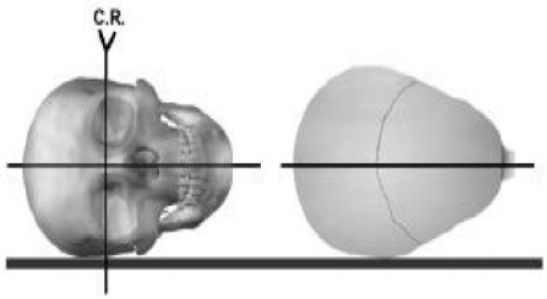
Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Ebrahimnejad et al. *J Dent (Tehran)*. 2016.[40,49-50,58-59,73] For educational purposes only.

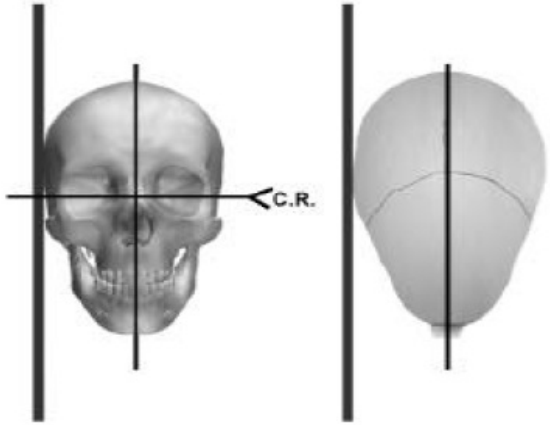
Figure 51. Caldwell Radiograph of the Orbits



A Caldwell radiograph showing opacification of frontal and ethmoidal sinuses.

Ebrahimnejad et al. *J Dent (Tehran)*. 2016.[73] For educational purposes only.

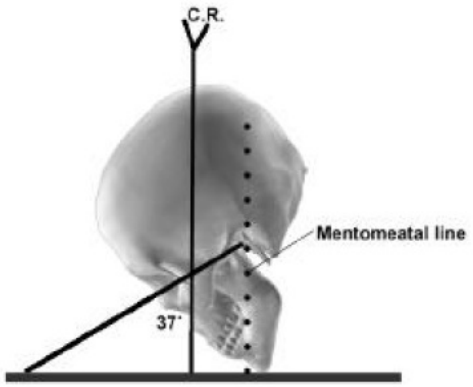
Table 17. Orbital Bones – Lateral (Right or Left)	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or semiprone position on the table, which may depend on the patient's health status. • The clinical side of interest should be against the IR. • The midsagittal line should be parallel to the IR. • The IPL should be perpendicular to IR. • The X-ray beam CR should be centered 2 cm posterior to the outer canthus. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 32. Lateral View Positioning**  **A.**

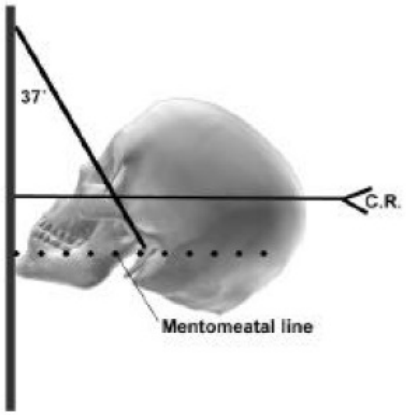
	 **B.** Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	• The superimposed halves of the cranium, the Sella turcica, the anterior clinoid processes, the dorsum sellae, and the posterior clinoid processes
Image Quality Criteria	• The images should demonstrate the entire cranium without rotation or tilt. • The orbital roofs, sphenoid bone, and the TMJs should be superimposed with the Sella turcica in profile. • There should be no overlap of the spine and mandible.

CR = central ray; IPL = interpupillary line; IR = image receptor; TMJ = temporomandibular joints.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO*

Manual of Diagnostic Imaging: Radiographic Technique and Projections. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

Table 18. Orbital Bones – Parietoacanthial-Waters Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's health status. • The patient should rest their chin on the IR. • The MML should be parallel to the X-ray beam CR and perpendicular to the IR. • The patient's neck should be gently hyperextended (if clinically safe to do so) so that the OML forms a 37° angle to the IR. • The X-ray beam CR should be perpendicular to the IR, exiting at the acanthion. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 33. Parietoacanthial-Waters View Positioning**  **A.**

