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OSTEOMYELITIS OF THE SKULL

EDGAR F. FINCHER, JR., M. D.,

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THE skull is not as commonly invaded by pyogenic organisms as some of the other bones in the body, yet osteomyelitis of the skull is far more frequent than is generally recognized. A review of the literature does not support the latter part of this statement. There are many individual case reports, the majority of which are to be found in the otolaryngologic journals, but the recording of the problems that have confronted the general or neurologic surgeon has been somewhat neglected. This can not be because of the results, for certainly the treatment of these cases has been gratifying and may be listed along with other surgical triumphs. Already from a limited experience, the early complete excision of infected skull has repeatedly demonstrated the value of radical surgical efforts. The involved etiologic factors themselves, omitting the specific causative organisms, offer sufficient subject matter for the basis of a thesis. These etiologic influences are usually easily established in a carefully developed history. In lieu of a number of detailed facts concerning the development, course, treatment and results, individual case reports of variable etiologic background will be given, illustrating the problems and management of these cases. It is hoped that these illustrative cases will serve to prompt earlier recognition of osteomyelitis of the skull, thus permitting earlier treatment and preventing sequelae and complications which in themselves are more dangerous than the primary disease.

CASE 1.—Osteomyelitis of the left frontal bone, secondary to a frontal sinus infection. Radical excision of all diseased bone. Cured.

History: A boy, aged 15 years, referred by Dr. Francis F. Belcher, of Monticello, Ga., entered the Piedmont Hospital on Oct. 30, 1930. Six weeks before a frontal sinus infection had been drained with some relief from pain. Two weeks later a radical frontal sinus operation had been performed. X-ray studies of the infected sinus revealed necrosis of the adjacent frontal bone. Following the sinus operation the patient was referred for treatment.

Examination: Neurologic examination was negative. Over the right eyebrow there was a 3 cm. linear scar which had not completely healed. There was a small draining sinus in the upper margin of the right eyelid. The involved frontal bone is depicted in Figure 1.

Treatment and Course: On October 31, all diseased bone was rongeuired away. On December 20, the patient was discharged from the hospital. The wound had healed by secondary intention. Figure 2 shows the bone defect after operation.

Read before the Seventh Annual Assembly of The Southeastern Surgical Congress, in New Orleans, March 9, 10 and 11, 1936.

This first case represents one of the most common types of skull infection encountered, namely, an osteomyelitis complicating a sinus infection. Before sketching the historical background of this subject there are several facts in reference to this first case that are worthy of mention. Only six weeks had elapsed from the onset of the sinus infection until a radical skull excision was carried out. The early recognition of the disease permitted a minimal sacrifice of bone. The infectious process had not progressed sufficiently to affect ma-



Fig. 1. Case 1. Osteomyelitis of frontal bone, secondary to a frontal sinus infection.

terially the patient's general health thus permitting a surgical latitude attended by little risk. Certainly in some cases the intracranial involvement must develop along with the bony disease. On the other hand complications do arise when the disease in the skull goes untreated. This first case illustrates the results following radical efforts in a simple case and is offered for comparison with the subsequent cases where longer periods of time elapsed before the diagnosis was established and proper treatment instigated.

Osteomyelitis of the skull is no new subject but the scarcity of literature would lead one to believe that it is a rare condition. Hippocrates called attention to skull diseases arising from infected

scalp wounds. After Percival Pott's description, in 1778, of local skull necrosis resulting from compounded skull injuries, focal skull infection without an opened scalp became known as "Pott's puffy tumor." In 1923 Fleming¹ brought out the more salient facts concerning the development of infection in the skull bones. His case reports are primarily those of traumatic origin. He stressed that the disease was much more common than was generally recognized and also emphasized that the course of the disease might be long drawn out before any localization was evident.

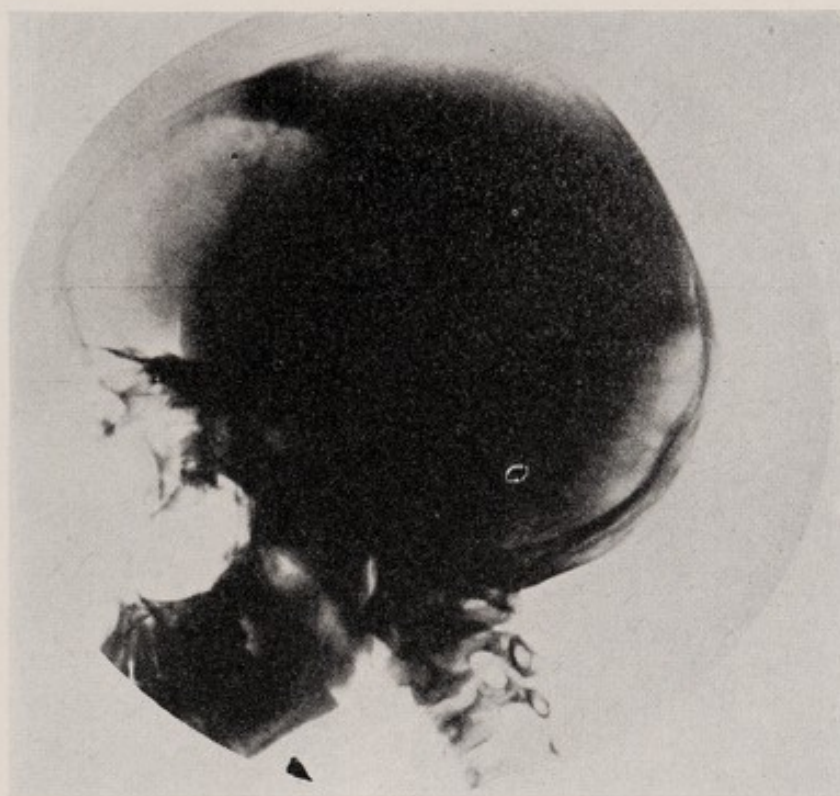


Fig. 2. Case 1. Illustrating the bone defect after radical excision.

