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President—E. COWPER TAMPLIN, M.C., F.R.C.S.Ed.

Submucous Rectification of the Nasal Septum

By H. V. FORSTER

THE operation of submucous resection of the nasal septum which I was taught to associate in its full development with such names as Killian, Ballenger and Freer, appeared to owe its success in establishing a wider nasal airway to the actual removal of those parts of the cartilaginous and bony frame which were deformed, though leaving enough support to prevent a subsidence of the bridge or roof of the nose. From the results which one sees from time to time I conclude that this tradition is still followed.

For many years operating by the submucous method, I have attempted to correct these deformities rather than remove them. In Sir StClair Thomson's book, *Diseases of the Nose and Throat*, 1926, 3rd edition, New York, the author states that for the previous fifteen years he had replaced most of the broken-up septum, the pieces being left lying between the mucosal flaps during the procedure. The resected cartilage was then divided into pieces to fit like a mosaic into the window made in the septum.

I had often wondered whether a difficulty here would be that as the wall of the middle partition of the nose was being rebuilt some pieces might fall down again before suitable packing had been put in to give them support. If this were a real difficulty then it might be avoided, as it appears to be by Cottle and Loring (1948), who put vaseline gauze into the nasal passages before rebuilding the wall. The mucosal flaps are then separated again by the long speculum and reconstruction is begun.

In these operations I prefer to use local surface anæsthesia, except for the few who call for a general anæsthetic, and in children where I proceed to interfere with less anxiety than formerly because of the use of a conservative method. In many cases the final objective is to uncover, isolate and often remove that deformity which we might call the ethmo-vomerine knuckle. This will be found to have a constant companion likewise deformed, the small processus sphenoidalis septi cartilaginei, but in making the advance it should be possible to turn aside, rather than remove, the greater quadrilateral cartilage and dispense with that ingenious instrument, the swivel knife of Ballenger.

The cartilage is separated from the nasal spine and from the vomer which so often carries a shelf or spur, and next from the vertical leading edge of the ethmoid plate, and is then turned aside.

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The ethmo-vomerine knuckle is uncovered, and at times it may be convenient to restore it to a median position though more often to isolate and remove it, either before or after reducing any bony shelf already uncovered in the advance.

In removing some spurs or when dealing with the nasal spine it is not necessary to upset their bony foundations but to thin them laterally with the chisel or gouge, and in working here I like to have the assistance of a " third hand " to wield the mallet with such force as the operator directs, the assistant accepting the role of " blacksmith's striker ".

At times one may correct these basal deformities by fracture and so retain much of their substance.

It may be asked whether in separating vertically the quadrilateral cartilage from the ethmoid plate, there is a risk of holing the underlying mucosal covering, but I do not find this a real hazard, and I am prepared to arrive at this stage of the operation after working beneath the muco-perichondrium of one side only.

Another question might be, may not the spring-like plate of cartilage tend to return to its original position ? But freed as it is now in front, below and behind, it is amenable to direction by such adjustments as may be made by the ingenuity of the operator. If by chance a tear has been made in the unsupported area of mucosa below, we have a reserve at hand from which a piece may be cut and dropped into the gap.

I would not claim that it is always possible to preserve the whole of a deflected ethmoid plate, but much can be done by fracture or division to bring it into the mid-line. If we turn next to the problem of the columella which has been deprived of support by a deflection of the free edge of the cartilaginous septum, one is faced with special difficulties ; but at times one is able to persuade the free edge to enter a pocket cut in reverse beneath the skin of the vestibule. These difficulties are discussed in the recent article by Cottle and Loring.

In conclusion I would say that in performing a more or less conservative operation within the nasal septum one has the satisfaction of preserving much of its structure and the result is kinder to its mucosal covering.

Perforations are less likely to follow submucous rectification than after resection, and recently I saw a perfect example of the " flapping " septum after the latter operation. I was at a loss to suggest a suitable remedy for this post-operative inconvenience, but it is one which should not follow the more conservative routine.

It has been suggested that fibrous tissue may develop in the membranous middle partition of the nose after resection of the skeleton, and that there might be a tendency for it to pull down the beam which has been retained beneath the roof, with the result that in time the profile may change ; but preservation of the skeleton should offer strong resistance to the pull of fibrous tissue, and at best some may form in the scar of the original incision whichever method is used.

The relatively larger inferior turbinate body in the wider side of the nose should be fractured and displaced laterally rather than sacrifice any part of it. This important body regulates the volume of air admitted to the nose, and its surface represents a wide area. The importance of the relationship of surface

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area to the capacity of the nasal chambers will not be questioned, for their air-conditioning function comprises cleaning, moistening and, in these latitudes, warming the stream which eventually finds its way to the lungs.

When we think of the ciliated epithelium which lines these surfaces it is encouraging to recall the opinion expressed by Dr. Arthur Proetz (1948) that the individual cilia have greater powers of resistance than perhaps had been realized.

In performing operations on the nasal septum, therefore, let us proceed kindly and do our best to retain a firm base of operations for these minute but sturdy elements whose duty it is to remove those impurities from which a healthy nose should protect the lower respiratory tract.

REFERENCES

COTTLE, MAURICE H., and LORING, ROLAND M., 1948, "Surgery of the Nasal Septum," *Ann. Otol., Rhin. and Laryng.*, lvii, 705.

PROETZ, ARTHUR W., 1948, "Recent Progress in Nasal Physiology," *Proc. R. Soc. Med.*, xli, 793.

MR. H. V. FORSTER said, in reply to discussion, that when a general anæsthetic was demanded the rebreathing through a wide-bore laryngeal tube with closed circuit provided a sense of security to the operator, but in spite of added local anæsthesia and ischæmia, he had found there was more congestion and the need for more frequent mopping of blood from the field of operation.

He preferred a local surface anæsthetic alone, and most patients were agreeable to its being used.

He appreciated Mr. Layton's support in the conservative treatment of the inferior turbinate.

