

Incorporation of allograft for acetabular reconstruction

Single photon emission CT in 21 hip arthroplasties followed for 2.5-5 years

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We studied 21 hips in 20 patients who had acetabular reconstruction with a femoral head allograft in primary (n 2) and secondary (n 19) total hip arthroplasty. The fate of the graft was evaluated by serial bone SPECTs (single photon emission computed tomography). With a mean follow-up period of 37 (30-60) months, 14 of the 21 hips showed evidence

of incorporation at earliest 13 (6-18) months after operation. There was no correlation between the fate of allograft and the compatibility of A, B, O blood typing between host and donor, the use of bone cement in the fixation of acetabular component, or loosening of the acetabular component.

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Submitted 94-02-26. Accepted 94-08-22

A femoral head allograft is commonly used for acetabular reconstruction during total hip arthroplasty, but the long-term results tend to be poor (Mulroy and Harris 1990, Pollock and Whiteside 1992, Hoikka et al. 1993). Multiple radiographs, tomograms, or bone scan have been used to assess the extent of graft incorporation. Moreover, SPECT (single photon emission computed tomography) has been applied for this evaluation (Gordon et al. 1985, Trancik et al. 1986, Sanzén et al. 1988). As yet, the serial changes of reconstruction allografts by SPECT have not been reported. We used serial bone SPECTs to elucidate the biological changes occurring in the allograft.

Patients and methods

20 patients (21 hips) with femoral head allografts for reconstruction of a severely deficient acetabulum during a primary or revision total hip arthroplasty, were studied with prospective serial SPECTs (Table 1). 9 patients were men and 11 were women, with a mean age of 49 (28-73) years. The mean follow-up period was 37 (30-60) months. The operations included revision arthroplasty in 14 hips, revision of acetabular component in 5, and primary arthroplasty due to sequelae of septic arthritis in 2 hips. The acetabular bone deficiency was classified by D'Antonio et al.'s method (1989) and included 3 type I (seg-

mental), 4 type II (cavitary), and 14 type III (combined). Preoperative prophylactic antibiotics were administered during induction of the anesthesia. A posterolateral approach and a structural bone allograft without additional use of autogenous bone graft were used in all cases. All allografts were taken from patients who had had a hemiarthroplasty or total hip arthroplasty and did not have specific systemic and infectious disease. Cultures were obtained at the time of harvest and then the femoral head was placed in a sterile, double-sealed container and frozen at -70 °C. Just before use, the grafts were thawed at room temperature in Keflin solution, the cartilage and osteophytes were removed, and the remaining cancellous allogenic bone was contoured to replace the deficient parts of the acetabulum. The graft was securely fixed with AO screws, except in patients with a medial cavitary defect, in whom no internal fixation was used. The reconstructed acetabulum then was reamed to accommodate an appropriate acetabular component. A total of 31 femoral head allografts were placed in 21 acetabula. Porous-Coated Anatomic (Howmedica®, Rutherford, New Jersey) and Osteonics (Osteonics®, Warsaw, Indiana) hip prostheses were implanted in 10 and 11 hips, respectively. Cement was used in 16 hips (8 PCA, 8 Osteonics), where stable fixation of the acetabular component could not be obtained by press-fit. Postoperatively, all patients were ambulatory and partly weight bearing with crutches or a walker at