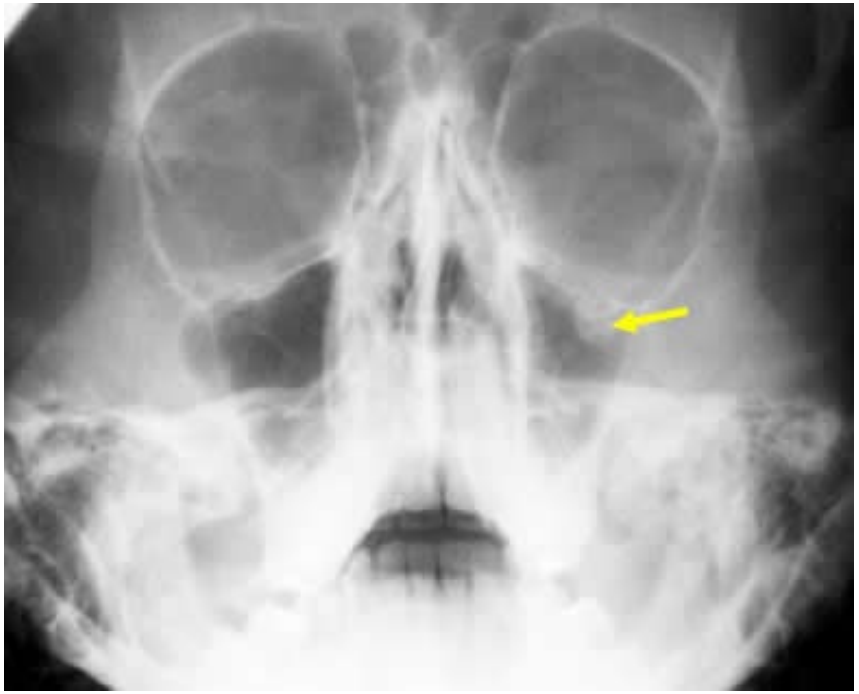
	 **B.** Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	• The facial bones, the maxillary sinus groups, the orbits, maxilla, and zygomatic arches • This is an ideal view for visualizing the orbital floors to rule out "blow-out" fractures of the orbits (Figure 52).[74]
Image Quality Criteria	• The petrous ridges of the temporal bone should be below the maxillary sinuses. • The distance between the lateral skull and the orbit should be equal on both sides.

CR = central ray; IR = image receptor; MML = mentomeatal line; OML = orbitomeatal line.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO*

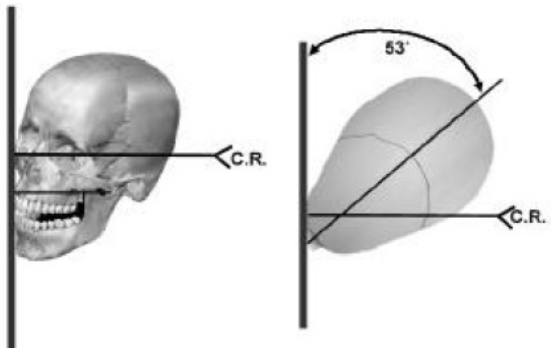
Manual of Diagnostic Imaging: Radiographic Technique and Projections. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Whittaker JD. Zygomatic Complex and Nasal Injury: Other Radiological Investigations. RCEM Learning. Available at: https://www.rcemlearning.co.uk/modules/zygomatic-complex-and-nasal-injury/lessons/investigations-37/topic/other-radiological-investigations/. Published May 28, 2021. Accessed November 22, 2024.[40,49-50,58-59,74] For educational purposes only.

Figure 52. Orbital Blow-Out Fracture – Waters View



A Waters view radiograph of the orbital bones revealing a "teardrop" sign (arrow) indicating an orbital "blow-out" fracture.

Whittaker JD. Zygomatic Complex and Nasal Injury: Other Radiological Investigations. RCEM Learning. Available at: https://www.rcemlearning.co.uk/modules/zygomatic-complex-and-nasal-injury/lessons/investigations-37/topic/other-radiological-investigations/. Published May 28, 2021. Accessed November 22, 2024.[74]

Table 19. Orbital Bones – Parieto-Orbital Oblique/Rhese Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or semiprone position on the table, which may depend on the patient's health status. • The clinical side of interest should be placed against the IR. • Depending on the patient's position, the zygoma (cheek), nose, and chin should be positioned against the IR. • The patient's head should be adjusted so that the AML is perpendicular to the IR. • Gently rotate the patient's head so that the midsagittal plane forms a 53° angle with the IR. • The X-ray beam CR should be perpendicular and centered to exit the affected orbit. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 53. Parieto-orbital Oblique/Rhese Method Patient Positioning**  Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.