Osteomyelitis of the Frontal Bone of Rhinogenic Origin

By RONALD G. MACBETH

OSTEOMYELITIS of the skull may occur wherever there is diploetic bone in the neighbourhood of an infected air-sinus. Consequently, the frontal bone is by far the most frequent site, with the maxilla next in frequency, while the ethmoid and sphenoid are only rarely involved.

While it is convenient to consider the acute and chronic conditions separately because of their different clinical manifestations, it is generally agreed that the chronic form is pathologically an extension of the acute. In the chronic, however, reparative processes are outrunning destruction.

A. ACUTE OSTEOMYELITIS

This condition may occur spontaneously as a sequel to untreated sinusitis of acute or acute-on-chronic type, or it may follow operations upon the sinuses. The material collected and published by different observers gives contradictory evidence as to the relative frequency of these two classes of case, though the warnings in most published work and textbooks about the dangers of operations

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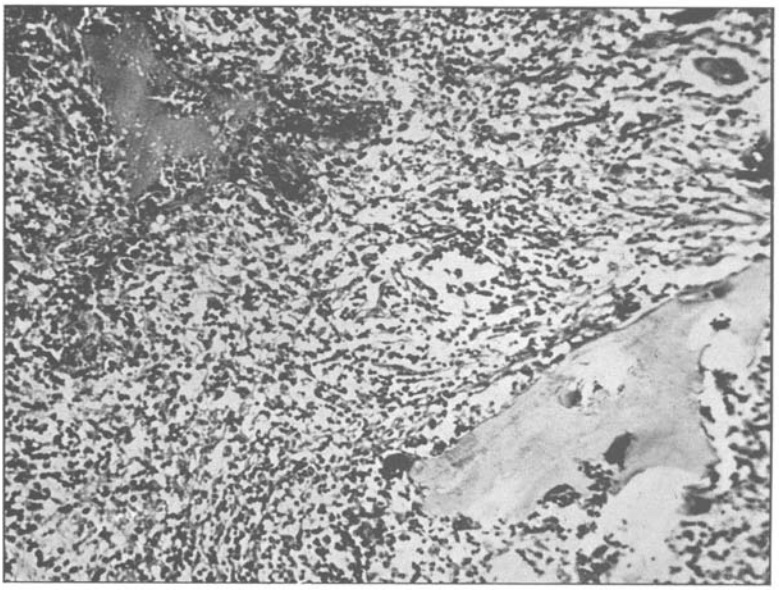


Fig. 1.

This photomicrograph illustrates a relatively acute osteomyelitis of the frontal bone in the established phase (actually of traumatic causation). The marrow space is filled with round cells and fibroblasts, and there is a considerable area of granulation and exudate near the left upper corner. Towards the right lower corner there is a bony partition showing erosion by osteoclasts, and this is in the process of becoming a sequestrum. (×230.)

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lead one to suppose that, as a whole, rhinologists are more conscious of the post-operative group. Figures are possibly further clouded by the fact that cranial osteomyelitis may occur after quite trivial operative measures—such as removal of an ethmoidal polypus—not normally classified as operations. It is probable that in the cases occurring after operation there is a pre-existing spread of infection.

Ætiology.—This disease occurs most frequently in children and young adults. There would appear to be a predilection for the female sex, but this is probably unimportant.

Pus under pressure in the sinuses, and without drainage, is the main ætiological factor.

Recent freshwater swimming and diving are often elicited as predisposing factors in the history of spontaneous cases.

Scarlet fever, erysipelas, and acute infective fevers are thought to predispose to the less acute forms of osteomyelitis of the skull.

Finally, to explain why some patients do and others do not develop osteomyelitis in identical circumstances, one must invoke the imponderable general factors of high virulence of the infecting organisms, and low resistance of the patient's tissues. A low vitamin level, particularly of vitamin C, may possibly contribute to this low resistance.

Bacteriology.—The same organisms commonly found in sinusitis are implicated in this disease, but *Staph. aureus* and anaerobic streptococci account for most of the cases. The hæmolytic streptococcus, pneumococcus, and *H. influenzae* are also found. This last is more likely to be associated with a circumscribed subacute lesion. In addition, records of two cases by the *S. typhosus* have been found in the literature,[9] but it is possible that these may have been metastatic in origin.

In the ten-year period 1937-46, there were admitted to the Radcliffe Infirmary, Oxford, 37 cases of osteomyelitis of the skull bones, of which 29 were attributable to sinusitis; and of these latter bacterial records are available in 23 cases :—

Staph. aur. 9, *Anaerobic strep.* 8, *Staph. albus* 1, *Hæmolytic strep.* 2, *Sterile* 3 cases.

The comparatively frequent occurrence of an anaerobic streptococcus is of the greatest possible importance. Unless special anaerobic cultural methods are employed it is apt to be missed, and a sterile report is recorded. Furthermore, such anaerobic (or micro-aerophilic) streptococci may be relatively resistant to the sulphonamides and to penicillin, and it is evidently important in all cases to have a report upon the sensitivity of the infecting organism to these drugs.

It has been found by Cairns[3] that the culture of the bone in these cases does not always correspond with that of the implicating sinuses, anaerobic streptococci being sometimes found in the bone while *Staph. aureus* is found in the sinus. In such cases the probability is that the staphylococcus is a secondary invader. Galloway[6] has noted that anaerobic and micro-aerophilic streptococci are often found in association with infections about the head.

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Pathology.—The main pathological fact in both the spontaneous and post-operative groups of cases is infection of the diploic space. In the former group, the pathological process involved must in the earlier stages be a matter for conjecture, because material has not been available for examination; but it seems very likely that there occurs a thrombo-phlebitis of the veins of the sinus mucosa, and that this extends by direct spread into the diploic veins. This would seem to be a rational event. Further, in established cases, venous thrombosis is found in the diploe in advance of the spreading lesion.