Table 1. Clinical data in 20 patients with SPECT studies for allografts

| A | B | C | D | E | F | G | H | I | J | K | L |
|------|----|---|---|---|-----|---|---|-------|-----|---------|-----|
| 1 | 28 | 1 | 1 | 1 | 1 O | 1 | 2 | v 1 | 1.5 | 1 | 4.5 |
| 2 | 66 | 2 | 2 | 1 | 1 P | 1 | 1 | v 1.5 | 1 | 1 | 3.5 |
| 3 | 51 | 1 | 5 | 1 | 1 O | 2 | 1 | v 1 | 1 | 2 | 5 |
| 4 | 49 | 2 | 4 | 3 | 1 O | 1 | 1 | v 1 | 1 | 3 (2.5) | 3 |
| 5 | 33 | 2 | 4 | 3 | 3 O | 1 | 1 | v 1 | 1 | 1 | 3.5 |
| 6 | 39 | 1 | 3 | 1 | 1 P | 1 | 3 | v 1 | 1 | 1 | 4 |
| 7 | 38 | 2 | 4 | 1 | 1 P | 1 | 3 | v 1 | 0.5 | 1 | 3 |
| 8 | 42 | 2 | 5 | 1 | 2 P | 1 | 2 | v 2 | 1 | 1 | 3 |
| 9 | 58 | 2 | 2 | 1 | 1 O | 1 | 1 | v 1 | 1 | 1 | 3 |
| 10 | 44 | 2 | 2 | 1 | 1 P | 1 | 2 | v 1 | 1.5 | 1 | 2.5 |
| 11 | 56 | 2 | 4 | 1 | 2 O | 1 | 1 | n 3 | - | 3 (3) | 3.5 |
| 12 | 51 | 1 | 5 | 4 | 1 P | 2 | 1 | n 3 | 1 | 1 | 3 |
| 13 | 29 | 1 | 5 | 1 | 2 O | 1 | 1 | n 3.5 | 1 | 1 | 2.5 |
| 14 | 61 | 2 | 2 | 1 | 1 P | 1 | 1 | v 0.5 | 2 | 1 | 2.5 |
| 15 | 52 | 2 | 5 | 1 | 2 O | 1 | 2 | v 1 | 1 | 1 | 2.5 |
| 16 r | 59 | 2 | 2 | 1 | 1 P | 1 | 1 | n 4 | 2 | 1 | 4 |
| l | 60 | | | 1 | 1 P | 2 | 1 | v 1 | 1 | 1 | 3 |
| 17 | 73 | 1 | 1 | 1 | 2 P | 1 | 1 | n 2.5 | 1 | 1 | 2.5 |
| 18 | 32 | 1 | 1 | 2 | 1 O | 2 | 1 | v 1.5 | 1 | 1 | 2.5 |
| 19 | 43 | 1 | 5 | 1 | 1 O | 2 | 2 | n 2.5 | 1 | 1 | 2.5 |
| 20 | 56 | 1 | 3 | 1 | 1 O | 1 | 2 | n 2.5 | 1 | 1 | 2.5 |

| | |
|--|--|
| A Case | 2 revision acetabular component |
| B Age at operations | 3 primary THA |
| C Sex | O Osteonics |
| 1 man | P PCA |
| 2 woman | G Cement use |
| D Primary diagnosis | 1 cemented |
| 1 femoral neck fracture | 2 uncemented |
| 2 dysplastic hip | H Number of femoral head allografts used |
| 3 ankylosing spondylitis | I SPECT results |
| 4 septic hip | v viable, first evidence in yrs |
| 5 avascular necrosis | n nonviable, latest follow-up in yrs |
| E Etiology of index operation | J Allograft union time, yrs |
| 1 THA loosening | K Acetabular component |
| 2 failed Moore | 1 stable |
| 3 sequelae of septic hip | 2 loosening without revision |
| 4 septic loosening of THA | 3 loosening with revision (survival time in yrs) |
| F Index operations and prosthesis type | L Follow-up, yrs |
| 1 revision THA | |

discharge. External support was used for at least 6 months except for patients with an opposite hip-problem, persistent abductor weakness, or other specific conditions. Patients were followed up at 3 and 6 months and then every 6 months after operation. Preoperative and follow-up hip scores were assessed according to d'Aubigné et al. (1954) as modified by Charnley (1972). The hips and grafts were also evaluated radiographically for evidence of graft resorption, graft union, circumferential radiolucency line and loosening of acetabular component. Graft resorption was rated as mild if it involved less than one-third of the graft, moderate if it involved between a third and a half, and severe if it involved over half of the graft. The allograft was assumed to be incorporated when osseous trabeculae had completely bridged the space between the host acetabulum and the graft (Trancik et al. 1986). Migration of

the acetabular component or a continuous radiolucency more than 2 mm around the prosthesis was considered as loosening.

