NOTE ON TUNNELS AND LARGE CAVITIES IN BONE.

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DURING the six months since the Queen Alexandra Military Hospital Extension was opened at Millbank, our attention has been particularly drawn to cases of chronic suppuration in bone. Among the first fifty patients admitted, there were no less than nine who had been wounded more than six months previously, all of whom had discharging sinuses in their limbs. They had been in various hospitals and convalescent homes, and all had had their sinuses scraped on several occasions.

Skiaograms were taken of these cases, and it was immediately found that they fell into two groups: In four instances foreign bodies—pieces of shrapnel or bullets, etc.—were found, generally on the side of the limb remote from the opening of the sinus, which perhaps explains why they had been missed, the remaining five cases had been compound fractures of the long bones in which the bone had been perforated by the bullet. The skiaograms showed that the bones had united on each side of a central cavity or tunnel, as is well shown in the illustrations. On investigating the history of these cases, it was found that a tube had been passed along the track of the bullet shortly after the receipt of the wound, and kept in for some considerable time for drainage. The sinus was generally situated on the upper aspect of the limb as the patient was lying in bed, while the more dependent scar had healed over. At the time these patients came under our notice, it was impossible to tell from an examination of their wounds which had been the entrance and which the exit wound. Several more cases of a similar nature have since come under our care.

FIG. 89.—Case 1, before operation. The probe passes right through the bone.

Typical histories are as follows —

Case 1.—Cpl. W.: Bullet wound of left femur five inches from lower end, compound fracture. Wounded Sept. 9, 1914. Wound freely drained, a tube being passed right through the limb. Bone plated at St. Nazaire, Sept. 24. In October bullet was removed. Wound continued to discharge freely. In November the plate was removed at Millbank. The fracture now united. Wound was scraped, disinfected, and drained in April, May, August, and November, 1915, and on Jan.

13, 1916, when a tunnel traversing obliquely from before backwards through the lower end of femur was found (*Figs. 89, 90*).

FIG. 90.—*Case 1*, after operation. The whole of the outer wall of the tunnel has been removed, and the drainage tube inserted from behind. This case healed up completely two months after the operation described in the text.

Case 2.—Pte. C. Bullet wound of right arm, causing compound fracture of humerus in lower third. Wounded at Neuve Chapelle on March 10, 1915. Complicated by musculospiral nerve injury and wrist-drop. Next day wound was cleaned up and freely drained, a tube being passed right through the humerus from side to side. Bone joined in about eight weeks, but wound continued to discharge. Sinus scraped and cleaned in May and July, 1915. Admitted to Millbank Nov 11, 1915. X rays show a tunnel through the lower end of the humerus from side to side (*Figs. 91, 92*). On Nov 7 the sinus was scraped and drained, with counter-incision through lower scar, which had healed.

The histories of the other cases are precisely similar: many attempts to obtain healing by routine methods of curetting and disinfection of the sinuses, which nearly heal; transference of the patient to a convalescent home, where the sinus breaks down, return to the same or another hospital, and the process is repeated.

Of eight cases treated in this way during the last three months, only one has healed. In this case there was a tunnel passing from side to side through the middle of the shaft of the humerus; several small sequestra were removed from the cavity, and the sinus healed up one month later (see *Fig. 93*), the patient had had the sinus scraped out and drained on no less than six occasions before the skiagram was taken. The remaining cases invariably improved to a certain extent, and then came to a standstill, a small sinus persisting, from which a little seropurulent material continued to ooze.

FIG. 91.—*Case 2*, before operation. The probe passes right through the humerus.

FIG. 92.—*Case 2*, after operation. The anterior wall of the tunnel has been removed subperiosteally. This case had healed completely three months after the operation described and shown in the above figure.

The reason why these cases fail to heal is probably mainly anatomical. There is present in the walls of the cavity a slight chronic infection, with which the tissues are unable to deal in the ordinary way. This cavity cannot be obliterated by granulations, because the walls are rigid and will not collapse; when such granulations grow up beyond a certain point, the contracting scar tissue underneath, being unable to draw the surfaces together, strangulates the blood-supply to the more superficial granulations. (See also note on page 158.)

FIG. 93.—Showing a tunnel through the humerus, with several small pieces of bone in its lumen. This case returned to us from a convalescent home three and a half months later, the sinus having broken down a fortnight after the patient had been sent there. A complete subperiosteal resection of the anterior wall of the tunnel was performed, and the wound has now nearly healed again, one month since the operation. The result of this operation is shown in Fig. 94.

There is not much evidence of osteosclerosis being present, as during operation the bones are not found to be unduly dense. The signs are rather those of a subacute or chronic periostitis, and it seems probable that in some cases flakes or superficial plaques of bone continue to be thrown off into the tunnel (see *Figs. 93* and *95*, where each sinus had been scraped out several times before the skiagrams were taken). We have not, however, seen these sequestra develop in any case we have had under our care.

