STRUCTURAL BULK ALLOGRAFTS IN ACETABULAR RECONSTRUCTION
ANALYSIS OF TWO GRAFTS RETRIEVED AT POST-MORTEM

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Two acetabula which contained large bone allografts introduced at revision arthroplasty were obtained at post-mortem. The allografts had been placed in superior defects to support cementless acetabular components, and both hips were functioning well at the time of death. Clinical radiographs demonstrated apparent healing of graft to host bone, no graft collapse and stability of the acetabular components. Microscopic examination of sections through these specimens showed that the bulk allografts were encapsulated in fibrous tissue. Vascularity was increased at the host-graft interface, but there was limited evidence of bone union between the graft and the host. In the few areas where union had occurred, revascularisation extended no more than 2 mm beyond the graft-host interface.

Within the body of the graft, the acellular matrix of trabecular bone maintained structural integrity up to 48 months after surgery. In areas where the allograft was adjacent to an implant, there was fibrous tissue orientated parallel to the implant surface. The acetabulum which contained a porous-coated component showed evidence of bone growth into the porous surface where it was in contact with viable host bone. No ingrowth occurred in areas where the porous coating was in contact with the graft. Although the grafts were functioning well, allograft revascularisation and remodelling were minimal, and the radiological appearance of healing did not correlate with histological findings.
ment the superior part of the acetabulum. The grafts had been in situ for 25 and 48 months, respectively, before retrieval.

Case 1. A 64-year-old woman with rheumatoid arthritis had had a left total hip arthroplasty using a cemented acetabular component. Six years after operation the hip became painful on weight-bearing and eventually restricted walking. Radiographs showed that a loose acetabular component had created a large superior medial defect (Fig. 1a). At revision this was enlarged with hemispherical reamers to a diameter of 46 mm. A fresh-frozen femoral-head allograft was then contoured by hemispherical resurfacing reamers to a size of 48 mm in diameter and was impacted into the defect as a press-fit (Engh and Bobyn 1985). The reconstructed acetabulum was reamed to a diameter of 51 mm and a 51 mm threaded metal cup (Anderson Cup; Joint Medical Products, Stamford, Connecticut) screwed into the prepared bed. Five cortical screws were placed through the rim of the component to give additional fixation (Fig. 1b).

After operation the patient had relief of her pain and was able to bear full body-weight on her left leg and walk indoors with a frame. Radiographs taken 13 months after the revision showed no change in the position of the acetabular component. The lucency noted at the graft-host interface on the postoperative radiographs had decreased, suggesting incorporation of the graft (Fig. 1c). The patient died from unrelated medical problems 25 months after revision and the hemipelvis was retrieved.

Case 2. A 76-year-old man developed rapidly progressive degenerative arthritis of both hips. When the right hip was replaced the deficiency at the superior part of the acetabulum (Fig. 2a) was reconstructed with a fresh-frozen femoral-head allograft, using the technique described in case 1. A 54 mm diameter Arthropor I (Joint Medical Products, Stamford, Connecticut) porous-coated acetabular component was introduced as a press-fit into the reconstructed acetabulum and three screws were placed through the rim of the component and into the host bone via the graft (Fig. 2b). A left total hip arthroplasty was performed five months later.

Three months after operation on the left side the patient was allowed to walk using a cane. At one year, he walked without a cane and without a detectable limp. A radiograph of his right hip taken one year after operation (Fig. 2c) showed partial obliteration of the graft-host interface at the superolateral acetabular rim and increased density of the
Case 2. Figure 2a – Preoperative radiograph showing superolateral acetabular deficiency with associated femoral-head deficiency. Figure 2b – Radiograph after femoral-head allografting and cementless total hip arthroplasty. Figure 2c – One year after surgery with trabecular bridging superolaterally (black arrows) and obscured interface medially, consistent with partial incorporation. Figure 2d – Specimen radiograph showing persistence of the sclerotic border circumferentially around the femoral-head allograft with partial graft healing in two areas (white arrows).

Microscopic examination was performed in these four areas of interest.
bone at the graft-host interface superomedial to the cup.

The patient did not return for further follow-up, stating by telephone interview that his hips functioned well. He remained physically active until his death, 48 months after the first operation.

