THE ROLE OF COMPUTED TOMOGRAPHY IN THE EVALUATION OF CRANIOFACIAL TRAUMA

THESIS

Submitted for the partial fulfillment of Master degree in Radiodiagnosis

By

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CONTENTS

INTRODUCTION AND AIM OF WORK

- Millions of people sustain trauma to the head and face resulting in complex fractures which, if not correctly diagnosed and treated, may cause permanent functional and cosmetic deformities. During the past decade, advances in radiographic procedures, the utilization of craniofacial surgical techniques, and the advent of rigid miniplate fixation have tremendously improved the functional and aesthetic results in facial fracture management.

  ***(DR. BERNSTEIN., 1999)*.**

- The greatest number of traumatic head injuries comes from motor vehicle collisions, followed by falls, and the populations most affected are young adult males and the elderly. Alcohol use further increases these risks. Fortunately, however, the use of seatbelts, airbags, and helmets has brought about decline in incidence of traumatic brain injury. ***(DR. Ponce de león., 2002)***

- Primary goal in managing severe head injury patients is to preserve life and neurologic function. The secondary goal is to identify intracranial lesions that will negatively affect outcome. CT is the method of choice for rapid, accurate evaluation of intracranial and craniofacial injury.

  ***(DR. BERNSTEIN., 1999)*.**

- The accurate diagnosis of facial fractures has been greatly improved by the addition of two- and three-dimensional CT scans which have replaced the plain radiographs for the diagnosis of many types of fractures. The three-dimensional reconstructions have enhanced preoperative bone analysis and planning by providing a life-like simulation of the fractures.

  (Dr .led Larry., 2001)

❖ **The aim of this work is to evaluate the role of CT scan in the diagnosis of cases with craniofacial trauma.**

EMBRYOLOGIC DEVELOPMENT OF THE SKULL

Cellular contribution

- The origin of bone can be followed back to the first three weeks of human development, the Pre-embryonic period. During this period, the cells that will eventually give rise to all structures of the body differentiate into three germ layers. These specialized layers of cells are ectoderm (forming all nerve and some epithelial tissue); mesoderm (forming all connective, muscle and some epithelial tissue) and endoderm (forming some epithelial tissue) (*see Fig. 1*).

- These cells undergo rapid regional development in the embryo, producing the precursors of adult structures, many of which become increasingly recognizable internally and externally.

(Carlson, Bruce M.2000)

- Of interest during skull development, are primarily ectoderm and mesoderm. At the end of 3rd week, ectoderm differentiates into neuroectoderm and epidermis. The latter covers the outside of the body. Neuroectoderm forms the neural tube (eventually becoming the brain and spinal cord) and neural crest. The neural crest is first defined as a region. However, neural crest cells are migratory and begin leaving the neural crest at about Week 5 to reach various target areas where further specialization occurs *(see Fig. 3)*.

- Mesoderm is divided into regions, named for their position relative to the embryo's midline. That portion of mesoderm that migrates to the periphery of the embryo during the second month is called lateral plate mesoderm (*see Fig. 2*).

- As the development of the head progresses, neural crest cells and lateral plate mesoderm both migrate into rapidly forming pharyngeal arches, a series of bump-like structures on both sides of the embryonic head (*see Fig. 2, Fig. 3*). These arches surround the endoderm tube, the beginnings of the mouth and digestive system.

(England, Marjorie A.2004)

- Neural crest cells, in addition to forming nerve tissue, produce the bones of the cranial vault, part of the neurocranium. Within the pharyngeal arches, neural crest cells and lateral plate mesoderm give rise to bones of the jaw and lower face, the viscerocranium *(see Fig. 4).* Lateral plate mesoderm also contributes to the formation of the cartilages of the larynx

(Carlson, Bruce M.2000)

Types of Ossification

- The creation of bone in all living organisms is known as ossification. Bone throughout the body is formed by one of two types of ossification processes: endochondral ossification, and intramembranous ossification. Individual bones can form from one of the other of these two types of ossification or as a combination of the two. The final adult bones, although produced by two different methods, result in bone material that has the same properties and structure. In the skull, different bones within the neurocranium and the viscerocranium are formed by one of the two types of ossification *(see Fig. 4).*

Endochondral ossification:

- It is a bone formation process that begins within (endo) cartilage (chondral). Bone tissue is derived from mesenchyme, specialized mesoderm cells. These mesenchymal cells first form cartilaginous centers in the location where bone will eventually form within the developing embryo starting at Week 5. These cartilage structures are then modified and transformed into bone through the work of osteoblasts (bone forming cells) and osteoclasts (bone cells that break down previously formed bone). **(Carlson, Bruce M.2000)**

- These cells migrate into ossification centers, where bone will begin to be produced. as osteoblasts secrete a calcified bony matrix, osteoclasts remodel the growing bone by destroying or resorbing sections. Osteoclasts and osteoblasts continue to work in conjunction throughout craniofacial growth and development to modify the shape of growing bones. **(England, Marjorie A.2004)**

- The ossification of cartilaginous models of facial bones begins at approximately the third month of development, during the beginning of the fetal period. The cranial base region of the neurocranium and select portions of the viscerocranium are formed by using this method of bone formation.

(Carlson, Bruce M.2000)

Intramembranous, or direct, ossification:

It is a process whereby bone is formed directly without first going through a cartilage stage. The cells destined to become bone derive from specialized mesoderm cells that form membranous sheets, loci of which differentiate into

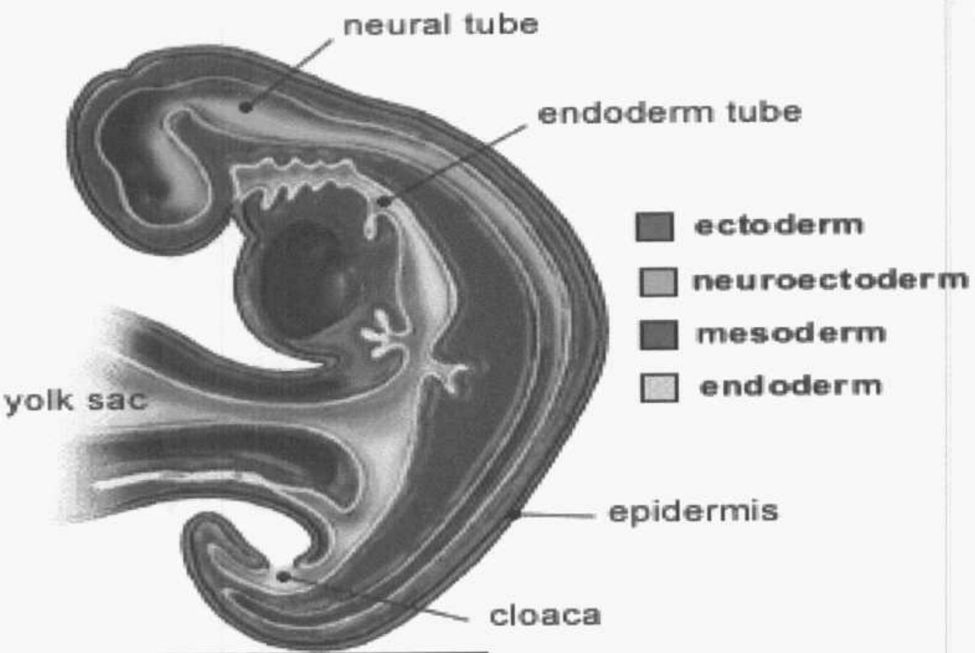


Fig. 1. Embryonic germ layers

Embryonic external features

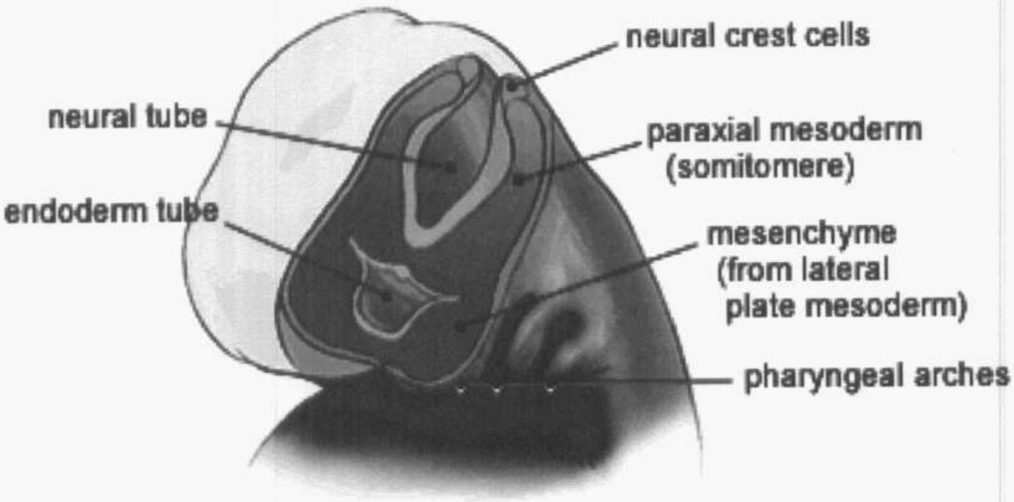


Fig. 2. Germ layer components, embryonic head

England, Marjorie A.2004

osteoblasts and osteoclasts. This type of ossification takes place in several regions within the skull. Both the cranial vault portion of the neurocranium and select portions of the viscerocranium utilize this method of bone formation.

(England, Marjorie A.2004)

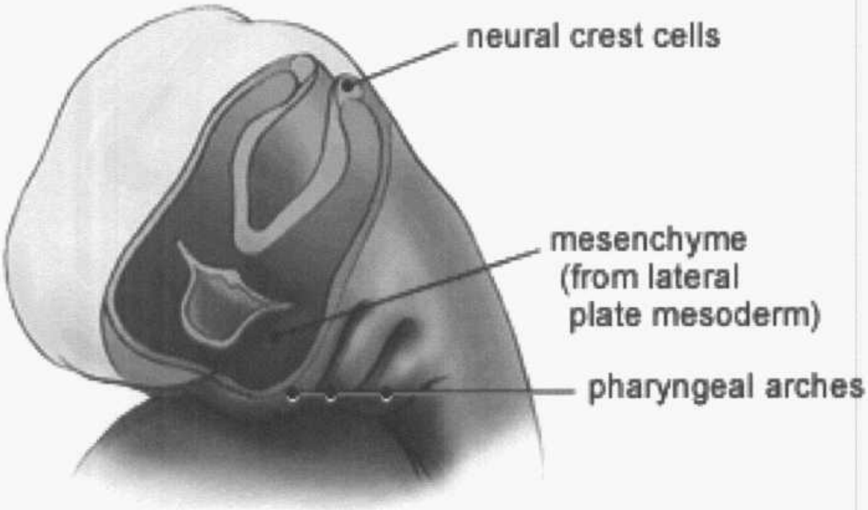
- The bones of the skull are created as these regions of ossification merge. A single bone can therefore be made up of many smaller bones which fuse together during ossification. Single bones, once ossified, are united at their borders by a series of joints or articulations. The 22 bones of the adult skull are joined by two types of joints: amphiarthroses (slightly movable) and synarthroses (immovable). The bones of the cranial base joined by synchondroses, cartilaginous joints

(England, Marjorie A.2004).

- An important synchodrosis is the basioccipital synchondrosis. The bones of the cranial vault are united by sutures, a type of synarthosis. Sutures are relatively immovable, but are also active sites of bone deposition and resorption, allowing changes in size, shape and reorientation of other craniofacial elements. If sutures close prematurely this is known as synostosis, which hinders normal skull and potentially brain development.

(Sweeney, Lauren J.2002)

Fig. 3. Neural crest cell migration



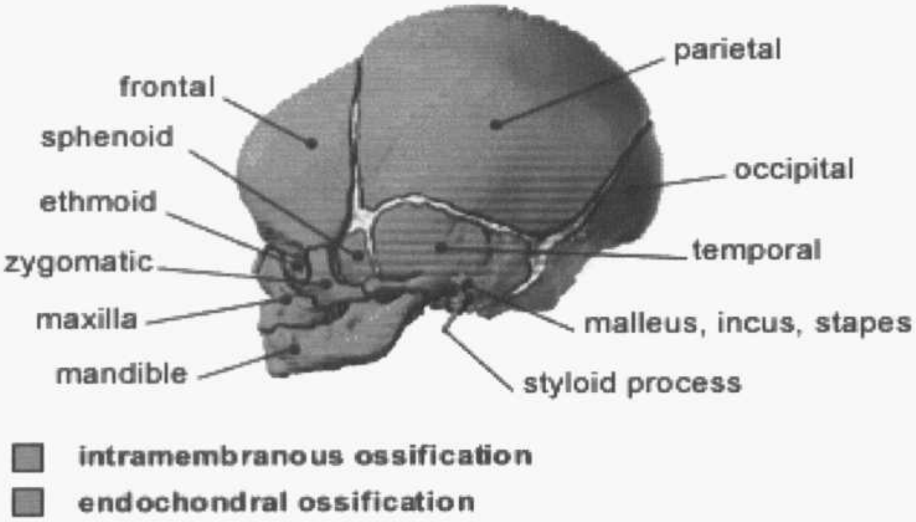


Fig. 4. Types of ossification

Regions of neurocranium and viscerocranium

England, Marjorie A.2004

C.T. ANATOMY OF THE SKULL

The skull can be described in two parts: the cranial base and skull vault.

For better orientation of the normal anatomy of the skull as seen by computed tomography, the various sections are shown from caudal to cephalic direction for axial projection **(Fig 9 a → l)** and in an anteroposterior direction for coronal projection **(Fig. 10)**

I. Skull base: - (Fig. 6, 7)

The osseous components of the skull base, from posterior to anterior, include the occipital bone, clivus ,mastoid segments of the temporal bone, basisphenoid, greater and lesser sphenoid wings, orbital plate of the frontal bone and upper surface of the ethmoid. The cranial base can be divided into posterior, middle and anterior cranial fossae.

(Williams & Wilkins; 2001).

▪ Posterior cranial fossa:

The posterior cranial fossa is the largest of the cranial fossae. It is bounded in front by the dorsum sellae, posterior aspect of the sphenoid body and basioccipital bone, behind by the lower part of the occipital squama, laterally by the petrous and mastoid parts of the temporal bone and lateral parts of the occipital bone.

(Williams & Wilkins; 2001).

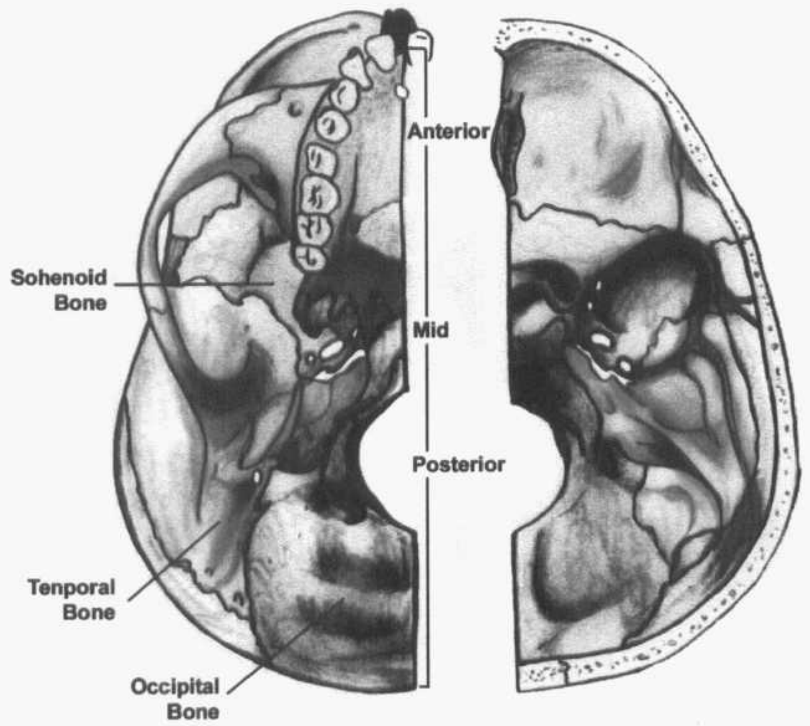
❖ *Occipital bone:* (Fig. 6)

The occipital bone forms the floor of the posterior fossa. It can be divided into three regions: squamosal (posterior), condylar (lateral) and basioccipital (clivus and jugular tubercles).

(Williams & Wilkins; 2001).

A. Squamosal portion:

The major portion of the endocranial aspect of the squamosal portion of the occiput is smooth. Indentations



Osseous components and compartments of the cranial base.

Fig (6): osseous components and compartments of cranial base.

(Williams & Wilkins; 2001).

formed by grooves for the transverse and sigmoid sinuses are located posteriorly and laterally.

B. Condylar part:

The long axis of the condyle has an anteromedial to postero lateral orientation. The condyle articulates with the atlas, a relationship best shown in the coronal plane.

(Williams & Wilkins; 2001).

C. Basioccipital segment:

The basiocciput comprised of the jugular tubercles and clivus. The jugular tubercles form the medial boundary of the jugular foramen. The clivus extends from the anterior rim of the foramen magnum inferiorly to the dorsum sella superiorly.

(Williams & Wilkins; 2001).

Aperatures in the occipital bone and transmitted structures:

1 .Foramen magnum: (Fig7)

The foramen magnum transmits more neural, vascular and connective tissue structures than any other passageway in the skull base.

Through the foramen magnum pass the following structures: brain stem, the cervical roots of the spinal accessory nerve vertebral arteries, posterior spinal arteries, posterior inferior cerebellar arteries, anterior spinal artery and vein and connective tissues . **(Duckert LG, 1998)**

2. Posterior condyloid canal:

The paired posterior condyloid canals traverse the base of the occipital condyle. These canals transmit emissary veins and a meningeal branch of the occipital artery.

(Duckert LG, 1998)

3.Hypoglossal canal :-

The hypoglossal canals and the jugular foraminae are usually separated by the jugular tubercles. Each canal transmits the hypoglossal nerve and a meningeal branch of the ascending pharyngeal artery.

(Duckert LG, 1998)

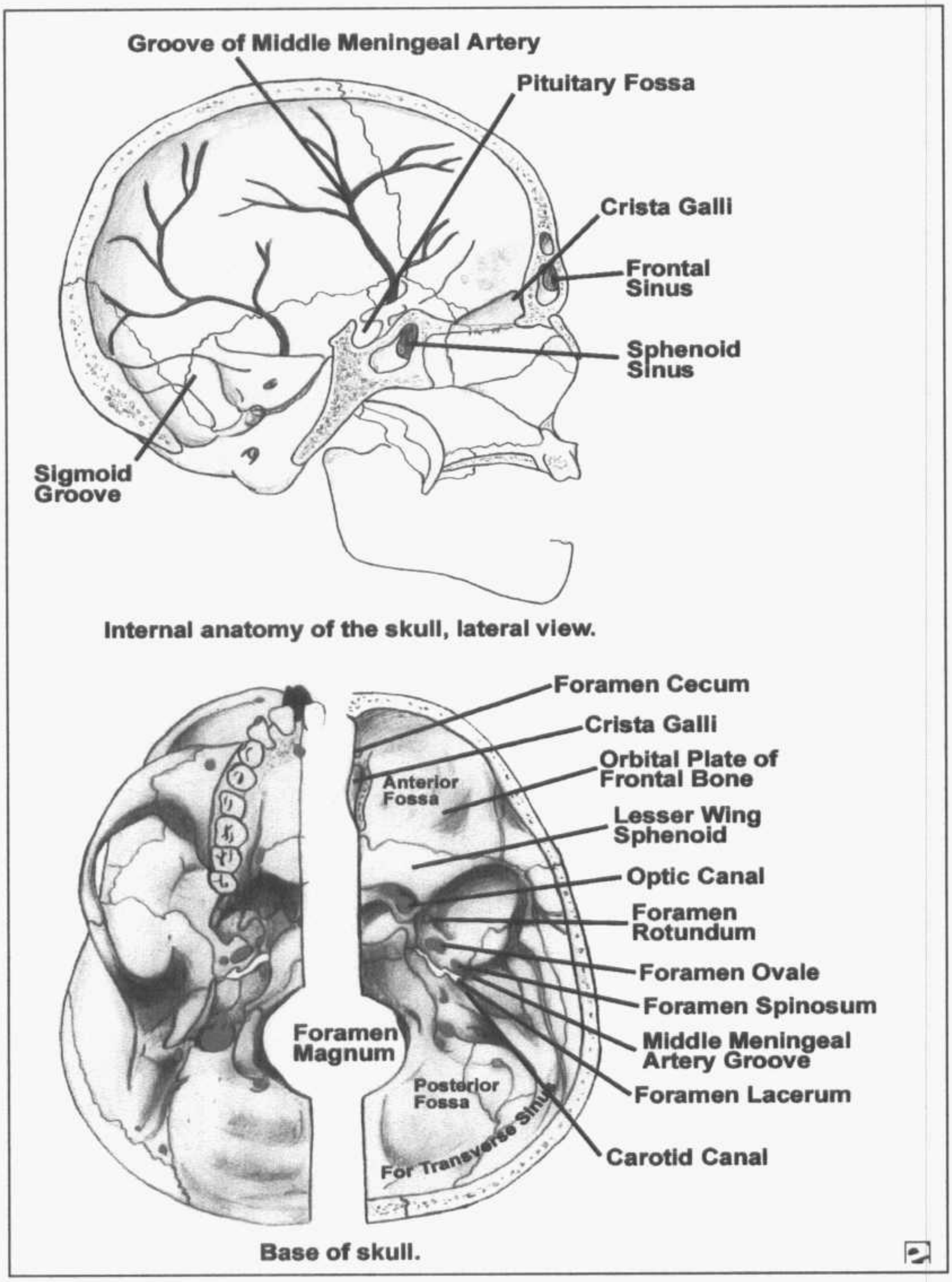


Fig (7): internal anatomy of skull and base of skull

(Duckert LG, 1998)

❖ *Temporal bone:-* **fig 8,fig (8 a→n)**

The caudal aspect of the temporal bone is an integral part of the skull base. The four components of the temporal bone include the tympanic segment, the squamous part, the petrous pyramid and mastoid process.

The tympanic segment forms most of the tympanic ring and external auditory canal. The temporal squamosa comprises only a small lateral portion of the floor of the middle fossa. The petrous pyramid, especially the inferior surface, and the mastoid process form the major portion of the skull base between the posterior and middle cranial fossae.

(Swartz JD,2001).

A. the petrous part of the temporal bone:-

The petrous part is wedged between the sphenoid and occipital bone. The apex of the petrous pyramid joins the anterolaleral edge of the clivus and the postero medial margin of the greater wing of the sphenoid along the basisphenoid synchondrosis.

The jugular foramen, carotid canal, eustachian tube and facial canal pass through this part of the temporal bone **.**

(Swartz JD,2001).

•Jugular foramen:-

The jugular foramen passes between the petrous and occipital bones anterolaleral to the foramen magnum. Each canal is divided by a fibrous or osseous septum into two compartments: - the anteromedial compartment (pars nervosa) contains the ninth cranial nerve and receives the inferior petrosal sinus. The postero lateral compartment (pars vascularis) contains the tenth and eleventh cranial nerves and the jugular bulb.

On CT scans, the jugular foramen appears at the same sections as the condylar process of the mandible, carotid canal, and external auditory canal and sometimes foramen ovale and spinosum.

(Guinto FC, 2003).

•Carotid canal:- fig(7)

The paired petrous carotid canals conduct the internal carotid arteries and associated structures (a nerve from the cervical sympathetic and venous plexus). From its external ostium anterior to the jugular fossa, each canal ascends vertically and then turns horizontally to enter the middle fossa posterior to the foramen lacerum.

(Guinto FC, 2003).

•Facial canal:-

The facial canal has three segments as it traverses the temporal bone, which is labyrinthine, tympanic and mastoid segment.

Due to its convoluted pathway, the facial canal appears on CT images at different levels, the labyrinthine segment is seen at the same plane as the semicircular canals. The tympanic segment is seen on successive scans which include the carotid canal, mandibular condyle and foramen ovale and spinosum. The mastoid segment is seen on successively lower scans lateral to the jugular foramen.

(Guinto FC, 2003).

Henry Gray (1825–1861). Anatomy of the Human Body. 1918.

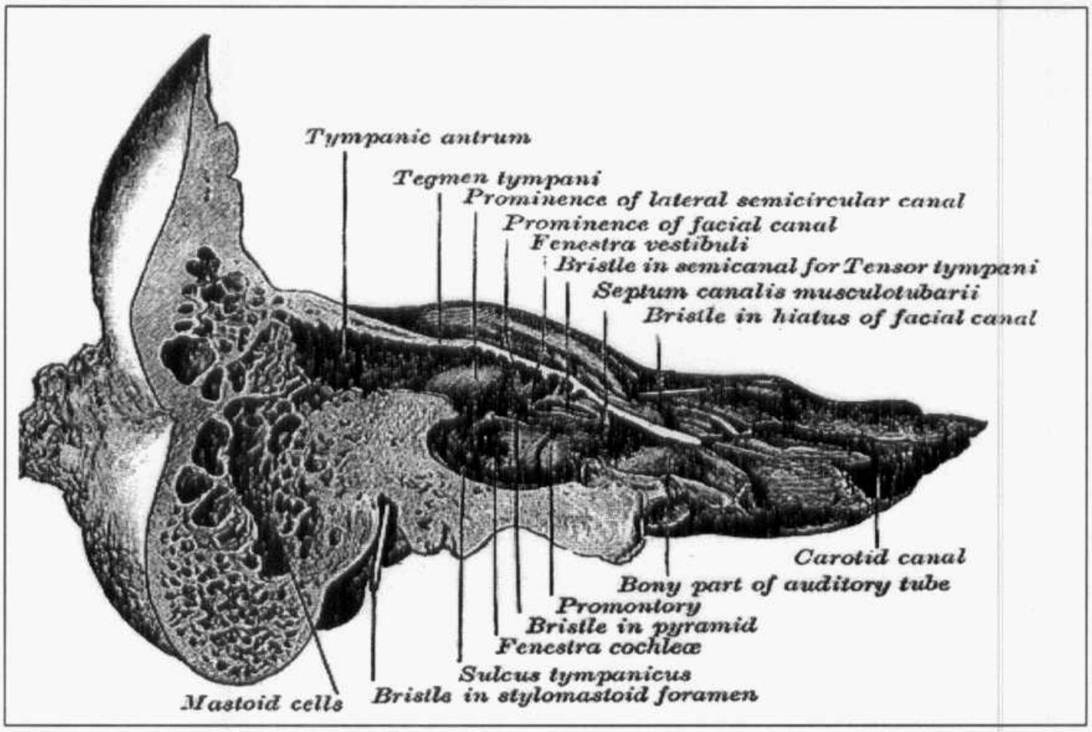
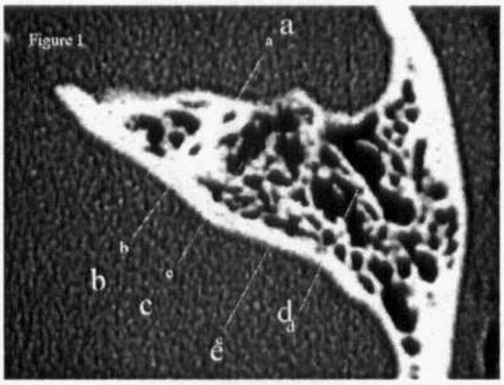


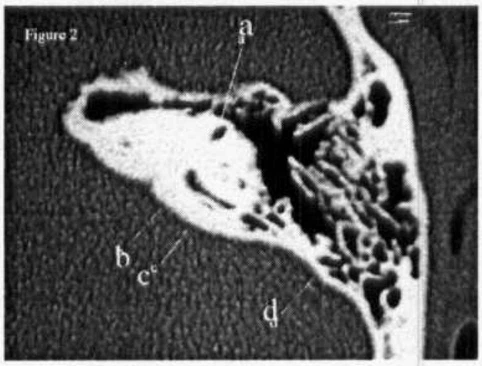
Fig (8): anatomy of the temporal bone



Caption: Picture 1. CT scan, temporal bone. An axial view through the superior portion of the temporal bone, which demonstrates the anterior (a) and posterior (b) crura of the superior semicircular canal. The surrounding otic capsule is observed as dense white bone. The mastoid air cells (c) are lateral to the otic capsule. The squamous air cells are separated from the petrous air cells by the Koerner sep

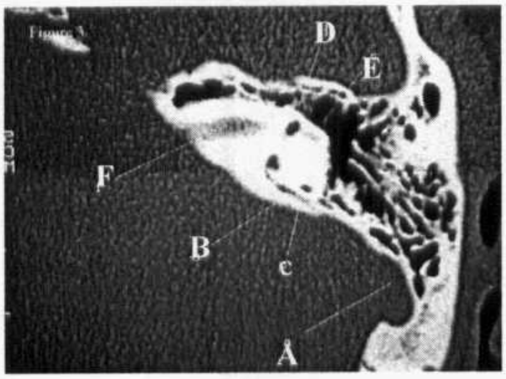
um (d). The posterior margin of the temporal bone, or cerebellar plate, (e) forms the anterior margin of the

Fig (8,a)



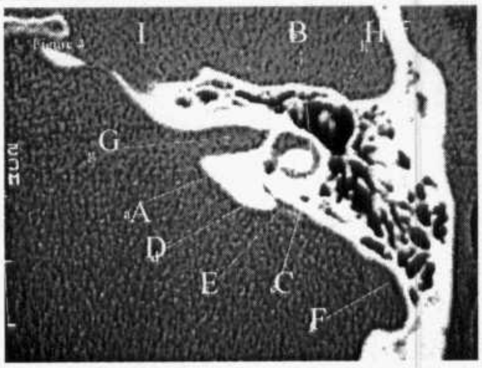
Caption: Picture 2. CT scan, temporal bone. The anterior limb of the superior semicircular canal can be observed (a). Posteriorly, the posterior limb of the superior semicircular canal forms the crus commune (b) by joining with the posterior semicircular canal (c). The mastoid air cells (d) and cerebellar plate again are visible

fig (8,b)



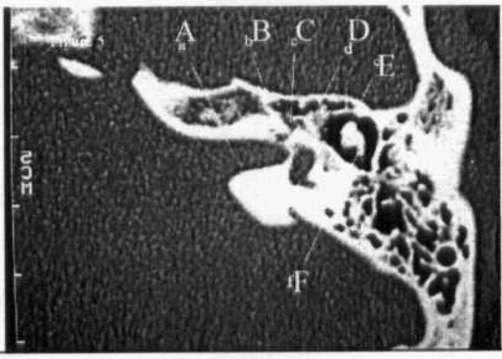
Caption: Picture 3. CT scan, temporal bone. The sigmoid sinus indents the cerebellar plate posteriorly (a). More inferiorly, the sigmoid sinus forms the origin of the internal jugular vein inferiorly. The vestibular aqueduct (b) courses posterior to the posterior semicircular canal (c) and the more anteriorly located superior semicircular canal (d). The superior aspect of the lateral semicircular canal (e) is located lateral to the other semicircular canals. The most superior portion of the internal auditory canal (f), carrying the facial, cochlear, and superior and inferior vestibular nerves, is the lucency in the medial of the petrous bone.