Serial scintigraphy (25 mCi ^{99m}Tc -MDP) was performed at each follow-up. Dynamic flow study, blood pool image and planar images were recorded sequentially by a gamma camera with selected collimator. SPECT was then undertaken with a 400 mm field of view gamma camera in 64 × 64 matrix, 60 projections each for 20 sec. Following uniformity correction, 6 mm (1 pixel) thick transaxial, coronal, and sagittal SPECT images were reconstructed by filtered backprojection with a ramp filter (Heller and Goodwin 1987, O'Connor et al. 1991). Each scintigraphic examination was reviewed with the help of radiographs for accurately localizing the graft region. Interpretation of SPECT imaging was undertaken by review at the computer terminal. The scintigraphic

Table 2. Relationship of various factors with the incorporation of allograft

| Allograft | n | ABO compatibility | | Cementation | | Acetabular comp. | |
|-----------------|----|-------------------|----|-------------|----|------------------|-------|
| | | yes | no | yes | no | stable | loose |
| Incorporated | 14 | 10 | 4 | 11 | 3 | 12 | 2 |
| Nonincorporated | 7 | 3 | 4 | 5 | 2 | 6 | 1 |

image was not interpreted until the blood flow study and blood pool image showed a symmetrical distribution in both hip areas. Usually, the highest point of the iliac crest was selected to compare the density and size of serial images (Gates 1988a, b). Continuous bridging of radioactivity from host bone to allograft and graded increase in extent of uptake were taken to indicate that the graft was undergoing incorporation (Gordon et al. 1985, Trancik et al. 1986, Sanzén et al. 1988). A sustained cold area at the allograft region was considered to indicate no incorporation (Moskowitz and Lukash 1988).

The statistical correlations between the loosening of acetabular component, host-donor A, B, O blood typing, cement use, and the incorporation of graft were studied with Fischer's exact test.

Results

Clinical and radiographic evaluation

Preoperative hip scores averaged 11 (6-15) points. At the end of follow-up, 3 acetabular components became loose radiographically at 30-51 months (Cases 3, 4, and 11). Case 4 was revised with the healed allograft in place. In the revision of Case 11, further acetabular reconstruction with allograft was necessary due to complete necrosis of the original allograft. Case 3 was not revised because of the patient's refusal. The 18 surviving hips had a mean score of 17 (12-18) points at the latest follow-up. 20 allografts united within an average of 13 (6-24) months. Nonunion occurred in 1 hip. Graft resorption was mild in 4 hips and appeared at a mean of 23 months postoperatively (Table 1).

Scintigraphic studies

SPECT analyses showed incorporation of 14 of the 21 allografts. The first scintigraphic evidence of incorporation occurred on average 13 (6-18) months postoperatively. 1 patient (Case 4) had radiographic failure of the acetabular component at 30 months after operation. In this case, SPECT showed an incorporated allograft from 12 months postopera-

tively until the last SPECT study before revision. Biopsy of the allograft showed clear evidence of a creeping substitution process between the host and graft consistent with our SPECT definition of graft-incorporation (Figure 1). 7 allografts appeared not to be incorporated, showing a cold area in the graft region for more than 24 months. Of these patients, Case 11 showed the acetabular component loosening radiographically without any uptake in serial SPECT studies until the last follow-up. This hip was revised and there was histologic evidence of necrosis of the allograft without any invasion of granulation tissue (Figure 2).