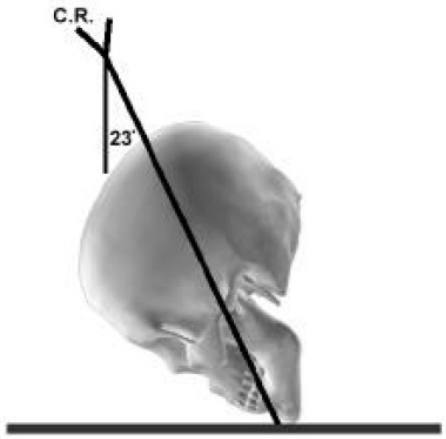
Anatomy Best Depicted	• The orbital apex, particularly the optic foramen, optic strut, and the upper ethmoid sinus • The optic foramen, if properly imaged, should be in the inferior and lateral quadrant of the orbit • The ethmoid, sphenoid, and frontal sinus should be demonstrated in a parieto-orbital projection.
Image Quality Criteria	• The entire orbital rim should be visualized with the supraorbital margins lying in the same horizontal line. • Lateral deviation indicates incorrect rotation. Longitudinal deviation indicates incorrect angulation of the AML.

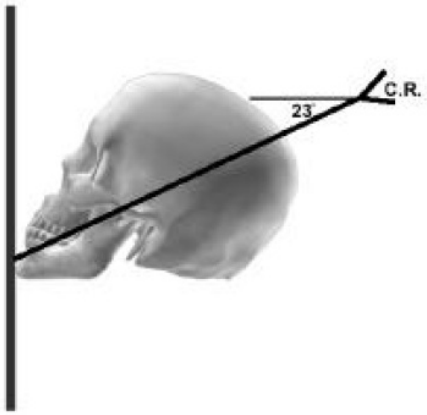
AML = acanthiomeatal line; CR = central ray; IR = image receptor.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

*Positioning Techniques for Imaging the Zygomatic Arch*es

Most protocols for DR of the zygomatic arches include the PA axial-modified Titterington method, an AP-axial modified Towne method, a Waters view, a submentovertex-Schüller method, and an oblique inferosuperior tangential projection (commonly referred to as the "jug handle" view) due to the fact that the zygomatic arches look like bucket handles on screen.[75] Fractures can also be seen on a Waters projection, and in some patients, also on a Towne view, which is typically performed as part of a standard FBR series. A Waters view provides excellent visualization of the orbital rim as well as the floor of the orbits, nasal bones, zygoma, maxilla, and maxillary sinuses in patients with facial trauma.[50] Tables 20 through 23 outline the positioning nuances that make up crucial DR images of the orbits. Figures 42 and 54 through 60 depict examples of patient positioning for the PA axial-modified Titterington method, AP-axial modified Towne view, submentovertex/Schüller method, and the oblique inferosuperior tangential projection (jug handle view) as well as select resultant DR images of the zygomatic arches with and without abnormalities.[36,40,49-50,58-59,76-78]

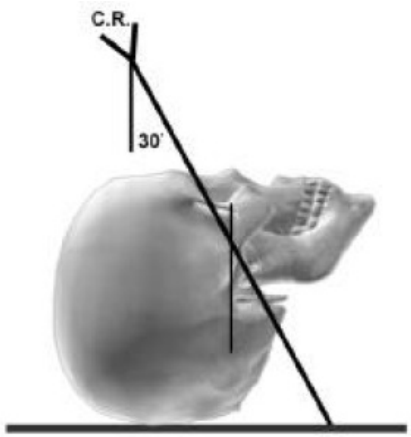
Table 20. Zygomatic Arches – PA Axial-Modified Titterington Position/Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or prone position on the table, which may depend on the patient's health status. • Have the patient gently rest their chin and the tip of their nose on the IR. • Adjust the patient's head so that the midsagittal plane is perpendicular to the IR. • The X-ray beam CR should be angled between 23°–38° caudally entering midway between the zygomatic arches. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 54. PA Axial Modified Titterington Position/Method Patient Positioning**  **A.**

	 **B.** Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	• The zygomatic arches, which should be symmetrical • Depending on the caudal angle used (23°–38°), modifications of this view can be made to visualize the petrous pyramids and IACs.
Image Quality Criteria	There should be no rotation of the skull; the zygomatic arches should be symmetrical.

CR = central ray; IACs = internal auditory canals; IR = image receptor; PA = posteroanterior.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. *e*RADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO*

Manual of Diagnostic Imaging: Radiographic Technique and Projections. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

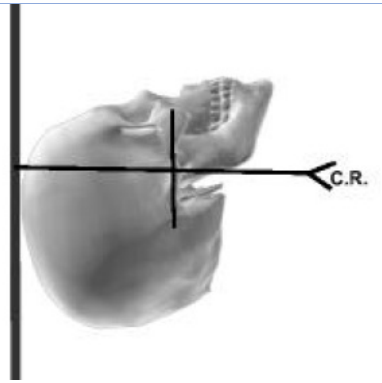
Table 21. Zygomatic Arches – AP-Axial Modified Towne Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or supine position on the table, which may depend on the patient's health status. • Gently adjust the patient's head so that the OML and midsagittal plane are perpendicular to the IR. • The X-ray beam CR should be angled 30° caudal entering the glabella. • If the patient cannot flex their neck due to their condition or injuries, adjust their head so that the IOML is perpendicular to the IR and increase the caudal angle to 37°. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should taken on suspended respiration; the patient should be instructed not to move.
Patient Positioning Example	**Figure 55. AP-Axial Modified Towne Method Patient Positioning** 

	Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	The zygomatic arches, which should be symmetrical
Image Quality Criteria	There should be no rotation of the skull, and the zygomatic arches should be projected lateral to the mandibular rami.