Fig (8,c)



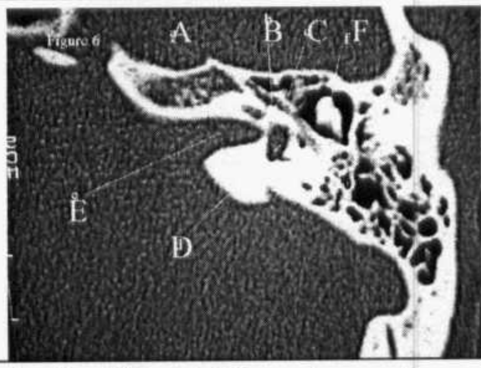
Caption: Picture 4. CT scan, temporal bone. An axial section through the vestibule (a) and lateral semicircular canal (b). The posterior semicircular canal (c) and vestibular aqueduct (d) still are visible posteriorly. The vestibular aqueduct is passing from the endolymphatic sac (e), which indents the posterior margin of the petrous bone, towards the vestibule. Posteriorly and laterally, the sigmoid sinus (f) is visible, and medially, the internal auditory canal (g) is the indentation on the medial border of the petrous bone. Note the middle ear space superior to the uppermost aspect of the tympanic membrane, the epitympanum, which houses the head of the malleus, as well as the body and short process of the incus (h). The petrous apex is visible (i).

Fig (8,d)



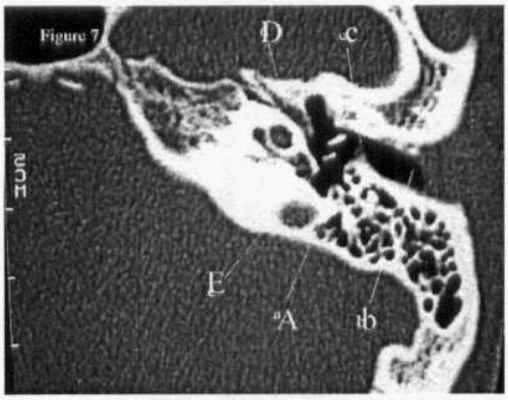
Caption: Picture 5. CT scan, temporal bone. The facial nerve can be observed coursing from the internal auditory canal (a). From here, the facial nerve turns anteriorly as the labyrinthine segment (b). This segment ends at the geniculate ganglion anteriorly (c). The nerve then continues posteriorly as the tympanic segment (d). The section passes through the vestibule, horizontal semicircular canal, and posterior semicircular canal. In addition, the image better depicts the head of the malleus (e)

Fig.(8,e)



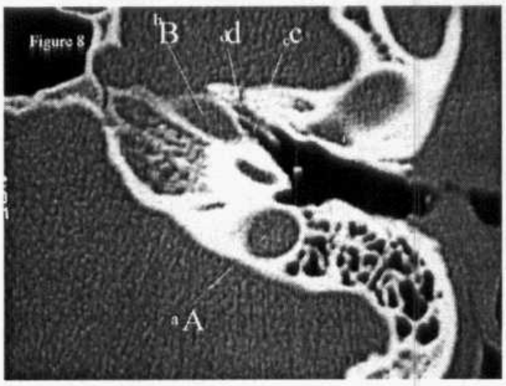
Caption: Picture 6. CT scan, temporal bone. The basal turn of the cochlea (a) is demonstrated. The geniculate ganglion (b) and tympanic branch of the facial nerve (c) also are well visualized. The vestibule (d), internal auditory canal (e), and ossicles (f) are visible

Fig.(8,f)



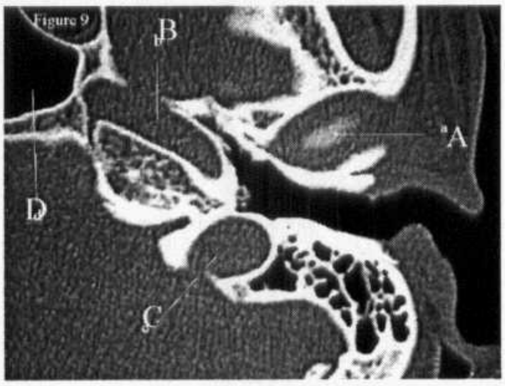
Caption: Picture 7. CT scan, temporal bone. The pyramidal eminence (a), which gives rise to the stapedius tendon, is shown. The space between the medial wall of the tympanum and the pyramidal eminence is the sinus tympani. The external auditory canal (b) and the tympanic membrane (c) are located laterally. The tensor tympani, which runs along the eustachian tube and attaches to the neck of the malleus, is visible anteriorly (d). Finally, the round window niche is observed (e).

Fig (8, g)



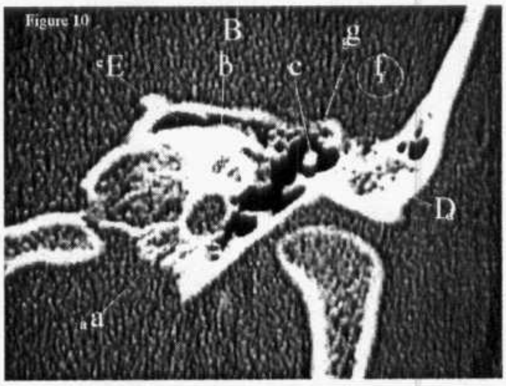
Caption: Picture 8. CT scan, temporal bone. Continuing inferiorly, the superior aspect of the jugular bulb (a) is demonstrated. The carotid artery is located more anteriorly (b). Immediately anterolateral to the course of the carotid is the eustachian tube (c). The tensor tympani muscle shares a wall of the eustachian tube (d).

fig(8,h)



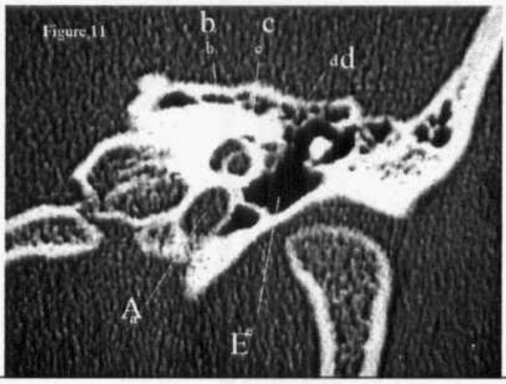
Caption: Picture 9. CT scan, temporal bone. Some of the inferior-most structures in the temporal bone. The glenoid fossa (a) is observed anteriorly. The carotid artery (b) courses medially and anteriorly. The sigmoid sinuses flow into the jugular vein (c). Anteromedial to the carotid, the sphenoid sinus is observed (d).

Fig (8, i)



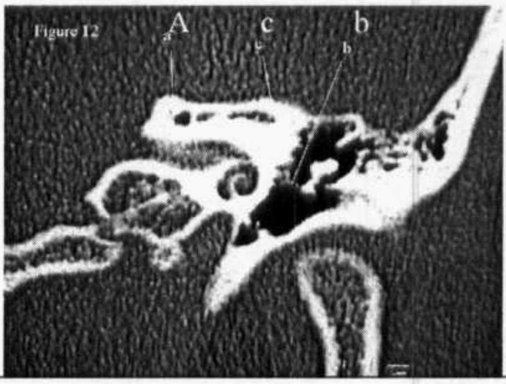
Caption: Picture 10. CT scan, temporal bone. Coronal section through the anterior temporal bone demonstrates the carotid artery (a) near the basal turn of the cochlea (b). The head of the malleus (c) lies in the epitympanum. The mastoid air cells can be observed superiorly and laterally to the superior margin of the glenoid fossa (d), and the supralabyrinthine air cells (e) can be observed superior to the otic capsule. The middle ear space is separated from the middle cranial fossa (f) by the tegmen tympani (g). To help orientation, note the condyle of the mandible inferior to the glenoid fossa

fig(8,j)



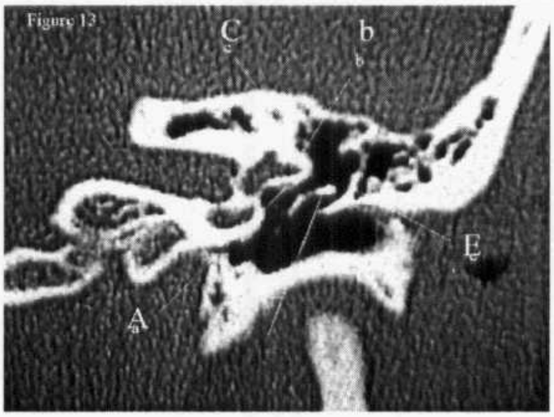
Caption: Picture 11. CT scan, temporal bone. The carotid artery (a) and the cochlea (b) are shown. The labyrinthine (c) and tympanic (d) portions of the facial nerve are visible. The middle ear space extends quite inferiorly, creating the hypotympanum (e). This section passes through the ossicles in the epitympanum

Fig (8, k)



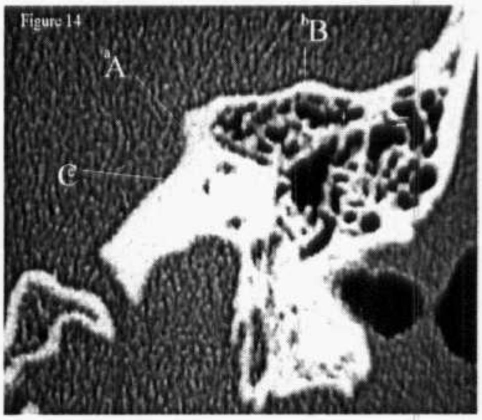
. **Caption:** Picture 12. CT scan, temporal bone. This section demonstrates the internal auditory canal (a), the tensor tympani muscle (b), and the tympanic portion of the facial nerve (c).

Fig (8, l)



Caption: Picture 13. CT scan, temporal bone. The facial nerve (a) courses just inferior to the lateral semicircular canal (b). The apex of the superior semicircular canal (c) is observed. Laterally, the ossicles are visible (d). The lateral boundary of the epitympanum is the scutum (e), which is a clinically important landmark because erosion of the scutum is often observed in patients with cholesteatoma

Fig (8, m)



Caption: Picture 14. CT scan, temporal bone. This section passes through the posterior semicircular canal (a). The tegmen tympani is well outlined (b). A short segment of the vestibular aqueduct is visible (c

Fig (8, n)

(Swartz JD, 2001).

Fig 8 & (8 a→n): Serial axial ct scans for temporal bone.

B. The mastoid part of the temporal bone: -

It is the posterior part of the temporal bone which projects down as the mastoid process.

The mastoid antrum is cone-shaped with its base upwards. It is about 6 mm in its basal transverse diameter and 10 mm in vertical diameter.

Some variations exist due to variable pneumatization of the air cells which drain into the antrum.

(Swartz JD, 2001).

C. The tympanic part of the temporal bone:-fig (8)

The tympanic segment forms an incomplete ring around the anterior and inferior walls of the external auditory canal.

• The external auditory canal: -

The external auditory canal is a tubular orifice which measures approximately 25 mm in length along its postero superior wall. The osseous inner portion constitutes two-thirds of its length and the cartilaginous out portion forms the remainder of the canal. The canal measures 9 to 10 mm in its greatest vertical diameter.

(Platzer W et al. 1999).

Middle Cranial Fossa:-

This fossa is bounded in front by the posterior borders of the lesser wings and anterior clinoid processes, behind by the superior borders of the petrous temporal bone and dorsum sellae, laterally by the temporal squamae, parietal bones and sphenoidal greater wings.

(Williams & Wilkins; 2001).

The sphenoid bone:-

The sphenoid bone is divided into the basisphenoid and greater and lesser wings. The basisphenoid comprises the dorsum sellae, posterior clinoid processes, and sella turcica. In adults, the basisphenoid is fused with the clivus. In infants and children, the basisphenoid is separated from the clivus by the spheno-occipital synchondrosis.

(Weiss RL, Bailey BJ, 1998).

Aperatures in middle cranial fossa and transmitted structures:

The middle cranial fossa contains the greatest number of the basal foramina and canals. These foramina include:-

a. Foramen ovale: - fig (7)

The foramen ovale traverses the greater wing of the sphenoid. It transmits the third, mandibular division of the fifth nerve, the accessory meningeal artery and emissiary veins .On axial CT scans, the foramen ovale appears at the same level with the foramen spinosum and carotid artery medial to the eustachian tube. **(Thomas J Vogl et al., 1999).**

b. Foramen spinosum: - fig (7)

The foramen spinosum penetrates the greater wing of the sphenoid posterolateral to the foramen ovale. Each foramen conducts the middle meningeal artery, meningeal vein and meningeal branch of the fifth cranial nerve.

The foramen spinosum is visualized on axial CT sections almost coplanar with the foramen ovale.

(Thomas J Vogl et al., 1999).

c. Foramen lacerum: - fig (7)

The foramen lacerum is formed by the synchondrosis of the sphenoid, occipital and petrous bones. A meningeal branch of the ascending pharyngeal artery and emissary vein traverse the foramen lacerum.

On axial CT sections, the foramen lacerum is seen at the medial aspect of the internal carotid artery.

(Thomas J Vogl et al., 1999).

d. Foramen rotundum: - fig (7)

The sphenoid sinus forms the medial wall of the foramen rotundum. It transmits the second (maxillary) division of the fifth (trigeminal) nerve.

On CT scans, the foramen rotundum is seen at the level of the carotid groove.

(Tiedemann K, 1997).

e. Superior orbital fissure:-

The superior orbital fissure is a large aperature connecting the middle cranial fossa with the orbit. It transmits the third (oculomotor), fourth (trochlear) and sixth (abducent) cranial nerves, the frontal nerve which is the largest branch of the first (ophthalmic) division of the trigeminal nerve, nasociliary nerve and superior ophthalmic vein.

On CT scans, the superior orbital fissure is seen as a defect in the lateral wall of the orbit near its apex, It is seen on several contiguous CT sections due to its large craniocaudal extent. The most inferior portion of the fissure is at the level of the sella turcica and upper sphenoid sinus. The superior extent of the fissure is at the level of the dorsum sella and optic canal lateral to the anterior clinoid process.

(DL Daniels et al .2003).

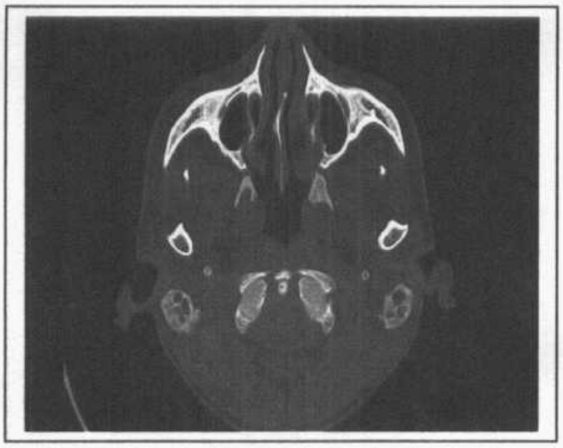
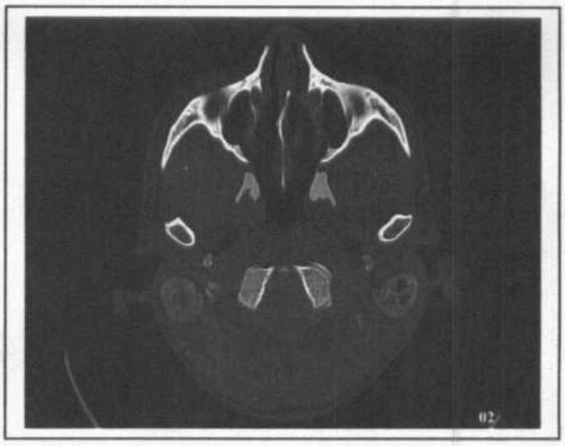


Fig (9, a)



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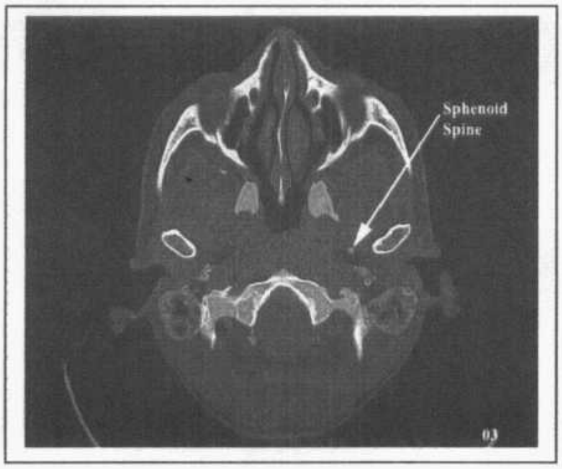

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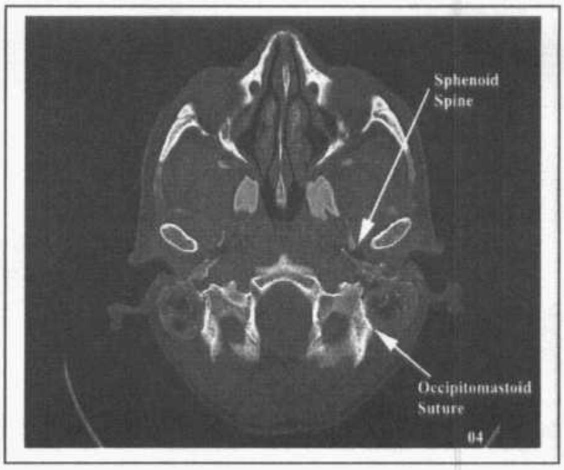
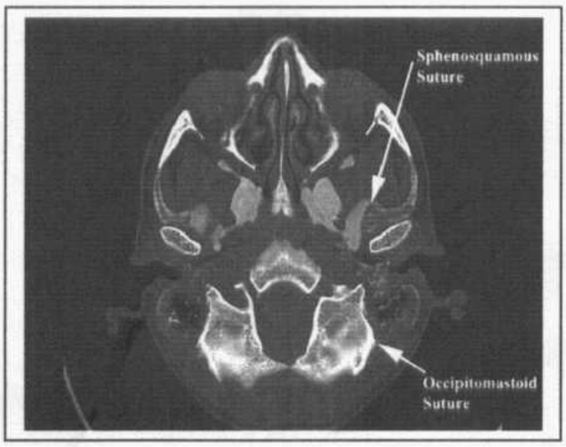


fig (9, d)



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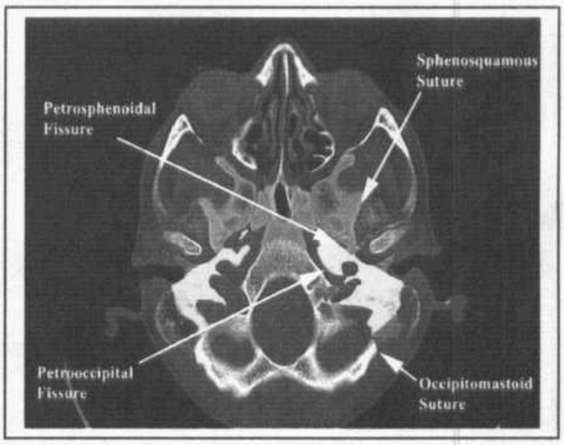


fig (9, f)

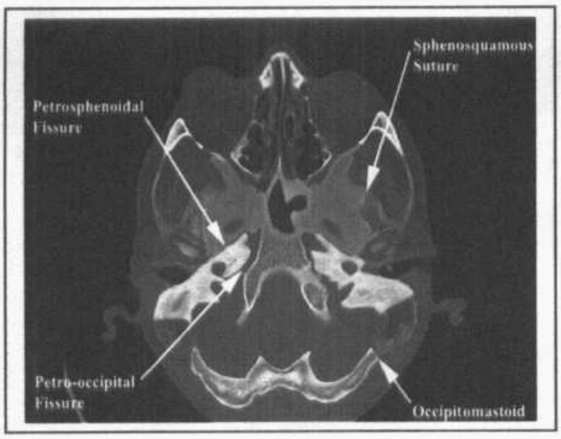


Fig (9, g)

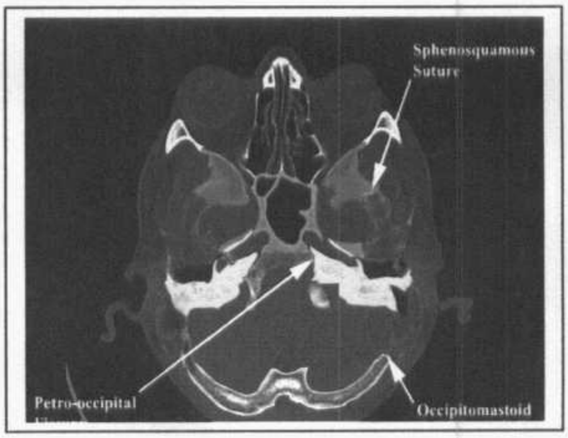


fig (9, h)

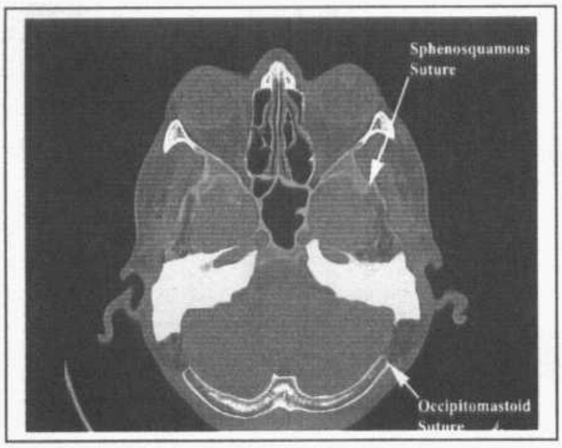


Fig (9, i)

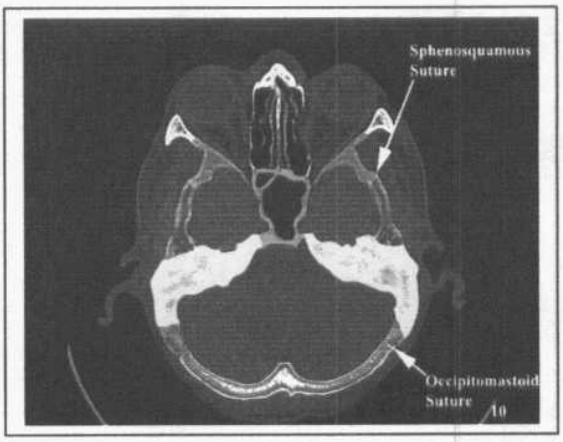


fig (9, j)

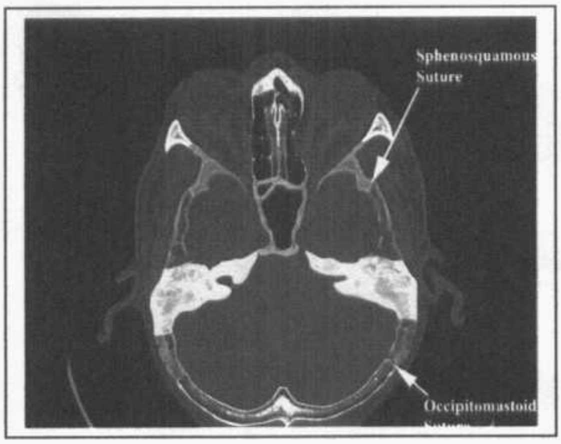


Fig (9, k)

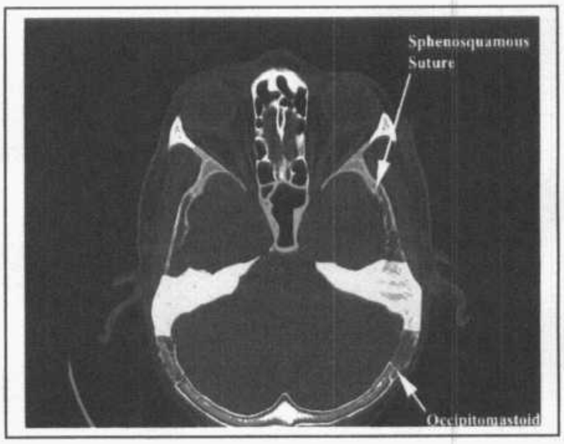


fig (9, l) **(DL Daniels et al., 2003).**

Fig. (9 a→l): serial axial CT sections from caudad to cephalad through the skull base.

f. Optic canal:-

The optic canal is formed between the lesser wing and body of sphenoid bone. It transmits the optic nerve and the ophthalmic artery.

On axial CT scans, the optic canal is identified near the upper level of the superior orbital fissure. The canal is seen at the level of the orbit, dorsum sella and sphenoid sinus.

(Wolfgang, Md. Dahnert 2003).

Anterior Cranial Fossa: -

The anterior cranial fossa is bounded laterally and anteriorly by the frontal bone. The floor is comprised of the orbital plate of the frontal bone laterally, the cribriform plate of the ethmoid bone centrally, the lesser wing of the sphenoid bone posterolaterally and tuberculum sellae posteromedially .

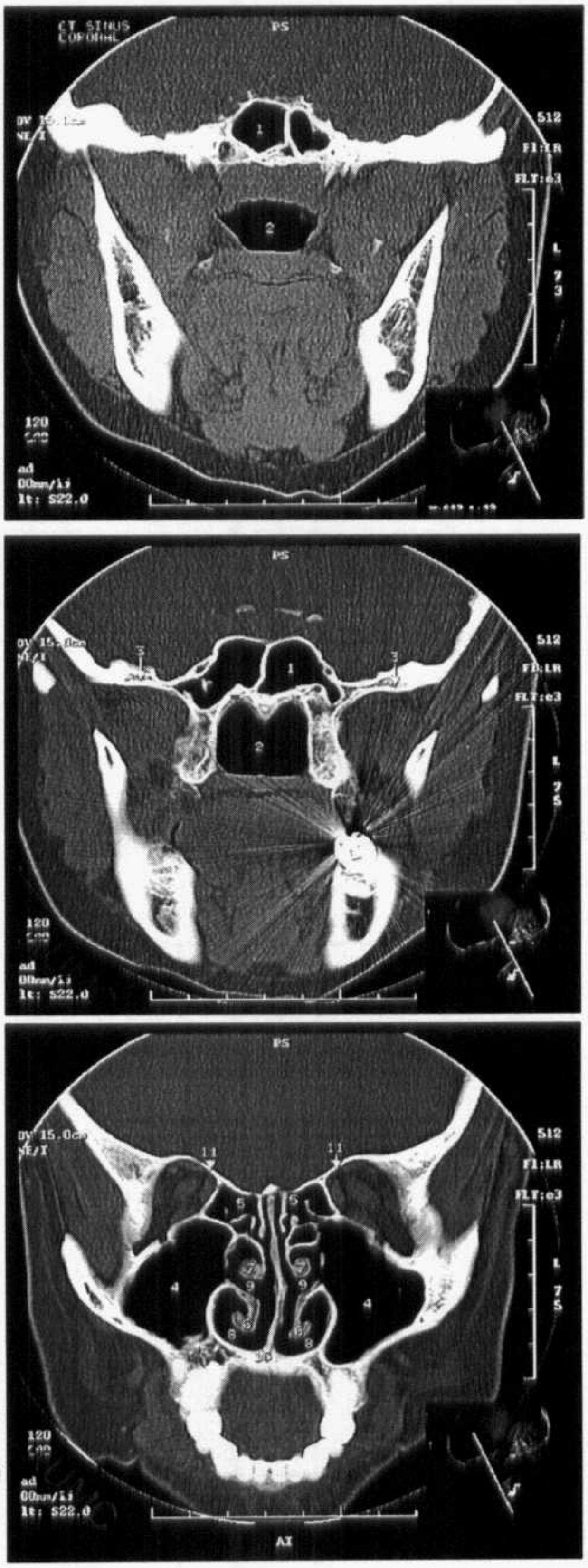
(Durden DD, Williams DW 2001).

The crista galli, a thin crest of bone, projects upwards anteriorly in the midline to anchor the antero-inferior margin of the falx cerebri. The foramen caecum, a small depression located anterior to the crista galli, may occasionally be identified. The foramen caecum ends blindly and may transmits an emissary vein.

The inner table of the frontal sinus marks the anteromedial limit of the anterior cranial fossa. The orbits, the sphenoid and ethmoid sinuses and the nasal cavity lie below the frontal sinuses. The lateral portion of the orbital plate of the frontal bone is thin and undulating.

The orbital roof and cribriform plate lie in a plane which parallels Reid's baseline. These structures are poorly defined on axial CT sections due to partial volume effects.

(Williams & Wilkins; 2001).



ANATOMICAL FEATURES:

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2. Nasopharynx
3. Greater wing of sphenoid
4. Maxillary sinus
5. Ethmoid air cells
6. Inferior nasal concha (turbinate)
7. Middle nasal concha (turbinate)
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9. Middle meatus
10. Hard palate
11. Lesser wing of sphenoid
12. Crista galli
13. Perpendicular plate of ethmoid bone
14. Vomer
15. Nasal bones
16. Frontal sinus

(George C. Enders, Ph.D.2005)

Fig. (10) Coronal CT sections through the skull base.

II. The Skull Vault: - fig (11)

The skull vault or calvarium forms the walls and roofs of the cranial cavity. It consists of the frontal bone, the parietal bones, the squamous and tympanic portions of the temporal bones and the upper part of the occipital squama. A midline metopic suture separates the frontal bone into two halves. A midline sagittal suture separates the right and left parietal bones. The coronal suture separates the frontal bone from the parietal bones. The lambdoid sutures separate the parietal bones from the occipital squama. Two squamosal sutures separate the parietal bones from the temporal bones.

The Width of the sutures varies in the neonates. The coronal and lambdoid sutures range between 1.5 and 5 mm .The sagittal suture ranges between 3 and 6 mm..

(Sadler TW, Langman J. 2000).

- ## Anatomy of the Fontanels:- fig(12)

Fontanels are the fibrous, membrane-covered gaps created when more than two cranial bones are juxtaposed, as opposed to sutures, which are narrow seams of fibrous connective tissue that separate the flat bones of the skull.

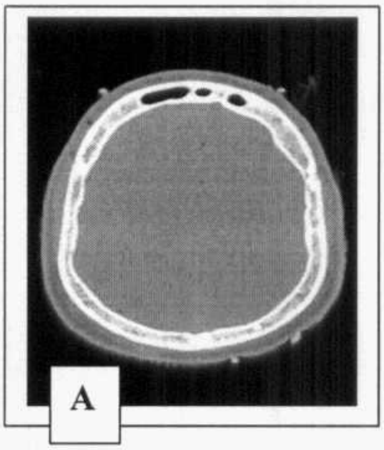
(Am Fam Physician 2003).

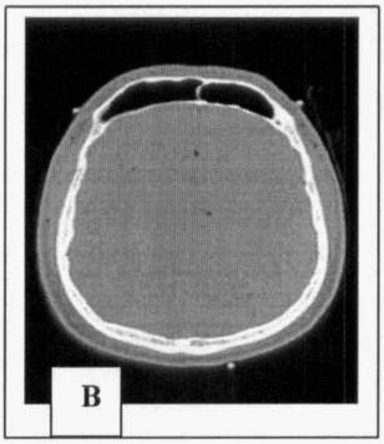
A newborn has six fontanels: - the anterior and posterior, two mastoids, and two sphenoids. The rhomboid-shaped anterior fontanel, located at the junction of the two parietal and two frontal bones, is the most prominent. The superior sagittal dural venous sinus is partially situated beneath the anterior fontanel. The triangular posterior fontanel is located at the junction of the occipital and two parietal bones. **(Am Fam Physician 2003).**

Closure of the fontanelles begins with the posterior and sphenoid fontanelles which are dosed at full term, mastoid fontanelles at the end of the first year and anterior fontanelle at 1.5 to 2 years of age. The metopic suture usually closes between .the second and third years of life.

The coronal, lambdoid and sagittal sutures disappear slowly and may not close completely for 30 to 40 years.

(Am Fam Physician 2003).





Axial CT sections of the skull vault

Performed with bone target imaging technique.

A. Section at the level of the lower convexity.

B. Section at the level of the middle convexity.

C. Section at the level of upper convexity.

(John A. McNulty .Jun 1, 1998)

Fig. (11) a,b,c, axial CT sections of the skull vault.