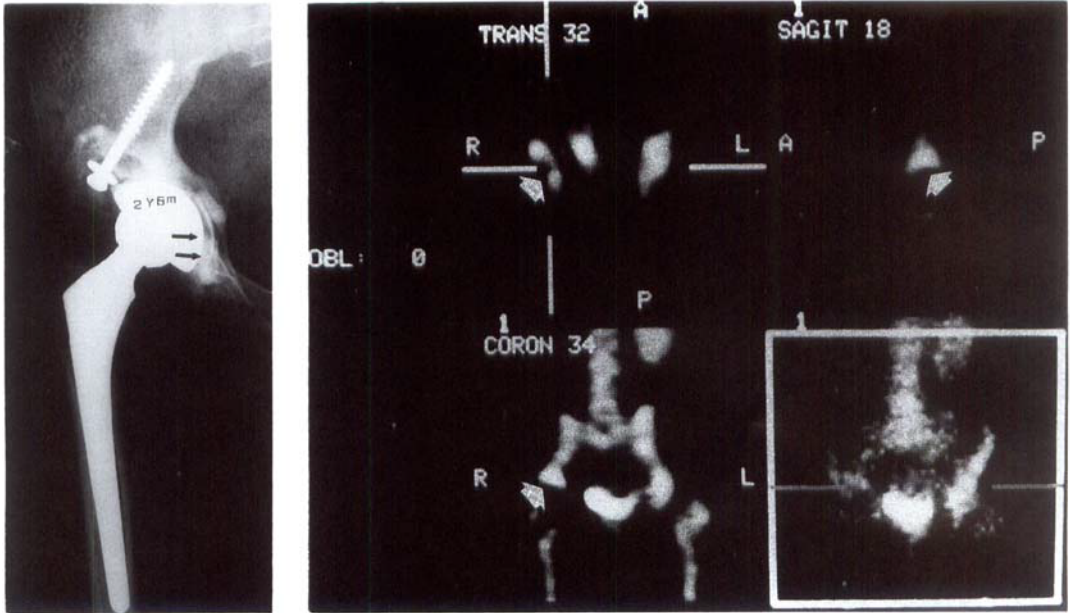
The use of cemented versus cementless fixation and the compatibility of A, B, O blood typing did not correlate with graft incorporation. The finding of allograft incorporation also did not correlate with acetabular loosening (Table 2).

Discussion

The use of large structural femoral head allografts in revision has given good primary results (Harris 1982, Oakeshott et al. 1987) but the long-term results have not been satisfactory (Mulroy et al. 1990, Hoikka et al. 1993). Allografts are dead at implantation; initially they serve as passive scaffolding. The long-term fate of the allograft is unknown. Up to date, there is little histologic evidence of the occurrence of viable osteocytes (Jasty and Harris, 1987).

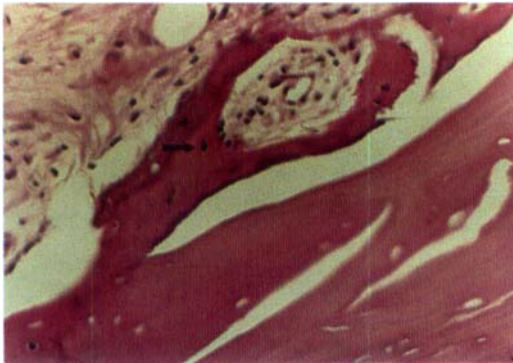
Scintimetry with ^{99m}Tc-labeled diphosphonates is an accepted method for the assessment of bone graft viability (Kelly et al. 1975, Berggren et al. 1982, Dzeblo et al. 1982, Collier et al. 1987, Fig et al. 1990, Lukash et al. 1990, Ramsay et al. 1991). However, in the hip it is unreliable because a thin layer of living bone overlying dead bone can lead to misinterpretations; the precise location of the increased activity is difficult to determine because of the 2-dimensional visualization. The SPECT can provide better assessment of the status of the graft due to its 3-dimensional characteristics. By comparing coronal, sagittal, and transverse scans, it was possible to

Figure 1. Case 4. A 49-year-old woman had a sequelae of a septic hip, with marked acetabular deficiency. The primary arthroplasty included acetabular reconstruction with allograft.



Loosening of the acetabular component (arrow) 30 months after operation.

At this time, SPECT revealed increased uptake at the allograft region (arrow).



A second revision was performed. A biopsy specimen of the allograft showed viable osteocytes around the bony trabeculae (arrow) indicating creeping substitution (HE, $\times 200$).