In 1930 Woodward² reported an osteomyelitis of the skull secondary to frontal sinus infections. He stressed the necessity for bacteriologic studies in these cases and in that the majority of the organism was *Staphylococcus pyogenes aureus*, he felt that the treatment might well be standardized. In 1933 Adson³ emphasized the necessity of radical efforts in the surgical management of these cases. In this same year Adelstein and Courville,⁴ offering a classification, discussed the anatomic facts and mode of entrance of the organisms as influencing the course of the disease. They concluded that conservative surgical intervention was preferable in the treatment of osteomyelitis of the skull but that radical efforts might be necessary for the sequelae or complications. They too based their studies on cases of traumatic origin. Listed among individual case

reports are innumerable cures following radical efforts. Other articles deal with the mode of spread and development of the infection. There are a few publications on the roentgenographic changes in the skull that follow pyogenic destruction. There are, however, no case reports of any therapeutic efforts utilizing the maggot treatment introduced by Baer in treating osteomyelitis of other bones.

CASE 2.—Osteomyelitis of the right parietal bone subsequent to an injury. Radical excision of all infected bone. Secondary healing. Cured.

History: A man, aged 29 years, referred by Dr. Earl Campbell, of Chattanooga, was admitted on Sept. 7, 1934. Three months before he had struck the right side of his head. He suffered considerable pain at the time of the injury and from then on he had continued to have pain in the right parietal area from time to time, with a tendency for the pain to radiate into the temporal region. Two months after the injury a swelling of the scalp developed in the painful area. When fluctuation was evident incision was done and the pus drainage gave relief. X-ray studies at this time revealed no bone destruction. Ten days after drainage, the scalp wound sealed and pain returned. The wound was reopened with little drainage but a roughening of the outer skull table was disclosed. X-ray studies at this time showed definite bone necrosis and patient was referred for treatment.

Examination: Neurologic examination was entirely negative. There was a small draining sinus in the right preauricular area, about which there was an edematous tender scalp. The cervical glands on the right side of the neck were swollen and tender. X-ray studies showed a mottled bony necrosis in the right parietal region over an area some 4 to 5 cm. in diameter.

Treatment and Course: On Sept. 8, 1934, through a crossed scalp incision, all of the diseased bone was removed. The wound healed by secondary intention and he was discharged from the hospital on Oct. 1, 1934. Until complete epithelialization his dressing was continued. Figure 3 is a photograph of the X-ray studies made three months after operation. There has been no further discomfort or evidence of bone disease.

The rapidity with which pyogenic destruction of the skull may progress must depend somewhat as do other infections upon the resistance of the individual as well as the virulence of the invading organisms. There are, however, anatomic facts responsible for the frequency with which certain bones of the skull are affected in preference to others. These responsible anatomic facts are primarily the location of the accessory nasal sinuses and the vascularity of the individual bones that make up the skull. Another influencing factor in the spread of the bone disease is the presence of periosteal partitions between the individual bones of the skull. These are present in children but with age the sutures become firmly knitted and the skull may be considered as one large flat bone. With these facts in mind it is easy to understand the frequency of frontal bone infection. The temporal bone, as may be reasoned, is the second most common site for the appearance of osteomyelitis of the skull, with

the occipital bone the least susceptible. In those cases that develop from or as a part of an accessory sinus infection the rapidity of spread is greater and usually more rapid than in those instances developing from compounded skull injuries. In cases where the skull invasion is a development in a systemic bacterial disease the necrosis, as might be anticipated, is more patchy, extensive and rapid than in those rare instances where the skull bones are involved in the course of osteomyelitic infections elsewhere in the body. In

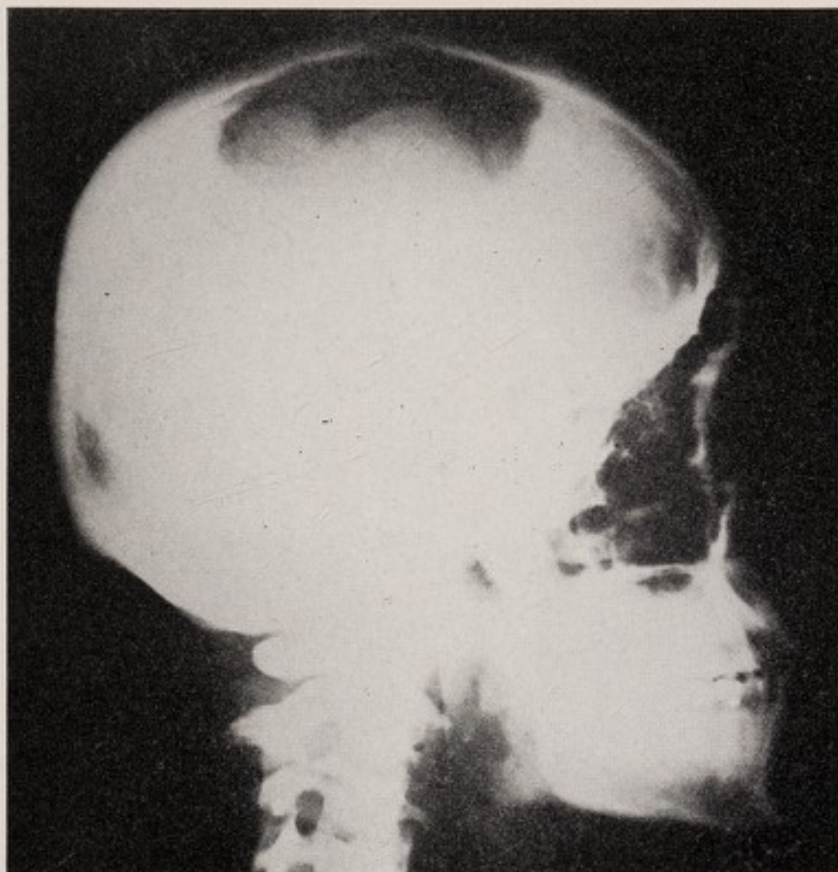


Fig. 3. Case 2. The bony necrosis before this complete excision was of a diffuse rather a circumscribed character.

these cases which develop skull infection from trauma with no scalp wound, as is illustrated in this last case, the involved bone may be fairly discrete, remaining as such, or the x-ray studies may depict multiple necrotic areas confined to a relatively small portion of the skull. As a group such bone destruction extends comparatively slowly in these cases.