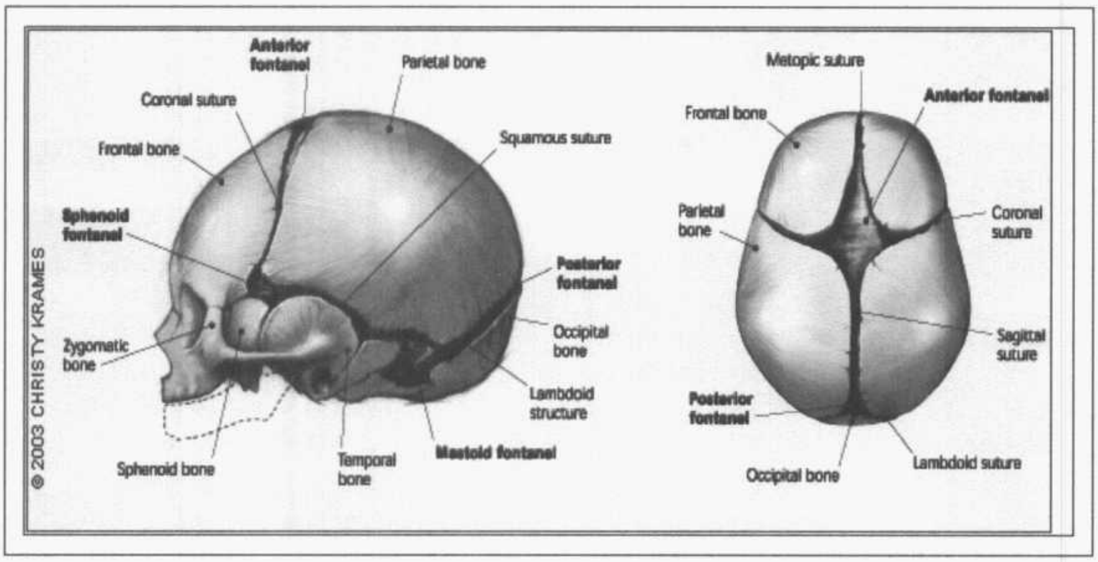


Fig (12): Anatomy of the Fontanels **Christy krames 2003**

EMBRYOLOGIC DEVELOPMENT OF THE FACE: - *fig (13, 14)*

The face is formed by three swelling: the frontonasal prominence, maxillary prominence (pharyngeal arch 1), and mandibular prominence (pharyngeal arch 1).

By week six, a median prominence overhangs the cephalic end of the oral cavity. This is called the **frontonasal prominence (or process)**. **Nasal (olfactory) pits** are located on either side of the frontonasall prominence and are surrounded by horseshoe-shaped eminences. The medial portion of these eminences is called the **medial nasal process**. The lateral portion of which is called the **lateral nasal process**. The lateral nasal process is separated from the **maxillary process** (the more rostral portion of the first branchial arch) by a furrow which reaches the medial aspect of the developing eye. This furrow is called the **nasolacrimal groove** (naso-optic furrow). The oral cavity is bounded inferiorly by the mandible which has formed by the fusion of the right and left **mandibular processes** of the first branchial arch. The maxillary processes grow and as they do they crowd the medial nasal processes toward the midline where they unite with one another. The medial nasal processes also crowd the frontal prominence upward. At the same time, the medial nasal processes fuse laterally with the maxillary processes. Later, the lateral nasal processes fuse to the maxillary processes, obliterating the nasolacrimal groove.

(Ronald W Dudek, James D; 2004).

Development of the Nasal Cavities and Palate

Thickening of the surface ectoderm on either side of the frontal prominence just above the stomodeum is the first indication of the nasal cavity. These are called the **nasal (olfactory) placodes**. These placodes begin to invaginate by the 5th week and are called the **nasal pits**. The nasal pits invaginate by 1) forward growth of the medial nasal and lateral nasal processes, and, 2) posteroinferior growth of the pits themselves, the placode tissue comes to line the roof of each pit. The pits grow and approach the primitive oral cavity. A thin **oronasal membrane** is located between the pits and the oral cavity. This membrane then ruptures and forms the **primitive choanae**. The placode tissue differentiates into the **olfactory epithelium** while the general epithelium of the nasal cavity differentiates from the remainder of the surface ectoderm lining the nasal pits.

At the end of the second month, as the maxilla develops, a partition between the primitive nasal chambers and the oral cavity begins to form. The anterior aspect of this partition is derived from the area of the upper jaw formed by the medial nasal processes (intermaxillary segment) and is called the **primary palate** (median palatine process). Most of the palatine partition, however, is derived from the medial growth of shelf-like processes originating from the maxillary process called the **palatine shelves** (lateral palatine processes). This segment of the palate is called the **secondary palate**. As the secondary palate is formed, the **nasal septum** grows inferiorly toward it. The nasal septum and the two palatine shelves unite to form separate right and left nasal chambers, an oral cavity, and the **definitive choanae**.

(Ronald W Dudek, James D; 2004).

Development of the eye:

The eye globe develops from the optic vesicles which appear as two lateral diverticuli from the sides of the fore brain at fifth week of gestation.

The proximal part of the optic vesicle forms the optic stack which later forms the optic nerve. The outer wall of the optic vesicle forms optic cup which gives rise to sclera, retina and choriod.

(John V Forrester etal. 2001).

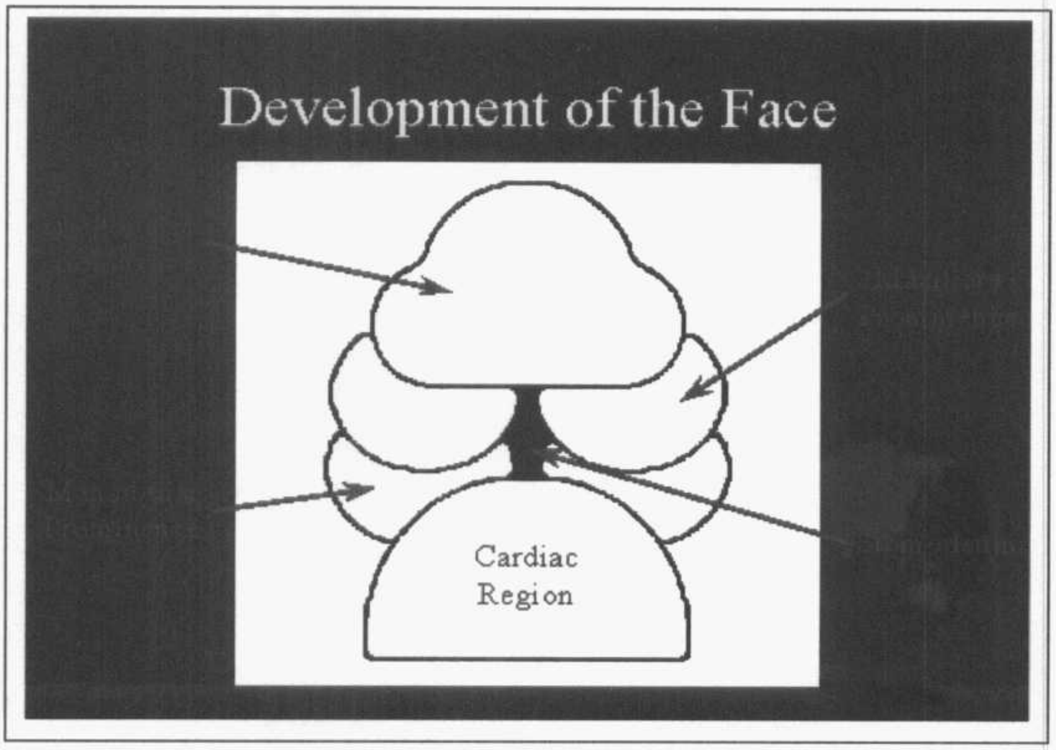


Fig. (13): embryonic development of the face with designation of the facial processes

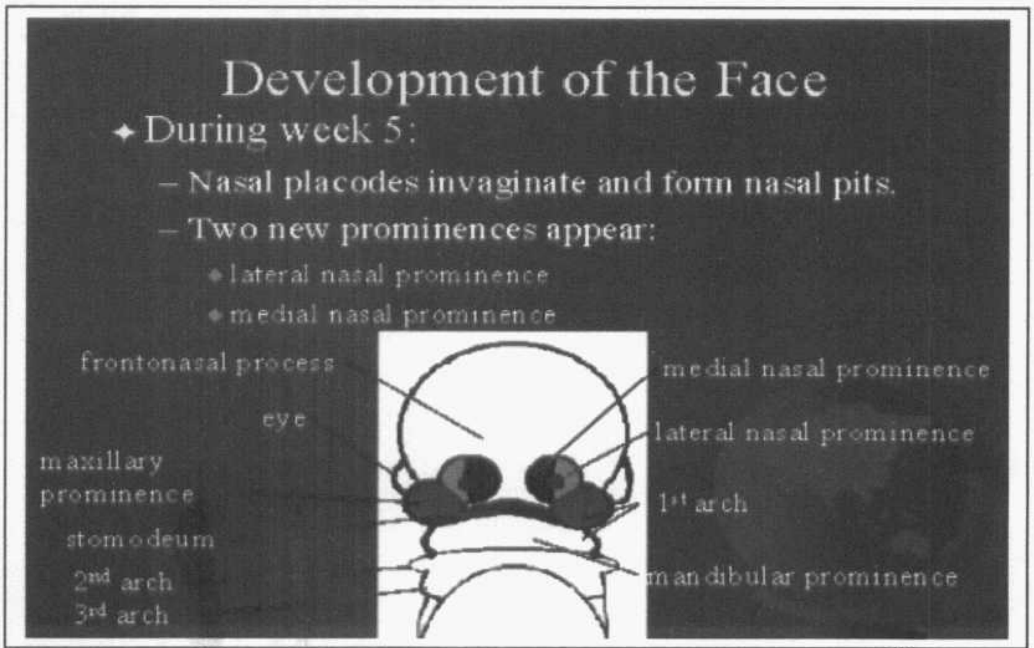


Fig. (14): embryonic development of the face during 5^{th} week

Ronald W Dudek, James D; 2004

CT ANATOMY OF FACIAL AND NASAL BONES *Fig (15a→f, 16)*

The skeleton of the face is geometrically conceptualized as a series of osseous buttresses. These buttress provide structural support , separate the face from the intracranial spaces; compartmentalize the face into oral, nasal, para nasal and orbital parts; provide attachment for facial and extra ocular muscles; and protect vital soft-tissue structures from traumatic stresses.

(Peter Banks, Andrew Brown; 2001)

Nasal Cavity:-

The nasal cavity is a centrally located compartment of the face surrounded by bone and cartilage which divided by the midline nasal septum into two essentially equal chambers.

Each chamber of the nasal cavity is bounded superiorly by the cribriform plate. The cribriform plate contains 15 to 20 foraminae which transmit the olfactory nerves. The maxillary sinuses form the lateral borders of the nasal cavity. The floor, which separates the nasal cavity from the oral cavity, is formed by the palatine process of the maxilla and the horizontal segment of the palatine bone.

The osseous nasal framework consists of paired nasal bones, each of which articulates laterally with the maxilla and superiorly with the frontal bone. Most of the remaindering framework of the nose is cartilagenous with two superior lateral cartilages and two inferior alar cartilages. The nasal septum is formed by a combination of bony and cartilagenous tissues.

Three bulky turbinates formed by mucosal folds extending longitudinally in the sagittal direction, projecting into the nasal cavity from the lateral walls. The turbinates are attached to the lateral walls by convoluted bony conchae. The space beneath each concha is designated as a meatus.

(Keith L Moore, Anne M R Agur ; 2002).

Paranasal Sinuses:- *fig (15, 16)*

▪ Frontal Sinus:-

The frontal sinus lies within the frontal bone between the inner and outer tables of the skull. The sinus cavity is usually divided by a midline bony septum and may be further subdivided by several intersinus septae inferiorly, the lateral portion of the frontal sinus lies above the orbital plate. More medially, the frontal sinus is positioned above the ethmoid air cells posteriorly and the frontal process of the maxilla anteriorly.

Each frontal sinus drains separately either directly into the ethmoid air cells or through the nasofrontal duct which empties beneath the middle turbinate of the ipsilateral nasal cavity.

(Thomas J Vogl et al., 1999).

▪ Ethmoid Sinus:-

The ethmoid sinuses are positioned between the orbits and consist of 3 large or up to 18 small thin walled cavities developing within the ethmoid labyrinth. They are divided into three groups. The anterior and middle cell groups open into the middle meatus and the posterior cell group opens into the superior meatus.

(Paul Butler et al. 1999).

▪ Sphenoid Sinus:-

The sphenoid sinuses are paired cuboidal cavities lying above and behind the nasal cavities within the sphenoid bone. They are divided by a vertical septum. The sphenoid sinuses drain separately through ostia. In the anterosuperior sinus wall into the sphenoethnoidal recesses of the nasal cavities.

(Keith L Moore 2005).

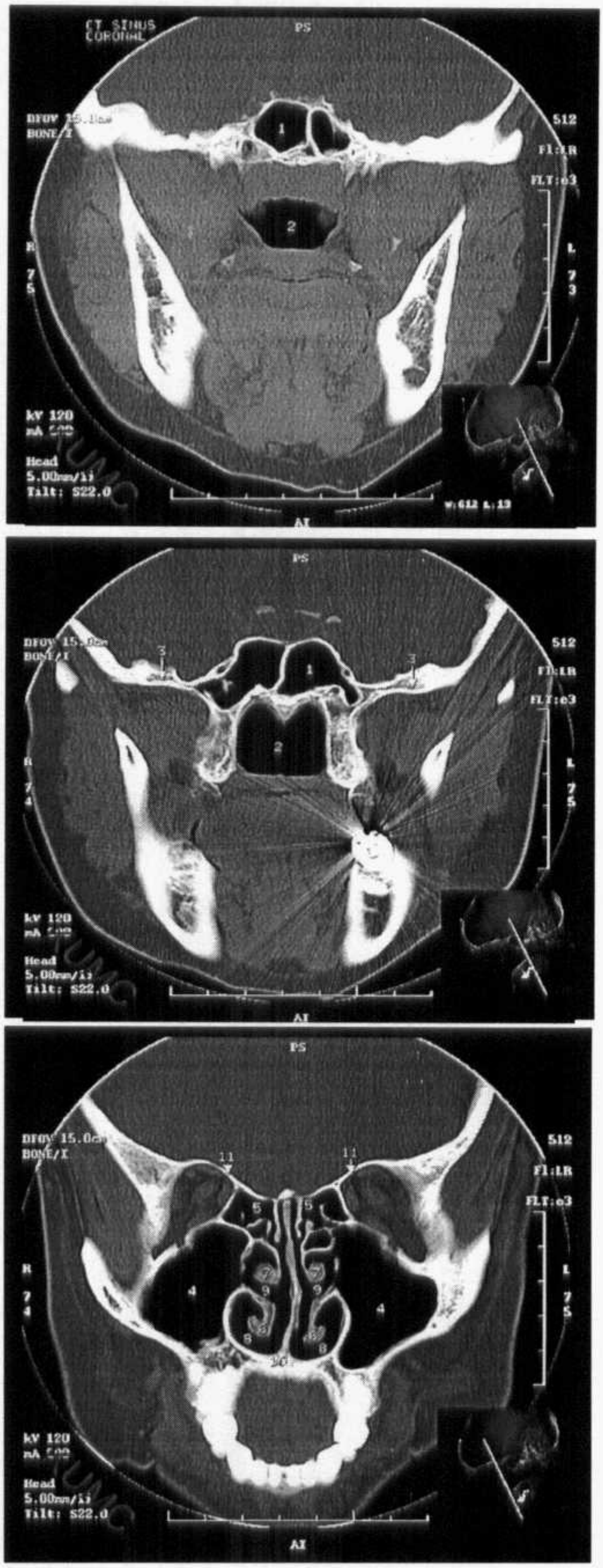
- **Maxillary Sinus:-**

The maxillary sinuses are paired pyramidal cavities within the maxillary bone. Each central sinus cavity has zygomatic, alveolar and palatine recesses which extend into the zygomatic, alveolar and palatine processes of the maxilla.

The roof of the maxillary sinus forms the floor of the orbit, while the medial wall forms the lateral wall of the nasal cavity. The alveolar ridge, containing the teeth, forms the floor of the maxillary sinus, while the anterior wall of the maxilla forms the anterior boundary of the maxillary sinus .

The ostium of the maxillary, sinus is in the upper medial wall of the sinus and drains into the hiatus semilunaris below the middle nasal concha.

(Keith L Moore, Anne M R Agur 2002).



ANATOMICAL FEATURES:

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2. Nasopharynx
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5. Ethmoid air cells
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7. Middle nasal concha (turbinate)
8. Inferior meatus
9. Middle meatus
10. Hard palate
11. Lesser wing of sphenoid
12. Crista galli
13. Perpendicular plate of ethmoid bone
14. Vomer
15. Nasal bones
16. Frontal sinus

Fig (15): a, b, c

Fig (15): d, e, f

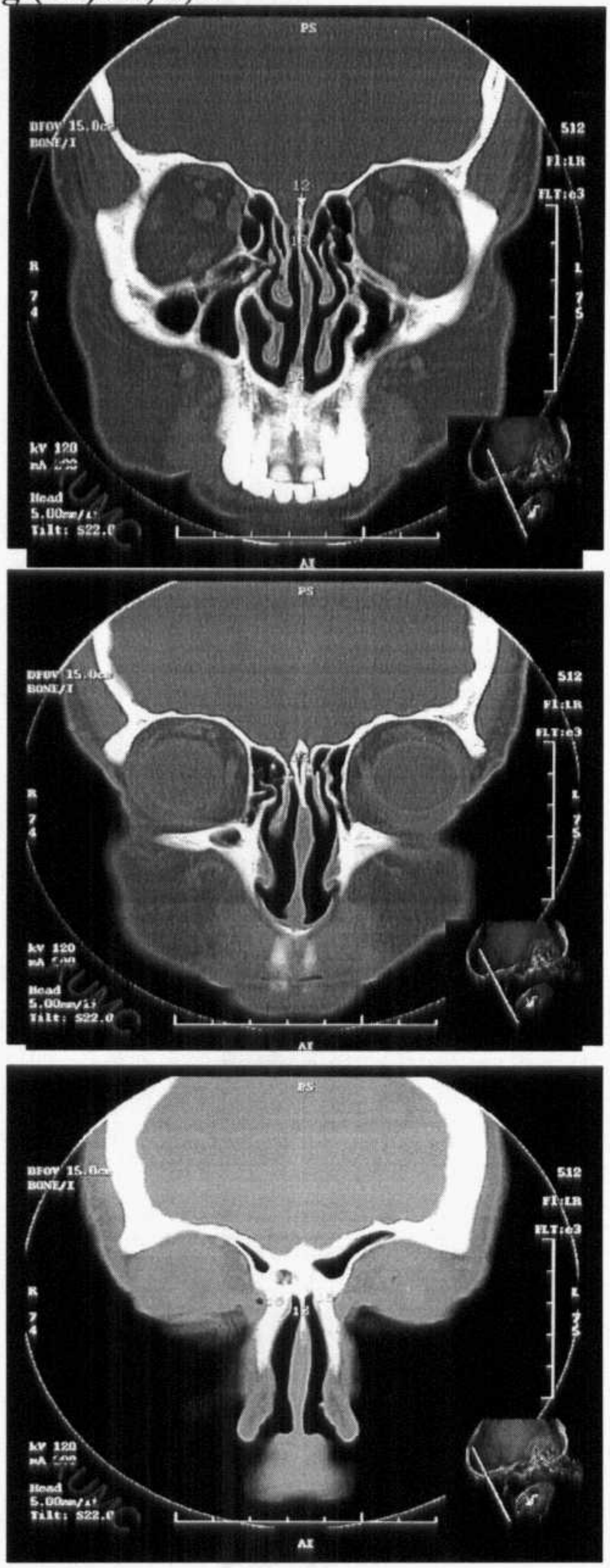

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Fig (15a→f): Coronal ct sections through the facial bones

(George C. Enders, Ph.D.2005)

Facial Bones:-

▪ Orbits:- Fig(16)

The orbits are paired bony structures separated in the midline by the interorbital space which is the portion of the nasal cavity situated between the orbits .

The bony orbit is a conical compartment containing the globe and its adnexal structures. Portions of the frontal, ethmoid, lacrimal, maxillary, zygomatic and sphenoid bones form the walls of the orbit. The orbit could be divided into four components: the roof, the floor, the medial orbital wall and the lateral orbital wall. **(Paul Butler et al. 1999).**

The orbital roof is triangular shaped and its main anterior portion is formed by the frontal bone, containing the frontal sinuses. The floor of the frontal sinus is usually thin. The posterior orbital roof formed by the sphenoid bone, is usually thicker. The roof of the orbit has a shallow fossa for the lacrimal gland in its anterior and lateral portion.

(Paul Butler et al. 1999).

The orbital floor is formed by the orbital plate of the maxilla and the orbita1 surface of the zygomatic bone. The orbital plate of the maxilla represents only a thin lamella of bone which is easily fractured by minor trauma (blow-out fractures). Inflammatory and neoplastic lesions within the underlying maxillary sinus may invade the orbit by this route.

The medial orbital wall is almost rectangular: Anteriorly, it is formed by the frontal process of the maxillary bone, which together with lacrimal bone forms the lacrimal fossa that contains the lacrimal sac.

The lamina papyracea of the ethmoidal air cells forms the midportion of medial wall of the orbit which is a very thin bony septum. The posterior segment of the medial orbital wall is formed by a small portion the sphenoid bone.

The lateral orbital wall forms an angle of about 45° with the midsagittal plane. It is formed anteriorly by the orbital surface of the zygomatic bone and posteriorly by the greater wing of the sphenoid.

(Paul Butler et al. 1999).

Several foramina and fissures are located in the orbital walls:-

1) The optic foramen, which is the uppermost foramen within the orbital apex leading to the optic canal through which the optic nerve and ophthalmic artery pass.

2) The superior orbital fissure which lies between the roof and the lateral wall of the orbit and transmits, from medial to lateral, the 3r, 4th , and 5th cranial nerves, the ophthalmic veins, and the ophthalmic 'division of the 5th nerve.

3) The inferior orbital fissure which lies between the floor and lateral wall of the orbit. It is usually closed anteriorly by the zygomatic bone. Through it; the infra orbital and nerves pass.

4) The foramen rotundum which lies directly below the superior orbital fissure from which it is separated by the roof of the greater sphenoid wing. It transmits the second (maxillary) division of the fifth (trigeminal) nerve.

5) The infra orbital groove which extends forwards from the inferior orbital fissure to the inferior orbital rim. This groove becomes a canal anteriorly that opens into the infra orbital foramen and contains the infra orbital neurovascular bundle.

(Paul Butler et al. 1999).

▪ Zygoma:-

The zygoma (molar bone) is a buttress of the facial skeleton that gives prominance to the cheek area. It is a quadrilateral bone with frontal, temporal and orbital processes. The frontal process articulates with the zygomatic process of the frontal bone forming the lateral orbital wall. The temporal process articulates with the zygomatic process of the temporal bone forming the curved zygomatic arch. The articulation with the maxilla form the infra orbital rim and part of the anterior surface of the facial skeleton.

(Donald Rizzo 2000).

- **Maxilla:-**

The maxilla contributes to the formation of the mid portion of the face and forms part of the orbit, nose and palate and its hollow interior comprises the maxillary sinuses.

The maxilla consists of a body and four processes, the frontal, zygomatic, palatine and alveolar processes. The maxillary body is roughly pyramidal and has anterior and posterior (infra temporal) surfaces. Its zygomatic process forms the medial portion of the infra orbital rim. Its frontal process forms the lateral wall of the nasal cavity. Its alveolar process supports the upper teeth and its palatine process forms the anterior section of the hard palate.

(Howard L Levine, M Pais Clemente 2005).

- **Mandible and Tempromandibular Joint:-**

The mandible or the lower jaw has two compartments, the mandible proper and an alveolar portion containing sockets for teeth. The mandibular proper consists of a horizontal segment (body) and two roughly vertical segments (rami) that join the body posteriorly at nearly right angles (gonial angles).

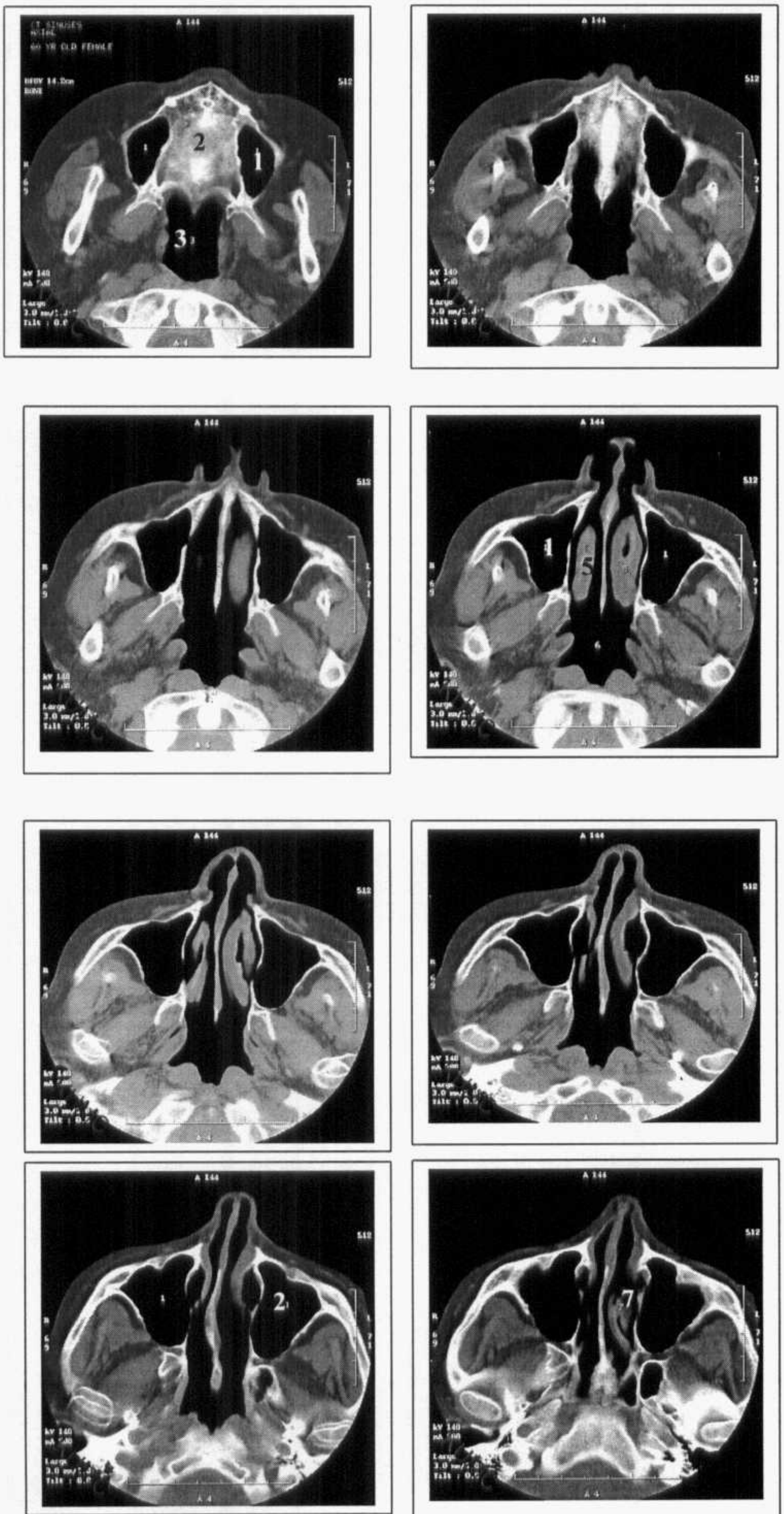
The mandibular body is convex forwards. Anteriorly, it shows a faint median ridge, often absent, indicating fusion of the halves of the fetal bone (symphysis menti). Below the second premolar is the mental foramen, from which emerge the mental nerve and vessels.

The body of the mandible change direction abruptly at the angles to form the rami. Each ramus then slants upward toward coronoid process (anteriorly) and condylar process (posteriorly). The mandibular notch forms a hiatus between these processes. The coronoid process extends superiorly and anteriorly just medial to the zygomatic arch. The condylar process is covered by fibrocartilage and articulates with the temporal bone's mandibular fossa. Below the condylar head is the narrower neck which is slightly flattened. **(Paul Butler et al. 1999).**

The mandible is strong bone but has certain areas of weakness through which fractures frequently occur. It is weak at the angles where the body changes its direction to join with the ramus and at the thin neck of the condyle. The mental foramen is large in some individuals and is an area of weakness. With loss of teeth from tie mandible, atrophic changes in the alveolar portion weaken the bone The glenoid fossa is an impression is the base' of the temporal bone containing the tempromandibular joint. The joint is compound with a disc dividing it into superior and inferior compartments. The condylar process has an elliptical shape corresponding to the oval shape of the glenoid fossa. The glenoid fossa is bounded by an articular tubercle anteriorly.

In the closed mouth position, the condyle lies within the glenoid fossa. During the movement of opening the mouth, the condyle rotates against the inferior surface of the fossa and it moves anteriorly until at maximum mouth opening the condyle is situated inferior to the articular tubercle.

(Paul Butler et al. 1999).