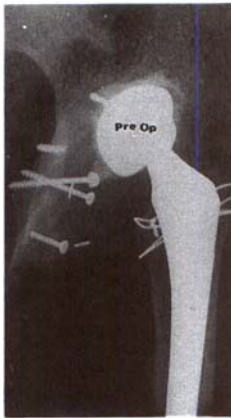
determine the relationships of the increased activity to the graft and the host bone.

Gordon et al. (1985) presented the first report of SPECT scanning in the assessment of acetabular bone graft healing. Trancik et al. (1985) found isotope activity to be increased in the graft, as compared with the ileum. Sanzen et al. (1988), however, found that single SPECT imaging did not correlate with progressing bone resorption, nonunion, or loss of bone structure in the acetabular roof reconstruction, which could be adequately provided by high-quality serial radiographs. The serial changes in

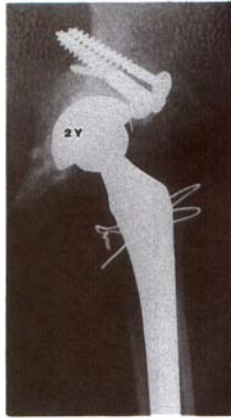
reconstructed allograft by SPECT have not been reported previously. By comparing the changes in serial SPECT images at the selected specific reference anatomic area, the increasing area of isotopic activity could be demonstrated by the computer.

Our study showed that SPECT evidence of revascularization of allograft was present already at 6 months after surgery. It also showed that SPECT evidence of nonincorporation of the allograft could not be used as an early predictor of acetabular component loosening.

Figure 2. Case 11. A 59-year-old woman had a dislodged acetabular component 3 years after a second revision (arrow).



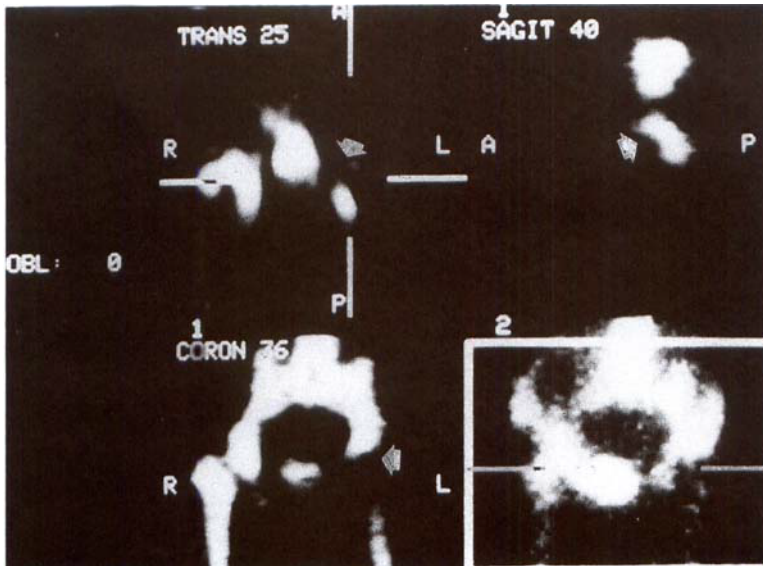
Before second revision.



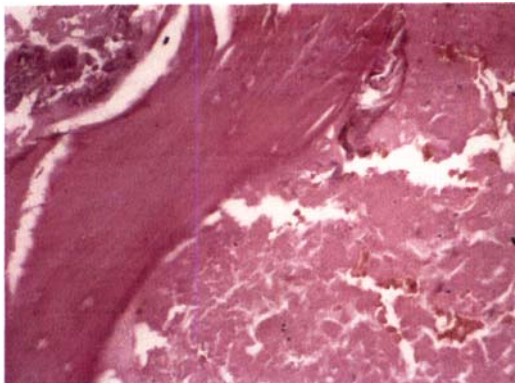
2 years after second revision.



Dislodged acetabular component at 3 years (arrow).



SPECT showed sustained cold area at the allograft region (arrow) at this time.



A specimen of the allograft during third revision showed complete necrosis of fragmented trabeculae without evidence of active incorporation (HE, $\times 200$).

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