EXPERIENCES WITH BOILED CADAVERIC BONE


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Boiled bone—homogenous and heterogenous—as material for grafting has, in the past, received considerable attention, but earlier results did not appear to justify further trials, and fresh autogenous transplants superseded boiled grafts almost entirely. Boiled cadaveric bone was regarded as less reliable than autogenous bone, slow to become incorporated into the host, and not altogether free from the suspicion that foreign proteins might carry their own peculiar dangers. Hey Groves (1917), however, advocated it if bone pegs were to be used and if the supply of fresh autogenous bone was scanty or the removal of a suitable graft was contra-indicated. “Os purum” (Orell 1938) was sterilized by boiling in saline.

Reviewing the experiences of previous workers we found that many of the failures may have been due to technical errors. The modern principles of careful preparation of the bed so as to obtain a large area of vascular host bone in contact with the graft, absence of bending stress and firm apposition of the graft to its bed by precise joinery or efficient internal fixation, were not well established, and in consequence failures with any type of graft were common.

If it is assumed that cortical bone grafts become incorporated by a process of invasion by the host and that the graft does not survive in its transplanted state, it is difficult to understand why boiled bone should not be a useful addition to the bone bank. Furthermore, a far from unique case of our own in which a graft cut from the tibia was contaminated and had to be boiled before its transfer to the radius illustrated that fusion follows without undue delay. Recent experimental evidence (Reynolds and Oliver 1950, Odell, Mueller and Key 1951) indicates, however, that boiled bone, although capable of carrying out the functions of a fresh or frozen graft, does so more slowly—findings which conflict with those of Hey Groves (1917), who was unable to show any difference in behaviour between boiled and fresh bone transplants. On the basis of these considerations, and stimulated by the experiences of others with stored homogenous bone, which demonstrated that foreign protein reactions do not exist as a practical problem even in unboiled bone, we resolved to resurrect in our practice the use of boiled cadaveric bone—tentatively at first, but later, as our knowledge grew, with greater confidence.

PREPARATION AND STORAGE

The bone is obtained at necropsy from the tibia and ilium, and soft tissue is scraped away. The bone is boiled for half an hour, cut into convenient lengths of the tibia or blocks of the ilium, and stored dry in a household refrigerator. Before use it is boiled again for twenty minutes. This method has the virtue of simplicity, and it does not require elaborate methods of asepsis or bacteriological control. Needless to say, the source is infinite.

RESULTS

In earlier cases we limited ourselves to replacing tibial and iliac defects remaining after autogenous grafts had been taken (Fig. 1). Since there was no untoward reaction, we then applied boiled grafts to long bones when undertaking open reduction and internal fixation of fractures, using the bone in addition to the necessary metallic fixation. We learnt from these cases that the grafts served in the same way as fresh autogenous grafts; the risk of sepsis did not seem to be increased, and there was no tendency for the grafts to be rejected as foreign bodies.
Figure 1—Reconstruction of a tibial defect by means of a cadaveric graft. Autogenous bone had been removed for spinal fusion. Figure 2—Bone graft for ununited fracture of tibia. The fracture occurred after removal of tibial bone for spinal fusion. The massive cadaveric graft was inlaid into the defect and across the fracture in the manner of a sliding graft.

Figure 3—Twin onlay bone grafts for ununited fracture of the humerus. Figure 4—Arthrodesis of tuberculous elbow by crossed cadaveric grafts. Sound fusion was secured in four months despite the sacrifice of bone to a previous unsuccessful arthroplasty.
Fig. 6
Arthrodesis of wrist by a cadaveric iliac graft applied to the dorsal surface.

Fig. 5
Ischio-femoral arthrodesis of the hip for poliomyelitis. The cadaveric graft was used four months after an intra-articular operation because union was progressing very slowly. Fusion followed rapidly.
Our experience now extends over two years and includes 112 bone-grafting operations. In fifty-five of these cases cadaveric bone was used in the spine, often in association with autogenous bone (these cases are to be reported after a three-year follow-up). There remain thirty-four cases that have been under observation for more than one year after grafting, and these form the subject of this report. The types of operation and the results are summarised in Table I, and illustrative radiographs are shown in Figures 1 to 8. It will be seen that of the thirty-four cases, fusion of the graft has been observed in twenty-six. Eight, however, have failed, and these merit further consideration and an attempt at explanation.