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4. Nasal septum (vomer)
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7. Middle nasal conchae
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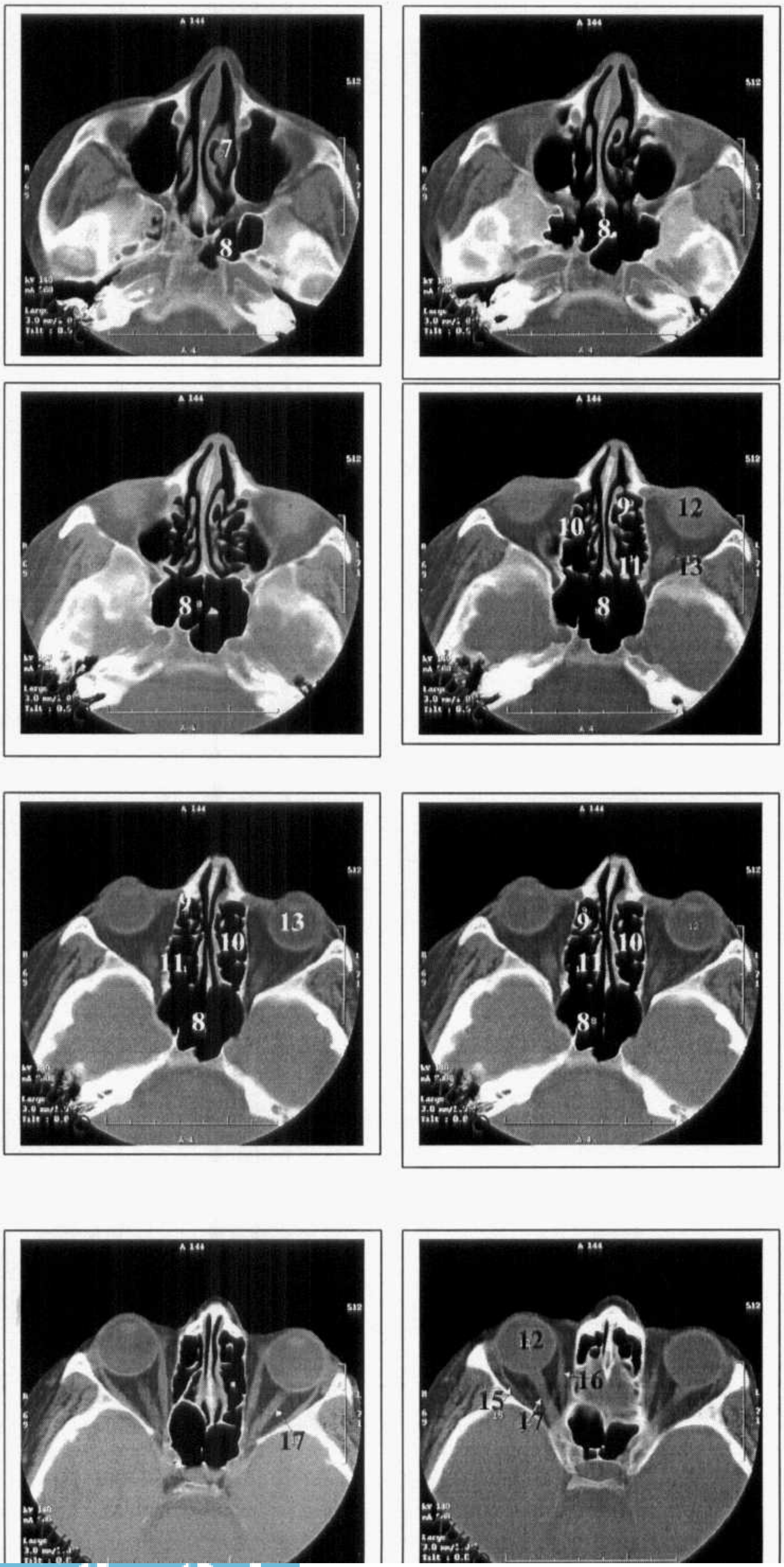
9. Anterior ethmoid air cells
10. Middle ethmoid air cells
11. Posterior ethmoid air cells
12. Eyeball
13. Inferior rectus muscle
14. Lens of eye
15. Lateral rectus muscle
16. Medial recuts muscle
17. Optic nerve
18. Crista galli
19. Lacrimal gland
20. Frontal sinus
21. Superior oblique muscle
22. Superior rectus muscle



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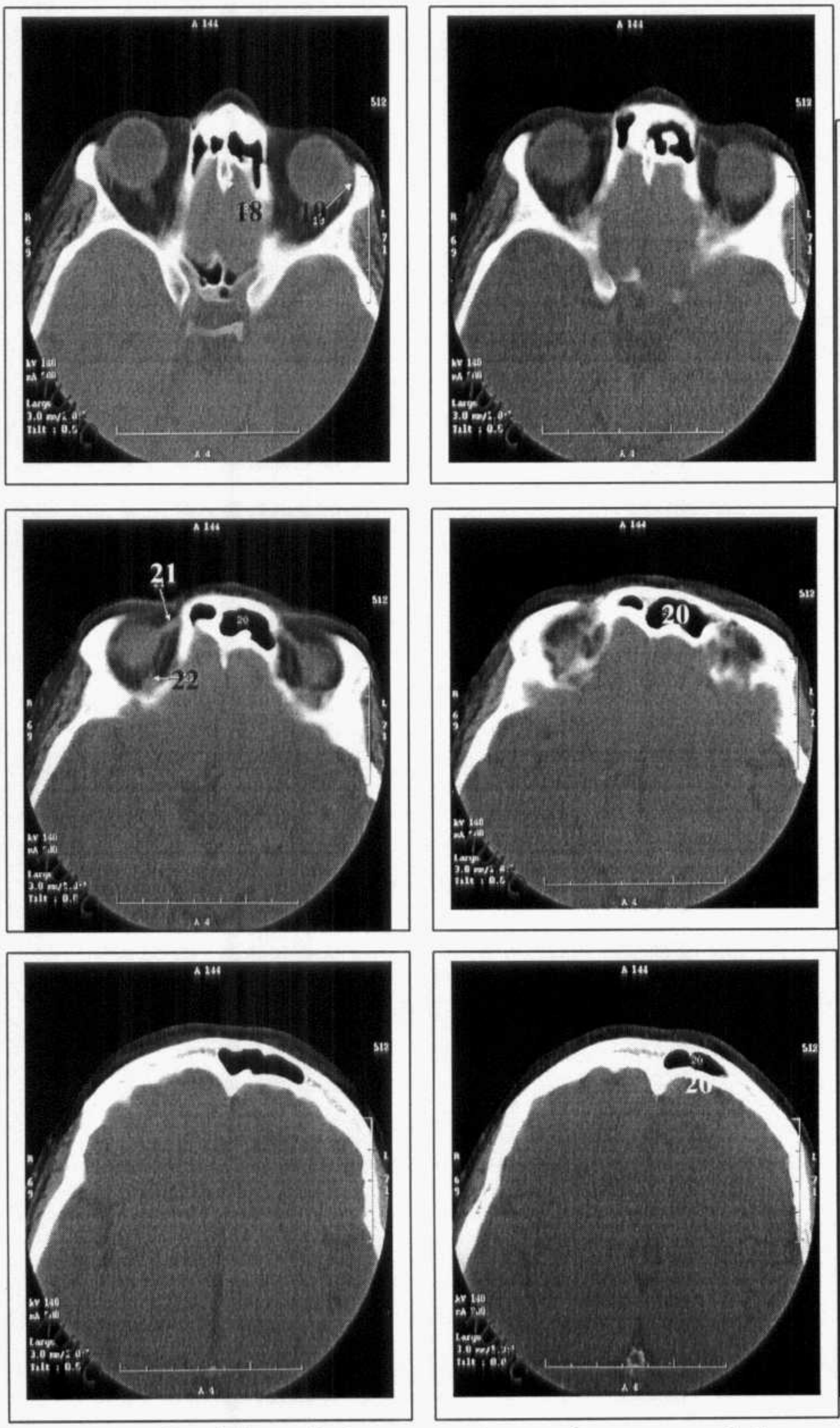

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5. Inferior nasal conchae (turbinate)
6. Nasopharynx
7. Middle nasal conchae
8. Sphenoid sinus
9. Anterior ethmoid air cells
10. Middle ethmoid air cells
11. Posterior ethmoid air cells
12. Eyeball
13. Inferior rectus muscle
14. Lens of eye
15. Lateral rectus muscle
16. Medial recuts muscle
17. Optic nerve
18. Crista galli
19. Lacrimal gland
20. Frontal sinus
21. Superior oblique muscle
22. Superior rectus muscle

Fig (16): ***Serial axial ct sections from caudal to cephalad through the facial bones*** **(George C. Enders, Ph.D.2005).**

PATHOLOGY

Craniofacial trauma is one of the most frequent and grave form of body trauma.

Pathological lesion of the craniofacial area will be described according to the following items:

A. Cranial fractures:

I- Skull vault fractures.

II- Skull base fractures

B. Facial bone fractures

1. Zygomaticomaxillary complex fracture
2. Fractures of the maxilla
3. Le Fort classification
4. Fractures of the zygoma
5. Fractures of the nasal bones
6. Fractures of the orbits
7. Naso-orbito-ethmoid fractures
8. Fracture of the frontal sinus
9. Smash fractures (Panfacial)
10. Mandibular fractures

A. Cranial fractures. (Fig 17,18)

The etiology of cranial fractures is largely the result of traffic accidents. According to studies of large numbers of cases, the skull is involved in 65% of all injured persons.

Less frequently, the following causes are listed: fall from height, sporting accidents and injuries due to violence by means of projectiles during fights and as a result of criminal actions.

The type of the cranial fractures depends on the severity of impact to the head, the velocity of a blow and the shape of the object producing a blow.

Classification:

Cranial fractures can be classified into:

I- Skull vault fracture.

II- Skull base fractures.

I- Skull vault fractures:

These can be further classified into the following types:

1. Linear fractures:

A common injury, especially in children. Linear skull fractures comprise 75% – 90% of all skull fractures. A linear skull fractures is a simple break in the skull that follows a relatively straight line. It can occur after seemingly minor head injuries (falls, blows such as being struck by a rock, stick, or other object; or from motor vehicle accidents). A linear skull fracture is not a serious injury unless there is an additional injury to the brain itself. **(M William Schwartz et al. 2003).**

Linear fracture results from low-energy blunt trauma over a wide surface area of the skull. It runs through the entire thickness of the bone and, by itself, is of little significance except when it runs through a vascular channel, venous sinus groove, or a suture. In these situations, it may cause epidural hematoma, venous sinus thrombosis and occlusion, and sutural diastasis, respectively. Differences between sutures and fractures are summarized in Table 1.

Table 1 Differences between Skull Fractures and Sutures

Fractures	Sutures
• Greater than 3 mm in width • Widest at the center and narrow at the ends • Runs through both the outer and the inner lamina of bone, hence appears darker • Usually over temporoparietal area • Usually runs in a straight line • Angular turns	• Less than 2 mm in width • Same width throughout • Lighter on x-rays compared to fracture lines • At specific anatomic sites • Does not run in a straight line • Curvaceous

(M William Schwartz et al. 2003).

2. Comminuted and Depressed fractures:

Depressed skull fractures result from a high-energy direct blow to a small surface area of the skull with a blunt object such as a baseball bat. Comminution of fragments starts from the point of maximum impact and spreads centrifugally. Most of the depressed fractures are over the frontoparietal region because the bone is thin and the specific location is prone to an assailant's attack. A free piece of bone should be depressed greater than the adjacent inner table of the skull to be of clinical significance and requiring elevation.

A depressed fracture may be open or closed. Open fractures, by definition, have either a skin laceration over the fracture or the fracture runs through the paranasal sinuses and the middle ear structures, resulting in communication between the external environment and the cranial cavity. Open fractures may be clean or contaminated with dirty. **(Latha Stead 2000).**

Approximately 25% of patients with depressed skull fracture do not report loss of consciousness, and another 25% loose consciousness for less than an hour. The presentation may vary depending on other associated intracranial injuries such as epidural hematoma, dural tears, and seizures.

(Latha Stead 2000).

3. Compound fractures:

Linear or depressed fractures may be compound as a result of communication through an associated scalp wound or by extension into a paranasal sinus or the middle ear.

Depressed compound fractures are associated with infection in 2.5-10.6 %.

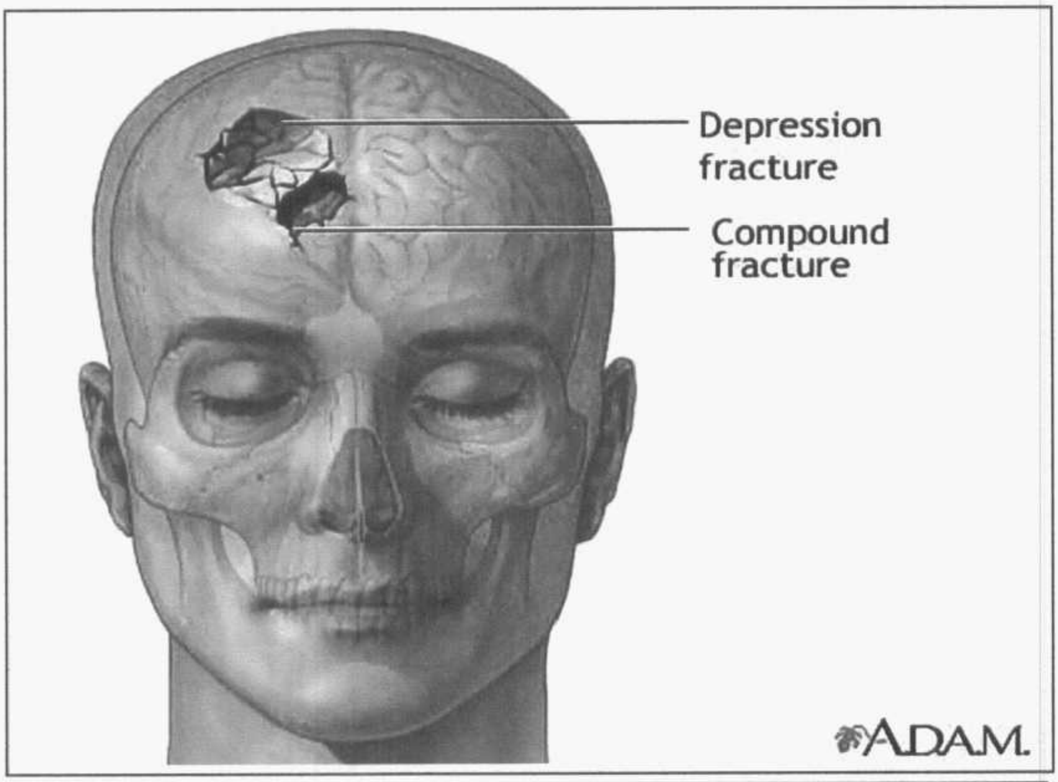
All fractures externally compounded, carry with them the danger of local secondary osteomyelitis.

(Jose I Suarez.2003).

II- Skull base fractures

Basal skull fractures are common and are often an extension of fractures of the vault. Fractures of the floor of the anterior and middle cranial fossae can extend into the frontal, ethmoid or sphenoid sinuses. Recognition of these fractures is essential since they may serve as a pathway for the introduction of pyogenic organisms leading to subdural empyema, or brain abscess.

Basal skull fractures may extend across cranial nerve foramina and cause nerve injury. For example, a fracture of the floor of



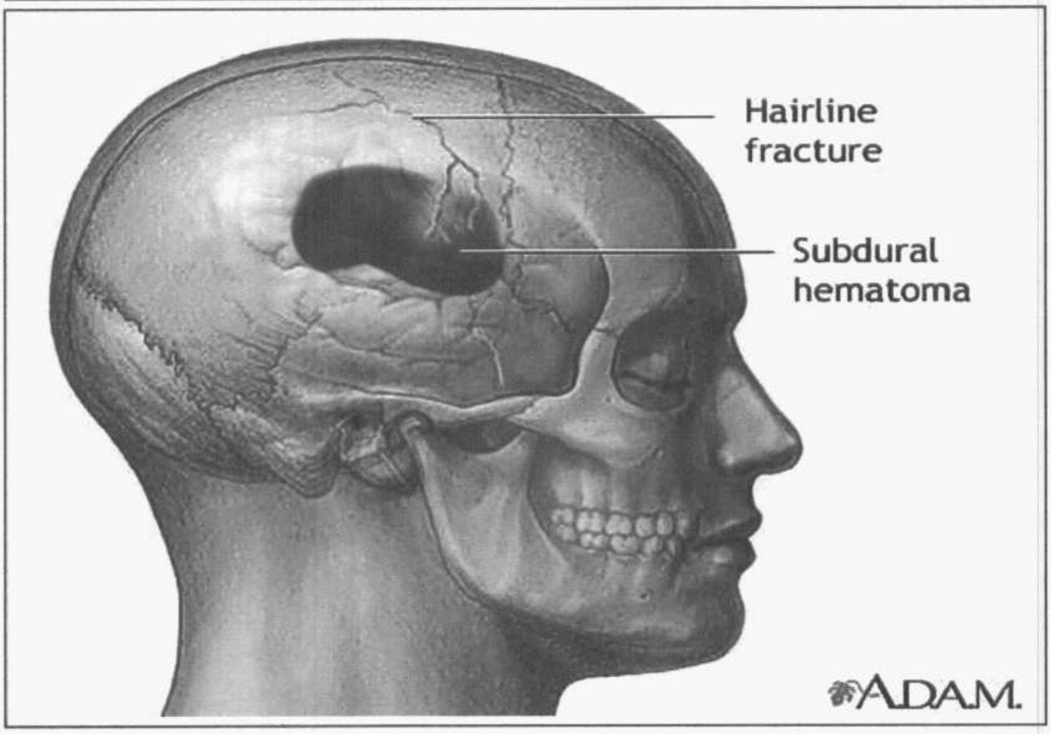


Fig (17) **Skull Fracture Types** (American Accreditation HealthCare 2003)

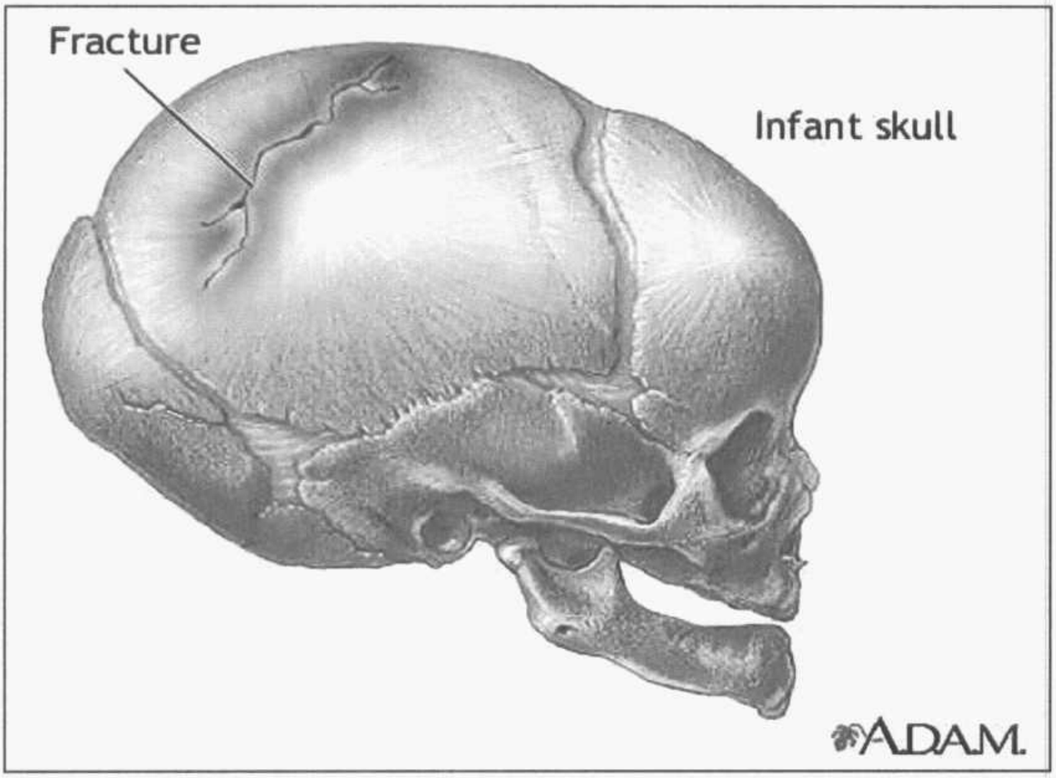


Fig (18) **Skull Fracture Types.** (American Accreditation HealthCare 2003)

the anterior cranial fossa can extend into the optic canal, causing optic nerve injury.

(Christopher Moulton ET al.1999).

Fractures in the floor of the middle fossa frequently extend into the petrous temporal bone where three types of fractures can be recognized:

a) Longitudinal fractures: These are the most common type of temporal bone fractures. They run along the longitudinal axis of the petrous pyramid in the horizontal plane. Long fractures typically extend from the temporal squamosa across the posterior aspect of the external auditory canal causing rupture of the tympanic membrane which results in conductive hearing loss.

(Norbert Hosten, Thomas Liebig 2002).

b) Transverse fractures: They run perpendicular to the longitudinal axis of the petrous pyramid. Associated traumatic lesions involving the tempromandibular joint, mandibular condyle or skull base can be evaluated.

c) Complex fractures: With increasingly more severe head injuries caused by high speed vehicular mishaps, the temporal bone is subject to a wide variety of fractures. Such fractures are usually multiple with severe distraction of the fracture fragments. Cerebrospinal fluid otorrhea and rhinorrhea extending from the subarachnoid space through the orifices of the temporal bone are the most serious sequences of these injuries.

(Norbert Hosten, Thomas Liebig 2002).

Complications of Cranial Fractures:

It has been pointed that a fracture of the cranium is, of itself, not of great importance, unless there is depression or unless there is some other direct complications, such as the fracture being compound. The extent of injury to the brain is the consideration of real concern and of much greater importance than the bony injury. Nevertheless, the presence d a fracture is an indication of injury of a significant force and its current medicolegal significance can not be discounted.

The complications of cranial fractures are:-

I. <u>Intracranial haemorrhage</u> :- **fig (19-20-21-22)**

1. Subdural hematoma:- **(fig 20,21)**

a) Acute subdural hematoma:-

In the acute traumatic subdural hematoma, blood collects between the dura mater and surface of the brain. Most commonly, the bleeding results from tearing of bridging veins located over the convexity of the brain surface. Bleeding originating from a small cortical artery represents the second most common source. Associated intracranial lesions, particularly cerebral contusions, are found in at least 50% of patients with acute traumatic subdural hematoma.

CT findings in subdural hematomas depend on the age of the hemorrhage. In the acute phase, subdural hematomas appear as a crescent-shaped extra-axial collection with increased attenuation that, when large enough, causes effacement of the adjacent sulci and midline shift. The attenuation changes as the hematoma ages. **(El-Kadi H, Kaufman HH 2000).**

b) Subacute subdural hematoma:-

Subacute subdural hematomas may be difficult to detect because they may have isoattenuation compared with adjacent gray matter. Displacement of the gray matter–white matter junction is an important sign that indicates the presence of a space-occupying lesion. **(El-Kadi H, Kaufman HH 2000).**

c) Chronic subdural hematoma:-

As described above, the chronic subdural hematoma is a collection of blood and blood products between the inner surface of the dura mater and the outer surface of the brain. Unlike the acute traumatic subdural hematoma, onset of symptoms and detection of the subdural hematoma occurs much later in the course. The hallmark of the chronic subdural hematoma is blood products, visualized on the CT scan, which are isodense or hypointense with respect to brain tissue. It is theorized that, like the acute traumatic subdural hematoma, the source of the blood products is lacerated bridging veins resulting from acceleration-deceleration forces applied to the skull. While this is usually the result of trauma, trauma may be mild, remote, and not remembered by the patient or family.

(El-Kadi H, Kaufman HH 2000).

2. Epidural hematoma:- (fig 19)

In the acute epidural hematoma, blood collects between the inner surface of the calvarium and the dura mater. Most commonly, the acute epidural hematoma results from fracture of the skull, stripping the dura mater from the inner table of the skull, and causing laceration of meningeal vessels or dural sinuses. Bleeding from the middle meningeal artery is responsible for many supratentorial epidural hematomas. In contrast to the subdural hematoma, the patient harboring an acute epidural hematoma may have an initial loss of consciousness, followed by a brief "lucid" interval, followed by progressive neurologic decline. This presentation is seen in approximately 1/3 of patients having an acute epidural hematoma.

(El-Kadi H, Kaufman HH 2000).

- Noncontrast CT scanning of the head not only visualizes skull fractures but also directly images an epidural hematoma.

- Acute epidural hematoma may appear as a hyperdense lenticular-shaped mass situated between the brain and the skull, though regions of hypodensity may be seen with serum or fresh blood. Planoconvex or crescent-shaped epidural hematoma must be differentiated from subdural hemorrhage. Subacute lesions are homogenously hyperdense.

- Chronic epidural hematoma may have a heterogeneous appearance due to neovascularization and granulation, with peripheral enhancement on contrast administration.

- CT scanning may also depict air collections and displacement of brain parenchyma.

- Clinical deterioration should prompt repeat imaging with CT scanning.

(El-Kadi H, Kaufman HH 2000).

3. Subarachnoid haemorrhage (SAH):-

Traumatic SAH is highly irritant to the brain-stem and is usually rapidly fatal. Traumatic SAH may is usually associated with contusion or laceration to the brain surface.

On CT scans, SAH appears as a high-attenuating, amorphous substance that fills the normally dark CSF-filled subarachnoid spaces around the brain. The normally black subarachnoid cisterns and sulci may appear white in acute hemorrhage. These findings are most evident in the largest subarachnoid spaces, such as the suprasellar cistern and Sylvian fissures.

Over the cerebral hemispheres, SAH is exhibited by the filling in of the normally low-attenuation (black) sulci with high-attenuating (white) subarachnoid blood. SAH is most conspicuous within 2-3 days of the onset of acute bleeding. Acute SAH is typically 50-60 HU. The protein content of the hemoglobin molecule is predominantly responsible for the attenuating effect of blood. Therefore, the absolute measurement in Hounsfield units varies somewhat with the hematocrit value.

(El-Kadi H, Kaufman HH 2000).

When CT scanning is performed several days to weeks after the initial bleed, the findings are more subtle. The initial high-attenuation of blood and clot tend to decrease, and these appear as intermediate gray. These findings can be isointense relative to normal brain parenchyma. If the patient presents during this subacute period, evidence of SAH includes (1) decreased visualization of the normally hypoattenuating fluid within the sulci and (2) basal cisterns and enlargement of the ventricles because of communicating hydrocephalus.

(El-Kadi H, Kaufman HH 2000).

4. Intracerebral haemorrhage:- (fig 22)

Traumatic Intracerebral haemorrhage formed due to extension of haemorrhage from surface contusions deep into the substance of the brain. Traumatic intracerebral haemorrhage may also be the result of rupture of small blood vessels deep within the brain due to shearing stress.

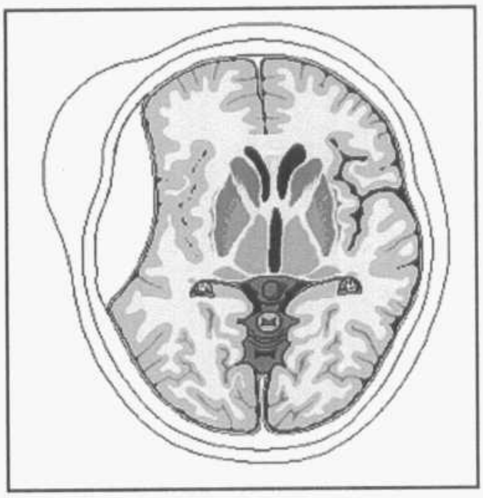
- CT scan readily demonstrates acute hemorrhage as hyperdense signal intensity .Multifocal hemorrhages at the frontal, temporal, or occipital poles suggest a traumatic etiology.
- Hematoma volume in cubic centimeters can be approximated by a modified ellipsoid equation: (A x B x C)/2, where A, B, and C represent the longest linear dimensions in centimeters of the hematoma in each orthogonal plane.
- Perihematomal edema and displacement of tissue with herniation also can be appreciated.

(Donald Rizzo 2000).

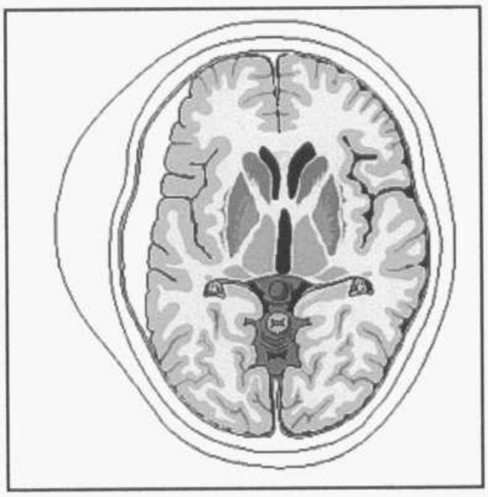
II. BRAIN INJURY:-

1. Brain swelling (cerebral oedema):-

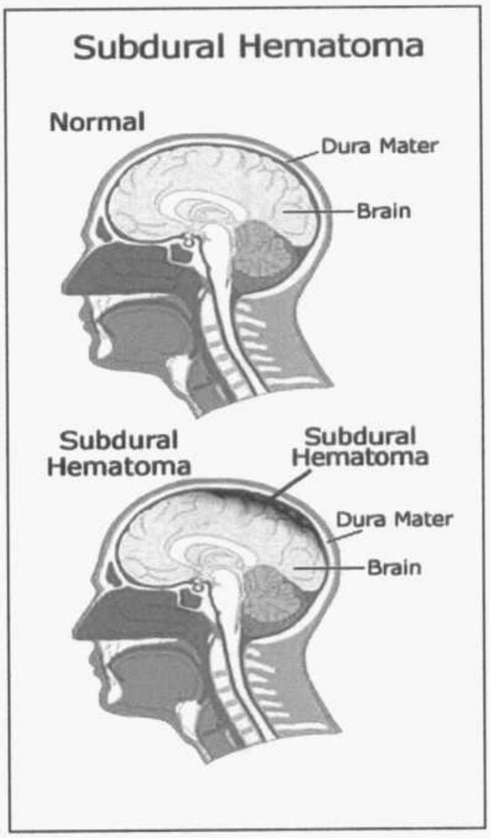
Cerebral oedema is a common and frequently fatal complication of head injury which may develop within minutes or hours of injury. Swelling may accompany diffuse axonal injury or a space-occupying lesion such as an intracranial haematoma. In children brain swelling may be the only identifiable feature of head injury. A swollen brain is heavy, with visible enlargement of the surface convolutions (gyri) at the expense of obliteration of the the intervening gaps (sulci) and compression of the fluid filled cavities (ventricles) deep within the brain. Emergency neurosurgical procedures frequently attempted include drainage of an ICH or removal of severely damaged brain tissue in an attempt to reduce



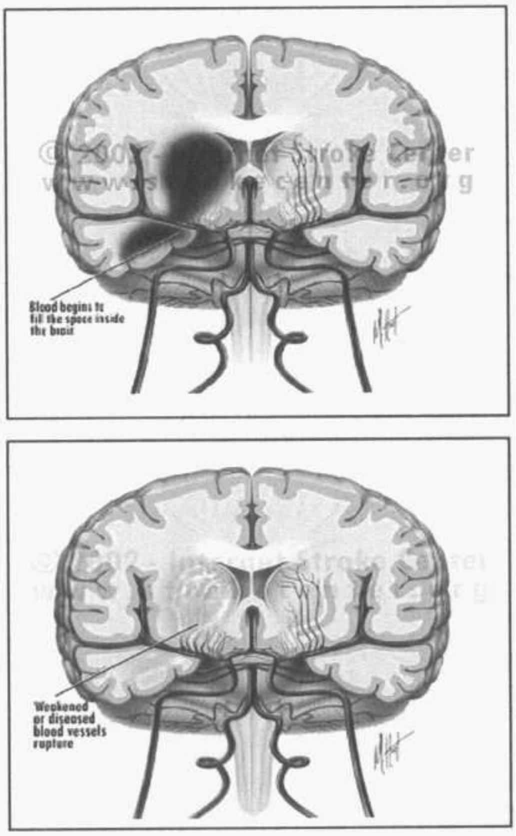
FIG(19) Epidural Hematoma
(El-Kadi H, Kaufman HH 2000).



FIG(20) Subdural Hematoma
(El-Kadi H, Kaufman HH 2000).



FIG(21) Subdural Hematoma
(Donald Rizzo 2000).



FIG(22) Intracerebral haemorrhage
(Donald Rizzo 2000).

intracranial pressure. Brain swelling is frequently the fatal complication even after such measures.

(Bullock R, Chesnut RM et al 2000).

CT images obtained immediately after the traumatic event often show no evidence of swelling or edema. Swelling or edema may become manifest on CT within a few hours with extensive loss of gray-white differentiation and diffuse hypodensity. These findings carry a poor clinical outcome regardless of the clinical grade. **(Bullock R, Chesnut RM et al 2000).**

2. Cerebral Contusion:-

A cerebral contusion is a focal brain injury caused primarily by impact of the brain surface and the bony ridges of the calvarium. Cerebral contusions are frequently found in the region of the frontal poles, anterior skull base, adjacent the sphenoid ridge, and at the temporal poles. Other locations include the cerebellar hemispheres and the occipital poles. A characteristic pattern of cerebral contusion called the "coup and contrecoup" injury is frequently seen. The coup contusion occurs at the sight of impact and the contrecoup contusion occurs in the brain at the point diametrically opposite the point of impact.