CASE 3.—Osteomyelitis of the vertex of the skull of 39 years' duration, secondary to a third degree scalp burn. Possible carcinoma of scalp. Radical excision of scalp and skull. Skin grafts. Cured.

History: A woman, aged 40, entered the Albert Steiner Clinic on July 28, 1933. At one year of age she had suffered a third degree burn of the scalp.

There was never a complete healing in the vertex region. The diseased area would epithelialize over, break down, drain pus for a period of time and seal over again. At the time of admission there had been some drainage for two years. Headaches had occurred frequently through the 39 years but had been constant and of increasing intensity for three months before entering the hospital.

Examination: There were no positive neurologic findings. The entire scalp vault was scar tissue devoid of hair. In the center of the scar (Fig. 4) was a small granulating wound beneath which frank pulsations were visible. Pus could be freely expressed from beneath the scalp. The zone about the granulating area was extremely tender.

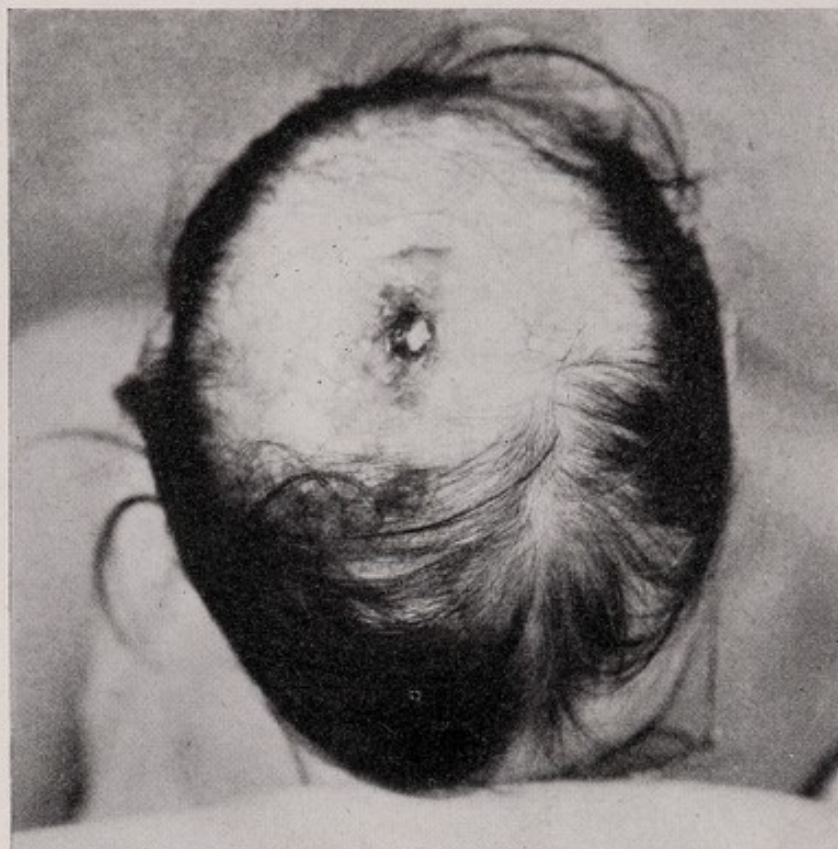


Fig. 4. Case 3. This granulating draining sinus was of 39 years' duration. The dura is visible in the center of the sinus.

Treatment and Course: Biopsy was made from the edge of the granulating area but was negative for any evidence of malignancy. On Aug. 15, 1933, a wide excision of the scalp and underlying bone was carried out. By September 2, granulation was complete and Dr. Calvin Stewart did a Thiersch skin graft. This was completed by the 14th and she was dismissed from the hospital on October 10, with a completely healed wound and no evidence of any further bone disease on x-ray examination (Figs. 5 & 6).

Osteomyelitis of the skull developing with or resulting from gross scalp destruction comprises a relatively small group. The disease develops in the skull as a result of diminished vascularity plus the accessibility to external invasion by pyogenic organisms. In that the tissue

is of low vitality the spread of the disease may sometimes be rapid and extensive. This particular patient had had a low grade infection over a period of 39 years and the question of a possible skin cancer was considered. It was this possibility that prompted such extensive sacrifice of bone and scalp. Such extreme efforts are rightfully open to criticism. The scalp was no more than thinned, scaly, scar tissue for a distance of 2.5 to 3 cm. about the draining sinus. It was feared that a feeble sacrifice of bone might carry infection into already