Methods. After retrieval, both specimens were carefully examined for signs of infection and stability of the graft and cup. They were then fixed in formalin, serially dehydrated in ethanol, and sectioned through the area of the graft by a high-speed saw using a diamond-edged blade (Mark V; Mark V Laboratory Inc, East Granby, Connecticut). Radiographs of the resultant 5 mm thick slabs were then examined and compared with the clinical films. Four thin sections with the cup in place were embedded in ethylmethacrylate and then ground down to a thickness of approximately 50 μm. They were stained with haematoxylin and eosin and examined microscopically for evidence of bone growth into the porous surfaces of the implant. The cups were carefully removed from four alternate sections. These sections were decalcified, embedded in paraffin, sectioned to a thickness of 5 μm, stained with haematoxylin and eosin, and used for microscopic evaluation of the graft-host interface and the body of the graft.

RESULTS

Gross examination of the specimens showed a stable attachment of the grafts to the pelvis. The acetabular components were also stable. There were no signs of infection.

A radiograph of the retrieved specimen of case 1 (Fig. 1d) was similar in appearance to the clinical radiographs, with persistence of the subchondral bone plate of the femoral-head allograft superiorly and obliteration of the radiolucent space between the graft and host medially. A slab radiograph of a 5 mm section through the middle of the specimen (Fig. 1e) showed focal areas of bone union of the host to the graft at the superolateral rim of the acetabulum and medial to the component. The host-graft interface directly superior to the component was not included in this section. The threads of the cup in contact with the graft did not appear to penetrate the graft fully, but there were no radiolucencies around the tips of the threads. At the junction of the cup and the host bone there was a continuous radiolucency around the threads.

A radiograph of a section through the specimen from case 2 (Fig. 2d) also showed the persistence of the sclerotic border of the femoral-head allograft. Along the superolateral rim of the acetabulum, where the graft and host had been in close contact, some evidence of host-graft union was present and union of the graft was also seen superomedially. The signs of graft union in the retrieved acetabula were much less extensive than had been suggested by the clinical radiographs. Radiographs of the sections also showed the difference in density between the graft and the host bone.

Systematic microscopic examination of the specimens was performed in four areas (Fig. 3): (1) the graft-to-hostbone interface; (2) the body of the graft; (3) the junction of the graft bone with the acetabular cup; and (4) the junction of the host bone with the acetabular cup.

Graft-to-host-bone interface. A boundary of fibrous tissue was seen at most parts of the interface between the graft and host bone (Fig. 4a) in both specimens, but vascular channels were present in limited areas of the graft-host interface, particularly where the graft and host bone had intimate contact. At these sites, there also appeared to be some graft union and remodelling (Fig. 4). On one section
In case 2, revascularisation advanced for 2 mm into the body of the bulk graft. In the remaining sections of case 2 and in those of case 1, histological evidence of allograft remodelling was either not visible or else the focal areas of revascularisation penetrated less than 1 mm into the graft. There was no evidence of foreign-body material such as metal or polyethylene, acute or chronic inflammation or of a granuloma response to debris.

Body of the graft. Within the body of the allografts the intratrabecular spaces contained myxofibrotic tissue and necrotic fat. The allografts were relatively acellular, with no visible vascular channels. Trabeculae within the graft were necrotic, as shown by empty lacunae and the lack of juxtaposed osteoblasts. Near the centre of the allografts they maintained their original architecture. There was no evidence of bone resorption, remodelling, or structural failure of the trabeculae in the body of the graft far from the interface.

In both cases, the intr trabecular spaces of the host bone adjacent to the allograft were vascular, indicating that this bone was viable. The trabeculae of the host bone appeared thin and porotic, particularly in comparison with those within the centre of the bulk allografts.

Implant-bone interface. In case 1, in which a threaded acetabular component had been used, myxofibrous tissue was found along the entire interface between the implant and the host, as well as between the cup and the allograft, with no evidence of debris or granuloma formation.