Contusions may progress with time. Imaging findings in brain contusions tend to vary because of the stages of evolution common to these lesions.

Acute CT initially demonstrates isoattenuating contusions that become more evident on follow-up CT. CT scans often demonstrate progression over time in the size and number of contusions and the amount of hemorrhage in the contusion. Initially, CT findings can be normal or minimally abnormal because the partial volumes between the dense microhemorrhages and the hypodense edema can render contusions isoattenuating relative to the surrounding brain tissue. **(Bullock R, Chesnut RM et al 2000).**

3. Brain Herniation:- fig(23)

Distortion of the midline brain structures secondary to brain trauma may lead to specific combinations of signs and symptoms which are collectively referred to as herniation syndromes

▪ Uncal herniation: -

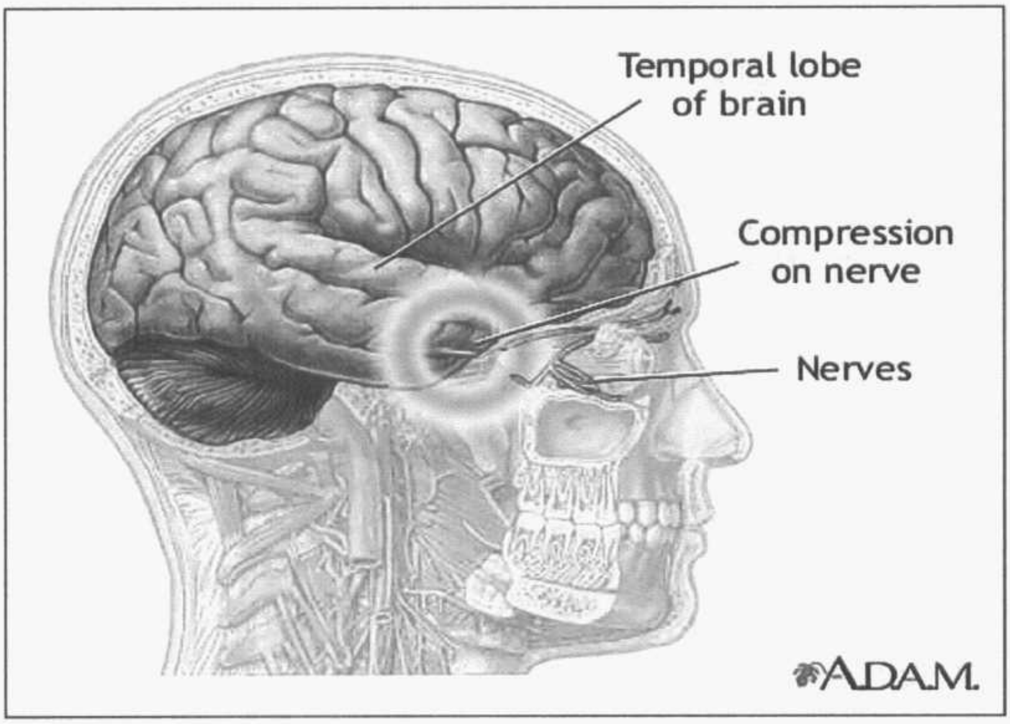
Most often results from a laterally placed mass displacing the brain stem contralaterally and pushing the uncus of the temporal lobe medially over the tentorial edge.

(Bullock R, Chesnut RM et al 2000).

▪ Tonsillar herniation: -

Results from downward displacement of the cerebellar tonsils through the foramen magnum, causing compression of the cervicomedullary junction. Frequently secondary to posterior fossa mass. May be precipitated by lumbar puncture in the presence of such a mass.

(Bullock R, Chesnut RM et al 2000).



fig(23) Brain herniation (American Accreditation HealthCare 2003)

▪Transtentorial herniation

Descending transtentorial herniation can cause various symptoms. Compression of the ipsilateral cranial nerve III may lead to ipsilateral dilatation of the pupil and abnormal extraocular movements. Compression of the ipsilateral corticospinal tracts in the brainstem may cause contralateral hemiparesis because these tracts decussate at the level of the medulla. Ipsilateral hemiparesis can also occur if there is sufficient mass effect causes the contralateral cerebral peduncle to be compressed against the adjacent incisura.

(Bullock R, Chesnut RM et al 2000).

▪Ascending transtentorial herniation

Ascending transtentorial herniation causing brainstem compression can cause nausea and vomiting, which may progress rapidly to coma if rapid changes occur in the intracranial anatomy. A slow-growing mass in the posterior fossa results in slow changes in the intracranial anatomy; these do not often present as an acute emergency.

(Bullock R, Chesnut RM et al 2000).

▪Sphenoid herniation

Associated clinical symptoms are usually minimal, though sphenoid herniations are often associated with other types of herniations.

Ct scan Findings of brain Herniation:-

With a descending transtentorial herniation, mass effect in the cerebrum pushes the supratentorial brain through the incisura .

With ascending transtentorial herniation, mass effect from the posterior fossa pushes the infratentorial brain through the incisura. This results in the distortion of the midbrain, flattening of the posterior quadrigeminal plate, and narrowing of the bilateral ambient cisterns. Hydrocephalus is frequently noted.

With tonsillar herniation, the infratentorial brain is displaced through the foramen magnum.

With sphenoid herniations, the supratentorial brain is sliding either anteriorly or posteriorly over the wing of the sphenoid bone. An anterior herniation occurs when the temporal lobe herniates anteriorly and superiorly over the sphenoid bone. Conversely, a posterior herniation occurs when the frontal lobe herniates posteriorly and inferiorly over the sphenoid bone.

With extracranial herniation, the brain is displaced through a cranial defect .

Degree of Confidence: Cross-sectional imaging provides a high degree of confidence. **(Bullock R, Chesnut RM et al 2000).**

4. Diffuse axonal injury:-

Diffuse axonal injury is the most severe form of diffuse brain injury. It is felt to be the most common cause of prolonged posttraumatic coma that is not due to mass lesion or ischemia. Diffuse axonal injury is characterized by focal hemorrhagic lesions involving the corpus callosum, rostral mid brain, superior cerebellar peduncles combined with microscopic evidence of widespread axonal damage. Patients with diffuse axonal injury frequently manifest decorticate or decerebrate posture and autonomic dysfunction in addition to their prolonged coma. Elevated intracranial pressure is frequently absent. Care is primarily supportive. In patients with prolonged coma, the prognosis is generally poor, with a 50% mortality and with an approximately 25% incidence of favorable outcome.

(Bullock R, Chesnut RM et al 2000).

Ct scan findings of patients proven eventually to have DAI, 50-80% demonstrate a normal CT scan upon presentation. Delayed CT scan may be helpful in demonstrating edema or atrophy, which are later findings. Characteristic CT findings in the acute setting are small petechial hemorrhages that are located at the gray-white matter junction, within the corpus callosum, and in the brainstem.

Specific CT scan criteria have been suggested by **Bullock R** et al (2000) as follows:-

- Single or multiple small intraparenchymal hemorrhages less than 2 cm in diameter in the cerebral hemispheres
- Intraventricular hemorrhage
- Hemorrhage within the corpus callosum
- Small focal areas of hemorrhage (<2 cm in diameter) adjacent to the third ventricle
- Brainstem hemorrhage

One also may observe small focal areas of low density on CT, which correspond to areas of edema at the areas of shearing injury.

(Bullock R, Chesnut RM et al 2000).

III. <u>Infection</u> :-

1. Osteomyelitis all fractures externally compounded carry with them the danger of local secondary osteomyelitis.

2. Meningitis and brain abscess: particularly common after penetrating (open) head injury and after fractures which disrupt the nasal and frontal air sinuses.

The most important role of **CT in imaging patients with meningitis** is to evaluate for contraindications to a lumbar puncture and for complications of meningitis. Some complications, such as symptomatic hydrocephalus, subdural empyema, and cerebral abscess, require prompt neurosurgical intervention.

- Nonenhanced CT findings may be normal (>50% of patients), or scans may demonstrate mild ventricular dilatation, cerebral edema , focal low-attenuating lesions , and effacement of sulci .
- Obliteration of the basal cisterns may result from increased attenuation, perhaps owing to the presence of exudate in the subarachnoid space or leptomeningeal hyperemia. Increased attenuation in the CSF spaces due to meningitis may simulate acute subarachnoid hemorrhage on CT.
- CT images must be performed by using iodinated contrast material in patients with suggested meningitis. Diffuse enhancement of the subarachnoid space is characteristic.
- Curvilinear meningeal enhancement over convexities, interhemispheric and sylvian fissures, and obliteration of basal cisterns with enhancement is usually seen on contrast-enhanced CT scans. Dural enhancement also may occur.

(Heinrich Mattle, Marco Mumenthaler 2004).

CT manifestations of an intracranial abscess depend on the stage of the abscess formation. The earliest phase may be related to meningitis, with no findings on unenhanced CT studies. Enhancement of the meningeal surfaces is a nonspecific and inconsistent finding in patients with meningitis.

- During early cerebritis, nonenhanced CT scans may demonstrate normal findings or may show only poorly marginated subcortical hypodense areas.
- Contrast-enhanced CT studies demonstrate an ill-defined contrast-enhancing area within the edematous region.
- During the early stage of a formed abscess, the lesion coalesces, with an irregular enhancing rim that surrounds a central low-attenuating area.
- Scans obtained with a time delay following contrast enhancement in cerebritis may show contrast "filling in" the central low-attenuating region. A formed abscess will not "fill in" the central portion of the abscess.

- Peripheral edema results in considerable mass effect with sulcal obliteration.
- The early capsule stage is characterized by a distinct collagenous capsule.
- A relatively thin well-delineated capsule marks the final stage of a fully formed abscess.

(Heinrich Mattle, Marco Mumenthaler 2004).

IV. Cerebrospinal fluid rhinorrhea and otorrhea:-

There are certain sites in which skull fractures will be complicated by rhinorrhea or otorrhea:-

1. The frontal sinus fracture with associated meningeal tear.
2. The middle fossa through the floor of the sella turcica.
3. Middle ear or mastoid where fluid passes to the middle ear causing otorrhea. **(Mortuaire, Geoffrey 2004).**

CT findings include fractures or other bone defects; meningocele; focal fluid accumulation in the ethmoid air cells, frontal, sphenoid, or maxillary sinuses or mastoid air cells; and, sometimes, pneumocephalus. **(Mortuaire, Geoffrey 2004).**

CT cisternography is performed with the injection into the lumbar subarachnoid space of 5-7 mL of nonionic myelographic contrast medium. The patient is maintained in the prone position until CT scan is performed. Ideally, the contrast medium is concentrated in the intracranial anterior and posterior skull base regions under fluoroscopic guidance by tilting the prone patient head downward on a fluoroscopic tilt table. Alternatively, with the patient lying prone on a stretcher, the patient's hips can be raised above the level of the head for one to two minutes to concentrate the contrast medium over the anterior and posterior regions of the skull base. Coronal CT images of 2-3 mm thickness are then obtained through the face and cranium, including all of the paranasal sinuses and the mastoid air cells.

CT cisternographic findings in CSF leak include the concentration of contrast medium in portions of a sinus or within ethmoid or mastoid air cells. Occasionally, a stream of contrast medium is demonstrated at the fistula site.

Digital subtraction radiographic cisternography can be similarly performed with a spinal subarachnoid injection of nonionic iodinated contrast medium. The images may demonstrate a CSF fistula, but this technique is used less frequently than the other cisternographic methods.

(Mortuaire, Geoffrey 2004).

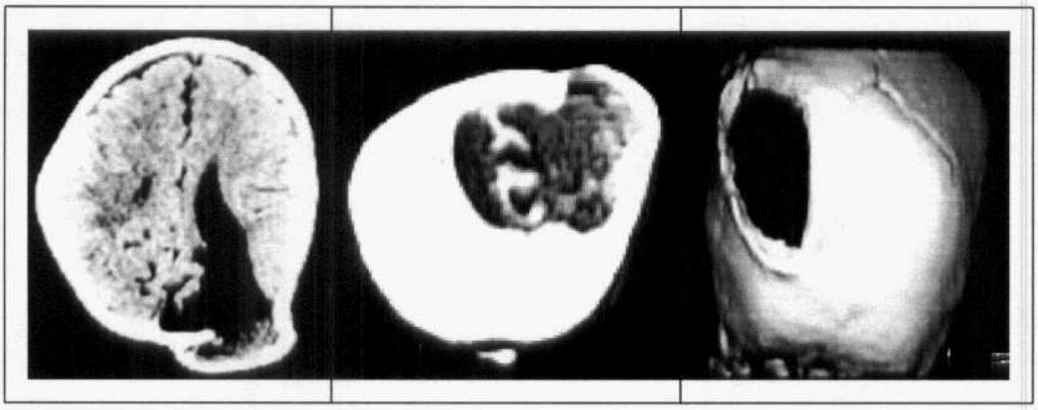
V. Leptomeningeal cysts, or growing skull fractures:- fig (24)

Growing skull fracture, recently termed as Craniocerebral Erosion, is a rare complication of skull fractures and mainly in infancy and early childhood. It is characterized by progressive diastatic enlargement of the fracture line. This late complication is also known as a Leptomeningeal cyst because of its frequent association with a cystic mass filled with CSF. They are typically diagnosed several weeks to months following the injury when an enlarging scalp mass is recognized. Seizures or motor weakness can accompany this process and imaging studies at diagnosis are notable for an underlying porencephalic cyst and a large calvarial defect. There is currently no evidence to suggest a spontaneous resolution of this lesion.

Occasionally, particularly in children, a rent in the dura may occur in association with linear fracture. A small projection of arachnoids through the dural tear may occur. The pressure and pulsation of the cerebrospinal fluid in the subarachnoid space may be interposed between the two edges of the dura and bone to prevent healing. Arachnoid's adhesions usually developed with an incomplete cyst being formed, commonly referred to as a Leptomeningeal cyst.

On CT scan a hypodense lesion is seen near the fracture site. Intracranial hypodense area may be an encephalomalacia, arachnoid loculation or cortical atrophy.

(Miltos Sugiultzoglu , Mark. Souweidane 1999).



(fig24) Leptomeningeal cysts (Mark. Souweidane 1999).

VI.Post traumatic epilepsy:

Healing and scarring of the meninges and brain surface may be the focus of later epileptic fits

- Brain MRI is the study of choice, and many clinicians perform it in all patients with PTE.
- If MRI is not readily available, head CT can be substituted. CT is less sensitive than MRI, but should be able to depict all pathology (eg, intracranial bleed) that needs urgent intervention.

(Simon D Shorvon 2000).

B. Facial Fractures:

The precise assessment of facial fractures and subsequent effective treatment are very important, since crippling and deleterious effects causing functional and cosmotic problems in the patients are possible. So, it is necessary to identify the fracture of each component of the facial bones.

(Robert W Dolan 2003).

Classification:-

Fracture Type		Prevalence
Zygomaticomaxillary complex (tripod fracture)		40 %
LeFort	I	15 %
	II	10 %
	III	10 %
Zygomatic arch		10 %
Alveolar process of maxilla		5 %
Smash fractures		5 %
Other		5 %

Table(2) **(Washington University 2005).**

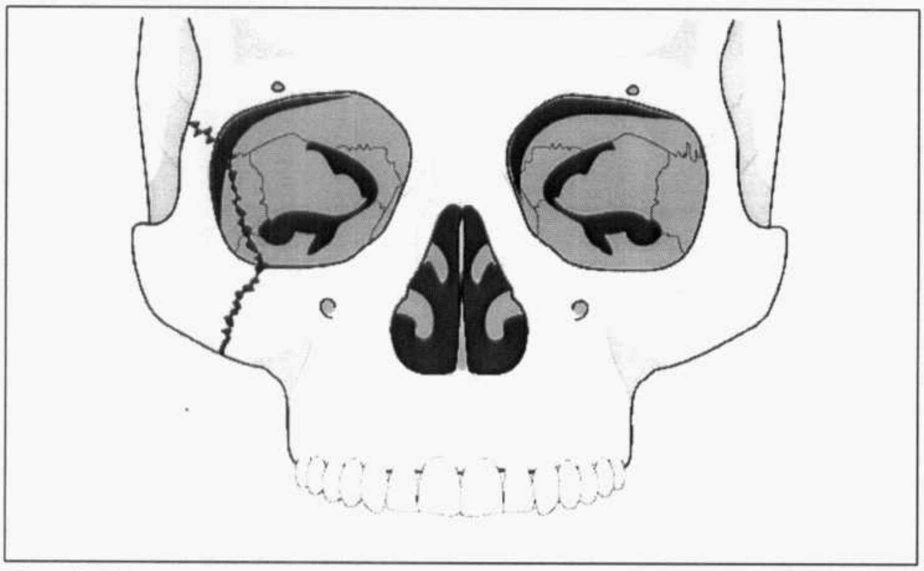


Fig (25):

Frontal view of a zygomaticomaxillary complex fracture.

(Glynn SM et.al 2003)

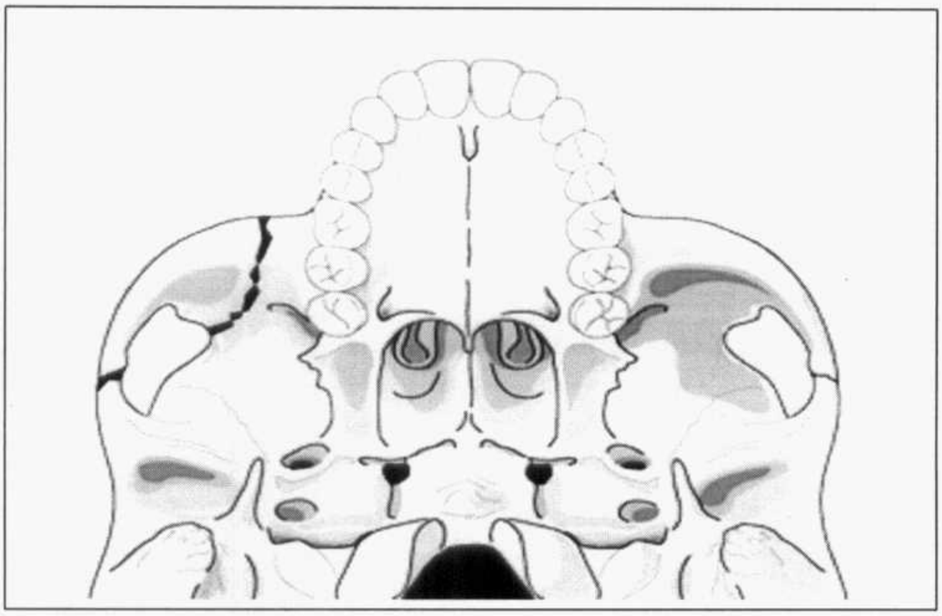


Fig (26):

Submentovertex view of a zygomaticomaxillary.

(Glynn SM et.al 2003)

Zygomaticomaxillary complex fracture: -fig(25, 26)

Probably the most common facial fracture is the tripod or zygomaticomaxillary complex fracture, so called because it involves separation of all three major attachments of the zygoma to the rest of the face.

Although it may be fractured, the separation of the frontal process of the zygoma from the frontal bone usually occurs in the form of a diastasis of the zygomaticofrontal suture. This fracture is usually due to a direct blow to the body of the zygoma. This fracture will generally cause contour abnormalities of all three of the lines of Dolan. Occasionally, extraocular muscles may become entrapped in the zygomaticomaxillary component of the fracture complex. The displaced tripod fragment may physically restrict motion of the mandible. In some cases, force may propagate along the long axis of the lateral orbital wall and involve the orbital apex or optic canal, resulting in diminished vision. CT is extremely helpful in evaluating these fractures.

(Glynn SM et.al 2003).

Fractures of the maxilla:-

Fractures are usually caused by direct severe impact to the bone. Such violent of injuries of the anterior face are dissipated and absorbed by the maxilla and other facial bones, thus protecting brain and spinal cord.

Classification:-

1- Alveolar fractures: Fractures of the dento alveolar portion of the maxilla may be caused by a direct force or by indirect blow to the undersurface of the mandible with transmission of upward and outward forces causing alveolar fracture with lateral displacement.

2- Transverse fractures (Le Fort I) Fracture above the level of the apices of the teeth.

3- Pyramidal fractures (Le fort II): blows to the upper maxillary area may result in fractures through the thin portion of the frontal process extending laterally to the floor of the orbit and along the lateral wall of the maxilla.

4.Craniofacial disjunction (Le fort III): This may occur when the fracture extends through the fronto-zygomatic suture and the nasofrontal suture and across the floor of the orbits to effect complete separation of the structures of the middle third of the face.

5. Vertical fractures: In this case, the maxilla is split in a vertical direction along a sagittal plane. This usually occurs just lateral to the midline, which is reinforced by the vomer.

(Paul Coulthard et.al 2003).

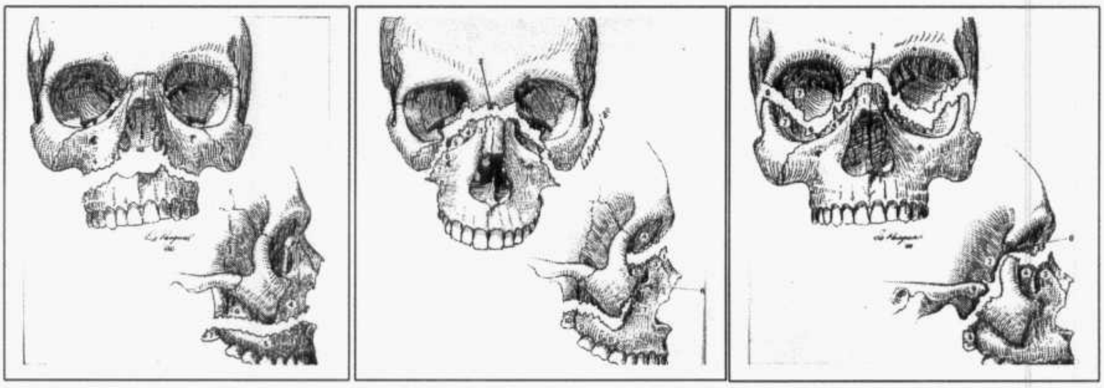
Le Fort classification: - **fig (27)**

Le Fort or midface fractures are classified into 3 types and occasionally are mixed from one side of the face to the other.

- Le Fort I: Horizontal maxillary fracture separates the maxillary process (hard palate) from the rest of the maxilla. Fracture extends through the lower third of the septum and involves the maxillary sinus. This is below the level of the infraorbital nerve and thus does not cause hypesthesia.

Le Fort II: Pyramidal fracture starts at the nasal bone, extends through the lacrimal bone, and courses downward through the zygomaticomaxillary suture. It courses posteriorly through the maxilla and below the zygoma into the upper pterygoid plates. The inner canthus of the nasal bridge is widened. Because the fracture extends through the zygoma, near the exit of the infraorbital nerve, hypesthesia often is present. Bilateral subcutaneous hematomas often are present.

(Norbert Hosten, Thomas Liebig 2002).



Lefort 1 Lefort 2 Lefort 3

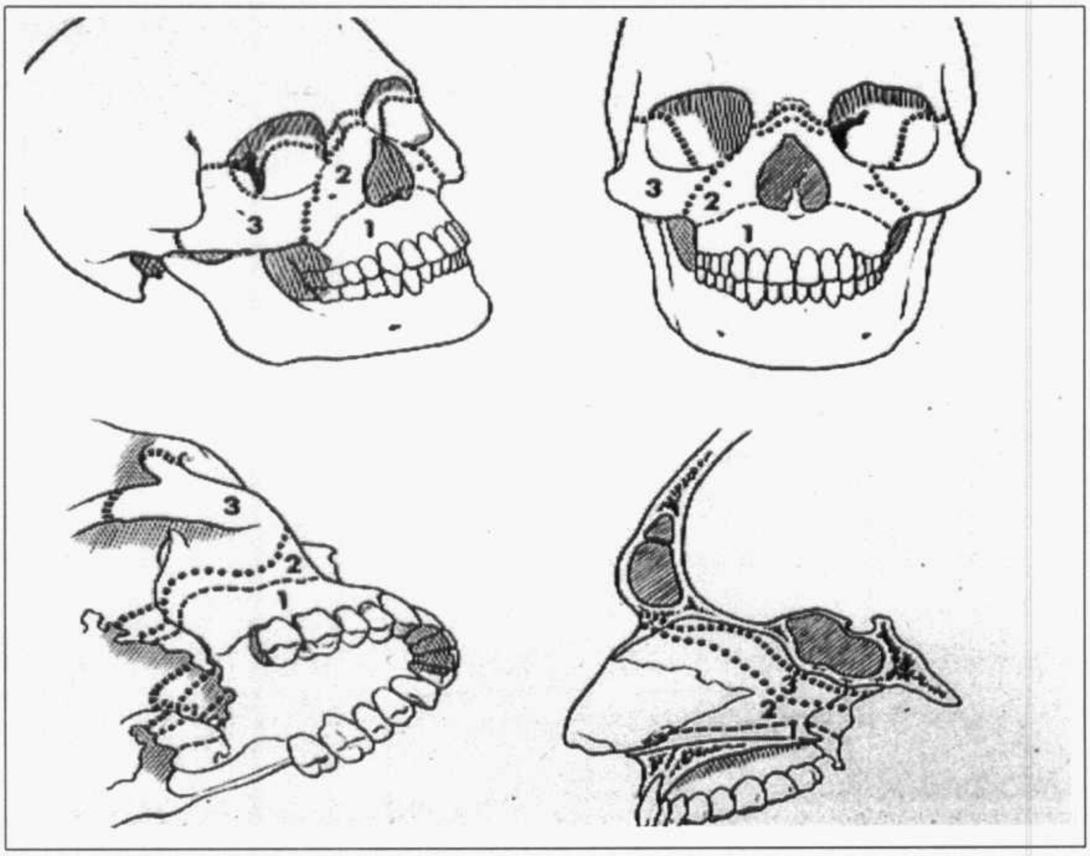


Fig (27): Lefort fractures types

Norbert Hosten, Thomas Liebig(2002)

- Le Fort III: Craniofacial dysjunction also starts at the nasal bridge. It extends posteriorly through the ethmoid bones and laterally through the orbits below the optic foramen, through the pterygomaxillary suture into the sphenopalatine fossa. This fracture separates facial bones from cranium, causing the face to appear long and flat (ie, dish face).

(Norbert Hosten, Thomas Liebig 2002).

Fractures of the zygoma:

Although sturdy, the zygoma is in a prominent location and is frequently subjected to injury.

Direct lateral force may result in fractures of the temporal portion of the zygoma and the zygomatic process of the temporal bone (which makes up the zygomatic arch) with medial displacement of the arch resulting in difficulty or inability to open the mouth.

(David Rowley et. al 2003).

Fractures of the nasal bones: - **fig (28, 29)**

Nasal bone fractures vary with the site of impact, direction and intensity of the force and age of the patients:-

Direct frontal blows of moderate intensity over the nasal dorsum results in fracture of the thin lower half of the nasal bone. The margins of the pyriform aperatures may be also fractured and dislocated into the nasal cavity, obstructing the airway.

(David Rowley et.al 2003).

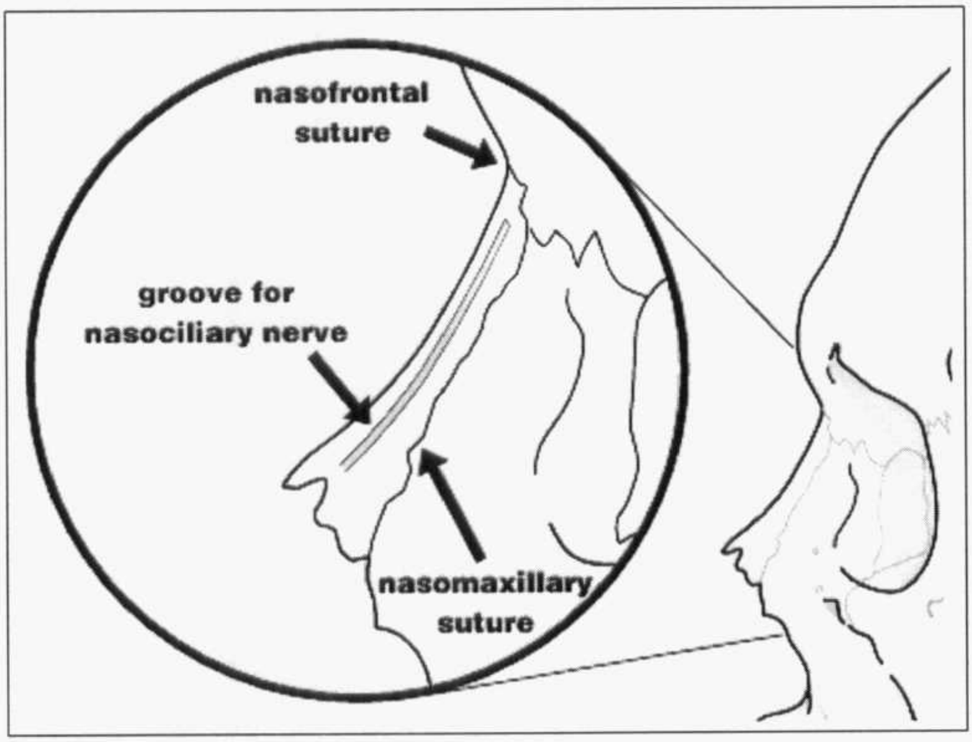
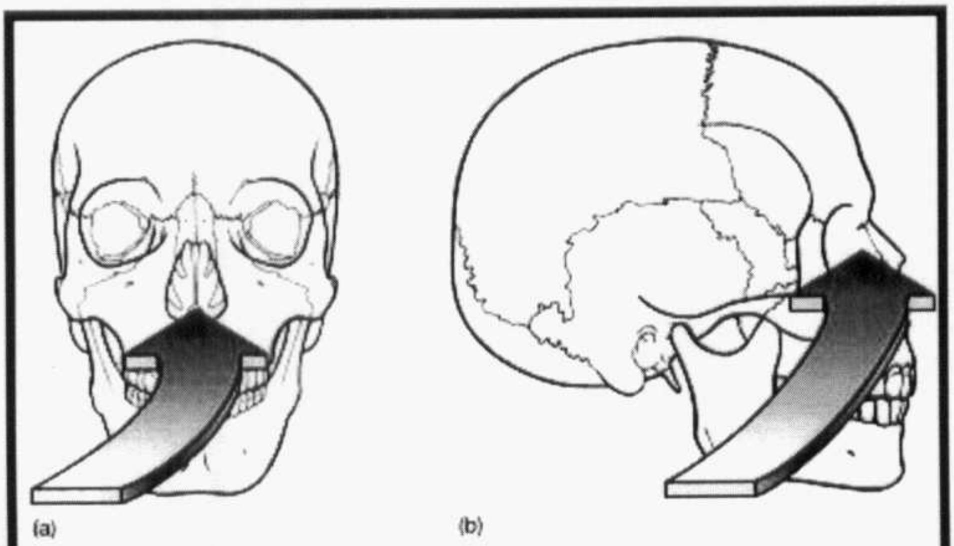


Fig (28): NORMAL NASAL BONE

David Rowley et.al 2003



Mechanism of injury in nasal fractures. A: Tangential forces displace nasal bones laterally. B: Posteriorly directed blows displace fracture fragments into other facial structures. ,

Brian Dolan, Lynda Holt 1999

Fig (29): MECHANISM OF NASAL FRACTURES

David Rowley et.al.(2003)

Fractures of the orbits:- fig(30)

Type	Involvement
I. Orbital blow out fractures	
A. Pure blow out fractures:	Fractures through orbital floor, medial and lateral walls while orbital rim is intact.
B. Impure blow out fractures:	May be associated with fracture of facial bones and the orbital rim is fractured.
II. Orbital fractures without blow out fractures:	
A. Linear fractures	In the upper maxillary and zygomatic fractures.
B. Comminuted fractures	Often associated with fractures of mid facial bones.

