CHAPTER FOUR

THE SKULL

With the advent of CT imaging plain view studies of the skull have become almost passé. I am reminded of the day my youngest son asked me "what was it like in the olden days Dad?" He was about 10 years old at the time. Well in the "olden days" of radiology I can remember as a resident sitting in front of a view box for hours on end with a real skull in my hands and the standard skull views in front of me just to learn the radiographic anatomy. I don't think it's necessary to spend a lot of time on that for the non-radiologist, but maybe a few tips are in order for those who will not have immediate access to a scanner, and who may have to screen cases by the old fashion methods.

The checklist for the skull includes:

1-SIZE AND SHAPE
2-BASILAR STRUCTURES
3-SINUSES AND MASTOIDS
4-SOFT TISSUES
5-CALVARIUM (for abnormal densities, lines, fractures)

The size and shape of the skull are important in kids in looking for premature closures of the sutures and in excluding hydrocephalus. Another one of the few measurements still valid to help you decide whether or not the skull size in an infant or child is normal is the cranial-facial index. Figure 101 gives the essentials.

Figure # 101. (above and left). AB+GH+JK divided by CD times 10 should give you a normal cranial-facial index of between 50 and 55. Measure the lines from the inner tables of the skull. The line CD is measured from the medial margins of the mandibular condyles. The line EF extends from the nasion to the opisthion, and the line GH is drawn at right angles from EF to the vertex of the skull. Anything over 55 is suspicious for hydrocephalus. Anything under 50 suggests premature closure of one or more of the sutures or some anomaly.
It’s also true that an infant’s head may be large with normal ventricles, or normal size with large ventricles (hydrocephalus), but these cases are unusual. The C-F index is a pretty good screen in borderline findings, when identification of abnormal head size is clinically not readily apparent.

Figures 102-105 show cases of hydrocephalus and premature closure of one of the sutures, which effects the shape of the skull.
Using the numbers in figures 102 and 103:
8.6 + 7.1 + 9.7 = 25.4.
25.4 divided by 4.3 = 5.9
X10 = 59. (Red arrow shows air in the lateral ventricles.)
The c-f index is above 55!

Figure # 105 (right). White arrows point to a segmental area of premature closure of the sagittal suture in a child. Over half (55%) of premature closures involve the sagittal suture. Note the distortion of the orbits and sphenoid wings as a result. The coronal, sagittal, and lambdoid sutures ordinarily persist throughout childhood.

Figure # 105a (left). Multi-slice reformatted CT images make the diagnosis of a left unilateral coronal suture synostosis much easier. “The speed of MSCT enables the completion of most pediatric work, including 3-D imaging, without sedation” Courtesy Diagnostic Imaging supplement sponsored by an educational grant from GE Medical Systems. November 1999.
Evaluation of the basilar structures includes a look at the sella turcica and surrounding structures, region of the dorsum sella, optic chiasm area, the petrous portions of the temporal bones including the acoustic canals, the orbits and orbital foramen. The other basilar foramen including the foramen magnum, the jugular and others require a submental vertex view and are more the prerogative of the diagnostic or neuroradiologist.

If you are interested however remember ROS for foramens rotundum, ovale and spinosum (from anterior to posterior). The foramen lacerum through which the internal carotid artery passes is adjacent to the jugular.

The sella is probably best evaluated in a lateral view and although measurements can be made, a cursory look will usually define any gross abnormality as shown in figure 107 below.
The basilar structures also include the acoustic canals, and the student interpreter should make a definite effort to look for them. They are easily seen on plain films in the Towne’s projection and also in a modified AP projection where the petrous ridges are seen projected through the orbits. They are, however, best seen by CT or MRI studies as illustrated in the next few images.

Note the normal acoustic canal on the right side (red arrows) as outlined in a Towne's projection of the skull in figure 108, as opposed to the expanded lucent area (black arrowheads) at the origin of the left acoustic canal. Here you are looking for asymmetry as shown in this patient with suppurative middle ear infection.

Figure # 108 left). Normal acoustic canal on the right (red arrows). Acoustic meatus on the left is normal (yellow arrows), but the area of the labyrinth is expanded (black arrowheads). We have outlined the acoustic canals, meatuses, and the lytic area on the left in the next illustration.

Figure # 109 (left). Red arrows point to the acoustic meatuses. Blue arrows indicate the acoustic canals and the black arrow and open arrowheads show the pathologic lytic area of suppurative labyrinthitis. Patients with an acoustic neuroma would usually show an expanded canal or meatus. Look for asymmetry!
Figure # 110 (left). CT study showing asymmetry of the acoustic canals. Note the widened meatus on the left (red arrows) compared to the normal on the right (blue arrows).