There is very little evidence of osteomyelitis, as the medullary cavities have been shut off by callus, which has become organized into quite definite layers of bone; this can be seen in any of the skiagrams, and is confirmed by the findings at operation, the medullary cavity being plugged with smooth firm bone. It is in this respect that these cases differ from those with cavities where the bullet has penetrated, but not fractured, the bone; in

the latter, little or no callus has been thrown out, and the medulla is shut off from the cavity by granulation tissue only (see *Fig. 99*).

As some of these tunnel cases are further complicated by injury to nerves, especially in the case of the humerus, where the musculospiral nerve is so apt to be involved, it is all the more desirable to find some means of shortening the period of healing; as, of course, no attempt at repair of the damaged nerve can be made till healing has occurred.

On referring to Binnie's *Operative Surgery*, we find no less than ten more or less different methods described for obtaining the closure of large cavities in bone, but all depending in some measure on adequate sterilization of the cavity as a preliminary measure. It is just this preliminary sterilization, however, that is the most difficult part. Professor Burghard writes in his *System of Surgery*. "The closure of a cavity in bone is practically impossible as long as sepsis persists; and obviously the first step in the treatment is to secure asepsis. Otherwise the cavity will discharge indefinitely. Sometimes it is fairly easy to make a cavity of this kind aseptic, but sometimes it is impossible." The methods he advises are, firstly, free incisions and adequate drainage, disinfection with hydrogen peroxide and 1-20 carbolic left in the cavity for ten minutes, and occasional scraping and the application of pure carbolic to the walls of the cavity, the latter under local anæsthesia. When no further improvement is obtained, he operates as follows: The surrounding parts are carefully purified, the sinus being plugged with pure carbolic, the sinus is then completely excised, and a quarter of an inch of bone is removed all round by chiselling and gouging. Having thus obtained an aseptic cavity, he closes it either by Schede's aseptic blood-clot method, the soft parts being mobilized and sutured over the aseptic blood-clot which fills the cavity, or by filling it with Mosetig-Moorhof's paste or Beck's bismuth paste, and suturing the skin over this. If a truly aseptic cavity can be obtained, fresh human bone chips might be used, as in Macewen's method of bone grafting. We have had no success with the bismuth paste method, being unable to make the cavity aseptic first. It has been impossible to adopt this technique in its entirety, as the removal of so much bone would have made an opening into the medullary cavity, further, the use of pure carbolic is contra-indicated owing to the proximity of important nerves and vessels.

FIG. 94.—Showing result of operation.

The operation we have devised to overcome these difficulties is sufficiently simple, yet it did not occur to us till we had watched these cases for three months. It consists in the complete removal of one wall of the tunnel subperiosteally, so as to allow the soft parts to fall down on to and obliterate the lumen of the tunnel, after the manner of Estlander's operation for mobilizing the chest wall.

With regard to the time at which this operation may be performed, it would probably be wise to wait until five or six months have elapsed since the injury, so that the fragments may be firmly consolidated. Also, the risk of setting up an acute osteomyelitis will be much less after an interval has elapsed long enough for the medullary canal to have been firmly sealed by new bone developed from the internal callus.

FIG. 95.—Perforation of radius and ulna by a bullet, with several small loose pieces of bone. In this case and in the one shown in *Fig. 93* the tunnels had been scraped out several times.

The procedure at the operation is as follows. The sinus is first scraped, and cleaned out with peroxide of hydrogen. The skin is then incised at each end of the tunnel in a direction at right angles to its length and in the long axis of the limb. This incision is now carried down to the bone on that side of the tunnel which it has been decided to remove, taking care not to injure any important structures in the neighbourhood. The periosteum is raised up with the skin and intervening soft parts from that wall of the tunnel which is to be removed. The bone is then sawn through so as to remove a wedge-shaped piece,

the broad end of the wedge being away from the tunnel. We find a Gigli saw an efficient instrument for this purpose. The sharp edges of the groove so made are smoothed off with a chisel, so that they shelve gently down to the cavity of the tunnel. This can generally be effected without opening up the medullary cavity of the bone at all. A drainage tube is inserted, going from the most dependent opening to the bone. Finally, the limb is bandaged firmly, so as to press the soft parts down into the tunnel and obliterate its lumen as far as possible.

At first there is some increase of the discharge, but this soon diminishes,

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and the sinus will heal. The radiographic appearances of *Cases 1* and *2* after operation are well shown in *Figs. 90* and *92*.

From the nature of these cases, the tunnel will usually be found to pass nearly through the middle of the bone. If the wound were much to one side, the pieces of bone on that side would probably be so shattered at

FIG. 96.—Showing tunnel through upper end of right tibia, seen from the front. The probe passes right through the tunnel. The wound has failed to heal after eight months, although scraped and cleaned up on several occasions.

the time of the injury that they would not unite to form a wall of a tunnel, but be discharged as sequestra.

Of course it will be necessary for some time to treat the bone thus weakened with great care, dealing with it in fact as after a sequestrotomy following acute osteomyelitis; but the single limb of the tunnel will soon throw out buttresses of bone and become quite strong.

With regard to large cavities in bone where a bullet has penetrated,

but not perforated, the bone—or where, if perforation occurred in the first instance, one side has joined firmly—it is generally necessary to enlarge the opening so that the walls of the cavity shelve gently down to the base. But after this has been done, it is found that healing is excessively slow. It may, in some cases, be possible to skin-graft such cavities; but even this will leave a very large hole in the bone, covered with skin that is certainly inadequately nourished, as it derives its blood-supply from scar tissue and has no underlying vascular subcutaneous tissue.