Table (3): Shows orbital fractures

(Norbert Hosten, Thomas Liebig 2002).

Naso-orbito-ethmoid fractures:-

A facial fracture is considered a naso-orbital-ethmoid (NOE) fracture if the fracture involves the bone to which the medial canthal tendon is attached. Naso-orbito-ethmoid (NOE) fractures are uncommon in children. The region is not prominent or well developed in the young child. These fractures range from simple fractures to severely comminuted fractures involving the orbits, maxilla, and frontal bone. Symptoms include a depressed and flattened nasal root, telecanthus, subconjunctival hemorrhage, and mobility of the medial canthal tendon on bimanual palpation. Additional clinical features include rounding of the medial canthus, horizontal shortening of the palpebral fissure, and an intercanthic distance greater than the palpebral fissure width.

(David Rowley et. al 2003).

Fracture of the frontal sinus:-

The frontal sinus account for 5-12% of all facial fractures. The frontal sinus (FS) is extremely resilient to injury. However, high-velocity impacts, such as motor vehicle accidents and assaults, can result in FS fractures. The potential for intracranial injuries, aesthetic deformities, and late mucocele formation is high. The treatment goals of FS fractures are an accurate diagnosis, avoidance of short- and long-term complications, return of normal sinus function, and reestablishment of the premorbid facial contour. The treating physician must have a concise algorithm for diagnosis and treatment of these injuries.

Isolated anterior table fractures account for 33% of FS fractures. Combined fractures of the anterior table, posterior table, and/or nasofrontal recess (NFR) appear in 67% of cases. Isolated posterior table injuries are rare. As many as 33% of patients have an associated CSF leak.

(Seth R Thaller, W Scott McDonald 2003)

The frontal bone and supra-orbital ridge are sturdy but they are subjected to fractures by direct force usually focused onto a small area. Glabellar or frontal sinus fractures are usually comminuted or depressed and often require reconstruction surgery with silicon implants.

(Brian Dolan, Lynda Holt 1999).

Smash fractures (Panfacial)

Panfacial injuries involve trauma to the upper, middle, and lower facial bones. Multisystem injury or polytrauma is commonly associated with these injuries; thus, treatment often requires a team approach. After stabilization of the patient, early and total restoration of facial form and function should be the goal of the maxillofacial surgeon.

(Caron G et.al 2000).

(Mandibular fractures):- fig (31)

The position and anatomy of the mandible is such that it is frequently subjected to injury.

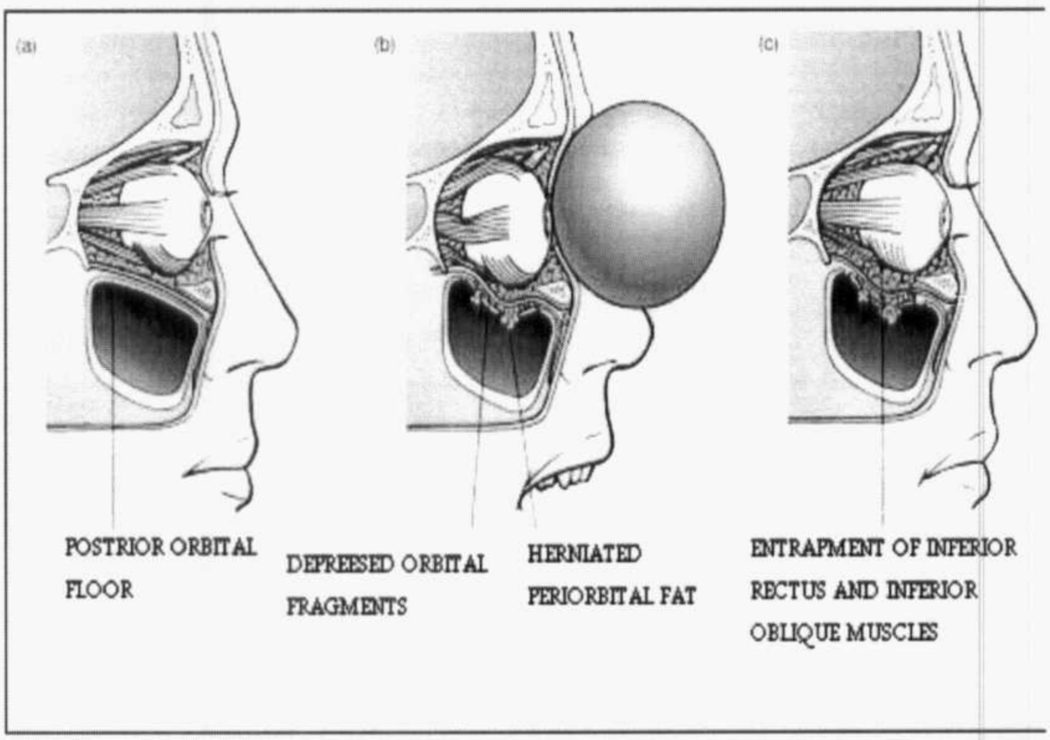
The mandible is a strong bone but has certain areas of weakness. It is thin at the angles where the body joins with the remus and at the neck of the condyle. The mental foramen is larger in some individuals and is an area of weakness through which fractures frequently occur. With loss of teeth from the mandible, atrophic changes in the alveolar portion weaken the bone.

(Washington University 2005).

Fracture Type	Prevalence
Body	30 - 40 %
Angle	25 - 31 %
Condyle	15 - 17 %
Symphysis	7 - 15 %
Ramus	3 - 9 %
Alveolar	2 - 4 %
Coronoid process	1 - 2 %

Table (4): fractures types of Mandible

(Washington University 2005).



Fig(30) Blowout fracture of the orbit.

(Norbert Hosten, Thomas Liebig 2002)

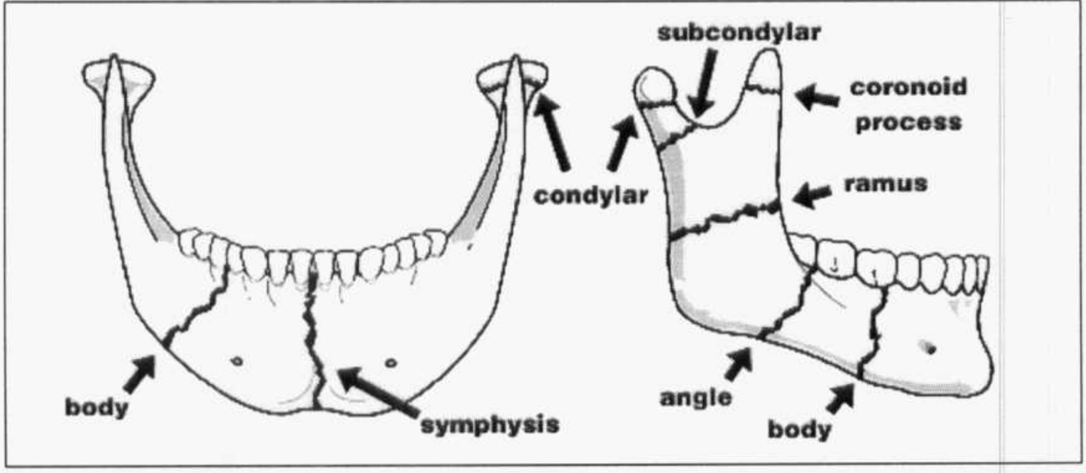


Fig (31): Mandibular fractures types.

(Paul Coulthard et.al 2003)

Classification:-

Mandibular fractures may be classified according to their location into: 1) parasymphyseal (those that occur in the symphysis area). 2) Body of the mandible. 3) Angle, 4) ramus (those fractures between the angle and the sigmoid notch). 5) Coronoid process and 6) Condylar fractures.

(Brian Dolan, Lynda Holt 1999).

Fractures of the condyle:-

The mandibular condyle is protected by the zygomatic arch and is supported by the capsule and ligaments of the tempromandibular joint.

The neck is the thinnest portion and is the most likely to be fractured by blow to the mandible. Violent blows to the symphysis region may result in bilateral condylar fractures.

Fractures of the Coronoid process:-

This portion of bone is well protected by the zygoma, so its fracture is of rare occurance and is usually due to penetrating wounds or gunshot.

(Paul Coulthard et.al 2003).

Complications of Facial Fractures:-

Prompt and accurate recognition of osseous and soft-tissue complications arising from facial fractures is necessary to assure optimal patient care. The failure to detect some complications in an early and more treatable stage is the major reason for the development of late sequalae in facial fractures.

(Lorne H Blackbourne 2003).

Complications of facial fractures include the following:-

I. Early complications:

1. Hemorrhage:-

Extensive haemorrhage may occur due to laceration of overlying soft tissues or due to tearing of major vessel passing the site of injury as severe bleeding usualy involves a lingual, internal maxillary, anterior ethmoid or posterior ethmoid artery Although at times bleeding from facial fractures is serious and life threatening it is usually minor and rarely cause of severe hypovolaemia. Thus presence of hypotension in patient with facial injuries should trigger a search for other causes.

Massive bleeding from facial injury may go unnoticed, especially in patients with impaired consciousness, because blood is swallowed. Risk of aspiration of blood either directly or in association with regurgitation or vomiting.

(Lorne H Blackbourne 2003).

2 .Airway obstruction:

Can develop by several mechanisms:-

- Posteriorly displaced distal fragment of a parasymphyseal mandibular fractures allows floor of mouth to fall backwards .
- In bilateral double fractures of body, free mandibular segment may be pulled medially by effect of mylohyoid, pushing tongue up to palate and thus obstructing airway .
- Swelling of tongue, palate, pharynx, floor of mouth secondary to oedema or haematoma.
- Fracture of pterygoid plate in association with midface fractue allow posterior shift of whole midface resulting in narrowing of nasopharynx. Not an immediate problem if patient is conscious

as simply results in mouth breathing but may result in severe airway obstruction in unconscious patient .

- Foreign bodies, blood, teeth, dentures.

(Bavitz JB, Collicott PE.1999).

3. Infection:

May be caused by contamination at the time of injury or by fractures through asinus with pre_existing chronic infection.

(Flalkov JA et al 2001).

4. Cerebrospinal fluid rhinorrhea and otorrhea:

- 25% of Le fort II and Le fort III fractures associated with CSF rhinorrhea.
- Associated with risk of meningitis, brain abscess and encephalitis.

CT findings include fractures or other bone defects; meningocele; focal fluid accumulation in the ethmoid air cells, frontal, sphenoid, or maxillary sinuses or mastoid air cells; and, sometimes, pneumocephalus.

(BELL RB et al 2004).

5. Orbital Complications:-

Which include the following:-

A) Enophthalmas: - due too many factors:-

-Escape of orbital contents into the maxillary sinus.

-Enlargement of orbital cavity from downward displacement of the orbital floor.

-Orbital fat necrosis: resulting from pressure caused by orbital haematoma.

B) Dipiopla:- due to e1trampt of the soft tissue structures in the fractured sites, or due to injury to the motor nerves of extra ocular muscles or direct injury to the muscles themselves.

C) Ocular globe complication: - Varies in severity from corneal abrasion to loss of vision from a ruptured globe or fracture involving the optical canal.

D) Lacrimal system complications: - Chronic inflammatory condition of the Lacrimal sac, or cystic dilation (mucocele) with ephiphora may developed.

(Gary R.et.al 2002).

6.Surgical emphysema and pneumomediastinum

- Uncommon.

- Air from maxillary and ethmoid sinuses can communicate with fascial planes of neck and thence with mediastinum.

- pneumomediastinum is a benign complication of facial fractures but may also be caused by injury to larynx, trachea, lungs or oesophagus. These should be excluded before assuming that it is a result of facial fractures.

(Journal of Craniofacial Surgery Nov. 2003).

II. Late Complications:

These include non union, malunion, scar tissue contracture and facial deformity.

Late complications may occur up to a decade after the injury. These include mucocele, mucopyocele, and delayed CSF leak with or without meningitis. For this reason, patients who have undergone repair and/or obliteration of the frontal sinuses should be monitored closely the first year after the repair and then yearly thereafter. Long-term follow-up care is mandatory for these patients. Any complaints of frontal pressure, pain, or headache should lead to an aggressive workup. Again, CT scanning provides the most accurate diagnostic information when evaluating a patient for complications.

(Beckhardt RN, et al 2003).

PATIENTS AND METHODS

This study was conducted on 50 selected traumatized patients referred to C T unite El-Mansoura International Specialized Hospital by using multi-slice scanner equipment for assessment of craniofacial lesions. These 50 patients comprised 45 males and 5 females, their ages ranged between 2 years – 72 years.

Table (5) Show the main clinical presentation of 50 patients.

Clinical presentations	No. of cases
1. Facial	21
2. Cranial	17
3. Craniofacial	4
4. Mandibular	5
5. Temporal bone	3

Clinical:

- **History**

Information regarding the mechanism of the injury may assist in determining a diagnosis. In particular, knowing the magnitude, location, and direction of the impact is helpful. High-energy trauma should cause concern about other possible concomitant injuries. A history of mental status changes or loss of consciousness should cause concern regarding intracranial injury. The presence of any functional deficiencies, such as those related to airway, vision, cranial nerves, occlusion, or hearing, may provide clues to fracture location and resultant adjacent nonosseous injury.

- **Physical examination**

Evaluation of the craniofacial should be undertaken only after the patient has been fully stabilized and life-threatening injuries have been addressed. In particular, airway considerations and intracranial injuries must take immediate priority.

In general, patients with facial fractures have obscuration of their bony architecture with soft tissue swelling, ecchymoses, gross blood, and hematoma. Nonetheless, observation alone may be informative. Focal areas of swelling or hematoma may overlie an isolated fracture. Periorbital swelling may indicate Le Fort II or III fractures. A global posterior retrusion of the mid face creates a flattened appearance of the face. The so-called dish-face or pan-face deformity may occur after an extensive Le Fort II or Le Fort III fracture. The maxillary segment is displaced posteriorly and inferiorly. This may cause premature contact of the molar teeth, resulting in an anterior open bite deformity. In severe cases, the upper airway may be compromised. In such a situation, disimpaction forceps may need to be placed into the nasal floor and hard palate to pull the bony segment forward to restore airway patency.

The face and cranium should be palpated to detect for bony irregularities, step-offs, crepitus, and sensory disturbances. Mobility of the mid face may be tested by grasping the anterior alveolar arch and pulling forward while stabilizing the patient with the other hand. The size and location of the mobile segment may identify which type of Le Fort fracture is present. If only an isolated segment of bone is mobile, a small alveolar or nasofrontal process chip fracture may be present. With high-impact force, the maxilla may be comminuted or impacted, in which case the bony framework is displaced or crushed but immobile.

A thorough nasal and intraoral examination should be completed. The nasal bones are typically quite mobile in Le Fort II fractures, along with the rest of the pyramidal free-floating segment. Intranasal examination may reveal fresh or old blood, septal hematoma, or cerebrospinal fluid rhinorrhea. The intraoral examination should assess occlusion, overall dentition, stability of the alveolar ridge and palate, and soft tissue. Finger palpation of the maxillary contour intraorally may provide additional information about the integrity of the nasomaxillary buttress, anterior maxillary sinus wall, and zygomaticomaxillary buttress.

During examination of the eyes and orbit, search for integrity of the orbital rims, orbital floor, vision, extraocular motion, position of the globe, and intercanthal distance. Unlike Le Fort II fractures, Le Fort III fractures are associated with lateral rim and zygomatic breaks. Visual changes may signify a disturbance of the optic canal, problems within the globe or retina, or other neurologic lesions. Disturbances of extraocular motion or enophthalmos may signify a blowout in the orbital floor. An increased intercanthal distance implies displacement of the frontomaxillary or lacrimal bones or avulsion of the medial canthal ligament. For extensive involvement of the orbit or globe, consultation with an ophthalmologist is appropriate.

Tools that may assist the examiner in the evaluation of maxillofacial trauma include a headlamp or mirror, tongue blades, a suction device, a nasal speculum, an otoscope, and a ruler. Early photographs may be helpful in preoperative planning and patient counseling.

Imaging Studies:

- **CT scans**
  - Generally, CT scan images are taken of all patients with possible cranoifacial fractures.
  - Recently, CT scanning has become the modern standard of care for diagnostic imaging (i.e., criterion standard).
  - Plain films are limited by their ability to penetrate through extensive soft tissue edema and to help distinguish between multiple planes of complex bony framework. CT imaging is superior to plain films in helping delineate multiple fractures, evaluate associated cartilaginous or soft tissue injury, and assess for the presence of impingement into the optic canal.

3D ?

CT examinations:

- All patients were subjected to axial CT examinations by axial scans.
- All axial scans were obtained with the patient supine and the head resting comfortably on the head rest.
- Coronal scans were obtained in 7 cases.

Table (6) shows the cases for which coronal scans were done.

Cases	No. of cases
Upper face fractures	2
Mid face fractures	2
Upper and mid face fractures	3
total	7

- The patients were instructed not to move, cough or swallow during the scanning as any movement even slight will appear as artifact.
- Infants and irritable children were slightly sedated before scanning either by chloral hydrate or light anaesthesia to minimize motion and improve registration of the scan sequence.
- To avoid the patient's movements,the exposure time should be kept to minimum

Examined area	Time of scanning
Craniofacial	30-35 min
Cranial	12-15 min
Facial	15-20 min
Mandible	10 min
Temporal bone	7 min

Table (7)

- The lateral scout was produced on the consol and was examined thoroughly to determine any associated pathology .

- Contiguous axial sections obtained on the scout lateral topogram and the boundaries of the examined area were suited according to each case as shown in tables.

Table (8) shows boundaries of examined areas in the lateral scout for axial projection.

Examined area	Boundaries	Gantry tilt	Plane of imaging
Craniofacial bones	From the lower mandibular region to the top of the skull	-20°→ -25°	// to the undersurface of the mandible.
Cranial bones	From the supra orbital ridge to the top of the skull	+ 20°°→ +25°	//to the petrous ridge.
Facial bones	From the mandible to supra orbital ridge	20°→ -25°	//to the under surface of the mandible.
Mandible	From adistance below symphysis menti to appoint just above T.M.J.	-20°→ -25°	//To the undersurface of the mandible.
Temporal bone	From mastoid tip to the petrous ridge	0°	//to the canthomeatal line.

Table (9): shows the boundaries of examined areas on lateral scout in the coronal projection.

Examined area	Boundaries	Gantry tilt	Plane of imaging
Orbits	From supra-rbital ridge to posterior clinoid process	0	⊥ to canthomeatal line
Maxilla	From supra-orbital ridge to external auditory meatus	0	⊥ to canthomeatal line
Temporal bone	From petrous ridge to the mastoid tip	0	⊥ to canthomeatal line

- Ct scans were recorded on 14 x 17 inch sheets of films with the use of multiformat camera in a 12.15.20.24. on-one format.
- In our cases the following structures are examined and assessed: frontal bone with its processes.orbital rims integrity and rim configuration, external auditory meatus and temporal bone, zygomatic bone with its processes , maxilla and its articulation with the zygomatic bone, anterior wall of mandibular ramus, condylar and coronoid processes and gonial angles.

RESULTS

The results of our study were classified into the following subgroups subgroups according to the site of fracture (table 10).

Table (10) Shows types of craniofacial fractures:

Type of fracture	No. of cases
i. Cranial	**17**
ii. Craniofacial	**4**
iii. Facial	**21**
a. upper facial	14
b. upper&mid facial	2
c. mid facial	4
d. mid facial&mandibular	1
iv. Mandibular	**5**
v. Temporal bone	**3**

Table (11) shows CT findings in craniofacial fractures:-

Site of fractures	Case no.	Age	sex	Etiology	Type of fractures	Involved bones	Notes
I.cranial fractures (17 cases)	1	3	M	car accident	Fissure fracture	right parietal bone	
	2	45	M	car accident	Multiple fractures	left parietal bone	
	3	40	M	car accident	Fissure fracture	left parietal bone	
	4	19	M	car accident	Comminuted fractures	right parietal bone	
	5	14	M	car accident	Fissure fractures	right parietal bone	
	6	2	M	car accident	fissures fracture	left parietal bone	+ right occipital bone
	7	35	M	car accident	fissures fracture	left parietal bone	+ bone fragments separation
	8	20	M	hummer hit	depressed fracture	left parietal bone	comminuted fracture
	9	5	M	car accident	linear fracture	left parietal bone	
	10	19	M	car accident	depressed fracture	right parietal bone	intracranial bone fragment
	11	25	M	car accident	fissure fracture	left parietal bone	intracerebral haemorrhage (I. C .H)
	12	50	M	car accident	depressed fractures	left parietal bone	
	13	25	M	car accident	linear fractures	left side of occipital bone	
	14	14	M	car accident	linear fracture	left parietal bone	comminuted fracture
	15	3	F	fall on stair	depressed fracture	left parietal bone	comminuted fracture
	16	5	M	fall on head	fissure fractures	Rt side of occipital bone	
	17	12	M	car accident	fissure fracture	right parietal bone	
II.Craniofacial fractures (4 cases)	18	63	M	car accident	linear fracture	frontal bone &left parieal	extended from fontal to Lt parietal
	19	9	M	car accident	multiple fractures	frontal & rt parietal bone	+cerebral contusion & I. C. H.
	20	5	M	car accident	linear fractures	Lt orbital wall&lt parietal	+intracerebral haemorrhage (I.C.H)
	21	26	M	car accident	comminuted fractures	Frontal b.& rt orbital roof	intracerebral bone fragements &air
III.Facial fractures (21cases) A)_upper facial	22	4	M	car accident	depressed fracture	Frontal b.& rt orbital roof	
	23	25	M	car accident	depressed fracture	Midline of fontal bone	comminuted fracture
	24	8	M	car accident	depressed fracture	Lt side of frontal bone	comminuted fracture
	25	25	M	car accident	depressed fracture	Frontal b.& rt orbital roof	

Table (12) shows CT findings in craniofacial fractures:-

ite of actures	Case no.	Age	sex	Etiology	Type of fractures	Involved bones	Notes
	26	50	M	car accident	Linear fractures	Frontal sinus	
	27	25	M	car accident	Depressed fractures	Frontal bone and sinus	comminuted fracture
	28	6	M	car accident	Fissure fracture	Frontal bone	
	29	19	M	car accident	comminuted fractures	Rt frontal sinus &rt orbital roof	I.C.H ,I.V.H & intracerebral air
	30	27	M	car accident	linear fractures	Frontal bone and rt orbital roof	
	31	9	F	fall 1st floor	linear fracture	Frontal sinus	
	32	4	F	car accident	multiple fractures	Frontal bone	Comminuted fractures
	33	12	M	car accident	depressed fracture	Frontal bone and lt orbital roof	Comminuted fracture
	34	72	M	car accident	depressed fracture	Midline of frontal bone	Comminuted fracture
	35	25	M	car accident	depressed fracture	Frontal bone	
upper and id facial	36	25	M	car accident	comminuted fractures	frontal &rt maxillary sinuses	high density (blood) in sinuses
	37	27	M	car accident	comminutes fractures	lt maxillary &zygomatic arch	blood&bone fragements in sinus
Mid facial	38	24	M	car accident	depressed fracture	right and left maxillary sinuses	high density (blood) in sinuses
	39	21	M	car accident	comminuted fractures	left maxillary sinus	blood&bone fragements in sinus
	40	18	M	car accident	comminuted fractures	right and left maxillary sinuses	blood&bone fragements in sinus
	41	34	M	car accident	comminuted fractures	nasal & both maxillary sinuses	high density (blood) in sinuses
)Mid facial mandible	42	22	M	car accident	comminuted fractures	both maxillary sinuses + symphsis menti of mandible	high density (blood) in both maxillary sinuses
	--------	---	--	-------------	-------------------------	-----------------------------------	
/.Mandibular actures	43	6	F	car accident	multiple fractures	lt mandibular body & S. menti	
	44	34	M	car accident	fissure fracture	symphsis menti	
	45	65	M	car accident	multiple fractures	rt mandibular body & rt. angle	
	46	22	M	car accident	multiple fractures	rt mandibular body & lt .angle	
	47	50	F	car accident	multiple fractures	rt side of mandibular body	
/.Temporal one fracture cases)	48	42	M	car accident	comminuted fractures	left temporal bone	
	49	18	M	car accident	fissure fracture	petrous part of left temporal	
	50	8	M	car accident	comminuted fractures	lt temporal and occipital bone	

Table (13) shows incidence of craniofacial bone affection

Affected bone	Cases No.	Average age of cases	Incidence In our study	Cases no. associated with brain injury
Right parietal bone	6	13 y	12%	2
Left parietal bone	12	26 y	24%	2
Frontal bone	17	25 y	34%	3
Occipital bone	3	23 y	6%	--
Right orbit	5	20 y	10%	2
Left orbit	2	9 y	4%	1
Rt. maxillary sinus	5	25 y	10%	--
Lt. maxillary sinus	6	24 y	12%	--
Zygomatic arch	1	27 y	2%	--
Mandible	6	26 y	12%	--
Temporal bone	3	22 y	6%	--

- Average age of craniofacial trauma in our study = **23.6** year.
- Incidence of craniofacial trauma according to sex in our study equal **9 male : 1 female**.
- Incidence of car accidents as the etiology of craniofacial trauma in our study = **92%**.

Illustrative cases

CASE 1

A 19 years old male presented with head trauma after collision with a car .On examination he was unconscious with right parietal swelling.

Axial CT scan of skull and brain:

Showed multiple compound depressed fractures of right parietal bone
Brain window study revealed intracerebral haemorrhage ,bone fragments ,air in right parietofrantal region with right parietal subgalial haematoma .

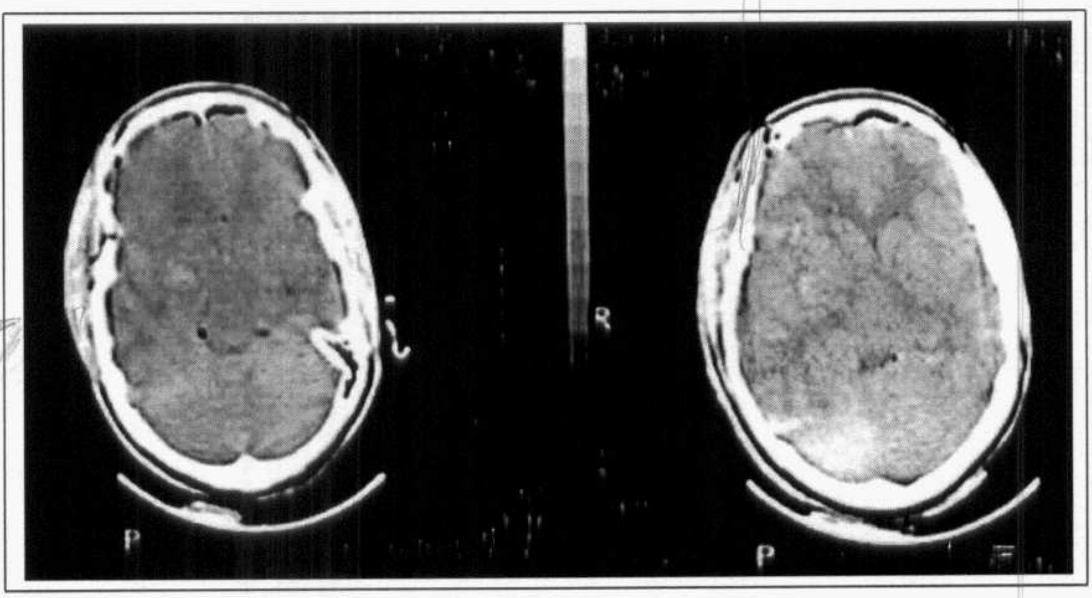


Fig (1): Axial CT scan of skull (brain window)

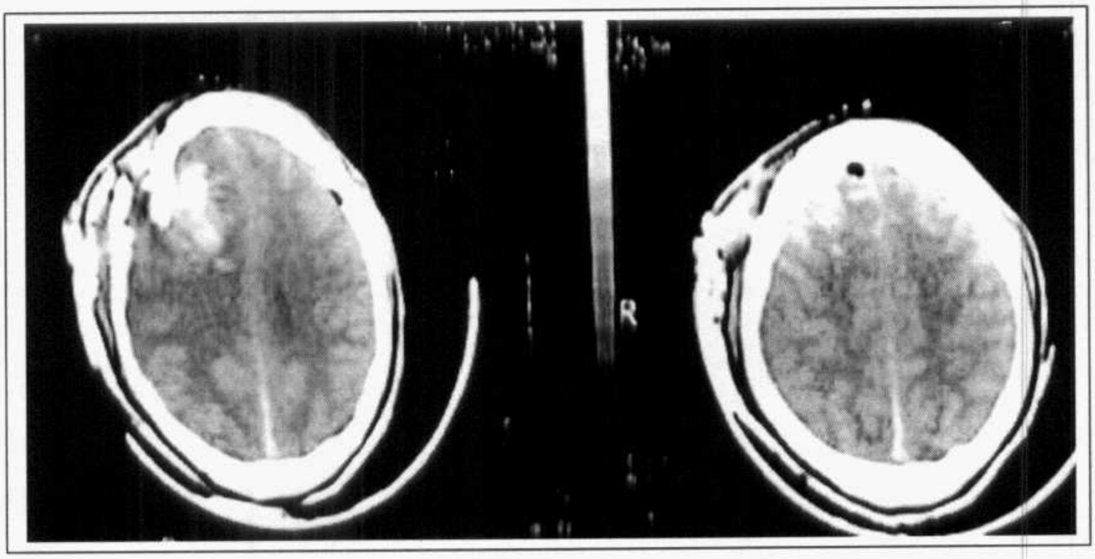


Fig (2): Axial CT scan of skull (brain window)

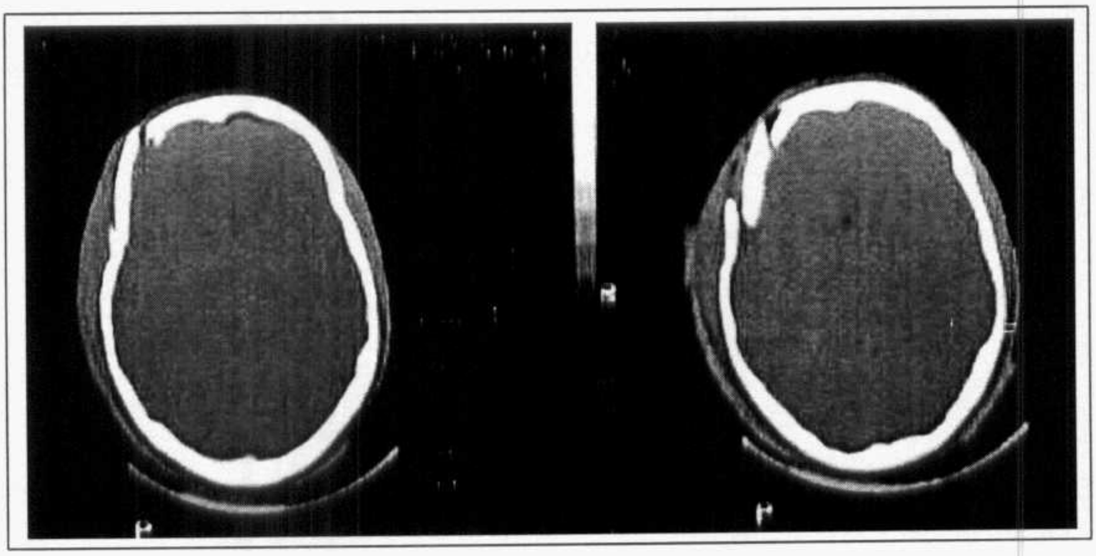


Fig (3): Axial CT scan of skull (bone window)

Diagnosis:

Multiple comminuted depressed fractures of right parietal bone with intracerebral haemorrhage & air in right frantoparietal region.