Figure # 111 (below). The MRI study on this same patient shows the cause of the expanded acoustic meatus, an acoustic neuroma! (green arrow).
The sinuses are probably best evaluated by coronal CT images, but for our purposes the Water’s view of the skull will suffice. In this projection a couple of tips include comparing the density of the frontal sinuses to the density of the orbits. They should be about the same in the normal individual. Also be sure to look at the thin lines of the floors of the maxillary sinuses. Note the subtle but real difference in the normal versus a patient with membrane thickening as demonstrated in figures 112-114. Of course it’s easy to spot the air fluid level.

**Figure # 112 (left).** Water’s view of the paranasal sinuses. This particular image shows normal maxillary sinuses. Note the thin walls and roof of the sinuses (red arrows). Compare to the findings in image # 114.

**Figure # 113 (right).** Normal Water’s view of the sinuses. Black arrow points to orbital rim. Note the comparable densities of the frontal sinuses (blue arrow) to the upper part of the orbits (red arrow).

**Figure # 114 (right).** Water’s view of a patient with acute maxillary sinusitis. Note the thickened membrane (red arrows) and the air-fluid level (blue arrow). The left maxillary sinus also shows polypoid thickening of the membrane of the floor of the sinus (green arrow). Be careful in this projection that the upper lip projected over the floor of the maxillary sinuses doesn’t fool you!
Also remember that the maxillary sinuses are aerated in infancy and deciduous teeth sometimes obscure the floors. Careful analysis can usually separate normal from pathologic in this situation.

The mastoids are also best evaluated by high resolution CT, but screening for abnormal conditions can be helpful by a quick check of the Towne’s and Waters’s views. Note the loss of normal mastoid aeration in this patient with acute sclerosing mastoiditis shown in figure 115.

Figure # 115 (left). Close up views of the left and right mastoids in a patient with acute sclerosing mastoiditis. Note the relatively normal mastoid air cell outlines in the section to your left as you face the page, compared to the sclerotic cells on the right. If the acute infectious process progresses, there will be cell wall destruction and coalescence of lytic bone destruction as shown in the next illustration.

Figure # 116 (right). Black arrows outline an area of lytic bone destruction in a patient with acute coalescing mastoiditis in this close-up view of the mastoid area, (very similar to the case shown in figure 108).
Bright lighting the soft tissues surrounding the skull is useful to help locate sites of trauma such as is demonstrated in figure 117 in a newborn with cephalhematoma.

![Figure # 117 (left). Close up of a Towne’s view of the skull showing a cephalhematoma (red arrows) in a newborn.](image)

Probably the most useful clues to screen for fractures of the skull include a look for lucent lines that are straight and that don’t terminate in a venous lake, comparison with the opposite side of the skull for symmetrical lines (sutures), and bright lighting the scalp to look for soft tissue swelling or hematomas.

![Figure # 118 (left). White arrow indicates a normal diploic vein in this lateral view of the skull. The red arrows point to normal venous lakes.](image)

![Figure # 119 (right). White arrow shows a transverse fracture, left side of the skull. Note the sharper edges compared to the diploic vein in the previous illustration. Also there is no apparent venous lake.](image)
On occasion there will be a line of increased density when a skull fracture is depressed or there are overlapping edges. These findings are illustrated in figures 120-121.

Finally, there are a few Aunt Minnies to be learned in evaluation of the skull. Some of the common ones are shown in the following illustrations.
The other (lytic) form of Paget’s disease, osteoporsis circumscripta, is not necessarily an “Aunt Minnie”. Note the difficulty of distinguishing osteoporosis circumscripta from metastatic bone disease in the next two figures.

**Figure # 122 (above).** The four characteristics of Paget’s disease (which you should memorize) on a radiograph of any bone are 1-Thickened cortex. 2-Course trabecular pattern. 3-Dense bone (therefore whiter on a film). 4- Soft bone (therefor sometimes deformed). Note the marked thickening of the cortex in the above figure as indicated by the white arrow and black line. Also note the increased density of the bone compared to the normal skull in figure 117. The coarsened trabecular pattern may require a magnifying glass to detect since there are few areas that have not progressed to coalescence of dense bone in this particular case.