AP = anteroposterior; CR = central ray; IOML = infraorbitomeatal line; IR = image receptor; OML = orbitomeatal line.

Data from Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005.[40,49-50,58-59] For educational purposes only.

Table 22. Zygomatic Arches – Submentovertex/Schüller Method	
Patient Positioning Techniques	• This view is best performed with the patient in an upright, seated, or supine position on the table, which may depend on the patient's health status. • To allow full extension of the patient's neck in the supine position, the patient's shoulders should be elevated on firm pillows. To avoid strain on the patient's neck muscles and to relax their abdominal muscles, have the patient flex their knees. This positioning should only be performed if clinically safe, based on the patient's health status. • The midsagittal plane of the patient's body should be centered to the midline of the IR. Full extension of the patients' neck will position their head on its vertex. • The IOML should be as parallel as possible with the IR plane. If this is not possible, angle the IR (whether it's an upright device or DR plate) so that it is parallel with the IOML. • The X-ray beam CR should be directed midway between the angles of the mandible and perpendicular to the IOML. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: Do not leave the patient in this position for an extended amount of time, as the increased cranial pressure may leave the patient dizzy for a few minutes once they sit up.
Patient Positioning Example	**Figure 42. Submentovertex/Schüller Method Patient Positioning**

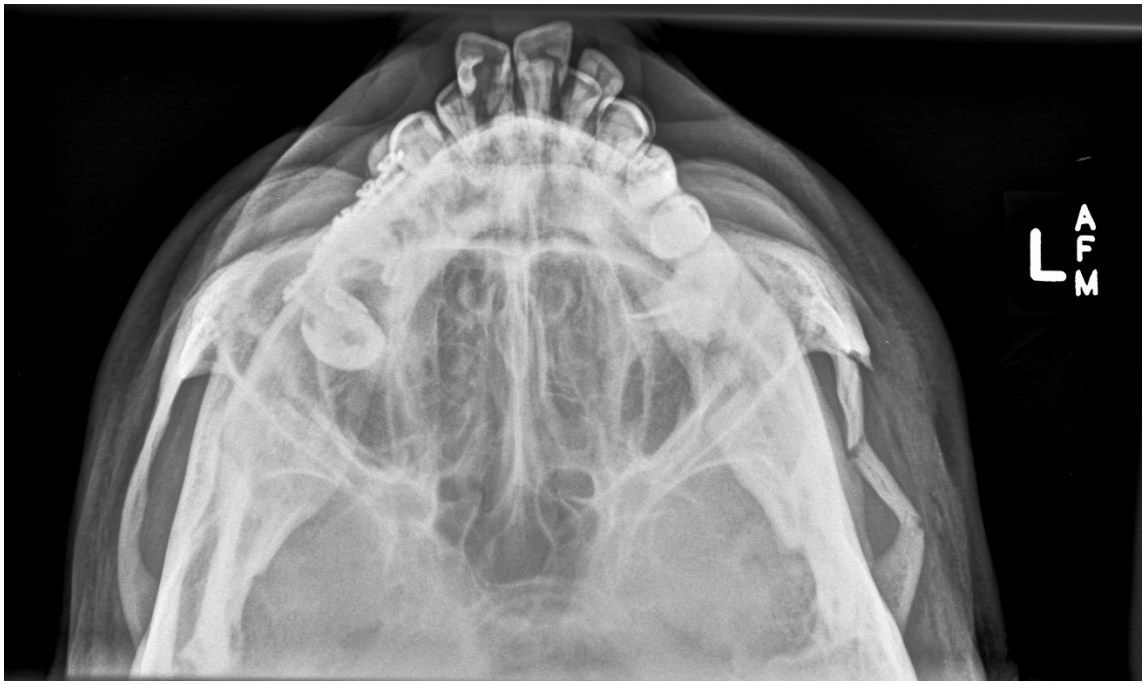
	 Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.
Anatomy Best Depicted	The zygomatic arches, which should be free of superimposed structures This view can image patients with either angulated and/or depressed fractures (Figures 56 and 57).[36,76]
Image Quality Criteria	The zygomatic arches should appear without foreshortening or rotation and should be free from overlying structures.

CR = central ray; IOML = infraorbitomeatal line; IR = image receptor.