CASE 2

A 25 years old male presented with head trauma after car accident .On examination he was comatosed with left parietal swelling.

Axial CT scan of skull and brain:

Showed multiple comminuted depressed fractures of left parietal bone.
Brain window study revealed intracerebral haemorrhage, bone fragments in left parietal region with left parietal subgalial haematoma.

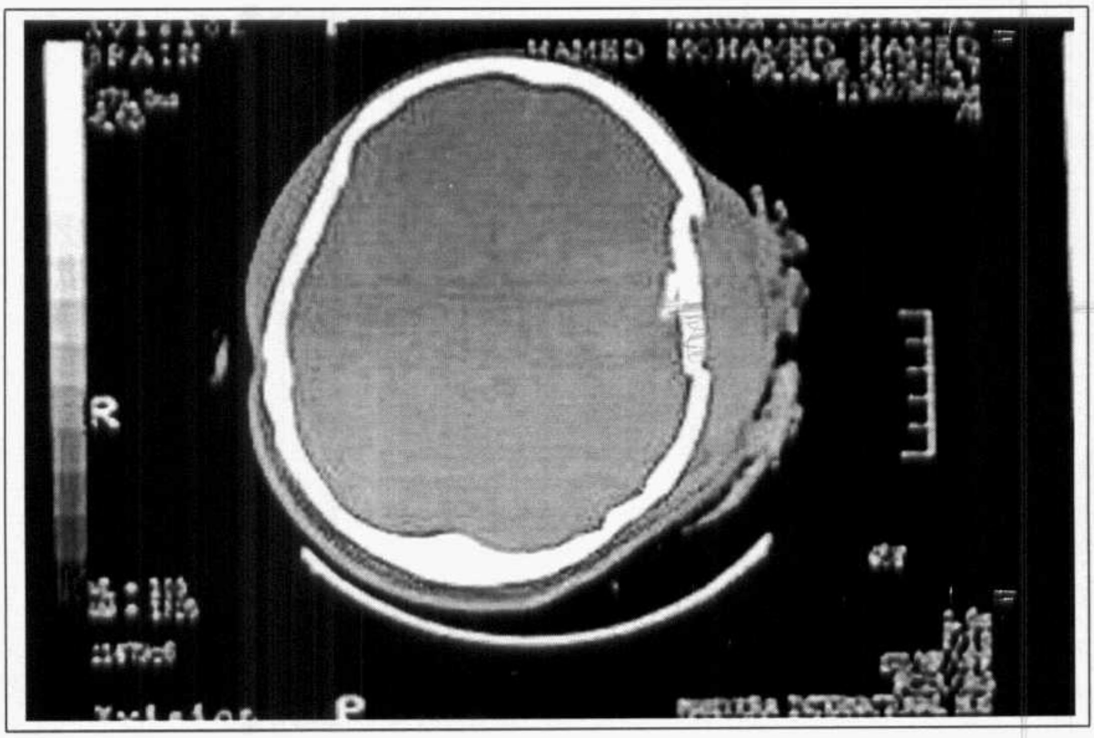


Fig (4): Axial CT scan of skull (bone window)

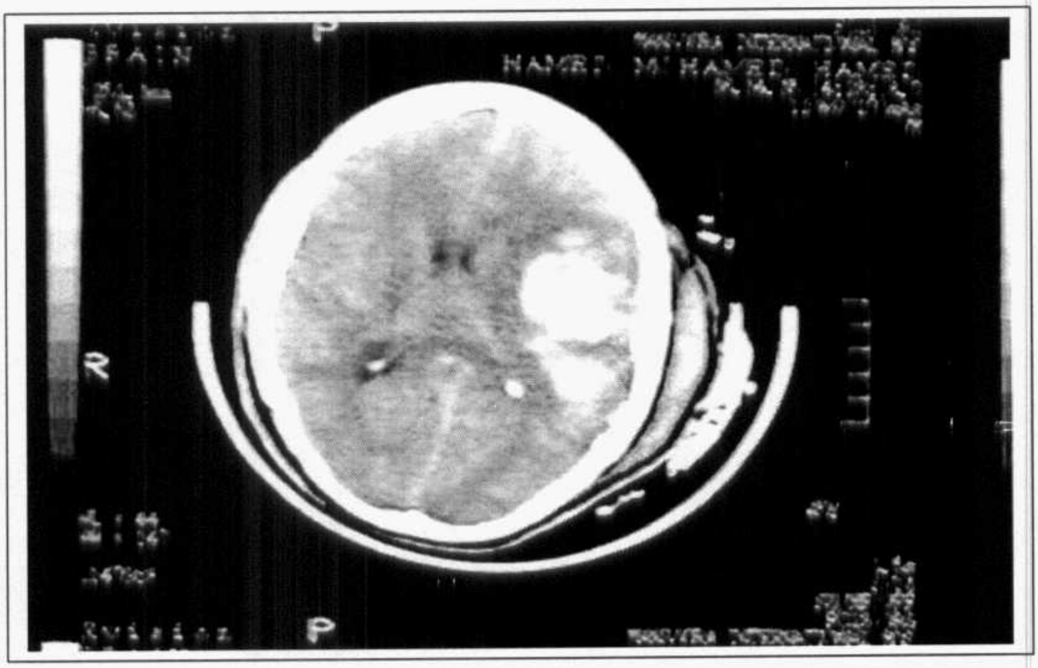


Fig (5): Axial CT scan of skull (brain window)

Fig (6): Axial CT scan of skull (brain window)

Diagnosis:-

Multiple comminuted depressed fractures of left parietal bone with intracerebelar haemorrhage.

CASE 3

A 3 years old female presented with head trauma after fall on the stair. On examination she was irritable with left parietal swelling.

Axial CT scan of skull and brain:

Showed comminuted depressed fracture of left parietal bone

Brain window study revealed small intracerebral haemorrhage in left parietal region with left parietal subgalial haematoma .

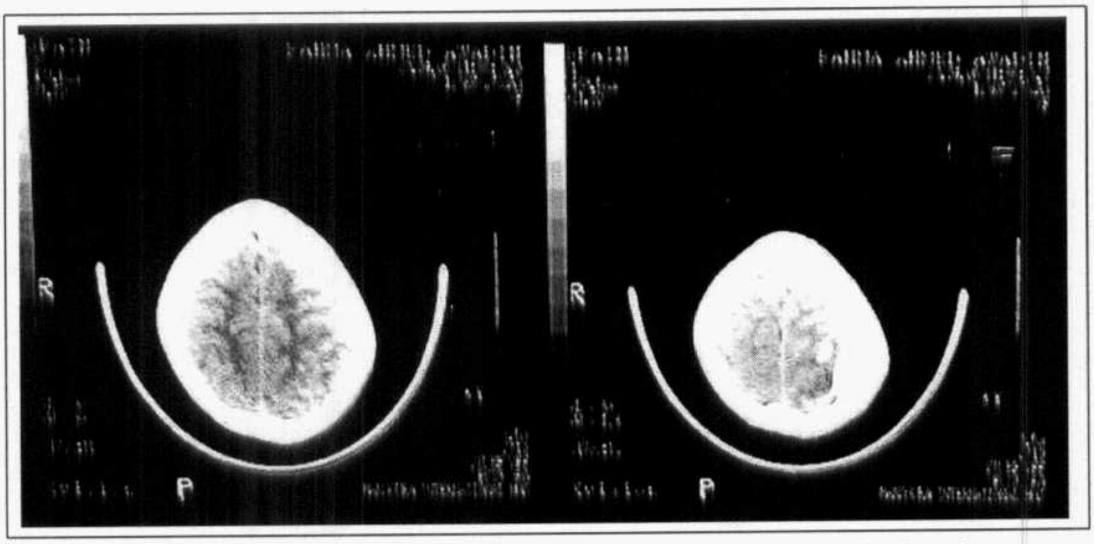


Fig (7): Axial CT scan of skull (brain window)

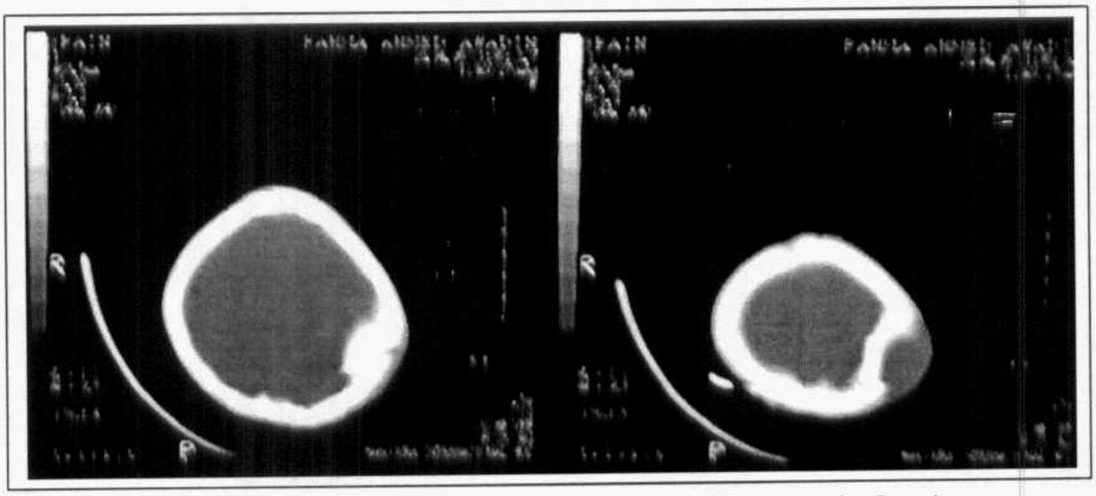


Fig (8): Axial CT scan of skull (bone window)

Diagnosis:-

Comminuted depressed fracture of left parietal bone with small intracerebral haemorrhage in left parietal region.

CASE 4

A 25 years old male presented with head trauma after car accident .On examination he was unconscious with frontal swelling .

Axial CT scan of skull and brain:

Showed multiple compound depressed fractures of frontal bone & fissure fracture to occipitomastoid suture.
Brain window study revealed cerebral contusion and multilacunae intracerebral haemorrhage to both frontal and temporal regions, with frontal subgalial haematoma.

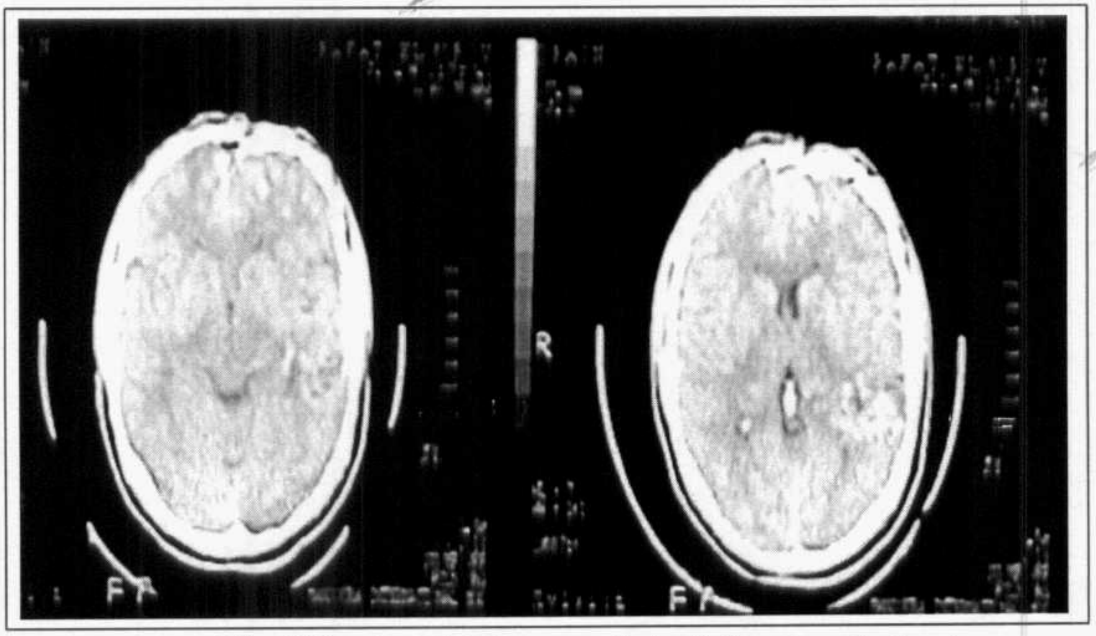


Fig (9): Axial CT scan of skull (brain window)

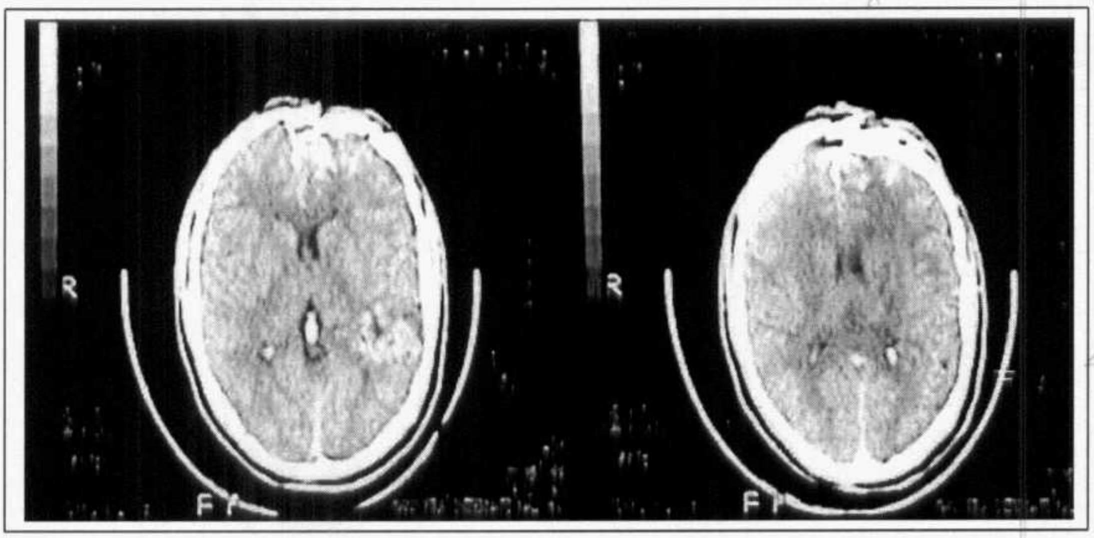


Fig (10): Axial CT scan of skull (brain window)

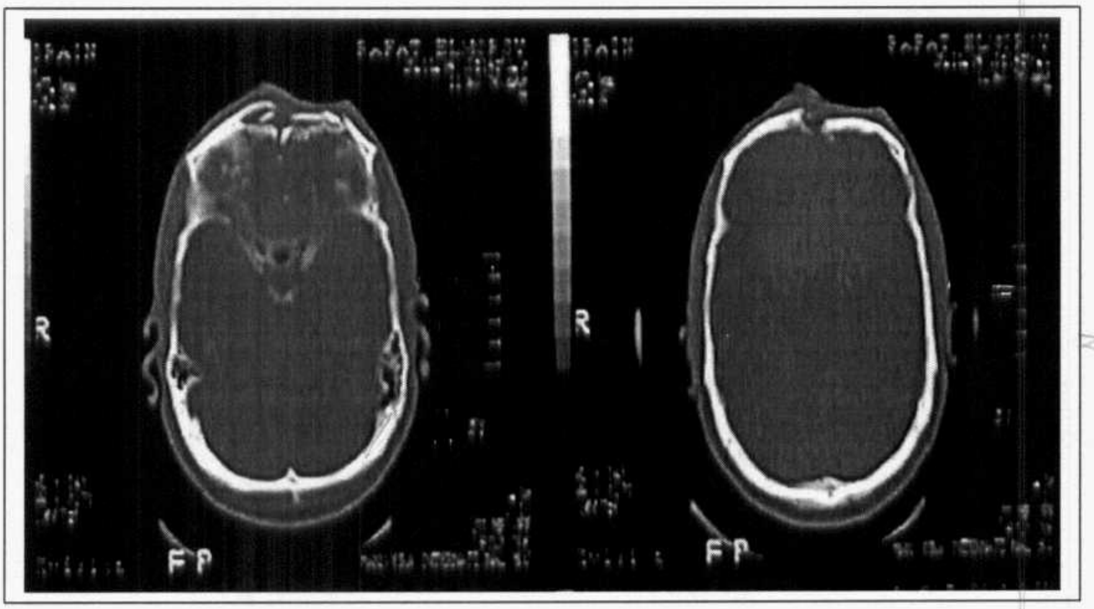


Fig (11): Axial CT scan of skull (bone window)

Diagnosis:-

Multiple compound depressed fractures of frontal bone & fissure fracture to occipitomastoid suture with cerebral contusion of both frontal and temporal regions.

CASE 5

A 9 years old female presented with head trauma after fall from 1st floor .On examination he was irritable with right frontal swelling.

Axial CT scan of skull and brain:

Showed linear fracture right side of frontal bone and right frontal sinus.

3-D reconstruction of facial bones:

Revealed better visualization of the extend, course and length of linear fracture involving the right frontal bone extending into the right superior orbital margin.

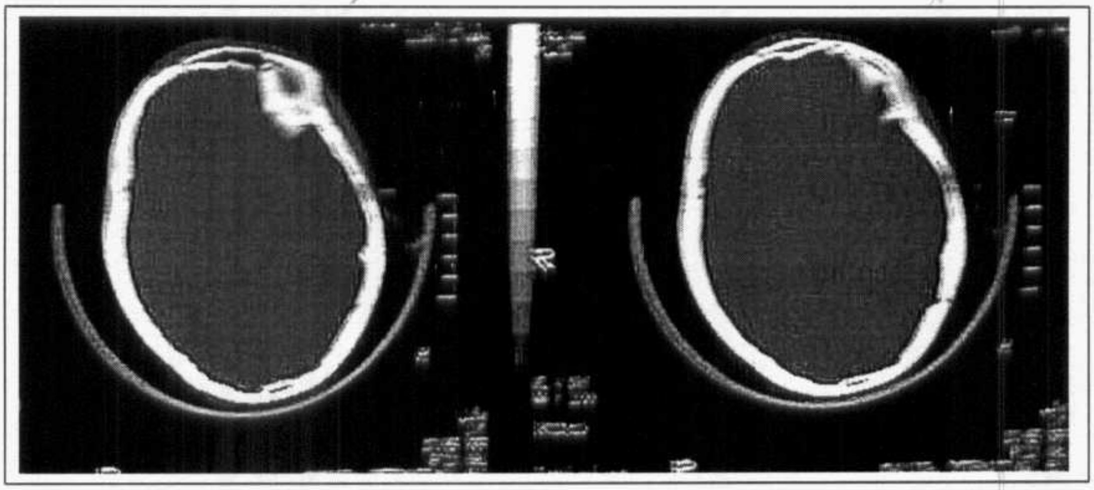


Fig (12): Axial CT scan of skull (bone window)

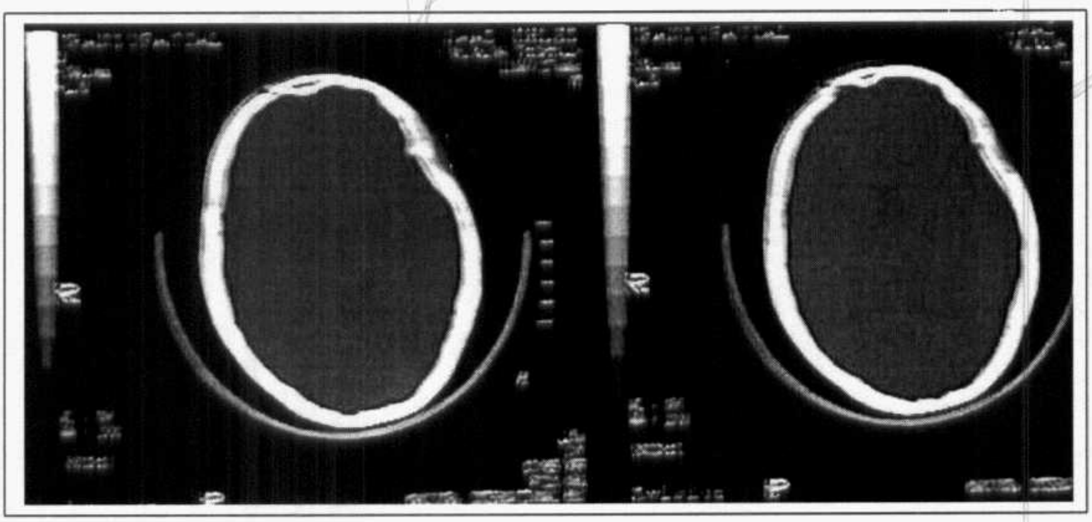


Fig (13): Axial CT scan of skull (bone window)

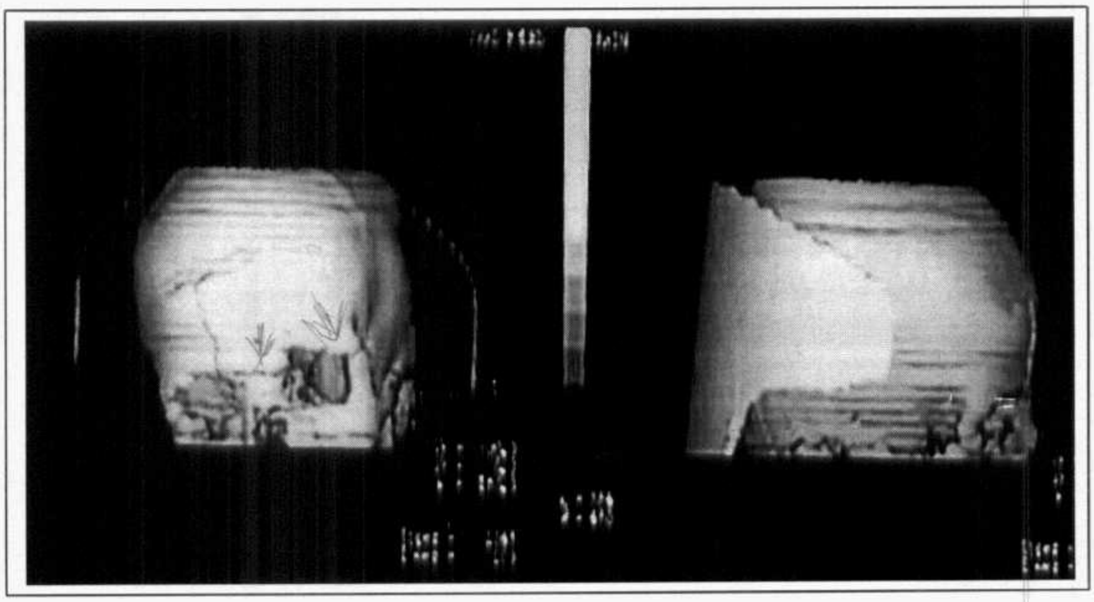


Fig (14):
3-D reconstruction of facial bones in frontal and right views

Diagnosis:-

Linear fissure fracture of right side of frontal bone.

CASE 6

A 72 years old male presented with head trauma after car accident .On examination he was comatosed with frontal swelling.

Axial CT scan of skull and brain:

Showed compound depressed fracture of frontal bone

Brain window study revealed multiple areas of intracerebral haemorrhage in right frontal and both tempropariietal regions, intraventricular haemorrhage in both posterior horns of lateral ventricles, subarachnoid haemorrhage and frontal subgalial haematoma .

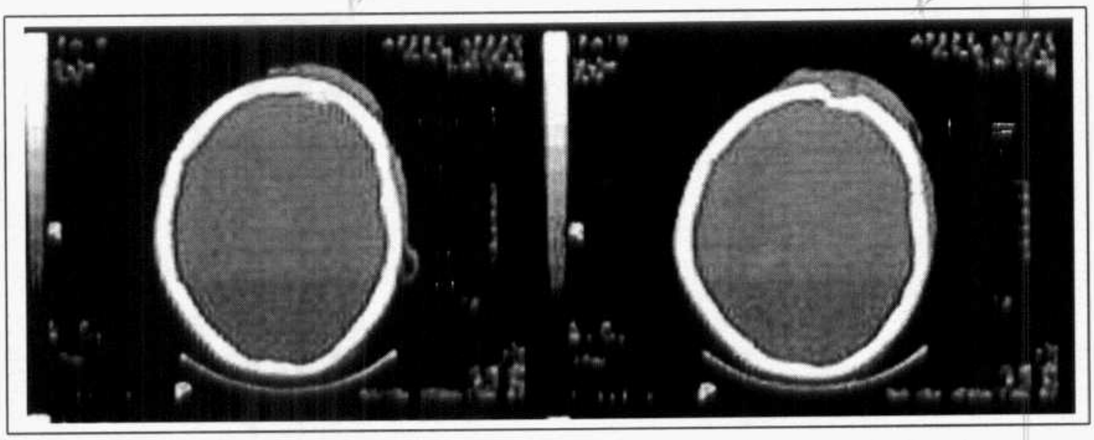


Fig (15): Axial CT scan of skull (bone window)

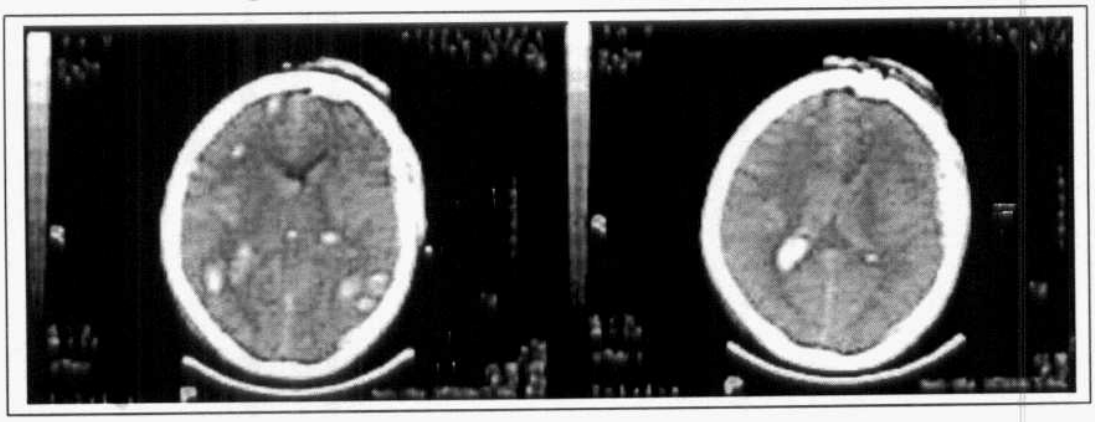


Fig (16): Axial CT scan of skull (brain window)

Diagnosis:-

Depressed fracture of frontal bone with intracerebral , intraventricular haemorrhage and Subarachnoid haemorrhage.

CASE 7

A 21 years old male presented with head trauma after car accident .On examination he was irritable with left side swelling of face.

Axial and coronal CT scan & 3-D CT reconstruction of facial bones:-

Showed multiple comminuted depressed fractures of both anterior and posterior walls of left maxillary sinus and high density fluid (blood) obliterating left maxillary sinus.

Other fractures was seen at lateral wall and floor of left orbit and left ramus of mandible proximal to T.M.J.

Fig (17): Axial CT scan of facial bones

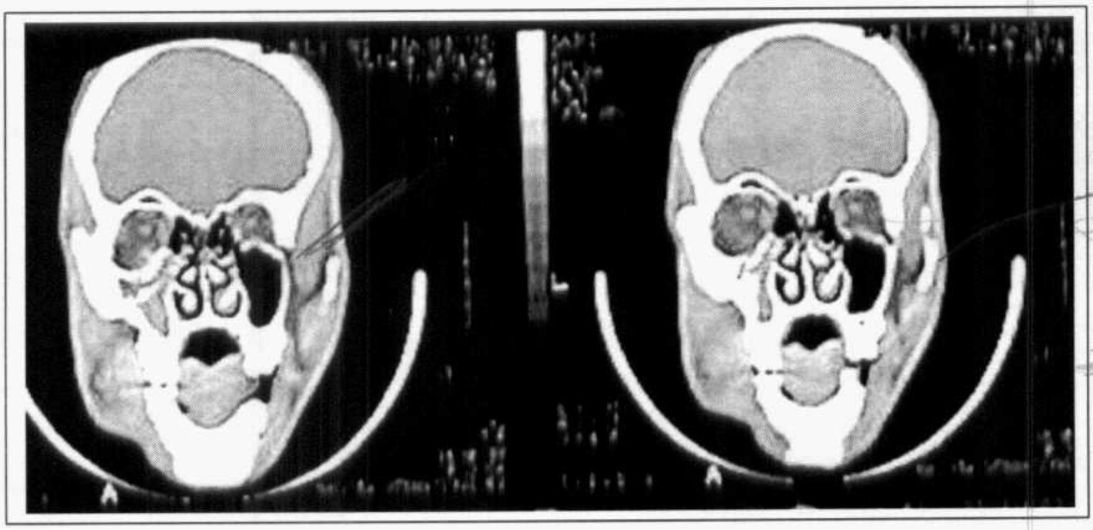


Fig (18): Coronal CT scans of facial bones

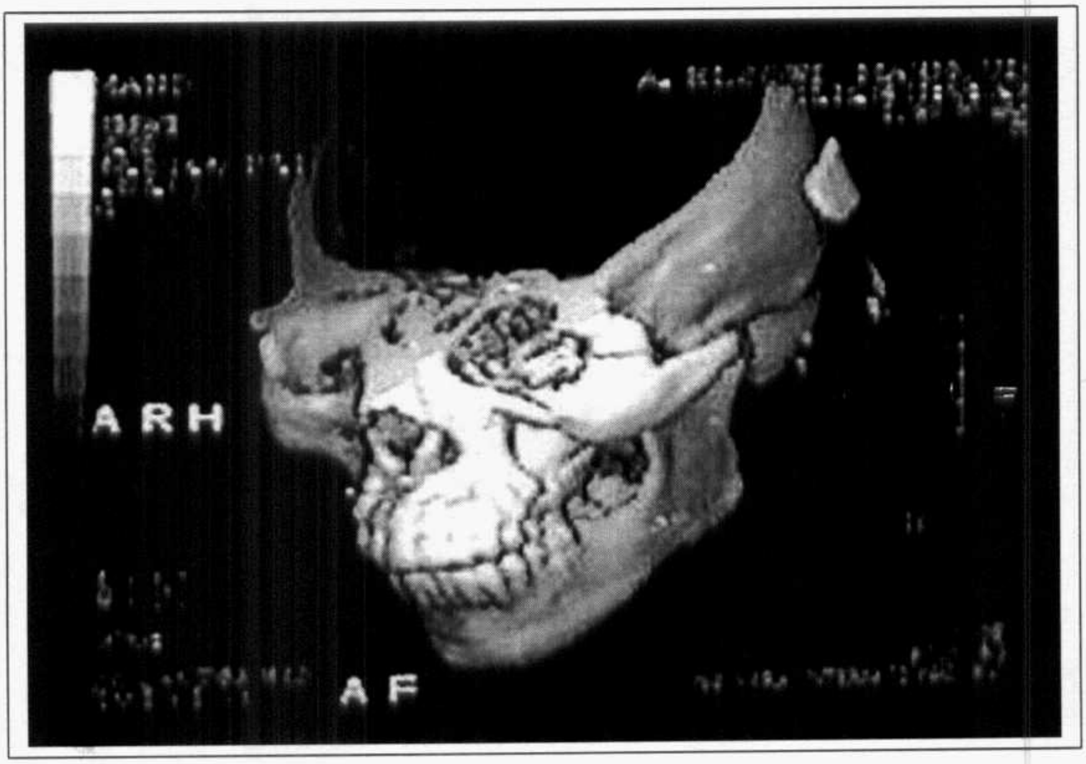


Fig (19): 3-D CT reconstruction of facial bones in left oblique view.