**Figure # 123 (left).** Lytic frontal bone area (red arrows) is due to osteoporosis circumscripta. 
**Figure # 124 (right).** Lytic frontal bone area (blue arrows) is due to metastatic thyroid carcinoma!
Granted that multiple punched out areas of the skull as shown in the figures above do not constitute a 100% Aunt Minnie, but the differential includes multiple myeloma and should be your first choice in patients of the right age group. In fact, radiologists will often request a lateral view of the skull if a lytic bone lesion is seen elsewhere in the skeleton of patients over the age of 50. Results like these will usually clinch the diagnosis even before laboratory confirmation!

Photomicrograph at x40 of a patient with myeloma. The punched out lesions seen in the previous skull radiograph are caused by increased osteoclastic response that is stimulated by cytokines released by the sheets of plasma cells shown in the section to your right. Erosion begins in the intramedullary space and progresses through the cortex to cause the lytic lesions. Only patients with complete remissions experience any bony healing.

Image courtesy of Bonetumor.org via the Internet.
Lytic, punched-out lesions of the skull in youngsters are almost “Aunt Minnies” as shown in the next two illustrations. If the lesion involves the outer table and has associated soft tissue localized swelling, then epidermoid cyst would be likely. Of course a rare metastatic lesion cannot be totally excluded, but would be unlikely in an asymptomatic patient. You won’t be confused by surgical defects (burr holes) once you’ve seen a few of them, but there are some other rare lesions that can mimic histiocytosis x. Check out the list in Felson’s and Reeder’s *Gamut’s* book.

Figure # 129 (left). The hair-on-end appearance seen here is the result of widened diploic space due to hyperplastic marrow seen in certain kinds of anemia. With erythroid hyperplasia the marrow may perforate the outer table. Stimulation of the periosteum then causes new bone formation, which arranges parallel to the marrow vessels, which are perpendicular to the table. This results in the hair-on-end appearance seen here. This particular case represents sickle cell anemia, but thalassemia develops this picture more frequently. The appearance is an “Aunt Minnie” for erythroid hyperplasia.

Figures # 127 (left) and 128 (right) are examples of histiocytosis x. The lesion on the right (red arrow) represents eosinophilic granuloma. If there is more than one, think Hand-Schuller-Christian (blue arrows) or Letterer-Siwe disease.
Figure # 130 (right). Fibrous dysplasia is a complicated entity in which fibrous tissue replaces bone. It has no definite known etiology and can present in the skull as sclerotic or lytic forms. The dense basilar sclerosis seen here is typical of enchondral bone involvement. The disease generally affects youngsters.

Figure # 131 (left). The broad area of relative lucency demonstrated here (arrows) is an Aunt Minnie for leptomeningeal cyst. The appearance results from a fracture in which the meninges get caught between the edges of the fracture preventing union. Thus diastasis occurs, the edges resorb and the space fills with fluid creating the cyst. Image courtesy of the U. of Utah via the internet.
Figure # 132 (left). The hammered metal appearance of the calvarium seen here is an Aunt Minnie for exaggerated digital markings sometimes called lukenschadel. It represents a normal variant. It should not be confused with lacunar skull or craniolacunia shown in figure 133 below.

Figure # 133 (left). Example of craniolacunia in a newborn. Note the similarity to the appearance of lukenschadel in the previous illustration. The difference is that this pattern is localized and may be associated with widened sutures, sellar demineralization or other signs of increased intracranial pressure. There may be absence of bone in the thinner (more lucent) areas. This appearance in a neonate is a sure Aunt Minnie for lacunar skull and is almost always associated with Arnold Chiari malformation, encephalocele, or spinal menigomyleocele. Image credit Barton Lane, MD, Radiologic Clinics of North America, Vol.XII, no.2, August, 1974.
Here are some more “Aunt Minnies” taken from Keats which are normal findings with which you should be familiar.

**Figure # 134 (left).** Small black arrows point to heavy calcification in the falx cerebri, a normal variant.

**Figure # 135 (right).** Calcification in the Choroid plexus of each lateral ventricle is another normal variant.

**Figures # 136 and 136a (below).** Black arrows indicate the presence of hyperostosis frontalis interna, another “Aunt Minnie” of no clinical significance in most cases.
A final review, then for your system in reading the skull is:

**Size and shape**

**Basilar structures**

**Sinuses and mastoids**

**Soft tissues**

**Calvarium for densities, lines, fractures.**

Get familiar with the normal appearance of the sella, the mastoids and sinuses, the acoustic canals, and the normal thickness of the calvarium cortex. There are some natural variations. Only by recognizing normal, will you feel confident in raising the question of abnormal! The interpretation of plain films of the skull is not easy, and diagnostic radiology consultation is indicated in all cases.