In the post-operative group, it is easy to assume that direct instrumentation may let micro-organisms into this space, and no doubt this occurs in some cases. In others, however, where the diploetic bone is not directly opened, this facile explanation will not hold. Such are cases where the frontal sinus has been opened *viâ* its floor, and where frontal osteomyelitis followed ethmoidal polypectomy or operations upon the maxillary sinus. In these cases, it must be assumed that disturbances in the near-by nasal region determine a temporary decrease in the drainage of a co-existent frontal sinusitis and therefore a commencing venous thrombo-phlebitis in the diploetic bone.

Wilensky in his review of the subject in 1932[13] divides the gross pathology into four stages: (1) The earliest when nothing can be seen by the naked eye. (2) Hyperæmia of the diploe with droplets of pus. (3) Medullary granulation tissue, and obvious thromboses. (4) Para-osseous abscess formation on both sides of the bone, and sequestration.

Thereafter the disease ceases to be localized to bone.

Kos[8] has made microscopic studies of the sequences occurring in the marrow. The earliest change noticed is dilatation of the vascular channels and invasion by organisms and round cells. This is followed immediately and rapidly overshadowed by hyperplasia of the marrow cells. The next state is thrombosis in the vessels, leading to broken masses of fibrin and débris resembling a " log-jammed stream ". The marrow spaces are replaced by granulation tissue, osteoclasts then appear and erosion of the bony partitions begins. Osteoblastic activity occurs between the inner table and the endosteum, and some new bone-formation begins along the dural surface. Finally, fibrosis occurs around the marrow elements.

Kos notes that these processes tend to shunt the infection towards the dura, and hence that intracranial complications may be expected. He concludes that the microscopic picture justifies radical treatment.

In the really acute cases there is only slight regenerative tendency, and this occurs mainly in the periphery and superficially on both sides. The dura mater is affected late, and is able to isolate large collections of extradural pus for a considerable time before invasion occurs.

In some cases, the spread of infection in the frontal bone seems to be subperiosteal and in the outer layer and this is true of the less fulminating types of disease. But Furstenberg[5] has noted in autopsy specimens that the inner plate of bone is often destroyed first. He points out that the arterial supply and venous return of the bone occur *viâ* the dura, which he regards as the physiologically effective periosteum. He also emphasizes the well-known fact that the first outward sign of the disease may appear superficially on the frontal region, a measurable distance away from the primary lesion in the sinus.

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He regards this observation as evidence supporting the idea that the osteomyelitis spreads by thrombophlebitis, which latter process may be partially metastatic and then retrograde in its spread.

Caussé,[4] on the other hand, challenges this conception and, on the basis of the histological examination of four cases, suggests that the main mode of spread of the infection is *viâ* the Haversian canals. He thereby readily explains the appearance of isolated subperiosteal swellings, and regards the thrombophlebitis as incidental.

Once it has begun, and unless treatment be instituted, the inflammatory process tends to spread in the diploe. The suture-lines have little or no isolating function because there are large venous connections across these, *viâ* which the inflammation spreads still further.

The more acute the condition, the greater is the tendency for it to spread, and the less the tendency towards regeneration. At the other end of the scale is the type which starts as a localized acute condition, and it is probable that it will become the commoner type clinically, because of the almost universal practice by family physicians of giving sulphonamides in small dosage for sinusitis.

Symptomatology and diagnosis.—The onset of the disease, in the spontaneous cases, usually occurs a few days after the underlying sinusitis has become established. Similarly, the post-operative cases begin a few days after the operative intervention. The first complaint is often of headache, either generalized or occipital in type, and worse at night. This change in the character of the head-pain in the absence of meningeal signs should be regarded as significant.

The temperature often rises at this time and there may even be a rigor. Thereafter pyrexia is variable, and it must be remembered that it may be masked by coincident chemotherapy.

The patient then usually notices a swelling over one frontal bone, or both bones, and this may, in fact, be the first manifestation of trouble. If, as is probable, sulphonamides have already been given, this swelling may arise quite painlessly. It is usually situated 2-3 cm. above the eyebrow—i.e. above the uppermost limits of the frontal sinus (see Fig. 2).

Initially the swelling is " doughy " and tender, and evidently subperiosteal, but in a few days it becomes soft and fluctuant, because pus has formed. Later, this bursts into the subcutaneous tissue, and at this stage the patient's pain may become less marked. The upper eyelid may or may not be swollen as a result of the underlying disease or operation, but if not it gradually becomes so. In post-operative cases, the scar becomes reddened and elevated.

Endonasal examination shows the signs of sinusitis or operation, or both.

Epileptiform attacks may occur because of extradural abscess, cerebral thrombosis, or abscess, and are an urgent indication for surgery.

Radiography in the first seven to ten days will show no changes in the bone, but thereafter a mottling appears in the P-A. and lateral views, with an area of impaired translucency in its periphery. The diagnosis, however, should be made before radiographic evidence is positive.

The clinical course of the disease from this time depends upon what treatment is given, but it may be mentioned here that unless vigorous steps are

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taken, there is a disappointing tendency for the condition to relapse and to progress. Reference will be made again to this point under the heading of treatment. In the untreated cases the area of œdema spreads, the patient begins to suffer from pyæmic invasion of the blood-stream, and death may result from infection of the brain or lungs.

Complications.—The commonest complications of severity—apart from those forming part of the generalized septicæmia—are pachymeningitis and abscess of the brain. The superior longitudinal venous sinus is often thrombosed at an early stage, and the thrombo-phlebitic process may readily extend to the cerebral veins. In a review of 23 cases of purulent pachymeningitis arising from sinusitis, Cairns found that there was osteomyelitis of the skull in 19 cases: extradural abscess, 12; sinus thrombosis, 4; cerebral abscess, 3; severe leptomeningitis, 6; pulmonary abscess, 2.

Treatment

(*a*) *Prophylactic.*—Where operations on infected sinuses are undertaken, it has been found that the post-operative progress is freer of incident, healing is more rapid and the temperature is controlled, if a full course of appropriate sulphonamide be given to the patient commencing on the day before operation. By this means, the patient is protected adequately and post-operative osteomyelitis is prevented, providing that the infective organisms are sulphonamide-sensitive. It is, therefore, important to culture all nasal flora before operation and to determine their sensitivity. Penicillin can obviously be used systemically in place of the sulphonamides as a prophylactic, but it is probably wiser to retain it for use in those cases in which complications are feared, and for the worst cases of acute frontal sinusitis.