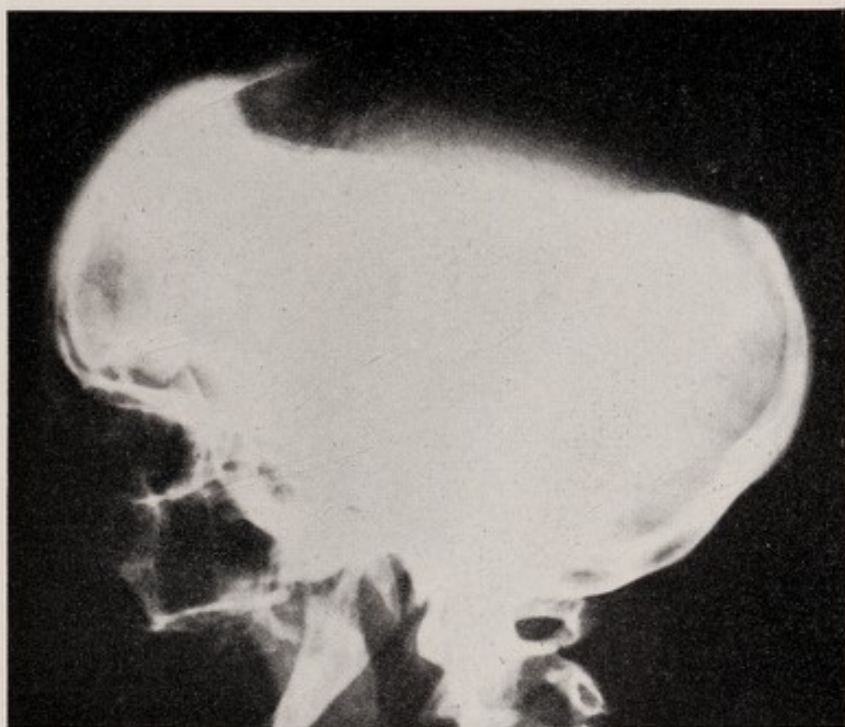


Fig. 5. Case 3. Illustrating an extensive bony sacrifice. Note the smoothed edges of the skull about the defect.

none too healthy tissues, and the scalp and skull therefore were removed without invading the infected zone after surgical preparation of the operative field. Usually where the scalp has been destroyed or by necessity sacrificed leaving exposed bone, one has no fears over secondary healing. This may be accomplished by multiple trephine openings of the outer skull table, but in this case some misgivings were entertained as to the development of granulations over such a large area of exposed dura. Within a month such fears were dispelled and skin grafting was begun. In this group such extensive bony removal as was carried out in this case is not indicated and most often a destruction of the immediately infected bone will be all that is necessary for secondary healing.

CASE 4.—Osteomyelitis of the right frontal bone, secondary to a frontal sinus infection. Frontal lobe abscess. Radical excision of diseased skull. Drainage of abscess. Cured.

History: A girl, aged 13 years, referred by Dr. W. T. Pace, of Smyrna, Ga., entered the Piedmont Hospital Nov. 17, 1930. Four months before there had developed an edema of both eyelids with some swelling in the right supra-orbital region. Incision and drainage in this frontal area had relieved the pain and swelling but drainage continued and the headaches persisted. Three and one-half months after the onset she began to have generalized convulsions on an average of three attacks each day. Diplopia was complained of from three weeks after onset of headaches. Three weeks before hospital admission a small fragment of bone was removed from the draining sinus.



Fig. 6. Case 3. Even though the vault of the skull has been sacrificed the contour of the head is maintained.

Examination: The positive neurologic findings were: bilaterally choked discs, a complete right internal strabismus, a left facial weakness (central type), and a weakness of the left hand grip. In the right frontal region there were three areas; one granulating wound (2 by .5 cm.) discharging pus, just to the right of the midline and about 4 cm. above the eyebrow; a second area (2.5 by .5 cm.) about 5 cm. above the first area; and a third healed scar 2 cm. above the outer angle of the right eye. This entire frontal area was edematous and tender to palpation. X-ray studies of the involved skull are depicted in Figure 7.

Treatment and Course: On November 19, all diseased bone was completely removed and the "stalk" of the underlying abscess exposed. Immediate drainage was carried out. She was dismissed from the hospital December 23, and one month later the wound had completely healed. Figure 8 was

made three months after hospital dismissal. There has been no subsequent evidence of any infection.

This case illustrates one of the more serious complications or conditions that may develop from or along with an osteomyelitis of the skull. It is not my purpose to discuss the diagnosis and management of brain abscesses but this case calls attention to one of the possibilities encountered in the surgical management of skull infec-



Fig. 7. Case 4. In younger people the periosteal partitions between the individual skull bones seem to act as a check upon the spread of the skull disease.

tions. Faced with such potentialities, every case in which the diagnosis of osteomyelitis of the skull has been established should have a careful neurologic examination. From such examination such laboratory aid as may be necessary can be estimated. In those cases in which the infection is blood borne, blood cultures should be carefully carried out. Lumbar puncture is only indicated where there is suggestive or definite evidence of intracranial complications. Not always are the neurologic findings frank evidence of cerebral invasion. At times a frank epidural collection of pus may be the factor in producing localizing neurologic symptoms. Such a collection of pus beneath the skull and outside the dura may give a very definite clinical picture of brain abscess. Occasionally a subdural collection of pus may be encountered in those cases where the clinical picture is suggestive of an abscess. The possibilities of a meningitis develop-

ing in these cases is easily understood. The dura is a strong barrier against infectious invasion and will resist such for a long period of time, but once broken through all the serious and dangerous complications may ensue. In that the bone infection in a majority of cases enters the skull through the small emissary veins, and in a still greater number progresses through the diploetic vessels which drain into the larger cerebral venous sinuses, it is evident that sinus thrombosis might easily be a common complication. With such dangerous complications as brain abscesses, sinus thromboses, men-



Fig. 8. Case 4. The postoperative bone defect three months after hospital dismissal.

ingitis, etc., there should be no hesitancy in carrying out radical efforts as soon as the diagnosis is made, and with earlier recognition there must be certain cases in which the bone disease can be eradicated before such complications have begun. The recognition of such serious complications seems to justify the statement that the disease itself is a simple one.

CASE 5.—Osteomyelitis of right parietal bone of 15 years' (?) duration secondary to trauma. Radical excision. Improvement. Subsequent course with autopsy findings.

