BONE GRAFTS AND CHRONIC OSTEOMYELITIS

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Chronic osteomyelitis still remains a problem despite advances in medicine. Modern trends emphasise the ischaemia rather than the infection of the bone (Clawson and Dunn 1967). Avascular bone or scar tissue acts as an impenetrable barrier to antibiotics. For antibiotics to be effective dead bone, scar tissue and sinuses must be removed. All dead space must be eliminated when the wound is closed, otherwise the cavity is easily reinfected (Hazlett 1954; Valls, Brewener and Segers 1959; Clawson and Stevenson 1965).

The removal of sequestra and scar tissue is usually done without difficulty, although from time to time the surgeon has to be less radical, lest the bone be unduly weakened (Horwitz and Lambert 1946, Reynolds and Zaepfel 1948).

Elimination of the dead space is the more difficult procedure (Bickel, Bateman and Johnson 1953; Rowling 1959; Rowe and Sakellarides 1961; Mercer and Duthie 1964). It has long been known that osteomyelitic cavities have a poor tendency to spontaneous obliteration by bone proliferation (Hogeman 1949). Ingenuity has resulted in a multiplicity of techniques. At present only three deserve interest: the free skin graft, the muscle flap and the bone graft (Hazlett 1954, Rowe and Sakellarides 1961, Mercer and Duthie 1964, Winter and Papp 1964, Evans and Davies 1969). The first two present technical difficulties that make them impracticable in many cases. Above all in the metaphysio-epiphysial regions difficulties are frequent (Bickel and colleagues 1953, Martini and Essafi 1965, Evans and Davies 1969). In these cases saucisation is usually impracticable. On the other hand, in regions such as the knee, ankle, wrist and shoulder it is difficult, or even impossible, to find muscle to fill the cavity (Coleman, Bateman, Dale and Starr 1946; Bickel and colleagues 1953). That is the reason why, when localised in one of those regions, chronic osteomyelitis continues to be a "therapeutic challenge" (Clawson and Dunn 1967).

The use of bone grafts, not universally accepted, seems to present many advantages (Bickel and colleagues 1953, Hazlett 1954). Their use in infected bone defects has been condemned since the beginning of the century after early failures (Hogeman 1949, Buchman and Blair 1951). The accepted practice was to wait one or even two years after the end of suppuration before grafts were used. With the advent of antibiotics only the period of waiting was changed (Boyd and Lipinski 1960, Judet and Judet 1965). The general idea of the necessary conditions of the "ground", so that the graft takes, persisted in spite of the protection of antibiotics (Hogeman 1949, Stringa 1958). Even with occasional good results the procedure seemed inconsistent with the basic principles of biology, "living transplant being unable to survive in an infected cavity" (Winter 1951).

Mowlem, of England, fighting against this opinion, and believing in protection by antibiotics, was the first to use bone grafts in infected cavities. In his papers (1944 and 1945) he emphasised the great resistance of cancellous bone chips to infection and the advantage of their use in reconstructive surgery of the skeleton. In conclusion, Mowlem said: "Nobody suggests that it is desirable to graft in the presence of infection. But it is our feeling that the existence of a low-grade infection did not represent a barrier to the graft. If the graft can be used before disuse atrophy of the limb, not only is much time saved, but also the possibilities of complete recuperation are greater." In subsequent years other authors have shown their

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interest in this subject (Knight and Wood 1945; Prigge 1946; Abbott, Schottstaedt, Saunders and Bost 1947). However, it was only when there appeared publications based on more extensive experience (Coleman and colleagues 1946, with fifty-two cases; Hogeman 1949, with eleven cases; Bickel and colleagues 1953, with thirty-six cases; Hazlett 1954, with 101 cases; Popkirow 1960, with sixty cases) that the method attracted attention.

The procedure has not achieved general acceptance. Buchman and Blair (1951), Boyd and Lipinski (1960) and Judet and Judet (1965) considered that it was based on incorrect principles. But the advantages of its use are evident. First, it is always possible to fill a cavity, no matter where. Secondly, the disadvantages of the occasional wide excision are greatly reduced once we can hope for good bone reconstruction. Finally, in cases of infected...
fracture with pseudarthrosis, the osteogenic activity of the graft is a fundamental factor in consolidation (Hogeman 1949, Bickel and colleagues 1953, Hazlett 1954). As Hogeman said, the main reason for its preference is that with other methods of treatment the cavity or dead space may persist for a long time after the operation, creating a locus of lessened mechanical resistance and of greater probability of re infection. With a muscle pedic le the vascularisation decreases with time (Buchman and Blair 1951), while with bone grafts the vascularisation increases. It has been known for a long time that the only safe indication of cure of chronic osteomyelitis is good bone reconstruction (Popkirow 1960). When the infected defects show little tendency to spontaneous obliteration the use of bone grafts may be best.
Clinical Study

In the last ten years 231 cases of chronic osteomyelitis have been treated in the orthopaedic department of Oporto Medical School. In 120 of these bone grafts were used; these cases are reviewed in the present paper. The patients, seventy-three male and forty-seven female, were aged between five and sixty years; most were in the first three decades of life (Fig. 1). The infection was haematogenous in 101 cases; it followed compound fracture in eighteen cases.
and direct contamination from wound sepsis in one. The femur and tibia were the bones most often affected (three-quarters of the cases), followed by the humerus and radius (Fig. 2). Most patients had been operated on before admission: only sixteen were fresh cases. More than half of the patients (sixty-eight) had had two to six previous operations (Fig. 3). The duration of the disease was from six months to forty-three years. In only twelve patients was it less than a year, while in eighty cases it was between two and fifteen years (Fig. 4).

