Case Report

Revascularization of a Total Bulk Acetabular Allograft at 14 Years

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Abstract: This case report describes the long-term outcome of a total bulk acetabular allograft placed for bone substitution after resection of recurrent pigmented villonodular synovitis of the hip joint. After 14 years in situ, the graft had completely incorporated and showed viable bleeding bone surfaces in all areas of the acetabular implant interface. The possibility of a bulk corticocancellous allograft to undergo revascularization over a long period of time has not been previously documented.

Key words: acetabulum, allograft, total hip, pigmented villonodular synovitis, revascularization.

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Allograft transplantation has provided an important solution for severe bone loss after malignant tumor resection and failed total hip arthroplasty [1–7]. Morphologic studies have indicated the potential for limited incorporation of these grafts with primary bony union at the interface and penetration of bone substitution of up to 5 mm. The biologic process is multifactorial and relates to graft apposition, interface stability, the healing potential of the host bone, and immunogenicity of the allograft. Also, the type of allograft structure, cancellous or cortical, will behave differently [8–10].

The long-term survival of transplanted allografts has been well documented. Gross and Hutchinson et al. [11] advised optimum fixation of femoral cortical grafts while avoiding any perforations or cuts that could weaken the allograft integrity. Fatigue failure of the transplanted bone and biologic dissolution represent primary causes of failure. Mechanical stresses applied through the graft appear to be necessary for long-term survival, but load substitution with implants may also be needed to prevent the nonviable bone from fatiguing [12].

This case report analyzes the long-term performance of a total bulk allograft placed to reconstruct a defect that remained after resection for recurrent pigmented villonodular synovitis. In other small case series, large bulk pelvic allografts have been used; however, none of these showed long-term followup [13–16]. The important finding was total revascularization of the graft after being in situ for 44 years.

Methods

In 1988, a total bulk acetabular allograft was placed in a 41-year-old white man after resection of a hip joint involved with recurrent pigmented villonodular synovitis [17]. The tumor was staged Enneking IIB, and a radical tumor excision with
margins was deemed necessary for a long-term cure, because the patient had undergone 3 previous attempts at local excision. Computed tomography showed the extent of involvement, with perforation of the quadrilateral plate of the medial acetabular wall and extensive infiltration of the femoral head (Fig. 1).

A salvage reconstruction, using a total bulk acetabular allograft was offered. Only a few pelvic transplants had been reported anecdotally at that time, and therefore, a novel approach and fixation method were attempted. We obtained a bulk pelvic allograft from the Musculoskeletal Foundation national tissue bank (Fig. 2). This graft was then sized using radiographs and had at least 3 cm of ilium above the superior acetabulum and extensions to the ischium and pubis inferiorly.

The approach was the extensive triradiate described by Stiehl et al. [18] with a modification of ilioinguinal extension to expose the inner table of the ilium and pubis. The tumor was resected with adequate margins. Most of the tumor involved the medial wall of the acetabulum and did not extend into the body of the ilium or significantly into the ischium or pubis. The acetabular allograft was then cut down to be slightly oversized to match the en bloc resections of the ilium, ischium, and superior pubic ramus. By springing the pelvis apart, we provided excellent stability by carefully matching the cut surfaces of the graft and host. For long-term support and graft fixation, AO Swiss pelvic reconstruction plates were applied with a 4.5 mm-hole plate to the posterior column and a 3.5 mm-hole plate to the anterior column along the ilioinguinal line.

After this step is completed, a total hip arthroplasty was performed; and trochanter ostectomy had not been needed for exposure. Healing of the reconstruction and the allograft was unremarkable, and no early postoperative complications occurred. The patient was kept non-weightbearing for 3 months and could use protected weightbearing for an additional 3 months. He then resumed his normal occupation as a road maintenance worker for a suburban community. This required driving and light-medium manual labor.

Annual radiographic and clinical evaluation revealed complete incorporation of the transplanted allograft and a Harris Hip score of 96 for several years. Incorporation was defined as complete disappearance of the host-allograft apposition zones with junctional union (Fig. 3). At the 8-year follow-up evaluation, thigh pain and evidence of loosening of a pressfit femoral stem were noted. This was revised to a fully porous-coated 8-in femoral stem. However, the graft appeared to be fully incorporated at the junctional zones, and acetabular fixation appeared to be sound. At the 12-year follow-up evaluation, the acetabular component fixation had failed and reconstruction of the acetabulum was attempted (Fig. 4).

The original incorporation zones remained completely healed and could not be detected. Roughly 50% of the posterior acetabular allograft wall and the most of the original subchondral plate of the inner acetabulum had dissolved, but the remaining acetabular graft had remained intact. These surfaces were scraped to remove nonviable debris of the old graft, and a new cup was cemented into the remaining solid graft. The persistence of the remaining bulk acetabular allograft was impressive,
but the viability of the structure could not be ascertained.

Within a year, this fixation had failed and a further reconstruction was deemed necessary. During the surgical procedure, the bony surface of the allograft reconstruction was explored. A fibrous soft tissue layer had formed over the entire acetabular surface under the failed cemented acetabular component. This was removed sharply, and the underlying acetabular surfaces revealed viable bleeding bone in virtually all areas. A bone biopsy was not obtained.