History: A man, 42 years old, referred by Dr. W. A. Smith, of Atlanta, entered the Piedmont Hospital Oct. 21, 1932. For fifteen years he had had attacks of right parietal pain at rather regular intervals. These followed an injury in the right parietal area at which time he was rendered unconscious,

sustained a scalp laceration, and was told his skull was fractured. For three years these attacks of headache had been more frequent and more severe. About one month before admission a swelling developed in the right parietal area, was drained, and skull plates were made (Fig. 9). On October 19, there had suddenly developed a weakness of the left leg and within twenty-four hours a complete hemiplegia had developed. Along with the hemiplegia the patient noticed a loss of sensation and a disturbance of vision.

Examination: The positive neurologic findings were: a complete left hemiplegia, a right homonymous hemianopsia, a hypesthesia of the entire left side of the body to light touch and pin prick, an absence of the left superficial

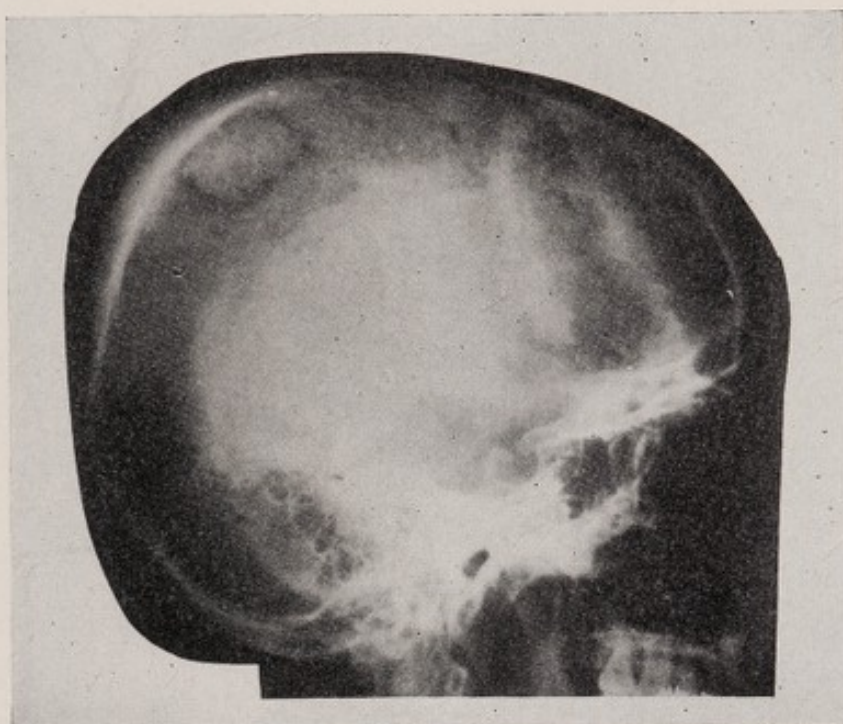


Fig. 9. Case 5. Illustrating the bony changes in chronic osteomyelitis of the skull.

reflexes, a hyperactivity of all left deep reflexes, with a positive Babinski and ankle clonus on this side. There was a draining wound in the right parieto-occipital area, about the edges of which there was a zone of edema which was extremely tender to palpation.

Treatment and Course: On Oct. 21, 1932, as an emergency procedure, all diseased bone was removed. The pathologic dura prompted subdural exploration. A massive subdural abscess was drained and an evident meningitis was disclosed. Free subdural drainage was instituted. On Oct. 29, 1932, his temperature had become normal and the hemiplegia had markedly improved. On November 4, the patient was dismissed from the hospital without any evident paralysis, visual field defects or sensory changes. The wound was dressed as often as necessary. On Jan. 10, 1933, he began to complain of some sensory changes in the left leg, and some associated subjective weakness. Hospitalization was advised but for economic reasons he went to a United States Veterans' Institution. Upon arrival on January 15, he was in a coma, although he had left home thirty-six hours before conscious and able to support his own weight. His serious condition prevented any radical efforts, and within a few

days he died. Autopsy revealed an "abscess, the size of a tennis ball, occupying the right parieto-occipital region."

This case illustrates the insidiousness with which osteomyelitis may develop in some instances. It further represents an experience that has received no attention, namely, that osteomyelitis of the skull may, with its complications, become a surgical emergency. There is no way of proving in this man's case that the infection was present fifteen years, but x-ray studies made at the time the scalp



Fig. 10. Case 6. Illustrating the extensiveness of bony involvement that may occur where no efforts to eradicate the disease are undertaken.

swelling appeared do testify to the fact that the skull disease had been present longer than one month before the appearance of any neurologic symptoms. It is well to bear in mind that in patients who complain of persistent localized pain in the head, and who give a definite history of a head injury, the exclusion of bone necrosis can only be made after careful roentgenologic studies. To say that some cases are surgical emergencies is likely to be misleading and some clarification is warranted. It is best to say that most of the cases are emergencies but there are some cases in which the possibilities of acutely developing intracranial pressure demand immediate surgical attention. The definite neurologic findings in the absence of an epidural abscess, if the dural disease alone had not been

so evident, made subdural inspection imperative. This case is an illustration of what at one time was known as Pott's puffy tumor, namely, an osteomyelitis developing after trauma. There was a history of a scalp laceration fifteen years before. Such developments following trauma are rather uncommon. A sufficient number of similar cases following focal injury without scalp wounds have occurred, as with osteomyelitis in other bones, as to dispel any doubts



Fig. 11. Case 6. This x-ray plate was made twenty months after Figure 10. Note the clearance of the disease in every part of the skull except the frontal areas.

about the injury being a mere coincidence. It is unquestionably the result of organisms invading tissues in which the resistance has been lowered by the bruise.

CASE 6.—Osteomyelitis of the entire skull secondary to a mastoid operation. No operation. Spontaneous healing.