The immediate treatment of the acute case of frontal sinusitis which did not settle down upon conservative measures has always been controversial. It was insisted by many that operation upon such a case was highly dangerous and very likely to lead to osteomyelitis. More recently it has been held that minimal external drainage is the safest treatment. Without embarking upon this controversy, it may be said that if penicillin be used locally, and sulphonamides given by mouth, a minimal external drainage *viâ* the floor of the sinus may be made with safety, and that this is now the method of choice. The general principle of allowing pus to escape is thus maintained, and the risk of thrombo-phlebitis is minimized.

Technique.—A small incision is made below the eyebrow and medial to the inner canthus. A dental cutting burr is used to remove a small piece of the floor of the sinus, the pus is sucked out, and a piece of fine rubber tubing is inserted. The wound is sewn up and the tubing allowed to project through the bandage. Twice daily the sinus is emptied by suction and 1 c.c. of saline containing penicillin 10,000 units is injected. After two or three days the penicillin usually appears at the nostril, showing that the duct has re-established patency.

(*b*) *Active.*—In the past, it had been realized that simple incisions of subperiosteal abscesses, and local removal of bone, had done no more than give the patient temporary relief. The disease progressed insidiously and the

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surgeon was led on from operation to operation, until much of the cranial vault had been removed, and in the end, in most cases, the patient succumbed to general septicæmia or meningitis.

It then became evident that the only chance of curing a patient suffering from this disease was early and wide removal of the affected bone, together with a surrounding area of healthy bone. After the adoption of this principle, surgeons began to report occasional successful cases.

The advent of the sulphonamide group of drugs, it was hoped, might lead to a cure of this disease without recourse to severe operations. But experience here was parallel with that gained in the treatment of osteomyelitis elsewhere—namely, that these drugs might have a beneficial prophylactic action and might combat the general spread of the sepsis, but that they had little or no local effect upon the established case. Further, it was soon realized that the administration of these drugs—particularly in half-hearted dosage—might even mask the symptomatology ; and that the infecting organisms might become resistant at a time when the drug would be most valuable, namely when radical operation was contemplated. It behoved surgeons, therefore, to treat their established cases by radical surgery as before, and to keep the sulphonamides as a valuable adjunct in the pre- and post-operative phases.

When penicillin appeared it was once more hoped that cranial osteomyelitis might be cured without operation. This proved to be only partly true, and a successful case is described below. Putney,[11] in a survey of the value of penicillin in otolaryngology in 1944, states that very early cases of acute osteomyelitis may be arrested and cured by penicillin therapy, but that its main use in established cases is to cause localization of the disease and reduction in the amount of bone ultimately needing to be removed at craniectomy. With this view most surgeons who have used penicillin intelligently would agree, and it is consistent with experience gained in the treatment of osteomyelitis in long bones.[12] Hall[7] has also reported early cases successfully treated without removal of bone, but agrees that the main role of penicillin is to make surgery minimal and safe.

It is probable that streptomycin and other antibiotics will also come to play a valuable part in treatment.

The sulpha drugs and antibiotics have reduced the incidence of osteomyelitis of the skull, enormously diminished the death-rate, and caused operations to be more limited.

It is felt that the method of treatment of the established case should be as follows :

(1) Commence three-hourly penicillin therapy and full sulpha-drug dosage. It is doubtful if more than 20,000 units of penicillin need be given at a time, but it may also be argued that because of the existing vascular thromboses, a larger dosage of 50,000 is advisable. Take a swab from the affected side of the nose, and ask that the sensitivity to penicillin be determined. This may influence the dosage.

(2) Drain the frontal sinus by a small external incision and burr-hole in the floor as described above.

(3) Maintain the penicillin and sulpha-drug dosage for five days, and watch

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the progress of the disease clinically and by X-ray. If the swelling be diminishing, the systemic penicillin may be reduced to 100,000 units eight-hourly, and the local penicillin probably can be discontinued altogether. Should the patient continue to make progress, after about two weeks he can be allowed to leave hospital, but he should continue to receive penicillin 100,000 units twice daily for another two weeks, either as an out-patient or from his family doctor. Thereafter, he is X-rayed, and the examination is repeated monthly. It must be emphasized that at the slightest suggestion of relapse he must return into hospital.

(4) If the lesion continues to spread, or—though localized—does not disappear, and if the X-ray shows no improvement, operative removal of the diseased area must be undertaken.

Operative technique.—The head is shaved and an incision is made through the scalp from one pre-auricular region over the vault to the other. The deep layer of the scalp is picked up with fine artery forceps and superficial bleeding thus brought under control. Burr-holes are made through healthy bone about 2 cm. peripheral to the obvious disease, and are joined by means of a Gigli saw. The main mass of diseased bone is then removed. Any doubtful areas of diploic bone are nibbled away, and the bone removal is carried anteriorly to the lowest limits of the frontal sinus or sinuses, and the anterior ethmoid cells are opened.

The dura mater is carefully inspected for necrotic areas, its surface is dusted over with sulphonamide powder mixed with penicillin, and the scalp is sutured. Although drainage may not be necessary, it is probably wisest to insert corrugated rubber drains through the extreme ends of the incisions and leave them for twenty-four hours. Blood-loss may be severe and a transfusion may be needed.

Usually healing is *per primam*, but if small sequestra make their appearance, these can be removed locally as required.

Illustrative Cases

Case 1.—D. D. (Case No. 70,408/48), a male aged 27, admitted to the Radcliffe Infirmary on 30.3.48, with a tender swelling over the right eye (see Figs. 2 and 3).