Data from Murphy A. Zygomatic arch fracture [Case study]. Radiopaedia.org. Available at: https://radiopaedia.org/cases/48597. Published October 16, 2016. Accessed November 26, 2024; Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Whittaker JD. Zygomatic Complex and Nasal Injury: Facial X rays (Views). RCEM Learning. Available at:

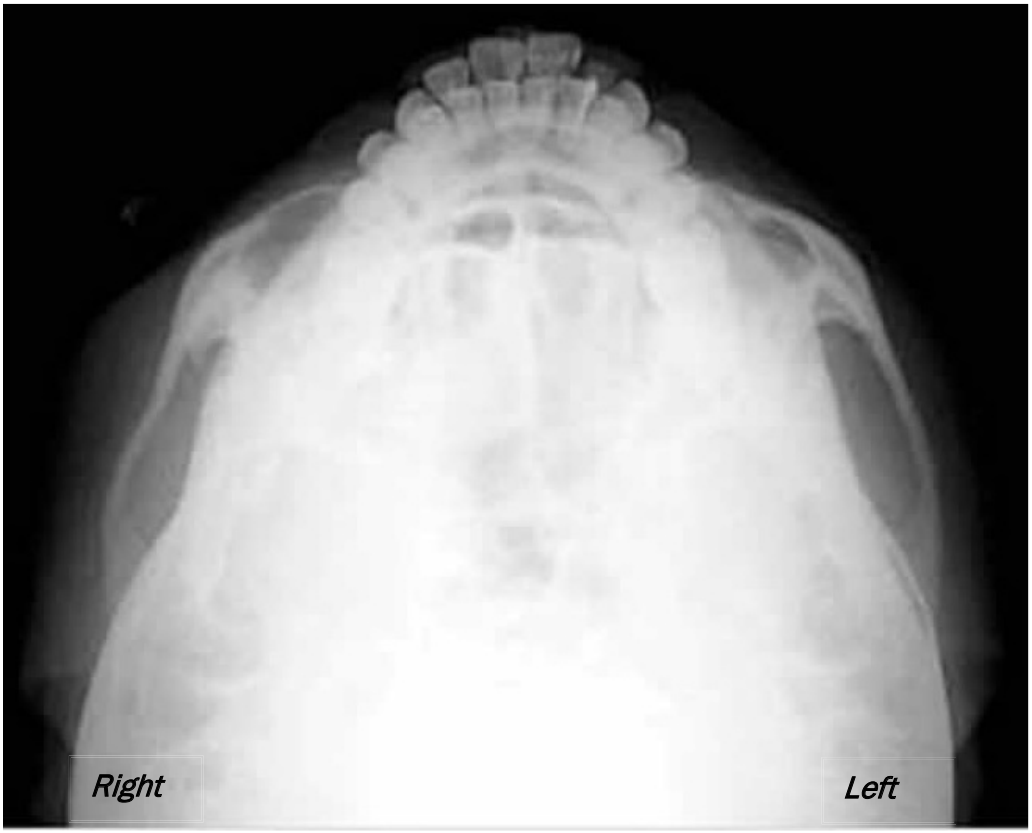
https://www.rcemlearning.co.uk/reference/zygomatic-and-nasal-injury/#1571913778901-92d3d184-f4b0. Published May 28, 2021. Accessed November 22, 2024.[36,40,49-50,58-59,76] For educational purposes only.

Figure 56. Left Zygomatic Arch Angulated Fracture – Submentovertical View



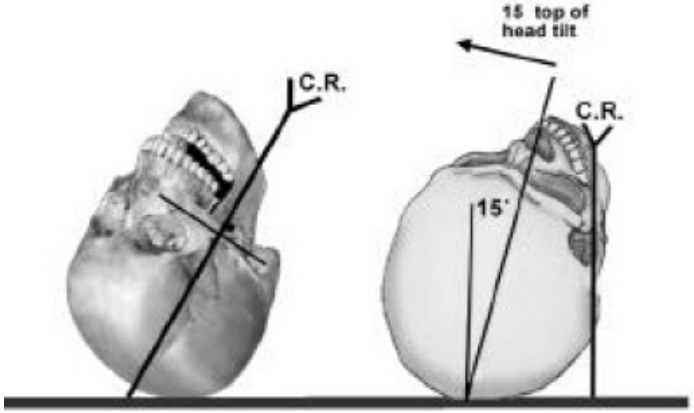
Murphy A. Zygomatic arch fracture [Case study]. Radiopaedia.org. Available at: https://radiopaedia.org/cases/48597. Published October 16, 2016. Accessed November 26, 2024.[36] For educational purposes only.