History: A woman, aged 25 years, entered Emory University Hospital July 13, 1933. Six months before an otitis media developed followed by a mastoid infection. A mastoidectomy was done and shortly afterward a second mastoid operation was performed. She was told at this time there was a definite skull infection and neurosurgical consultation was advised. Following the second mastoid operation she began to suffer intense unlocalized pains in her head. At times $\frac{1}{2}$ grain of morphine was necessary for relief. The patient had lost some 45 pounds in body weight over a period of four months.

Examination: There was a complete right facial nerve paralysis and complete deafness in the right ear. The entire scalp was edematous and pitted on pressure. Over the entire cranium, pressure produced excruciating pain. She was clinically anemic. X-ray studies of the skull are illustrated in Figure 10.

Treatment and Course: Morphia freely was necessary for relief of pain. A plan of treatment was outlined, directed mainly toward building up her general health, with the idea that as soon as her physical condition improved some conservative surgical efforts might be undertaken to rid her of the infection. Economic circumstances prevented prolonged hospitalization. In September, 1934, (20 months after the onset of her illness) she reported to the office for observation. She had used morphine freely for 6 months after leaving the



Fig. 12. Case 7. Illustrating the diffuse and widespread necrosis in a case of bacteremia.

hospital. With disappearance of pain she began to gain weight and noted some improvement in her facial paralysis. On examination there was frank improvement in her facial paralysis but there was complete bilateral deafness. There was no scalp edema and no areas of tenderness. Figure 11 shows the definite improvement of the diseased bone.

This case represents the extreme degree of development in osteomyelitis of the skull and answers one question as to what may happen if no complications develop. It also answers, at least for this case, what may happen if no surgical efforts are attempted. There have been recorded "spontaneous cures" in other skull cases, as well as in some of the infected long bones. It is not my purpose in using this case to advocate conservatism, for while the disease is disappearing there has been a complete loss of hearing. Had early radical efforts been carried out one might have anticipated a minimal bony sacrifice and prevented what now appears to be permanent deafness. Even though free from pain and with no clinical evidence of any infection there is still roentgenologically present frank bone disease. Her general health is such that if an outbreak recurs a possible eradication might now more safely be undertaken.

CASE 7.—*Osteomyelitis of the skull occurring as a part of a bacteriemic infection. Drainage. Recovery.*

History: A six-year-old boy entered Grady Hospital (Emory University Division) Sept. 26, 1933. One week before he had had a gastro-intestinal upset with an elevation in temperature. Two days before admission there was noted a swelling of the side of the face. During hospitalization he developed lobar pneumonia followed by an empyema, an osteomyelitis of the skull, and an osteomyelitis of the second metacarpal bone.



Fig. 13. Case 7. Note the complete disappearance of all suggestive bone disease fifteen months later.

Examination: On Oct. 5, 1933, there was a definite fluctuant painful scalp on the right side. Neurologic examination was entirely negative, as was the spinal fluid study. The child was critically ill. X-ray plates made at this time are shown in Figure 12.

Treatment and Course: On October 7, a 3 cm. incision was made in the scalp in the right parietal area and a rubber drain inserted. Hot wet dressings were used continuously. On October 17, a second drainage incision was made. From October 26 to November 24 his temperature chart was a septic one. After this there was a normal range for three weeks before his dismissal. Drainage had become minimal by December 7, and x-ray studies showed definite improvement in the bone necrosis. The patient was discharged from the hospital on December 16, and returned to the Out-Patient Department for an occasional dressing. X-ray pictures made Jan. 23, 1935 (Fig. 13) showed no evidence that there had ever been any bone disease.

This case represents another relatively small group. Occurring as a part of a generalized infection these patients are extremely poor surgical risks and, in that the osteomyelitis of the skull is not the primary focus, only conservative efforts are indicated.

CASE 8.—Osteomyelitis of the occipital bone (left) secondary to a compound fracture of the skull. Radical excision of diseased bone. Healing by secondary intention.

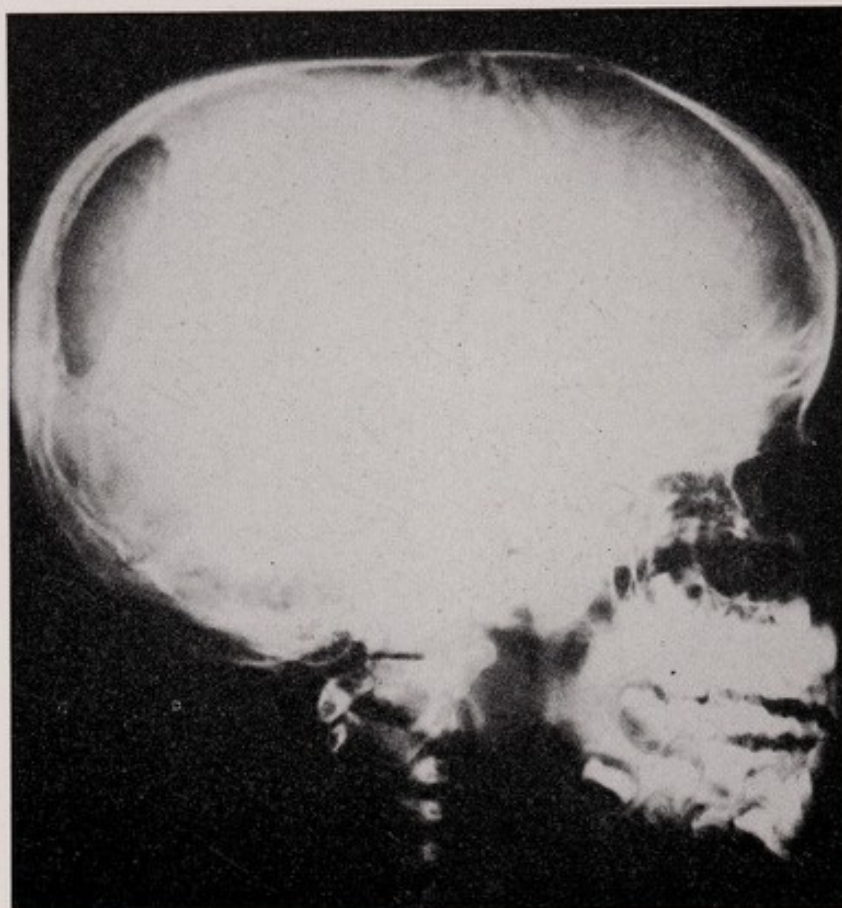


Fig. 14. Case 8. The bone defect is the result of the sacrifice of the fractured fragments at the time of the debridement. The small area of osteomyelitis is depicted along the anterior superior rim of the defect.