Diagnosis:-

Comminuted depressed and fissure fractures of mid facial bones.

CASE 8

A 22 years old male presented with head trauma after car accident .On examination he was unconscious.

Axial CT scan & 3-D CT reconstruction of facial bones:-

Showed multiple comminuted fractures of right zygomatic bone at zygomatic body.

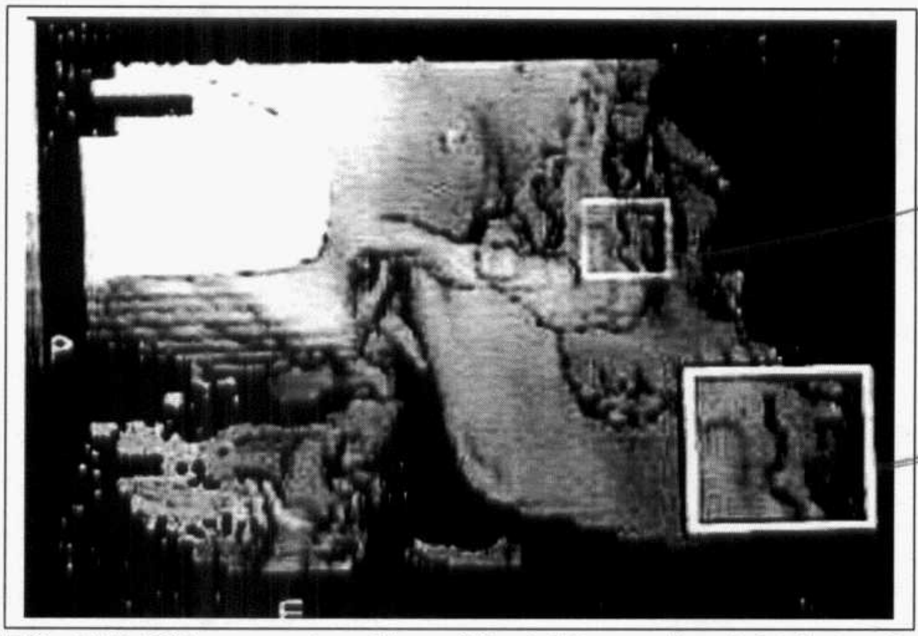


Fig (20): 3-D CT reconstruction of facial bones in right lateral view

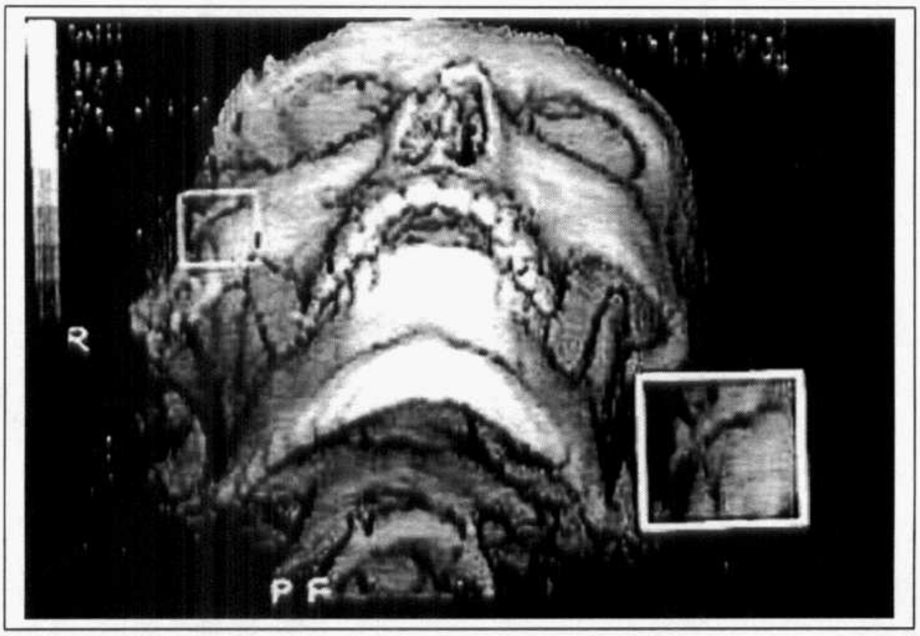


Fig (21): 3-D CT reconstruction of facial bones in antero-inferior view

Fig (22): Axial CT scan of facial bone

Fig (23): Axial CT scan of facial bone

Diagnosis:-

Multiple comminuted fractures of right zygomatic bone.

CASE 9

A 22 years old male presented with head trauma after car accident .On examination deformity was seen over his mouth.

Axial CT scan of the mandible:-

Showed fissure fracture to right side of mandibular body close to symphsis menti and other fracture to left mandibular angle.

Fig (24): Axial CT scan of the mandible

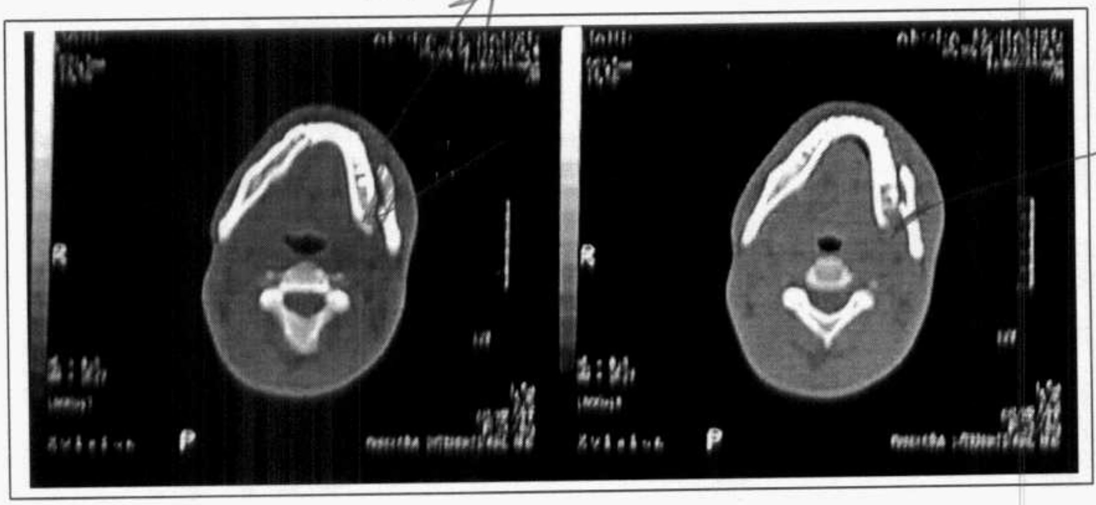


Fig (25): Axial CT scan of the mandible

Diagnosis:-

Multiple fractures of mandible.

CASE 10

An 8 years old male presented with head trauma after car accident .On examination he was unconscious with left occipital swelling.

Axial CT scan of skull and brain:-

Showed a linear fracture of left temporal bone and fissure fracture of occipital bone.

Brain window study revealed subdural haemorrhage with occipital subgalial haematoma.

Fig (26): Axial CT scan of skull (brain window)

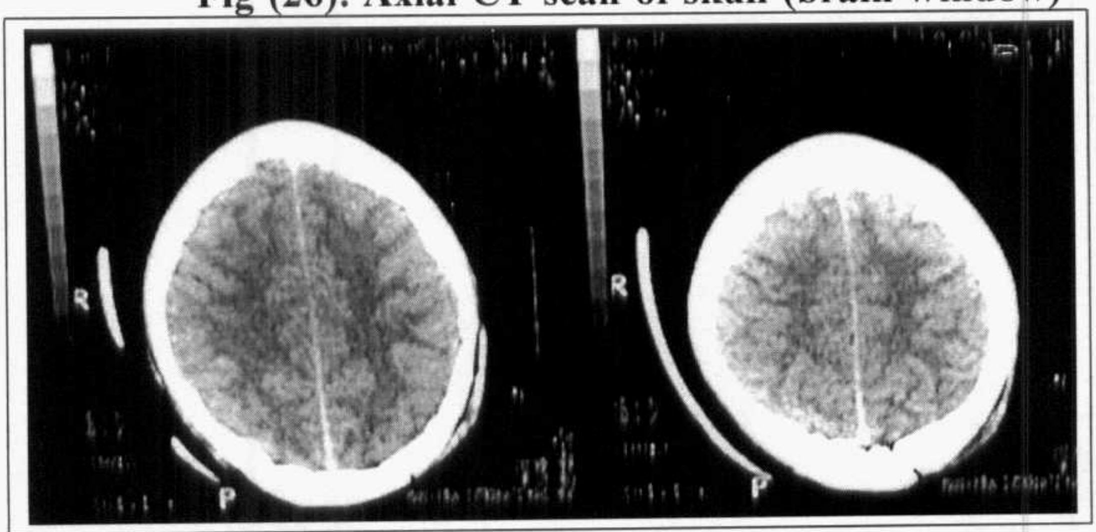


Fig (27): Axial CT scan of skull (brain window)

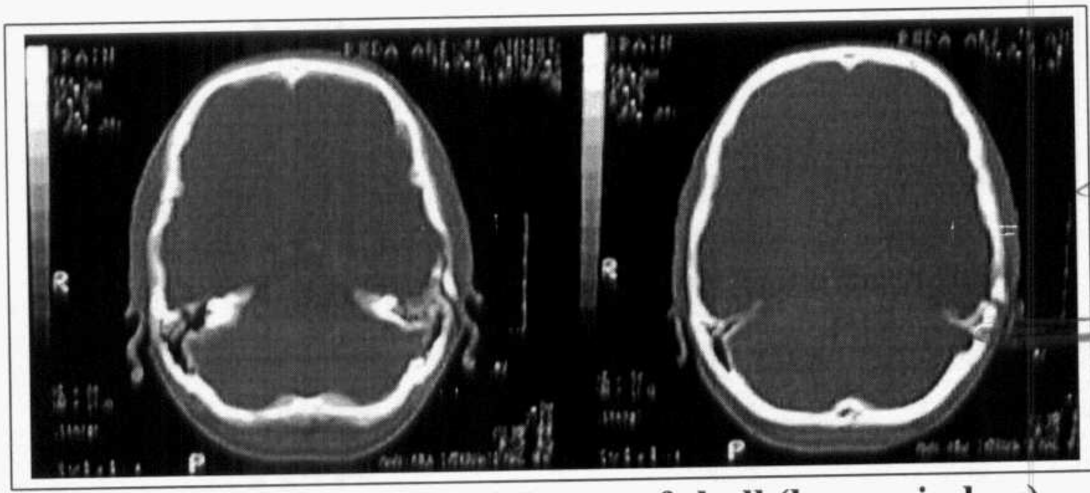


Fig (28): Axial CT scan of skull (bone window)

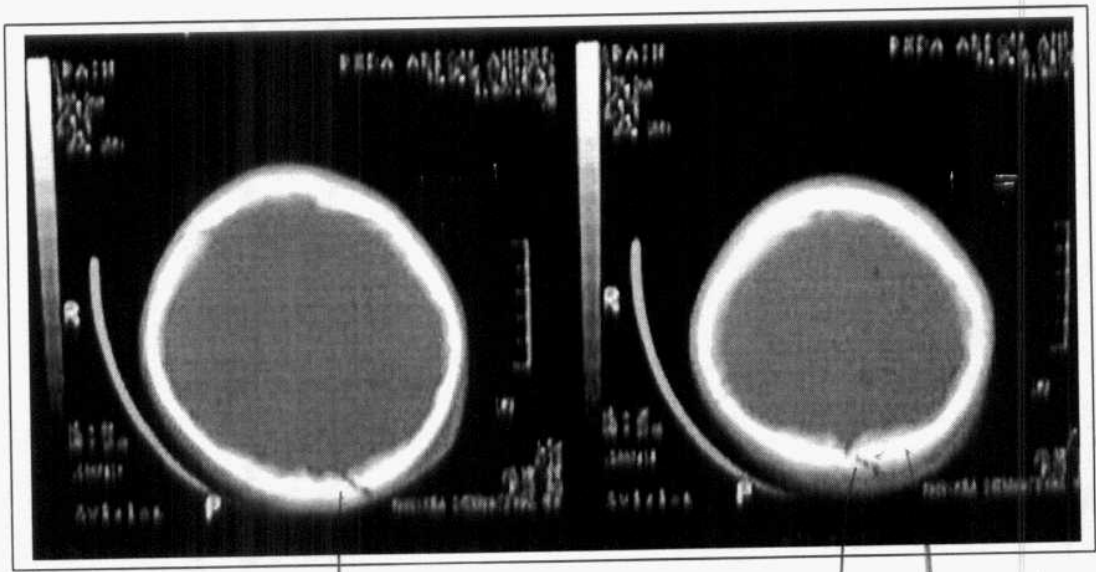


Fig (29): Axial CT scan of skull (bone window)

Diagnosis:-

A linear fracture of left temporal bone and fissure fracture of occipital bone, with subdural hemorrhage.

Discussion

□ Head injury is a major world health problem. Several reports point automobile accident as the most important cause of HT. Motor vehicle accident causes HT about 35% to 60% in diverse series, and is usually a leading cause of serious injuries with head trauma in youth and middle age people and a common cause of morbidity and mortality related to trauma. They are also the most frequent cause of death in individuals from 1 to 35 years of age. Previous studies of head trauma in the United States demonstrated traffic accidents accounting for about half the fatal cases. **(Castillo M, Harris JH 1999)**

□ It should be stressed that there is considerable controversy regarding the role of plain films vs. CT scans in craniofacial trauma. Although some radiologists feel that plain films are of little value, the emergency physician may find them a useful and cost-effective screen for facial fractures. CT provides far greater detail and assists surgical planning. CT is a vital tool in the assessment of patients with serious head injury, and revolutionized management when it was introduced. It remains the investigation of choice even following the advent of MRI, due both to the ease of monitoring of injured patients and the better demonstration of fresh bleeding and bony injury.

□ **Holland, Andrew J. et al (2001)** mentioned that the plain facial radiographs provided limited additional diagnostic information to careful clinical examination and often fail to detect or clearly define a craniofacial fracture. In the correct clinical setting, a facial CT scan allows accurate diagnosis of the injury and can reveal previously unsuspected additional fractures. CT is being utilized often in evaluation of craniofacial trauma. It is far superior to conventional pluri-directional tomography, since not only the complex fracture but also communication with the orbital or cranial contents can be demonstrated. The extend of soft-tissue trauma can also be better evaluated.

□ **Journal of Craniofacial Surgery (2002)** mentioned that the patients with head trauma constitute a large percentage of the cases referred for neuroimaging. Initially, the role of MR in these patients was considered limited due to the time required for the examination, difficulty in using life-support and monitoring equipment within the scanning room and problems in imaging acute hemorrhage. While some of these problems still remain, MR has come to be used more frequently in these patients, particularly in the subacute period.

Over the last decade, CT has become the primary diagnostic tool in the evaluation of the hemodynamically stable trauma patient. The primary goal in managing severe head injury patients is to preserve life and neurological function. The secondary goal is to identify intracranial lesions that will negatively affect outcome. CT is the method of choice for rapid, accurate evaluation of intracranial and craniofacial injury.

□ **Journal of the New Zealand Medical Association (2003)** mentioned that:-2307 patients were admitted with head injuries under the Neurosurgical Service over a 7-year period (1995–2002). Of these patients, 5% were documented as having an associated maxillofacial injury. Seventy-five percent of these patients were male. The average age was 27 years for men and 20 years for women, and the overall age range was 2–80 years.

□ The CT scan used in our study to assist in diagnosis of 50 patients with craniofacial fractures with age ranged between 2 years – 72 years.
All cases of craniofacial fractures detected using axial CT scan and seven of them evaluated using axial and coronal scan for

further diagnosis and four cases of craniofacial fissure fractures were detected using conventional ct scans, followed by 3d reconstruction technique in which 3D CT were very precise than conventional CT to detect the length, course and number of fissure as well as the spatial relationships to the surrounding bones.

This is consistent with **Bernstein et al. (2001),** who found that 3D is accurate in the display of craniofacial fissure fractures.

□ In this study, comminuted fractures were detected in 17 cases; cranial 4 cases, craniofacial one case, upper facial 5 cases, upper and mid facial 2 cases, mid facial 3 cases, temporal 2 cases. In these cases the degree of comminution, number of fragments, presence of associated depression and state of the surrounding bone, sinuses, brain, and eye balls were detected by axial CT scans & seven of them evaluated using axial and coronal scan for further diagnosis.

This is consistent with **Lee KF (1998)** who found that although computed tomography (CT) provides definitive diagnosis of complex craniofacial fractures, routine CT scanning is not necessary in every case of facial trauma. Axial imaging cuts horizontally through the face, and coronal images may be obtained either by a computer reconstruction or by true coronal imaging. While true coronals are more precise than their reconstructed counterparts, only patients whose cervical spines are cleared may place their head in the scanner at the angle required for these views. Computer reconstruction provides three-dimensional as well as sagittal and perisagittal images. While three-dimensional reconstructions are not necessary for the initial diagnosis of facial fractures, they are used in operative planning. The emergency physician does not need to order three-dimensional imaging, as the data collected in standard scanning may be reprocessed at a later time.

□ In this study, depressed fractures were detected 14 cases; 4cases cranial depressed fractures, 10 cases facial fractures. In these cases CT successful detected the degree of depression ,the shape of the depressed segment ,the state of the surrounding bone, sinuses, brain, , eye balls were detected and the deformity caused by such depression these preoperative data can improve the plastic ability to restore the craniofacial bones precisely.

This is supported by **Allan B Wolfson (2005)**, who mentioned that a depressed fracture is typically seen on a skull radiograph as a sclerotic line. The degree of depression may be appreciated on radiographs with a tangential projection but CT usually allows a more accurate quantification of the degree of depression. In general, depression of more than 5 mm is regarded as an indication for surgery.

□ In this study, fissure and linear fractures detected in 16 cases using conventional CT scan, four cases of craniofacial fissure fractures were detected using conventional ct scans, followed by 3d reconstruction technique in which 3D CT were very precise than conventional CT to detect the length, course and number of fissure as well as the spatial relationships to the surrounding bones.

This is in accordance with **Bullock R et.al (2001)** who mentioned that the Linear skull fractures are sometimes difficult to visualize on the individual axial images of a CT scan. The scout film of the CT scan, which is the equivalent of a lateral skull x-ray film, often demonstrates linear fractures. The intracranial sutures are easily mistaken for small linear fractures. However, the sutures have characteristic locations in the skull and have a symmetric suture line on the opposite side. Small diploic veins, which traverse the skull, may also be interpreted as fractures.

□ In this study , we found in 3 cases all type of fractures were presented in these cases, the degree of comminution, number of fragments, presence of associated depression , state of the surrounding bone and tissue were precisely detected.

This is supported by **Choi SC et.al (2000)** who declared that CT scanning is most valuable for the evaluation of complex craniofacial fractures, especially those involving the frontal sinus, nasoethmoidal region, and the orbits. Conventional CT scans accurately define these injuries. Patients who also need a CT scan of the head or who have clinically obvious periorbital fractures may undergo facial scanning without preliminary plain films. Finally, the facial CT should be deferred in patients who require surgery for a life-threatening injury.

□ During our study, conventional CT scan revealed multiple fractures of posterior maxillary walls and inner walls of orbits in 5 cases these fractures were not demonstrated by 3D CT.

This in agreement with **Lee KF (1998)**, who emphasized that 3D CT couldn't visualize inner orbital walls and posterior walls of paranasal sinuses, while conventional ct gives better visualization of the fractures of the internal orbital walls and paranasal sinuses.

□ In this study, five cases of mandiblular fractures were encountered in which CT scans precisely detected site, number of fractures lines and associated displacement as well as the relation of the condylar head to the glenoid fossa and articular eminence for detection of the resulting articulating disturbances.

This is in accordance with **Bullock R et.al (2001)** who mentioned that CT scan was also valuable than the standard x-ray films including panorama because it avoid overlap of anatomic structures.

And in agreement with **Journal of the New Zealand Medical Association 2003** mentioned that: - Computed tomography (CT) has been increasingly used in the examination of patients with craniofacial trauma. This technique is useful in the examination of the temporomandibular joint and allows the diagnosis of fractures of the mandibular condyle. Aiming to verify whether the three-dimensional reconstructed images from CT (3D-CT) produce more effective visual information than the two-dimensional (2D-CT) ones, we evaluated 2D-CT and 3D-CT examinations of 5 patients with mandibular condyle fractures. We observed that 2D-CT and 3D-CT reconstructed images produced similar information for the diagnosis of fractures of the mandibular condyle, although the 3D-CT allowed a better visualization of the position and displacement of bone fragments, as well as the comminution of fractures. These results, together with the possibility of refining and manipulating perspectives in 3D images, reinforce the importance of its use in the surgical planning and evaluation of treatment. We concluded that 3D-CT presented supplementary information for a more effective diagnosis of mandibular condyle fractures.

- During our study using CT scan of cranial region we found six cases with cerebral lesions as it give good details about degree of intracranial injuries and intracranial hemorrhage.

This is in accordance with **Kett-White R. et.al (2002),** who mentioned that CT scan - (after neurosurgical consultation) - useful for rapid diagnosis of suspected intracranial injuries and is the preferred investigation if clinical evidence of intracranial injury eg. -in abnormal / deteriorating conscious state. Clinical deterioration is usually an indication for repeat CT examination. So that A CT scan of the head should be obtained as soon as the patient's cardiopulmonary condition has been stabilized to determine the extent of intracranial damage and the presence of intracranial metallic fragments. The study always should include bone windows to evaluate for fractures, especially when the skull base or orbits are compromised.

And in accordance with **Johnson RM, McCarthy 2002** The availability of computed tomography (CT) scanning has been shown to reduce mortality in patients with acute extradural haematoma , as the time taken to diagnose and evacuate an intracerebral haematoma is critical in determining outcome. However, the majority of patients with brain injury do not have a lesion suitable for neurosurgical intervention. Recent guidelines have been produced in an attempt to improve outcome after severe traumatic brain injury. An understanding of the concept of secondary brain injury, caused by hypotension and hypoxia is fundamental and the treatment of a head-injured patient should emphasise early control of the airway (while immobilising the cervical spine), ensuring adequate ventilation and oxygenation, correcting hypovolaemia and prompt imaging by CT.

According to the studies of **(Castillo M, Harris JH 1999)** the accurate diagnosis of facial fractures has been greatly improved by the addition of two- and three-dimensional CT scans which have replaced the plain radiographs for the diagnosis of many types of fractures. The three-dimension- al reconstructions have enhanced pre-operative bone analysis and planning by providing a life-like simulation of the fractures. In acute trauma cases, the goal of reconstruction is a one-stage repair which has been made possible by the application of craniofacial techniques. Delayed treatment has been replaced by early or immediate surgical treatment and stabilization of small bone fragments augmented by bone grafts and miniplate fixation. These recent advances have allowed surgeons to approach and often reach the goal of restoring preinjury facial appearance and function while at the same time minimizing revisional surgery.
Without treatment in a timely manner, many individuals will develop future problems, the severity and consequences of which can be much greater than if the injury had been immediately repaired. However, modern craniofacial surgical

techniques can now offer hope for patients with pre-existing post-traumatic facial deformities despite considerable delays between injury, diagnosis, and treatment. These innovative techniques establish a higher standard of care for the management of facial injuries.

According to **Ohkawa et al.**, both 2D-CT and 3D-CT techniques have similar sensitivity for the diagnosis of fractures in the mandibular region. However, they also reported that the 3D-CT image allowed a better visualization. **Carls et al.** and **Rhea et al.** also observed that 3D images provide better identification and easier detection of specific characteristics of facial and cranial asymmetries, defects in the medial portion of the face and in the skull vault, and fractures associated with extensive bone displacement, which may affect different cranial sections. The present study, in which, in spite of the verification of 2D-CT and 3D-CT as similarly valid in the diagnosis of condylar fractures, the latter provided an improved examination of affected structures, is in agreement with these authors. The thickness of the sections, table feed, and reconstruction interval are some of the elements of a proper 3D-CT protocol, whose application permitted a better visualization of condylar fractures than 2D-CT images, from different angles, and a higher sensitivity when compared to the surgical observation. These images also permitted an overall visualization of the mandibular condyle, bone displacements and comminution of fractures. However, there are also restrictions to the use of 3D-CT images, which should not substitute, but should complement the 2D-CT technique. This observation accounts for the importance of further studies assessing the validity of 3D-CT images, before their widespread use can be adopted.

When performed under a proper protocol, both 2D-CT and 3D-CT presented similar validity in the diagnosis of condylar fractures. However, the 3D-CT technique produced images that allowed an improvement in the visualization of affected structures, which provided higher indicators of specificity in the identification of the anatomic localization of the fracture, and sensitivity in detecting comminution and bone displacement. Therefore, the present study reinforces the effectiveness of the 3D-CT technique as a supplementary procedure to the 2D-CT in the examination of the maxillofacial complex.

According to the studies by **Marcelo G. et al.(2004)** ,Spiral computed tomography (CT) is a powerful modality for evaluation of the musculoskeletal system, particularly when coupled with real-time, volume-rendering reconstruction techniques. Including volume-rendered spiral CT in routine musculoskeletal imaging protocols can change management in a significant number of cases. In cases of trauma, subtle fractures—particularly those oriented in the axial plane—are better seen on volume-rendered images. Complex injuries can be better demonstrated with volume-rendered images, and complicated spatial information about the relative positions of fracture fragments can be easily demonstrated to the orthopedic surgeons.

The use of intravenously administered contrast material allows simultaneous evaluation of osseous and vascular structures within the affected area. Evaluation of suspected infectious or neoplastic disease is also aided by including volume-rendered imaging in the musculoskeletal spiral CT examination. The extent of disease can be thoroughly evaluated with volume-rendered images, and therapeutic planning be it surgical or medical is aided by the anatomic information available from volume-rendered images.

Postoperative studies in patients with orthopedic hardware also benefit from volume-rendered imaging. Volume rendering eliminates most streak artifact and produces high-quality images on which the relationships among hardware, bones, and bone fragments are well demonstrated.
Conclusion: 3D computer graphics by spiral CT allowed sufficient precision for assessment of surgical management. Digital volumetric spiral CT imaging is valid quantitatively and qualitatively for craniofacial surgical planning and evaluation.

SUMMARY AND CONCLUSION

In this study, we aimed to demonstrate the role of CT scan in the evaluation of different craniofacial lesions.

In the course of our work we have described the embryologic development and CT anatomy of the skull and facial bones and the pathology of different craniofacial lesions .

This study was conducted on 50 patients. Their age between(2 - 72) years .all cases were subjected to clinical examination, CT scan and 3-D reconstruction was performed for 4 sub acute cases with fissure fractures .

CT scan was preformed in our study to diagnosis craniofacial fractures as it give good visualization of the extent and course of fracture lines, degree of comminution and number, size and direction of the displacement of fracture fragments and give good visualization of intracranial hemorrhage, degree of intracranial injuries, intracranial bone fragments and air entry. CT scan gives good images about paranasal sinuses, wall of the orbits and eye ball status.

From our study, we can conclude the following:-

1. CT of the head is now widely available and is performed in a relatively short time, at a reasonable cost especially when compared to MR imaging.
2. The exam shows some changes in bone better than any other imaging method.
3. It readily detects bleeding.
4. It provides detailed images of bone, soft tissue and blood vessels.

5. CT is the method of choice for rapidly screening trauma victims to detect intracranial bleeding or other life-threatening conditions.
6. CT is the method of choice to view the facial bones, jaw, and sinus cavities.

From our study we recommended that: - If CT is available, one should consider its use as a primary imaging modality for detecting craniofacial injuries, as the absence of skull fractures on plain X-ray does not exclude significant intracranial injury. Lack of a rapidly available CT scanner in the face of significant head trauma is a criterion for transfer of the patient to a trauma center. A non-contrast CT scan of the head can be used to rule out intracranial trauma, including skull fractures, subarachnoid hemorrhage, and lesions that require immediate surgical attention, such as intraparenchymal hemorrhage and extracerebral hematomas. Three window settings should be used: A narrow window width is used to evaluate the brain, a slightly wider window width will accentuate contrast between extra-axial fluid collections and the adjacent skull, and the skull is imaged with a very wide window.

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الباب الخامس: وبه النتائج.

الباب السادس: وبه حالات موضحة.

الباب السابع: وفيه تمت مناقشة نتائج هذا البحث مع نتائج الباحثين الآخرين الذين بحثوا فى هذا الموضوع سابقاً.

الباب الثامن: وبه الملخص والأستنتاج.

الباب التاسع: ويشتمل على المراجع.

ولقد وجد ان الفحص بالأشعة المقطعية الثنائية وكذلك الثلاثية الابعاد لها دورتوضيحى هام فى كسور الرأس والوجه والفكين والانف و الجيوب الانفيه حيث انها تعطى صورة موضحة لامتداد الكسور ومسارها ودرجة التفتت وعدد واتجاه الأجزاء المكسورة؛ كما وجد ان الاشعه المقطعيه ثنائية الابعاد تعطى صورة موضحة عن مدي تداعى الجيوب الأنفية وكذلك الجهاز العصبى المركزى .

ومما سبق يتضح ان استخدام الأشعة المقطعية الثنائيةوكذلك الثلاثية الابعاد ينصح بها في تشخيص صدمات الرأس والوجه لما لها من مقدرة فى التشخيص الدقيق الشامل لهذه الصدمات وتداعيتها فى نفس الوقت مايجعل الفرصة متاحة لأنقاذ هؤلاء المرضىوعلاجهم بالطريقه السليمه وتجنب المضاعفات وكذلك عمل تخطيط وتحليل لشكل العظام قبل اجراء الجراحات.

ملخص الرسالة

دور الأشعة المقطعية في تشخيص صدمات الرأس و الوجه

مقدمة :

التشخيص الدقيق لصدمات الوجه و الرأس أصبحت اكثر تقدما بعد ظهور الأشعة المقطعية ثنائية وثلاثية الأبعاد التي حلت محل أشعة اكس العادية في تشخيص العديد من أنواع الكسور؛ فالأشعة المقطعية ثلاثية الأبعاد قبل إجراء الجراحة ساعدت بشكل ملحوظ في التخطيط و التحليل لشكل العظام حيث أنها تضاهى لدرجة كبيرة الشكل الحقيقي للعظام .

الهدف :

توضيح دور الأشعة المقطعية في تشخيص حالات الاصابة بالرأس والوجه .

وقد اشتمل البحث علي الأبواب الآتية:

الباب الأول: وبه **المقدمة والهدف** من البحث.

الباب الثانى: ويشتمل على **وصف تشريحى ومقطعى** للوجه والجمجمة.

الباب الثالث: وبه وصف **الصفات المرضية** المختلفة الناجمة عن صدمات الوجه والرأس.

الباب الرابع:

ويشمل طرق الفحص: وقد أجريت هذه الدراسة على ٥٠ مريض مصابين بصدمات في الرأس و الوجه تتراوح أعمارهم بين ٢ - ٧٢ عاماً ولقد تم فحص هؤلاء المرضى اكلينيكياً وكذلك تم فحصهم بالأشعة المقطعية الثنائيةوالثلاثية الابعاد.

دور الأشعة المقطعية فى تشخيص صدمات الرأس والوجه

مقدمها

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