Preoperatively, a trabecular metal device was produced in an oblong shape to span the defect of the graft and to oppose host bone of the ilium and ischium. The idea was that if the old bulk acetabular allograft failed even further, it may be possible to reach the original host bone junctional sites. The dimensions of the device were confirmed using a computed tomographic 3-dimensional plastic reconstruction. Supplemental fixation was performed using a customized “cage” prosthesis with outriggers fixed to the ilium and ischium while the new cup was cemented into the trabecular metal shell.

Using acetabular reamers, the defect was then shaped to receive the trabecular metal shell, which was then pressfit into position. The custom cage was then cemented into the trabecular metal shell, and screw fixation was completed while the cement cured. Originally, 3 outriggers were designed and produced; however, but only the superior ilium extension and the inferior ischial extensions were used. Fully threaded screws were placed into solid bone of the ilium and ischium. The remaining reduction and wound closure were uncomplicated. No postoperative complications occurred, and the patient resumed ambulation at 3 months. He remains pain free with limited follow-up of 12 months (Fig. 5).

Discussion

The biologic factors influencing host–graft union and the incorporation of transplanted allografts have been extensively evaluated both in the laboratory and clinical settings. The principle components of the healing process are the vascular pedicle at the microscopic level and the presence of histocompatible bone-forming cells [8–10]. The surgical tactics needed for host–graft union are stability of the construct and close contact between the bone of host and graft. In the case of transplanted allografts, these process are delayed by the reduced healing potential of frozen or freeze-dried osteoblastic cells, antigen disparities between the donor and recipient, and mechanical instability required for lamellar bone healing [8–10,19].

Several retrievals of allograft transplants have indicated a high potential of consolidation of can-

![Fig. 3](image1.png)

**Fig. 3.** Radiograph taken at 4 years shows incorporated allograft and stable fixation of the cemented cup. Note the completely absent host–graft interface zones.

![Fig. 4](image2.png)

**Fig. 4.** Radiograph taken 13 years after surgery shows the failed cemented acetabular cup.
cellular particulate grafts but have not shown significant incorporation of bulk allografts [20–23]. Enneking and Campanacci [24] and Enneking and Mindell [25] have shown that, over the long term, cortical grafts had only a peripheral penetration of the surface of the graft, but the cancellous surfaces could allow up to 2.5-mm into the interstices of the graft. Deeper areas remained avascular, and over the long term did not show incorporation. None less, recent examples of neighboring tissue healing fractures within the allograft have been shown [26]. In contrast, vascularized autografts have shown the potential of revascularization over a couple weeks with the potential of normal bone function in time [10].

The clinical experience with transplanted bulk allografts about the hip in revision reconstructive surgery has shown predictable incorporation in most series [1,27,28]. Radiographic graft union and incorporation are noted to have occurred when the sclerotic line at the graft-host junction has disappeared and trabecular bone completely bridged the graft interval. Oakeshott and Morgan et al [29] showed incorporation in 8 of 9 whole bulk acetabular allografts, and Paprosky and Sekundiak [30] noted incorporation in all 20 cases of whole acetabular allografts. Stiehl [31] and Stiehl, Saluga, and Diener [32] reviewed a similar experience with pelvic bulk transplants and found incorporation in all 9 cases. However, most authors have found a high rate of complications with these complex reconstructions with infection, implant dislocation, and late implant loosening in up to 50%. Garbuz, Morsi, and Gross [33] were able to show substantial improvements in graft performance when a roof-reinforcement ring prosthesis was used to aid mechanical support and fixation [34].

This anecdotal case provides an interesting insight into the long-term performance of successfully transplanted allografts. Several principles of allograft surgical technique are shown, including carefully matching the allograft structure, in this case a total bulk acetabulum, to a mirrored defect in the host. Other important elements included careful apposition of the graft to viable bleeding host bone and rigid internal fixation of the interfaces. Finally, extended protection from load bearing, as would be typical of long bone fracture internal fixation, is needed to allow for primary bone union across the interfaces [30,32,34].

What makes this case unique is the apparent revascularization of the acetabular allograft after 14 years. The original bulk acetabular allograft fixation surfaces had completely dissolved, but the underlying graft had taken on the appearance of viable bone. This conclusion is substantiated by the development of a fibrous soft tissue layer after the first acetabular revision and the subsequent documented bleeding bone surfaces. One may speculate that the anatomic nature of the reconstruction using a carefully matched and inserted acetabulum graft allowed fairly rapid revascularization of the inner tables of the graft. Eventually, the remaining surfaces could undergo substitution. The physiologic loading of the anatomic reconstruction would be needed for long-term graft survival.

The observations in this report support the concept of transplanted allografts in complex reconstructive situations in which bone restoration is needed. A previously undescribed scientific observation regarding a long-term allograft has been made. However, unanswered questions remain, such as how to improve allograft incorporation in general and what biologic modulating factors could be used to enhance this process.

References

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