In three cases failure can be attributed to errors of technique. In a case of arthrodesis of the wrist by Brittain’s method too much was expected of the graft, which was found, in

<table>
<thead>
<tr>
<th>Operation</th>
<th>Number of cases</th>
<th>Successes</th>
<th>Failures</th>
</tr>
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<tbody>
<tr>
<td>Arthrodesis of hip</td>
<td>10</td>
<td>8</td>
<td>2</td>
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<tr>
<td>Arthrodesis of shoulder</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Arthrodesis of wrist</td>
<td>4</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Arthrodesis of knee</td>
<td>2</td>
<td>2</td>
<td>—</td>
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<tr>
<td>Arthrodesis of elbow</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Nail and graft for fractured neck of femur</td>
<td>3</td>
<td>2</td>
<td>1</td>
</tr>
<tr>
<td>Bone graft for ununited fracture of radius</td>
<td>2</td>
<td>2</td>
<td>—</td>
</tr>
<tr>
<td>Bone graft for ununited fracture of tibia</td>
<td>1</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Bone graft for ununited fracture of femur</td>
<td>2</td>
<td>1</td>
<td>1</td>
</tr>
<tr>
<td>Bone graft for ununited fracture of humerus</td>
<td>1</td>
<td>1</td>
<td>—</td>
</tr>
<tr>
<td>Filling of bone cavities</td>
<td>5</td>
<td>4</td>
<td>1</td>
</tr>
<tr>
<td><strong>Totals</strong></td>
<td><strong>34</strong></td>
<td><strong>26</strong></td>
<td><strong>8</strong></td>
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</table>

the post-operative radiograph, to be lying away from its bed and was thus unprotected from stress. In the second case nailing and grafting a four-weeks-old transcervical fracture of the neck of the femur was attempted, the displacement was accepted, non-union has occurred and the graft has broken. In the third case, chip grafts were extruded from a chronic osteomyelitic cavity which had been incompletely packed so that a residual pocket was left.

An arthrodesis of a tuberculous elbow failed because it was ill-timed. Attempts to bridge a gap were unsuccessful in two cases of extra-articular ischio-femoral arthrodesis without osteotomy, and in one of scapulo-humeral arthrodesis—severe tests of any graft. The remaining failure followed grafting for ununited fracture of the femur in a case of osteogenesis imperfecta. Here the fragility of the bone, coupled with the deformity produced by previous nearby fractures, made efficient joinery impossible.

It will be noted that if we exclude the case of osteogenesis imperfecta all our failures were in technique, in timing, or in attempting to make an unsupported cadaveric graft span a wide gap.

**DISCUSSION**

There was no sepsis in the group of cases reviewed, except in one case of failed cancellous chip grafting in chronic osteomyelitis. The four successful cases of chip grafting of bone cavities include the obliteration of two Brodie’s abscesses, one tuberculous cavity in the
tibia (all with sinuses) and the reconstruction of a metacarpal bone after excision of a chondroma (Figs. 7 and 8). This simple procedure has the advantage that little harm is done if the grafts should prove unsuccessful.

It remains only to consider the comparative time factors involved. It has been said that boiled grafts are slow to unite, and some experimental evidence tends to support this view. We have, however, seen union in old fracture of the humerus (Fig. 3) and of the radius three months after grafting. Arthrodesis of the wrist (Fig. 6) has been sound enough to dispense with plaster after a similar interval. It is not possible to assess accurately the time taken for chip grafts to fuse, but we feel that they are not long delayed in comparison with autogenous chips. In so small a series no useful comparison can be made between boiled homogenous and fresh autogenous transplants—neither conforms to a sufficiently reliable time-table. We can only say that our impression is that boiled bone is not significantly slower in becoming incorporated.

We consider that cadaveric bone grafting is worthy of further trial on the basis of the experience that we have described. We believe that boiled bone may be used with confidence when a bone graft is required for non-union of a fracture, to supplement an intra-articular arthrodesis, or to obliterate a bone cavity or surgically produced bone defect. Its capacity to bridge a gap cannot at present be assessed. However, as Wilson (1951) has pointed out, the possession of a bone bank brings with it a far greater application for bone grafting and if the bank is easily replenished and maintained further opportunities for its use will be found.

It gives me pleasure to thank Mr B. H. Burns and Mr R. H. Young, under whose care these patients were treated.

REFERENCES


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