History: A boy, aged 5 years, entered Grady Hospital (Emory University Division) Dec. 14, 1935. A victim of an automobile accident, he had a compound depressed skull fracture. Upon arrival he had regained consciousness. There were no neurologic symptoms. A debridement was carried out and the scalp was closed without drainage. On the sixth day there was an elevated temperature and a swelling along the wound edges. On opening the wound there was a free escape of pus.

Examination: Neurologic examination was entirely normal. There was an open wound in the left occipito-parietal area 4 cm. in length. Pus was freely expressed from beneath the wound edges. The cervical glands were swollen and tender and the scalp about the wound was quite edematous. Roentgenograms depicting the diseased bone are shown in Figure 14.

Treatment and Course: On December 20, the scalp wound was opened its entire length, Dakin tubes were inserted and the wound kept open with gauze packs. Irrigation with Dakin's solution was continued for three weeks. Gross drainage subsided and on Feb. 8, 1936, a radical excision of all diseased bone was carried out. At present the wound is healing by secondary intention.

The management of these cases is primarily one of prevention, but once developed the earlier the diseased bone is eradicated the less likelihood there is of complications. Such preventive efforts as



Fig. 15. Case 9. The skull of an adult illustrating an invasion of the bone posterior to coronal suture line.

debridement have been advocated. It might not be amiss to be more specific as to what a debridement in head injuries entails. After preliminary shaving, sterilization and anesthetization of the wound the procedure is carried forward with every surgical care and precaution as in any craniotomy. The scalp edges are freshened, destroying all macerated or contused tissues. No attempt should be made to catch individual scalp arteries but by simply catching the galea and laying the forceps back across the scalp hemostasis is easily accomplished. If the surgical attempts are within the first six or eight hours and it is unnecessary to leave the dura opened, the bone fragments should be preserved in some antiseptic solution for replacement before closing the scalp without drainage. In instances where surgical attempts are not carried out within a twelve hour lapse of time following injury the replacement of bone

fragments is inadvisable. In a repaired compounded skull fracture when a scalp infection appears, wide open drainage should be immediately instituted and careful and persistent exclusion of an underlying bone infection established. Secondary scalp healing may occur but these cases bear close watching and x-ray studies until complete healing has occurred.

CASE 9.—*Extensive osteomyelitis of the skull secondary to a frontal sinus infection. Two-stage operation excising all infected bone. Skin graft. Cured.*



Fig. 16. Case 9. Illustrating the gross sacrifice of diseased skull at the first operation.

History: A man, aged 37 years, referred by Dr. Rufus Thames, of Milton, Fla., entered the Piedmont Hospital, Jan. 7, 1930. Five months before an abscessed tooth had been extracted, followed by a chill and rise in temperature. Four months before an antral drainage had been necessary and one month later a frontal sinus infection had developed. The frontal sinus was drained externally but frontal pain and tenderness had continued. X-ray studies revealed a necrosis of the frontal bone and the patient was referred for treatment.

Examination: Neurologic examination was entirely negative. There was a discharging wound in the left supraorbital region. There was a healed wound over the left frontal sinus. The entire forehead was extremely tender and there was an evident edema of this area. The x-ray findings are illustrated in Figure 15.

Treatment and Course: On January 10, Dr. Dowman removed the entire frontal bone from the supraorbital ridges posterior to the coronal suture (Fig. 16). Three weeks later x-ray studies showed an extension of the disease in every direction except anteriorly and a second operation was carried out.

Before normal healthy bone was encountered the entire vault of the calvarium had been sacrificed (Fig. 17). On February 27, skin grafts were necessary to bridge the scalp defect across the vault. On March 23, the wound had completely healed and the patient was discharged from the hospital. A protective aluminum helmet was fitted to the inside of his hat before dismissal. There have been no subsequent discomforts or evidence of bone disease.

The surgical efforts that are sometimes necessary before skull infection is completely eradicated are well illustrated in this case. This is the greatest sacrifice of bone that has been carried out in any of the cases in this report. Once surgical efforts are begun it



Fig. 17. Case 9. Illustrating the radical efforts that were necessary before complete eradication of the infected bone.

is far wiser to remove a bit more of the healthy appearing bone than to err with conservative efforts. To leave a small area of diseased bone means further invasion of the skull and an interference with secondary healing. The amount of bone that is necessary to be removed is governed somewhat by the roentgenologic findings, in that these plates give the operator some preliminary idea of how extensive the operation will be. The actual amount of bone sacrificed will depend on the gross disease encountered after the scalp reflection. In every direction all questionably diseased bone must be sacrificed. This determination is not always possible from a view of the outer skull table for many times frank pus can be demonstrated in the small rongeuired bony fragments, as lying between the two tables of the bone. If the osteomyelitis is of long duration

dural granulations or low grade inflammatory changes are usually demonstrable. When such dural changes are present the skull sacrifice should extend beyond these pathologic areas. These dural findings, however, are no index of the extent of the skull disease and even though healthy dura be exposed beneath the entire rim of the bone defect there may be and usually is frankly diseased skull for a variable distance away. For instance the dural reaction may be limited to an area of 2 to 3 cm. while the skull sacrificed may be for an area several inches in diameter before normal skull is encountered. The gross changes such as small areas of complete bone destruction, granulation tissues, and isolated plugs of purulent material are easily recognizable. The removal of these products down to the dura is not difficult to carry out, nor is the reddened invaded skull about these older portions of the disease going to escape the surgeon's eye but the importance of recognizing the zone between disease and normal skull might escape inspection and demands emphasis. This part of the bone is whitened and in the true sense of the word is dead. Rongeur is accomplished here with less effort than in normal bone. It is relatively avascular and it is in these bony fragments that an active infectious process is taking place. When normal bone is encountered it will be found to be a pinkish pearly color and it bleeds freely. Only when such bone is encountered in all directions is one justified in feeling that a real attempt at eradicating the disease has been made. This is irrelevant to the amount of bone sacrificed as has been illustrated in the cases in which treatment was radical.