In sixty-eight cases the infection was in the metaphysio-epiphysial region, while in forty cases the main lesion was in the diaphysis. In ten cases both regions were involved. In sixty-eight cases the lesion had the aspect of a cavity, without radiologically demonstrable sequestra; in twenty-eight cases sequestra were visible in the radiograph; in fourteen cases there was a pseudarthrosis; and in ten cases the appearance was that of Brodie’s abscess, seven with sinuses. In 117 cases it was possible to identify the bacteria. The most frequent was staphylococcus aureus, alone or associated with other organisms (108 cases) followed by pseudomonas aeruginosa (fourteen cases). The bacteriological contaminants were more common in old sinuses than in open fractures.

Treatment—On admission the patient had radiographs taken in two planes, and sometimes tomography was done. If the disease affected a segment of the body with much muscle, sinography was also done. Pus from the depth of the wound was cultured for identification of the organism, and to determine the most suitable antibiotic. This was administered for three to five days before operation, and for four to six weeks afterwards.

Contrary to general experience, we have had only a few cases in which plastic procedures were needed before the bone operation was undertaken. This was because most of our cases were of haematogenous osteomyelitis. In only twelve patients was a plastic procedure necessary, six of them cross-leg flaps.

Operative technique—A pneumatic tourniquet was employed whenever feasible. After injection of the tract with 1 per cent methylene blue, an incision was made in such a way that the sinus and bone lesions could be removed. Sometimes a different approach to the sinus was necessary. After excision of all fibrosed or necrosed soft tissues down to the peristium, the sequestra (if any) and the granulation tissue were removed and the cavity was curetted. The walls of the cavity were excised, whenever possible down to healthy bone. We never tried to saucersise the cavities. Once all infected material had been removed the tourniquet was taken off and the way in which the walls bled was noted. In cases of any doubt the removal of bone was
continued until the remaining bone had a healthy aspect. The aim was always to obtain a cavity with walls of well vascularised bone. This was always feasible when the lesion was in

the metaphysio-epiphysial region. In contrast, in the diaphysis this was very difficult and sometimes impossible. The hard, compact structure of the diaphysis does not often allow the creation of a new cavity with walls of bone tissue of normal aspect. After the wound had
been cleaned and washed with physiological saline, the cavity was filled with cancellous bone grafts mixed with antibiotic and gently impacted. With pseudarthrosis without great loss of bone substance (ten cases) the procedure was similar. Once the infected soft tissue was removed and the bone ends curetted in such a way as to leave only tissue with a reasonable appearance, all the dead space was filled with cancellous grafts. After suture of the wound the limb was put in plaster. A suction drain was used for forty-eight hours.

**FIG. 1** Chronic osteomyelitis of the femur with sinuses. Figure 1—Appearance on admission. Figure 12—Two years after removal of infected soft tissues and bone, and filling the cavity with cancellous chips.

*Type of graft*—In 105 cases the only graft was of autogenous bone chips (iliac grafts removed just before the operation on the infected region started). In eleven cases the graft was of banked homologous cancellous bone. And, in four cases of pseudarthrosis with great loss of substance, delayed cortical autografts were associated with bone chips.

**RESULTS**

The duration of follow-up was between two and ten years, with an average of five years. Out of 120 patients 116 showed primary healing and are now free from infection. In four patients there has been recurrence of infection.

Clinical review was supplemented by radiographs. We sought particularly evidence of incorporation of the graft (Figs. 5 to 8). This was more rapid and more perfect in the metaphyso-epiphyseal region in the young patients. In some of them we found a true *restitutio ad integrum* (Figs. 9 and 10). But in the diaphysis the evolution had other aspects; although in most the graft was incorporated, some bone sclerosis was always visible (Figs. 11 and 12).

In seven patients the radiographs suggested recurrence, four of them in the cases with
Examples of pseudarthrosis of the tibia and response to treatment by removal of infected soft tissues and bone, and filling of cavity with cancellous chips. Figure 13—Pseudarthrosis after osteomyelitis. Figure 14—Three years after operation. Homograft was used. Figure 15—Infected pseudarthrosis after fracture and internal fixation. Figure 16—One year after operation.
clinical infection. All the cases were diaphysial infections, and a review of the clinical history showed that in six the removal of sclerosed bone had not been adequate.