History of pain over right eye for about two months, after an acute upper respiratory infection. Subacute infection of the right frontal sinus was confirmed by X-ray on 26.2.48 and patient was treated by shrinking drops and penicillin suction displacements. His symptoms improved, but the pain recurred and swelling appeared on 29.3.48. X-ray showed an area of osteitic rarefaction in the right frontal bone.

Treatment.—He was given penicillin 50,000 units three-hourly and sulphatriad in full dosage, and these were maintained for six days. On 31.3.48 the right frontal sinus was drained externally under local anæsthesia and penicillin irrigation tube was inserted and sewn in place. Yellow pus was found under pressure, a swab from which showed anaerobic streptococci on culture. The right antrum was punctured and washed out. After six days the penicillin

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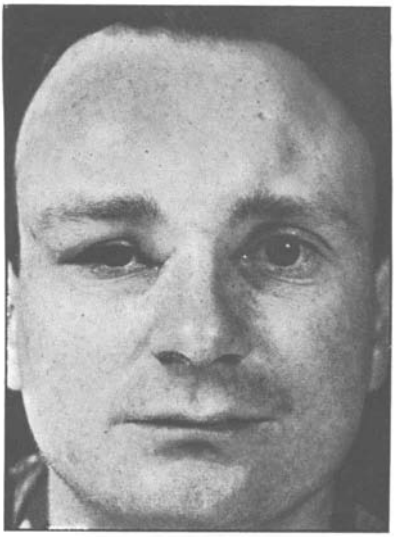


Fig. 2.

Showing how the main swelling in acute cases tends to appear 2-3 cm. above the eyebrow. This patient had had his sinusitis for four weeks before the osteitic signs developed. The infecting organism was an anaerobic streptococcus.

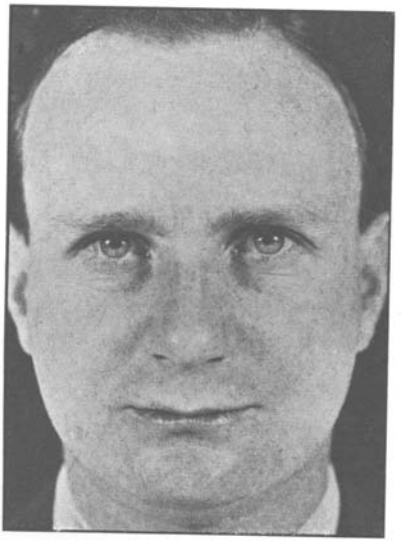


Fig. 3.

Shows the patient's final appearance after external drainage of the right frontal sinus, and penicillin therapy.

Case D.D. Figs. 2-5.

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FIG. 4.
Shows condition before drainage of sinus.

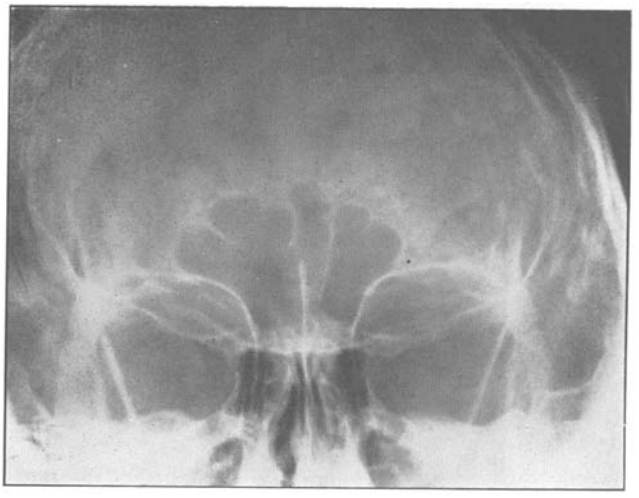


FIG. 5.
Shows condition nine months after drainage of sinus. (Figs. 4 and 5.—Serial skiagrams illustrating progress of case D. D.)

CASE D. D.—FIGS. 2 to 5.

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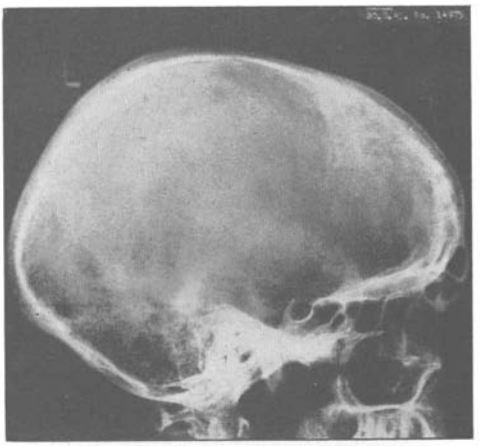


FIG. 6.
Skiagram of the established quiescent but uncured osteomyelitis in August, 1945.

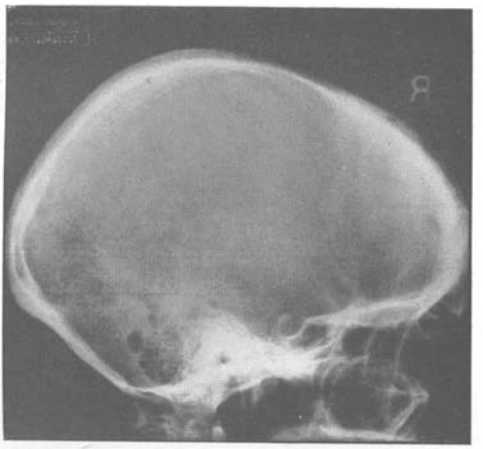


FIG. 7.
Shows condition three months later, bony sclerosis—i.e. chronic osteomyelitis of secondary type (see p. 623).

Case A.D. Figs. 6-12.

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FIG. 8.
Showing the bony defect after craniectomy.