Figure 57. Right Zygomatic Arch Depressed Fracture – Submentovertical View

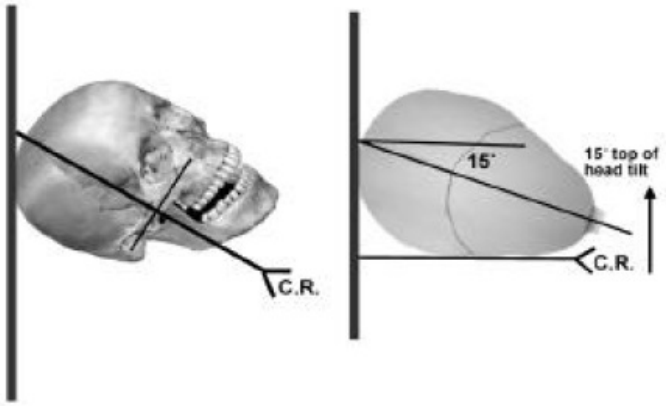


Whittaker JD. Zygomatic Complex and Nasal Injury: Facial X rays (Views). RCEM Learning. Available at: https://www.rcemlearning.co.uk/reference/zygomatic-and-nasal-injury/#1571913778901-92d3d184-f4b0. Published May 28, 2021. Accessed November 22, 2024.[76] For educational purposes only.

Table 23. Zygomatic Arches – Oblique Inferosuperior Tangential Projection (Jug Handle View)	
Patient Positioning Techniques	• This position is performed for 1 zygomatic arch (the side that sustained trauma) or for bilateral comparison; then both sides are imaged. • This view is best performed with the patient in an upright, seated, or supine position on the table, which may depend on the patient's health status. • The patient's neck should be gently hyperextended (if their condition safely allows). • The top of the patient's head should be placed on the IR. • The patient's head should be gently adjusted so that the IOML is as parallel as possible to the IR. • Properly center the zygomatic arch to the IR. • The patient's head should be rotated 15° from the midline towards the side being imaged; the chin should be tilted 15° towards the zygomatic arch being imaged. • The X-ray beam CR should be perpendicular to the IOML and centered to the zygomatic arch of clinical interest. • Right and left markers should be used if the position is performed with the patient upright. • Proper and safe immobilization techniques (if needed) and tight X-ray beam collimation should both be used. • The exposure should be taken on suspended respiration; the patient should be instructed not to move. NOTE: Some literature recommends that when performing this projection, not to use AEC. Instead, use a manual technique that is slightly less than the normal zygomatic arch exposure factor for a "cone-down" view of the affected arch (Figure 59).[77]
Patient Positioning Example	**Figure 58. Tangential Projection Patient Positioning**



A.



B.

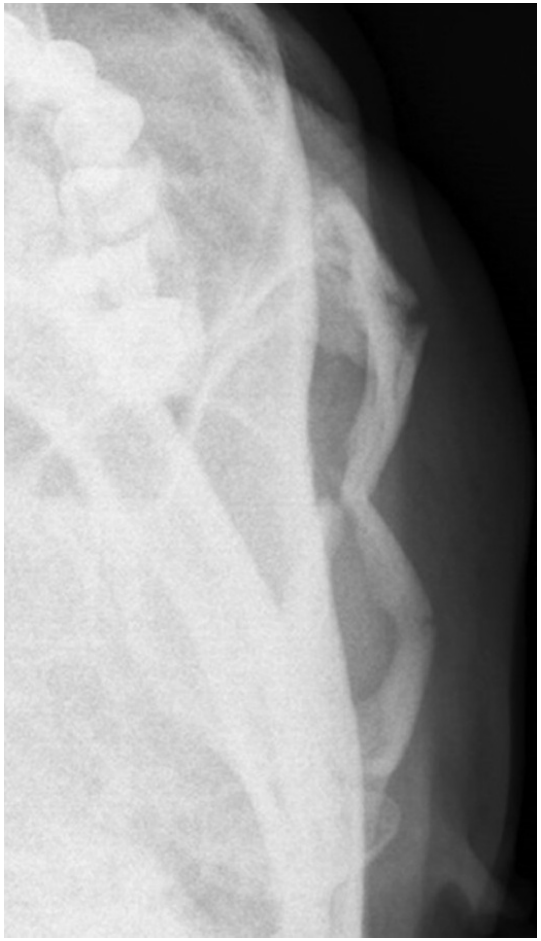
Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002.[50] For educational purposes only.

Anatomy Best Depicted	• The zygomatic arch of interest that should be free from superimposition (Figure 60)[78] • This view is useful for patients who present with depressed fractures.
Image Quality Criteria	Images should demonstrate the zygomatic arch of interest free from overlying structures. The anatomy should be an adequately exposed zygomatic arch (not over- or underexposed).

CR = central ray; IOML = infraorbitomeatal line; IR = image receptor.