Analysis of the relapsed cases shows some interesting points. In two the infecting organism was proteus vulgaris (besides staphylococcus aureus), resistant to a large number of antibiotics. In both cases the surgical wound had never completely healed, the suppuration persisting. At re-operation most of the grafted material was found sequestrated. In another patient (a child eight years old with osteomyelitis of the tibia) the recurrence appeared six weeks later, when the limb was still in plaster. The grafted material (bone bank) was partly sequestrated. Finally, in another case of diaphysial affection the suppuration appeared about four months after the operation, when the patient was already walking. Grafts from the iliac bone had been used but with much cortical material. At re-operation it was confirmed that the cancellous parts of the graft had taken while the cortical parts were sequestrated.

In all cases of pseudarthrosis we confirmed healing of infective process and bone consolidation (Figs. 13 to 18).

Complications—In six cases the healing of the wound was not normal, the discharge continuing for some weeks. In four of these cases the wound was healed after six weeks, while in two the discharge persisted. The only serious complication was laceration of the femoral artery while we were dissecting a sinus in the inner part of the thigh. The artery was sutured and the operation was completed satisfactorily, progress and recovery being normal.

DISCUSSION

We must admit that the follow-up is a little short for appraisal of the efficacy of treatment in a lesion with the elusive characteristics of chronic osteomyelitis. Recurrence of infection is common, so time is the only test of cure. However, we also know that if chronic osteomyelitis
can relapse many times, it is the more likely to happen if radiographic appearances are suspicious. And this, as stated already, was so in only a few cases. In a disease so variable as chronic osteomyelitis it becomes difficult to define exactly the indications and contra-indications of

![Fig. 19](image1.png)  ![Fig. 20](image2.png)

**Fig. 19**
Results of excision of lesion and replacement with cancellous chips. Figure 19—Tomographs showing lesion in the upper tibial metaphysis. Figure 20—Three years after operation.

![Fig. 21](image3.png)  ![Fig. 22](image4.png)

**Fig. 21**
Another example of excision of the lesion and replacement with cancellous chips. Figure 21—Chronic osteomyelitis of tibia, persistent after three operations. Figure 22—One year after operation.

the method. The main object of treatment is without any doubt to fill the cavity, eliminating dead space. It is also important to leave a good circulatory background in the affected area, not only because it gives a better defence but also because only thus is it possible to profit from the antibiotic.
Our experience shows that cancellous bone has the desired resistance that the cortical graft lacks, probably from the latter's greater resistance to vascularisation.

For vascularisation of the graft it is necessary 1) that the bed should be well vascularised, and 2) that in the critical period in which the graft is not yet penetrated by vessels it should not be floated off by discharge. Because it is almost always possible to find an appropriate antibiotic, the problem, from the practical point of view, is only to change one osteomyelitic cavity into another with better circulatory conditions. The ideal case—in which a bone graft is certainly indicated—is that in which it is possible to remove the lesion completely, leaving a cavity surrounded by healthy bone (Figs. 19 to 22). This is more often possible in the metaphysio-epiphysial lesions. In our experience it was in this type of lesion (in which it is more difficult to use saucerisation or a muscle pedicle) that we obtained speedier incorporation of the graft and more perfect reconstruction of the trabecular structure of the bone (Figs. 9, 10, 23 and 24).

In the diaphysial lesions total removal is harder to accomplish. The indication for bone grafting will depend on the extent of the lesion and on the bone sclerosis present. If it seems possible to remove all the affected bone, leaving a cavity with bleeding walls, the use of bone grafts is advisable (Figs. 11 to 16). Otherwise we have to choose another technique (saucerisation, free skin graft, muscle pedicle) because the use of bone grafts under such circumstances is dangerous, no matter how good the antibiotic protection may be.

Summing up our experience, we believe that, while chronic osteomyelitis has different aspects from the anatomico-pathological and clinical points of view, its treatment must also be undertaken by different procedures. Many of those used by other authors can be justified, but none of them can be considered a panacea. It is time, we think, to emphasise the value of bone grafts in treatment.

**SUMMARY**

1. In the treatment of chronic osteomyelitis the most troublesome factor is the infected bone cavity. This is seldom obliterated spontaneously by bone regeneration. The number of procedures designed to fill the cavity, since the beginning of the century, show how much it troubles the surgeon.
2. The use of bone grafts in the treatment of chronic osteomyelitis has been studied. One hundred and twenty cases are reviewed (the largest series in the literature), the follow-up
being between two and ten years. The most common lesion was a bone cavity, with or without a sequestrum.
3. Treatment must include the removal of infected soft tissues as well as sclerosed bone, and must be done under appropriate antibiotic control. The value of cancellous bone grafts in filling infected cavities in the metaphyso-epiphyseal regions is especially emphasised.
4. The results were gratifying, only four relapses occurring in 120 cases.

REFERENCES