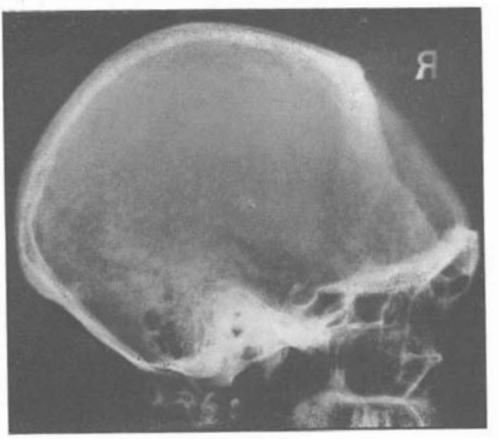


FIG. 9.
Showing the bony defect after craniectomy.

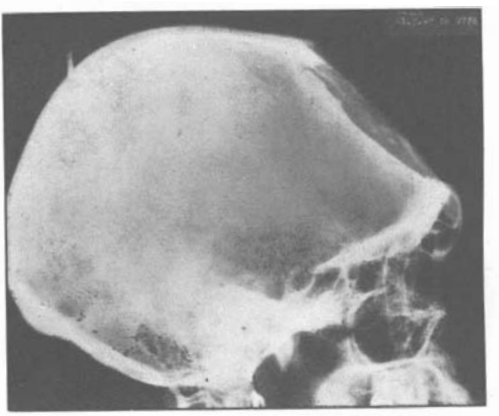


FIG. 10.
Shows very slight regeneration of bone after fourteen months.

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was given in doses of 100,000 units eight-hourly. The tube was removed from the frontal sinus after seven days.

He left hospital on 15.4.48, free of all symptoms and with the frontal swelling completely gone. He continued to receive penicillin 100,000 units b.d. for a further two weeks, and was X-rayed monthly. The skiagrams showed progressive improvement (Figs. 4 and 5).

Comment.—This is an early case of frontal osteitis successfully treated by simple drainage of the causative lesion, together with systemic and local penicillin, and sulphatriad in full dosage.

CASE 2.—A. D., a female aged 19, admitted to the Radcliffe Infirmary on 8.8.45, with a tender swelling in the centre of the forehead.

About the middle of June, 1945, she began to have severe frontal headaches, worse in the morning. These commenced a few days after swimming and diving in the Thames at a popular bathing place. A few days later still, the left eyelid swelled (June 23rd).

She was treated at Windsor by Mr. A. C. Maconie as a case of pansinusitis, given sulphadiazine, and the left antrum was punctured and washed out three times. After three weeks she was better and complained of nothing relevant until August 5th when a tender swelling occurred centrally in her forehead. Penicillin was given in Windsor Hospital three days, then she was transferred to Oxford.

Clinical examination at that time showed some degree of sinusitis on the left. The C.N.S. examination was negative. X-ray showed impairment of translucency of the left frontal, ethmoids, and antrum, but no changes in the diploe of frontal bone. Penicillin therapy was continued at a dosage of 20,000 units three-hourly.

12.8.45. Left frontal sinus was opened externally through a minimal incision, pus was found under pressure. A small tube was introduced and penicillin solution (10,000 units) was instilled twice daily. Bacteriological reports showed *Staphylococcus aureus*. On 16.8.45 penicillin solution began to flow down the fronto-nasal duct, so the tube was removed.

21.8.45. Left antrum was punctured and washed out, and found almost clean. The swelling had ceased to be soft and œdematous and had become much smaller and hard. Penicillin was discontinued and after consultation with Mr. Joe Pennybacker she returned home a week later, apparently controlled, and possibly cured. X-ray at this time showed some erosion and mottling of the frontal bone (Fig. 6).

7.11.45. She was very well. X-ray still showed the irregular mottling of the bone and considerable sclerosis (Fig. 7).

17.2.46. A painless swelling occurred over the left frontal bone. There was no precipitating nasal infection. She returned to Oxford on 20.2.46 and was given sulphadiazine and penicillin once more.

23.2.46. In view of the history and the unchanged X-ray findings, removal of the diseased bone was undertaken by Mr. Pennybacker through a coronal incision. Some granulation was seen superficially. The whole block of bone was removed to reveal its under-surface " worm-eaten ", and purulent granulation tissue covering the dura mater. A diploic channel filled with granulations

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connected the left frontal sinus with the diseased area, and was presumably the route whereby the infection had spread to the bone (Figs. 8, 9).

Superficial healing was uneventful, and she suffered no complications.

She regenerated hardly any new frontal bone, therefore on 23.5.47 a tantalum plate was made and inserted to fill the frontal defect (Figs. 10, 11, 12).

Comment.—This was a case treated successfully ; initially by a combination of conservative surgery and penicillin, and later by radical removal of the diseased area. The penicillin therapy enabled the patient to localize the infection, but did not cure it. The case was converted from one of acute osteomyelitis to one of secondary chronic infection.

Prognosis

If the disease is recognized early and treated by a combination of chemotherapy, antibiotics, and operation, the outlook for the patient's recovery is good. In general, the more fulminating the disease, the worse is the prognosis ; but even where septicæmia or intracranial suppuration has already occurred, and provided that the organisms are sensitive, the expectation of a cure is reasonable.

Sequelae

(*a*) *Local.*—The operation wound usually heals *per primam* and the patient is left with a large bony defect, through which the cerebral pulsation may be seen and felt. In cases where the dura mater has not been injured, nor its vitality impaired, new bone-formation may begin in the first months after operation. At first, irregular whorls of compact bone are laid down, which may be partially mobile, but later the defect is completely bridged and assumes the characteristic shape of the calvarium. Furthermore, in children, frontal sinuses whose outlines were destroyed at the operation sometimes re-develop. Younger patients are more likely to show this regenerative power than are older, though Furstenberg[5] reports complete repair in a patient aged 46.

Illustrative Case (Figs. 13 to 17)

F. C., a girl aged 10 years, admitted to the Radcliffe Infirmary on 26.11.41 with symptoms and signs of acute right frontal sinusitis.

History.—Nine days previously developed a head-cold, then a frontal headache began and five days previously right upper eyelid began to swell.

On admission : Sulphathiazole 3 grammes, followed by 1 gramme four-hourly.