Data from Murphy A. Zygomatic arch fracture [Case study]. Radiopaedia.org. Available at: https://radiopaedia.org/cases/48597. Published October 16, 2016. Accessed November 26, 2024; Tsoukatos G. A Review of Conventional Skull Digital Radiography Positioning and Techniques. eRADIMAGING. Available at: https://www.eradimaging.com/course/889. Published November 25, 2017. Accessed November 29, 2024; American Society of Radiologic Technologists. *Radiography Positioning Guide – Sinus and Mandible*. ASRT; 2019; Tip-TV Training in Partnership Program Supplement and Test for Imaging Professionals. *XR: Skull, Facial Bones, and Sinus Radiography.* General Electric Company; 2002; Sandström. *The WHO Manual of Diagnostic Imaging: Radiographic Technique and Projections*. 1st ed. The World Health Organization/International Society of Radiology; 2003; Whitley et al. *Clark's Positioning in Radiography.* 12th ed. CRC Press; 2005; Sorghabi et al. *Craniomaxillofacial Trauma & Reconstruction Open*. 2020:1-5; X-ray Anatomy - Tangential Zygomatic Arch. Quizlet.com. Available at: https://quizlet.com/377323276/x-ray-anatomy-tangential-zygomatic-arch-diagram/. Accessed December 18, 2024.[77-78]

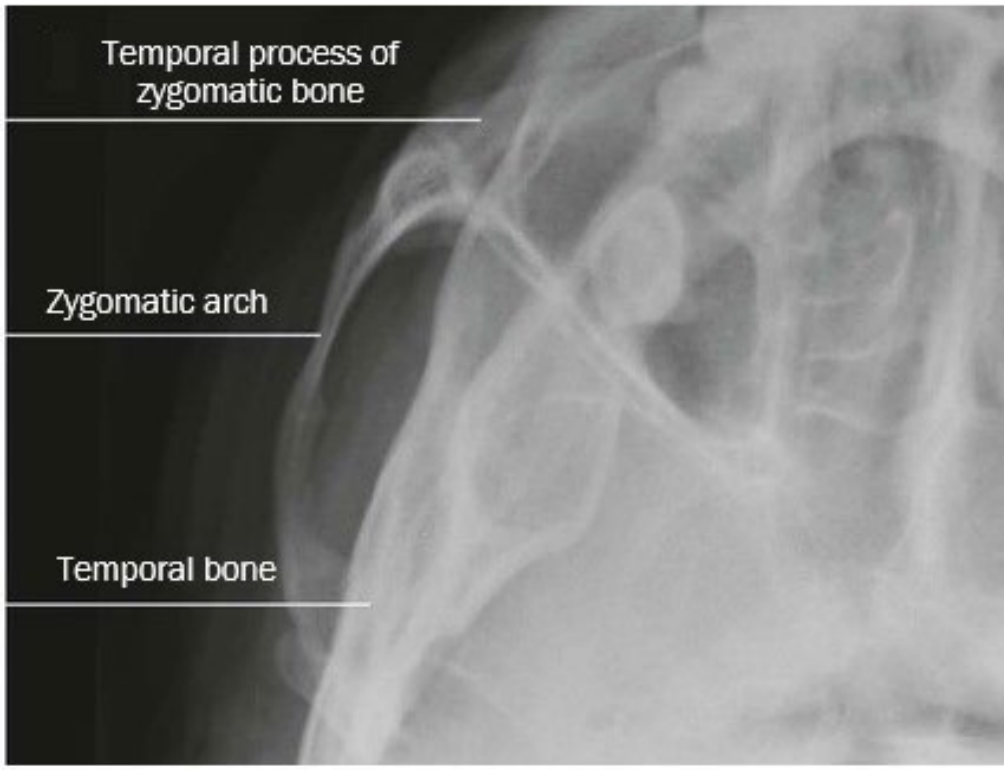
Figure 59. Isolated Left Zygomatic Arch Fracture



A “cone down” oblique inferorsuperior tangential view of an isolated zygomatic arch fracture on the left side.

Sorghabi et al. *Craniomaxillofacial Trauma & Reconstruction Open*. 2020.[77] For educational purposes only.

Figure 60. Normal Zygomatic Arch



An X-ray image of a normal zygomatic arch with labeled anatomy.

Adapted from X-ray Anatomy - Tangential Zygomatic Arch. Quizlet.com. Available at: https://quizlet.com/377323276/x-ray-anatomy-tangential-zygomatic-arch-diagram/. Accessed December 18, 2024.[78] For educational purposes only.