In case 2, which had a porous-coated cup, examination of the interface between the implant and host bone showed areas of bone growth into the porous surface (Fig. 5), with fibrous tissue at the other sites of contact. This fibrous tissue was usually orientated parallel to the implant surface, but in some areas the fibres were perpendicular to the surface and interdigitated with the beads, which is characteristic of the typical ingrowth response to porous-coated implants (Engh et al 1987).

The interface between the bulk allograft and the porous-coated components had a different appearance. Instead of bone or fibrous tissue ingrowth, fibrous or myxofibrous tissue lay between the bone and the implant. A similar pattern of disorganised fibrosis was also observed adjacent to the fixation screws penetrating the graft.

DISCUSSION

Bulk structural allografts are commonly used in complex acetabular reconstruction (Kwong et al 1993; Hooten et al 1994; Paprosky and Magnus 1994) and, although early clinical reports of their use were encouraging, five- to ten-year follow-up has shown a high rate of failure and collapse.

The biology of allograft incorporation is well described, the main feature being slow, gradual substitution with host bone (Mankin, Doppelt and Tomford 1983; Kandel et al 1985; Czitrom et al 1986; Stevenson and Horowitz 1992). Failure of structural allografts in acetabular reconstruction has been attributed to weakening of the graft and collapse secondary to this revascularisation and replacement (Kwong et al 1993). A clinically insignificant immunological response has been seen in animal models and in human studies (Brown and Cruess 1982; Stevenson 1987) but it is not thought to be a major contribution to graft biology or failure (Czitrom et al 1986; Stevenson 1987).

Analyses of our few specimens suggest that revascularisation and healing of these grafts are very limited. Failure is unlikely to be due to revascularisation and weakening, with subsequent collapse, but may be caused by repeated loading of a non-living graft bone leading to trabecular fatigue. We saw no sign of significant inflammatory or immune response at the interface between the graft and host.

These allografts were essentially encapsulated in fibrous tissue with only small areas of bone contact. The clinical radiographs exaggerated the amount of host-graft healing and incorporation at the interface suggesting that plain radiographs are inadequate and of limited reliability in evaluating graft union in acetabular reconstruction; they probably demonstrate only intimate graft-host contact, representing the quality of the fit of the graft to the host.

Other methods of evaluating the graft-host interface are needed. CT is limited by the radiographic beam scatter in the presence of metallic implants. Scintigraphy has been...
used to interpret allograft union and incorporation (Tranick et al 1986), but it has also been shown to have limited reliability. Single photon-emission CT potentially could provide a more accurate anatomical reconstruction than these planar studies (Gordon et al 1985), but Sanzén et al (1988) have reported that it is no better than serial radiography for assessing graft integrity and that graft uptake of the radiotracer did not correlate with progressive resorption, nonunion, or loss of bone structure. In the future, MRI with newer pulse sequences may be able to assess the interface with a higher degree of accuracy.

From a clinical standpoint when porous-coated cups are used, we recommend that contact with host bone be maximised and the extent of the porous surface in contact with the graft be limited. The studies of Harris and Engh demonstrated high rates of failure, particularly when the allograft supported more than 40% of the acetabular component (Kwong et al 1993; Hooten et al 1994).

The poor graft incorporation in our two cases may have been related to our surgical technique. The defects were large, and in order that the bulk allografts could be introduced as a press-fit subchondral bone was retained. If the grafting material had been cancellous, better incorporation may have occurred. Morsellised allograft incorporates much more rapidly than the bulk allografts used in these cases (Slooff et al 1984; Heekin, Engh and Vinh 1995). The extent of the initial host-graft contact is important and this is often difficult to achieve because of the complex geometry of the defects.

Based on this histological study and continuing clinical and radiological evaluation, we follow all bulk structural allografts in our patients very closely and recognise that they have a high probability of eventual collapse. Protected weight-bearing for these patients may be necessary for an extended period, and it may be argued that patients with grafts of this type should continue to use walking aids indefinitely to protect the integrity of the graft.

No benefits in any form have been received or will be received from a commercial party related directly or indirectly to the subject of this article.

REFERENCES


Harris WH. Allografting in total hip arthroplasty: in adults with severe acetabular deficiency including a pathological technique for bolting the graft to the ilium. Clin Orthop 1982;162:150-64.


VOL. 78-B, NO. 2, MARCH 1996