27.11.41. Right antral puncture—lavage produced pus. Immediately patient had an epileptiform attack, violent convulsions mainly on left side, with loss of consciousness. Controlled by pentothal 0·2 gramme intravenously. Right frontal sinus opened later and drained *viâ* floor.

Bacteriology.—*Staphylococcus aureus.*

29.11.41. Œdema over sinus diminished ; frontal bone slightly tender. Neurological examination negative. Lumbar puncture normal.

1.12.41. Fluctuant swelling in mid-frontal region. X-ray showed osteitis right frontal bone (Fig. 13). Operation *viâ* bitemporal coronal incision. Superficial abscess over area of roughened bone 5 cm. in diameter, mainly on

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Fig. 11.

Shows patient's appearance in May, 1947, immediately prior to implant of tantalum plate.



Fig. 12.

Shows her appearance two months later.

Case A. D.—Figs. 6-12.

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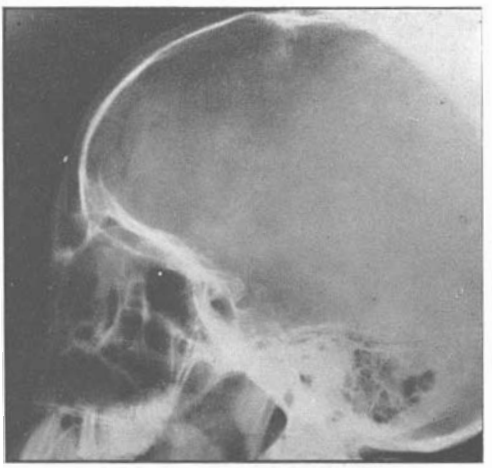


FIG. 13.
A skiagram taken before operative removal of frontal bone, December, 1941.

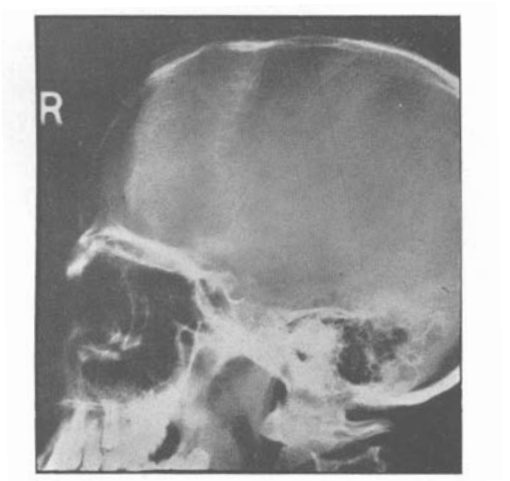


FIG. 14.
One of a series of X-rays showing gradual development of new bone over forehead.

Case F.C. Figs. 13-17 : see p. 624.

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FIG. 15.
Photograph of patient in 1943.

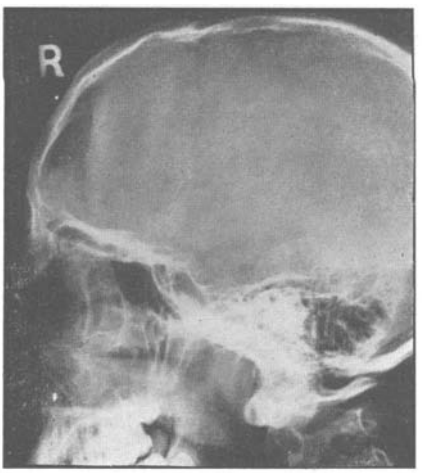


FIG. 16.
Skiagram taken 1944. Note complete regeneration of bone and enlargement of anterior ethmoid cells to replace frontal sinuses.

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right side. Bone removed widely; frontal sinuses and ethmoids opened anteriorly. Extradural abscess found under the necrotic bone. Skin sutured with lateral drainage at both ends of incision. 6.12.41: Given a blood transfusion. 8.12.41: Right intranasal antrostomy. 3.1.42: Went home.

Subsequent progress.—Had occasional headaches, and on several occasions minor puffiness of right eye. No nasal symptoms.

Serial X-rays showed gradual development of new bone over forehead (Fig. 14) and some regeneration of frontal sinuses.

Photograph (Fig. 15) taken 27.3.43. Last seen 21.6.44; very well (Fig. 16).

Fig. 17 shows the temperature and pulse chart of the illness.

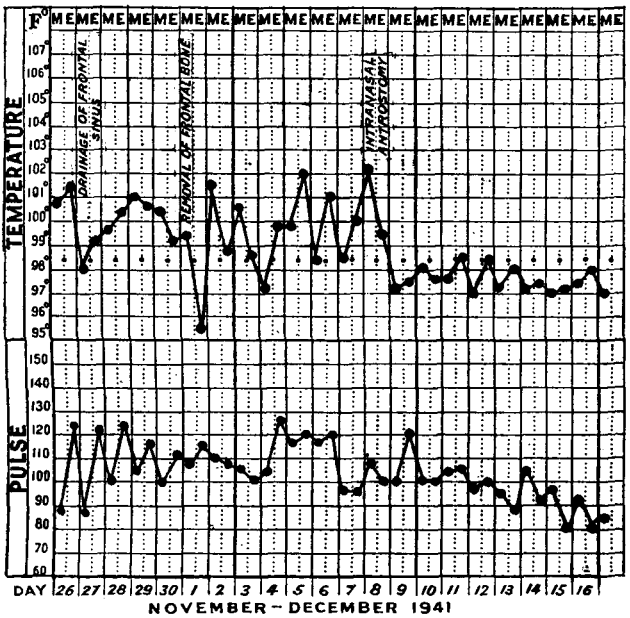


Fig. 17.

(Case F. C.)Patient treated by surgery before penicillin was available.

Case F. C.—Figs. 13-17.

Occasionally small sequestra separate weeks or months after the primary operation, and these may produce small localized abscesses, whose treatment needs no comment.

Where the patient fails to repair the bony defect spontaneously, it may be necessary to insert a plate of tantalum or acrylic resin, as in the case of A. D., described above.