Common Trauma Facial Bone Radiography Techniques and Positioning

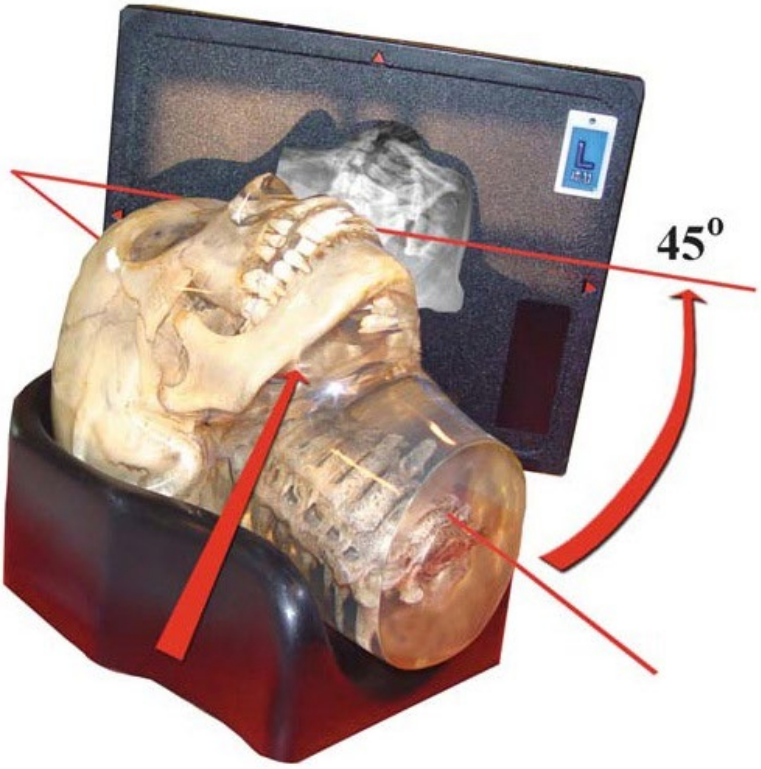
Assessing Trauma Situations

Every trauma patient should be considered to have a potential spinal injury and should be cleared by the ED physician or trauma surgeon before being moved. The RT should work closely with the ED staff to make sure all items that might cause an artifact on any radiographic images have been removed. When performing a trauma FBR series, it is important that the RT grasp the proper use and supplement of positioning aids, which are essential to obtaining quality diagnostic images. Sponges, sandbags, stationary grids, and IR holders are necessities because many projections require the use of a horizontal CR X-ray beam.[40]

Adapting Standard Positions

As important as the imaging equipment is, knowledge about how to adapt angles and place patients in alternative positions when necessary to compensate for the inability of the patient to be positioned with standard methods is equally important.[40] Many times, this requires performing cross-table imaging studies and considering all of the nuances and changes involved (Figure 61).[40,51] For these positions and views, proper accessories are needed to avoid nondiagnostic images that result in repeated studies and increased patient dose. This can be accomplished by choosing the correct size and type of CR and DR IR holder in order to secure the device and prevent motion artifacts.[53]

Figure 61. Cross-Table Positioning with a Phantom



A labelled photographic example of cross-table trauma positioning for an axiolateral mandibular projection using a skull phantom. The IR should be placed at a 45° angle to the crown of the head, and the CR should be perpendicular to the IR, entering just superior to the angle of the jaw.

CR = central ray; IR = image receptor.

Reused with permission from Hobbs et al. *Radiol Technol*. 2007.[51] For educational purposes only.

Maximizing Efficiency

To maximize efficiency and save time while minimizing patient movement, the RT should take all AP projections for the requested examinations moving superiorly to inferiorly, and then perform all of the requested lateral projections while moving inferiorly to superiorly. This method moves the X-ray tube in the most expeditious manner. RTs working with trauma patients should also be familiar with specialized beds or stretchers that have a movable tray to hold the IR. This type of stretcher allows the use of a mobile radiographic unit and eliminates the requirement and risk of transferring

an injured patient to the imaging table. Standard protocol is to perform radiographic image captures without removing the patient's immobilization devices that were secured by the ED staff. After the possible injuries have either been diagnosed or ruled out, the attending physician will give the order for immobilization devices to be removed, changed, or continued. Use of immobilization in trauma patients aims to avoid exacerbating the patient's injury and avoid increasing patient discomfort.[51] This also pertains to any additional restriction devices the RT may need to use to minimize patient movement in order to decrease the probability of motion artifacts.[40]

Conclusions

Appropriate imaging methods, combined with a working knowledge of normal facial anatomy, as well as standard patient positioning for imaging the facial bones allows for high-quality diagnostic images to be taken for the accurate diagnosis of injuries to this intricate area of the body. Many fractures are best identified through a combination of different views and methods, including compensation for the degree of trauma the patient may have sustained. Specialty physicians and surgeons require detailed and accurate information about the anatomic landmarks and features of the fracture, such as the degree of displacement and comminution, so they can plan treatment and predict possible complications. This can only be accomplished by a radiologist working closely with their RT staff in developing and executing comprehensive and detailed DR protocols for all factions of FBR.

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