The statement that best treatment is radical excision of all diseased bone is sufficient but a more detailed description of the actual procedure may be helpful to those interested. There are a few instances where drainage has already been superficially instituted. In some cases this drainage is so profuse and where there is no extremely rapid extension, treatment with Carrel-Dakin solution for a few days has helped in lessening the drainage, permitting a little cleaner surgical field. As in Wilensky's⁵ experience Dakinization had played no apparent role in delaying the disease but in a few instances may be an adjunct in the preoperative preparation. Once the patient is ready for operation the entire scalp is shaved on the morning of the operation. The operative field is prepared as carefully as for any craniotomy and the scalp incision is made with two considerations; first, the blood supply of soft tissues, and secondly, the cosmetic end results. The operation must depend a bit upon the roentgenologic findings as a lead for exposure, but after the scalp incision and bony exposure, the knowledge of gross pathology will be his guide. Trephining may be necessary but most often

sufficient sequestra formation has taken place to make this unnecessary. Once beneath the inner skull table one must proceed with extreme caution guarding always against a tear in the dura. This may be accomplished in one of several ways: by cotton pledget dissection, by means of a smooth-edged periosteal dissector or the use of small gauze packs. With any method it is wise as an extra precaution to keep the dura retracted downward with a small brain spoon with each maneuver of the bone rongeurs. When normal healthy bone has been encountered in every direction the bleeding

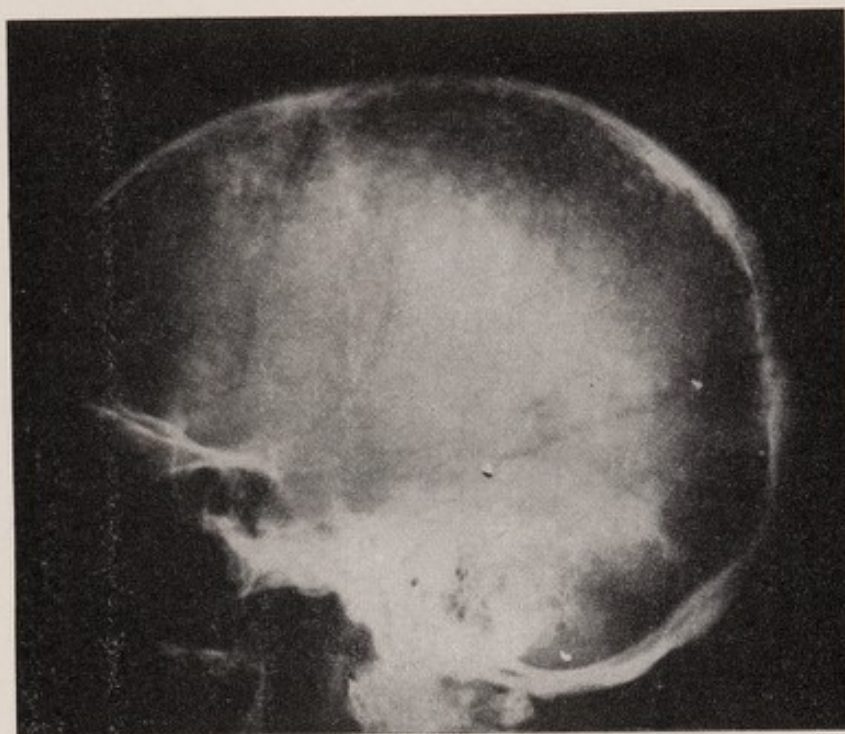


Fig. 18. A case of skull invasion by an occipital meningioma. Compared with Figure 10 it illustrates the problem that sometimes confronts the roentgenologist.

may best be controlled with cotton packs rather than with bone wax, which entails the risk of sealing in infection. After all the diseased bone has been sacrificed the healthy bone edges should be left as smooth and regular as possible. The wound is then irrigated thoroughly with some antiseptic solution. For this purpose Adson recommends tincture of iodine profusely. Removing the cotton pledgets that were used for temporary hemostasis, washed iodoform gauze is then packed firmly against the exposed bone edges, after which the skull defect is filled in with the same gauze strip. This packing should not be sufficient to cause any frank intracranial tension. After the packing, the scalp is closed with through and through interrupted sutures. The iodoform pack is loosened within 24 hours and partially removed at the end of the second 24 hours. After the

end of the third or fourth day, depending on the tendency of the scalp to ooze, all of the stitches are taken out and the remainder of the iodoform pack is removed. Daily dressings of sterile vaseline gauze are then used. The wound should be packed with this vaseline gauze not so firmly as to prevent drainage but sufficiently to allow the wound to be filled in with granulations from below. Approximately 30 days will be the average period before complete secondary healing takes place.

In conclusion, cases of osteomyelitis of the skull of variable etiologic origin have been given. There are a few instances in which the extensiveness of the disease and the associated debilitating effects on the patient prohibited radical surgical efforts. The complications and sequelae of the disease are all so dangerous that early recognition is the answer for prevention and radical surgical removal of all infected skull is the choice of treatment.

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