(*b*) *General.*—Cranial surgeons have reported epileptiform attacks as a long-term sequel to successful treatment of acute osteomyelitis of the frontal bone. Where these occur, it is evidently always necessary to exclude an abscess of the brain. It is recommended that patients who have had a resection of

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skull should be given a maintenance dose of phenobarbitone for at least six months post-operatively.

B. Chronic Osteomyelitis of the Skull

Brunner[1, 2] has published a series of cases. Maxwell[10] has pleaded for a recognition of the condition as a clinical entity and described a further series in 1946.

Ætiology.—The ætiology may vary considerably, but this article is concerned only with such cases as may arise from sinusitis. Chronic osteomyelitis of the skull may arise *de novo* (the commoner type), or secondarily as a quiet continuation of acute osteomyelitis. For the rest, the same factors are concerned as are relevant in the acute condition.

Bacteriology.—In the secondary type, the same organisms occur as are found in the acute disease. In the primary type also *Staph. aureus* and *Strep. hæmolyticus* are commonly found, but often there is a negative culture. This negative finding suggests that possibly in some cases an anaerobic streptococcus may actually be responsible, but that it has been missed because appropriate cultural methods have not been adopted.

Pathology.—As has already been noted, osteoporosis and osteogenesis proceed concurrently in all forms of osteomyelitis. In the more acute cases the virulence of the infection is relatively high and the blood supply relatively good, consequently osteoporosis predominates. In the more chronic cases the reverse is true. The blood supply is gradually cut off by a process of thrombosis and endarteritis, and consequently osteogenesis and calcification ensue.

Maxwell[10] has shown that excised normal frontal mucoperiosteum, if transplanted into the lumbar musculature of experimental animals, is capable of producing new bone. It is reasonable to suppose, therefore, that bony thickening occurs immediately subjacent to any chronically infected sinus mucosa. This probably leads to the types of obliterative sinusitis described by various authors. There is, indeed, no clearly established pathological differentiation between this type of thickening of the bony walls of the sinuses, osteitis fibrosa, and true osteoma formation.

It would seem that in common sinusitis the bony thickening is not of clinical significance, but when micro-organisms penetrate into the marrow spaces, a spreading chronic proliferative osteomyelitis may be set up. In the more chronic primary cases, the spreading process results in fibrosis of the marrow spaces and a more or less smooth healing ; in the less chronic secondary cases, osteophytic processes assume the irregular shape of the parent granulation tissue. The dura mater, when exposed at operation, is often covered with granulations. Sequestra are commoner in the secondary cases.

Symptomatology.—In the primary cases the onset is insidious. A gradually developing frontal headache, which slowly becomes more severe and continuous, is probably the first symptom. Toxæmia of greater or less degree accompanies this. Then an osseous swelling over the frontal region begins to appear. Later, superficial abscess formation and sequestration may follow. Occasionally the patient may exhibit proptosis of one or both eyes.

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In fact, the symptomatology is like that in acute cases, but very considerably slowed up.

The secondary cases are characterized by acute onset followed by slow progress. In other words there are the characteristic signs and symptoms of acute osteomyelitis, which give place to a slow thickening of the vault, and the formation of multiple sequestra. A very important feature is the accompanying chronic septicæmia, usually with metastases. These may occur anywhere, but are often found in long bones. Brunner[2] suggests that this feature is due to a thrombophlebitis of the superior longitudinal sinus, and consequent pyæmic emboli, rather than to the bony disease itself.

Complications.—The osteitic process may spread to the base of the skull and give rise to lesions of cranial nerves. Septic thrombophlebitis may lead to meningitis or brain abscess, and metastatic cases may develop amyloid disease.

Treatment.—(*a*) *Prophylactic.*—The secondary cases would not develop if the primary acute cases were treated efficiently and vigorously by radical excision of the diseased bone.

(*b*) *Active.*—Occasionally the local removal of sequestra and adequate treatment of the underlying sinusitis have been known to halt the spread of this disease, and sometimes the patient may present himself with the condition so advanced that radical treatment cannot be undertaken. But it would seem that among the cases published, wide excision of the osteitic bone is the treatment of choice. This is technically more difficult than in the acute cases, but the patient is usually less ill. The steps of the operation closely follow those already described. The sulphonamides and antibiotics, as would be expected, have little value other than as an aid to operation.

Prognosis.—In all cases the prognosis should be guarded because of the relative difficulty in extirpating the disease process.

I am indebted to a number of my colleagues for help in the preparation of this paper, notably Professor Sir Hugh Cairns and Mr. J. Pennybacker for their helpful criticism and access to the records of the Nuffield Department of Surgery.

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Ronald Macbeth, in reply to Mackenzie Ross, H. V. Forster, Donald Watson and others, said that with reference to the reconstructive

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practice chosen, different plastic surgeons had their different whims and fancies ; he thought that where there was no danger of infection being lit up again an acrylic resin or tantalum plate was of service.

He agreed that there was a place for the use of the anticoagulants heparin and dicoumarol in such cases as cavernous sinus thrombosis. He and his colleagues had not in fact tried these new preparations, probably because there had not been a suitable case.

Mr. Macbeth agreed that they would all try conservative measures before attempting drainage. He had been careful to say in his paper that the drainage treatment was undertaken in acute cases where conservative measures had failed, or where drainage was a matter of urgency.

On the question of how to discover whether an extradural abscess had occurred he could not give a categorical answer, but where trouble of this sort was suspected a " base-line " lumbar puncture would be helpful. An extradural abscess would give a high cell count even in the absence of symptomatology other than that of an obvious frontal sinusitis.

In the cases where ineffective sulphonamide therapy had been used bony changes could often be seen radiologically—changes which had gone on quite quietly. Radiologists stated, however, that it was usual for no bony changes to appear until a week after the clinical symptoms.

On the question of antral infection, operative treatment of the antral infection might be necessary where the help of penicillin was available ; it was usually unnecessary to carry out an operation on the antrum. His third case, which had been treated before penicillin, in fact, had done this.

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