This difficulty may in some cases be overcome by sliding flaps of skin over the cavity.

An alternative method that will be sometimes applicable is to convert the cavity into a tunnel, by making a counter-incision on the opposite side of the limb, and then to remove one wall of the tunnel subperiosteally. The counter-incision will give drainage in a dependent position, and the bridge of tissue may be expected to fall into and obliterate the tunnel. This method is particularly applicable to the tibia if the inner wall of the cavity is on the inner side in front of the calf muscles, as the fibula will become a splint for the time being.

One case, under the care of Major R. Scot Skirving, in which this procedure—slightly modified—was adopted, is illustrated in *Figs. 99 and 100*. In this case there was a large cavity in the anterior aspect of the tibia, from which a shrapnel ball had been extracted the sides and posterior wall of the tibia were intact, and the bone had not been

FIG. 97.—The same case as *Fig. 96*, seen from the side.

broken, so that there was practically no callus. This cavity had been scraped out six times in the previous eight months. The whole of the inner wall of the tibia for the length of the cavity, and part of the posterior wall, were chiselled away subperiosteally, and a counter-incision was made just behind the inner border of the bone, through which a drainage tube was inserted down to the bottom of the trough. It was found that the cavity could now be closed in front with sutures, as the soft parts were no longer held apart by the inner wall of the tibia.

One is perhaps not quite so hopeful of success in these cases, as it is impossible to obtain a shelving groove with a smooth surface, such as is obtained after operation on the tunnel cases. Since these bones have

generally not been actually broken across, there is very little callus thrown out, and the medullary canal has not been shut off from the cavity by internal callus. It will, however, have been filled by granulation tissue, and one may expect the bridge of tissue to adhere to this layer and so bring about healing.

It may not be out of place to refer to the local application of oxygen and ozone to these tardily healing sinuses and cavities. This method has been extensively used here and elsewhere by Major Stoker, who has devised the necessary technique. Judging by the cases in which he has carried out this treatment in this hospital, it is certain that the time taken for filling and sound healing is greatly shortened by the daily use of this application.

The manner of the action of the oxygen is easy to understand. We have seen that these cavities fail to heal because the rigidity of the walls prevents them from collapsing, and that the granulations are deprived of an adequate blood supply by the contraction of the subjacent scar tissue. The local application of oxygen enables these granulations to live and proliferate, and so fill up the cavities.

SUMMARY.

1. The presence of tunnels and large cavities in bones as the result of gunshot wounds, as well as from other pathological conditions, is a common cause of persistent sinuses, which continue to discharge practically indefinitely.

2. Tunnels occur in cases where a long bone has been perforated and fractured by a bullet, and where, in treating the septic condition associated with these compound fractures, a drainage tube has been passed right through the middle of the bone, the bone uniting round a central cavity.

3. The delay that takes place in the healing of the sinus is due to the fact that a chronic infection is present with which the tissues are unable to deal, since they are unable to obliterate the tunnel, the rigid walls of which will not collapse, so that the sinus which leads down to the tunnel continues to discharge indefinitely.

FIG. 98.—Perforating wound of upper end of right femur. The patient was wounded nearly twelve months before the skiagram was taken. The sinus has been scraped on several occasions, but still discharges.

FIG. 100.—The cavity shown in *Fig* 99, with the internal and part of the posterior walls removed

FIG 99.—Cavity in tibia caused by shrapnel bullet, without complete fracture of the bone

The clinical history of this case is as follows: Wounded May 16 Shrapnel bullet lodged in upper end of left tibia, removed next day Four days later leg freely incised and drained Bones scraped and drained on six occasions between June and December, 1916 January 26, 1916, operation described on page 162 was done The wound was soundly healed three months later Healing was undoubtedly accelerated by the local application of ozone, which Major Stoker was kind enough to undertake

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4. Attempts at sterilization of these cavities and tunnels by scraping and the use of disinfectants are almost uniformly unsuccessful, and therefore the use of such materials as bismuth paste or iodoform paste is doomed to failure.

5. The treatment advised is the subperiosteal resection of one wall of the tunnel—access being gained by longitudinal incisions down to the bone, at right angles to the length of the tunnel—so as to convert the tunnel into a shallow trough or groove; the trough so made is drained through the more dependent incision, and the bridge of soft tissues is pressed down into the bone by firm bandaging.

6. Large cavities in bone are treated in a similar manner, bone being removed subperiosteally so as to convert them into shallow troughs. They are drained by a suitably placed counter-incision, and the bridge of soft tissue is pressed down into the trough so as to obliterate the cavity.

In conclusion, I wish to express my indebtedness to Lieut.-Col. E. M. Pilcher, and to Major R. Scot Skirving, of Sydney, N.S.W., for their advice and for the use of cases, also to Mr. Pooley, radiographer to the Q.A.M.H. Extension, for the great pains he has taken in the preparation of the photographs which accompany this article.