Impacted graft incorporation after cemented acetabular revision

Histological evaluation in 8 patients

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We took core biopsies from the acetabulum in 8 patients (at reoperation) after a previous revision with impacted cancellous allograft chips in combination with cement.

Except for one biopsy specimen, the graft showed different stages of incorporation. In the specimens taken at 4 months, revascularization of the graft was found. Osteoclasts had removed parts of the graft, while woven bone had formed on the remnants of the graft and in the stroma that was invading the graft. Subsequent specimens showed that this mixture of graft and new bone was in due time remodeled into a normal trabecular bony structure with viable bone marrow that contained little or no remnants of the original graft.

The graft-cement interface was present in 4 biopsies taken at 1, 22, 28, and 72 months. The specimen obtained 28 months after revision showed vital bone locally in direct contact with the cement layer; however, a soft tissue interface predominated.

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Submitted 96-02-10. Accepted 96-09-03

Whenever possible, we use impaction of morsellized allograft to reconstruct bony defects in the acetabulum (Slooff et al. 1984). The clinical results of acetabular reconstruction with this technique are very good (Slooff et al. 1993, 1996). However, unresolved questions include: How fast does clinical incorporation occur? How complete is it? Does it take place in every case using this grafting technique?

We present the histological data concerning 9 biopsies taken from 8 grafted acetabula, 1–72 months after revision.

Patients and methods

All patients (Table 1) were revised with the technique described by Slooff et al. (1984, 1993, 1996). The acetabular defects were classified according to D'Antonio et al. (1989) (Table 1). Most defects were cavitary (Figure 1; cases 1, 3, 4, 6, 7, 8). In 2 patients (Figure 1; cases 2, 5) combined segmental-cavitary defects (non-contained defects) were reconstructed with a Vitallium mesh. The femoral heads received from the local bone bank were morsellized with a rongeur during surgery into chips of about 1/2 cm^3. The quantity of graft used varied from 1 to 3 femoral heads per patient. The graft surface was finally covered with a second metal mesh. A polyethylene cup was cemented directly into the graft. The graft thickness was at least 5 mm (Figure 1).

Reoperation of the grafted acetabula was necessary for the following reasons: infection of the implant (cases 1, 3, 6), aseptic cup loosening at the cement-graft interface (cases 7, 8), recurrent subluxation (case 2) and excision of ectopic bone (case 4). Biopsies were taken during these procedures with a Yanshini needle (diameter 4 mm) by the same surgeon who revised the cup (Figure 1). During the biopsy procedure, diagrams were made of the location of

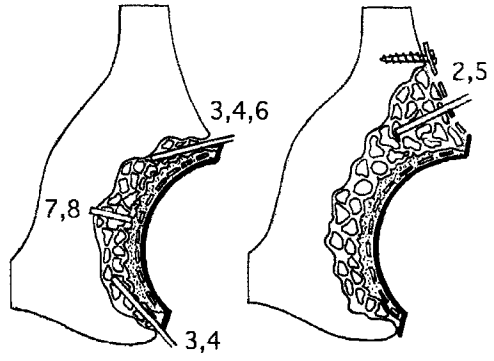

Figure 1. Diagram of locations of core biopsies. The numbers indicate the case numbers.

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Table 1. Summary of patient data

A	B	C	D	E	F	G	H	I	J	K	L	M
1	85	F	L	OA	0	Gamma nail	Exeter THP		2	1	Infected THP	Whole reconstr.
2	64	F	R	OA	1	Müller curved stem	Müller straight stem	Dorsal rim	1	4	Reduction of luxation	3 core biopsies
3	64	F	R	RA	1	Charnley Müller THP	Charnley THP		1	8	Infected THP	2 core biopsies
4	55	M	L	SOA	0	Wagner double cup	Charnley THP	Medial wall	1	9	Removing ectopic bone	2 core biopsies
5	45	F	L	SOA	0	–	Exeter THP	Dorsal rim	3	15 28	Sciatic nerve	2 core biopsies, whole reconstr.
6	76	M	L	OA	0	Müller straight stem	Charnley THP		Autograft	19	Infected THP	1 core biopsy
7	66	F	R	RA	0	Müller curved stem	Exeter THP	Medial wall	1	22	Mechanical failure	2 core biopsies
8	77	M	L	SOA	0	Mac Kee Farrar cup	Charnley THP		2	72	Mechanical failure	Bone at graft-cement interface

A Case
B Age, years
C Gender
D Side
E Original diagnosis
F Number previous revisions
G Implant removed at revision
H Implant placed at revision
I Type of defect besides cavitary defect present in all cases
J Autograft or number of femoral head allografts
K Follow-up, months
L Reason for taking biopsies
M Type of biopsy specimen

the biopsy needle. Only biopsies that remained intact during the whole embedding procedure were used for evaluation. In cases 2, 3, 4, 6, the cup remained in position during the biopsy procedure, which did not allow biopsies of the graft-cement interface. Biopsies were taken in these cases from the cranial or caudal part of the reconstruction. In case 5 with secondary arthrosis due to congenital hip dysplasia, the cup had been implanted at the original level of the tear drop with a voluminous acetabular graft during the first operation, thus moving the center of rotation about 5 cm more distally. The patient subsequently developed symptoms due to sciatic nerve overstretching. The sciatic nerve was released 15 months postoperatively and 2 biopsies were taken. As for persistent complaints the hip was re-revised and a new reconstruction with a higher center of rotation was created in order to release the sciatic nerve. During this re-revision, the first reconstruction was removed which allowed histological inspection of almost the whole previous graft, including the graft-cement interface.

The specimens were fixed in phosphate-buffered (0.1 M, pH 7.4) 4% formalin and embedded not decalcified in methylmethacrylate. Serial sections (7 µm thick) were stained with hematoxylin-eosin and Masson trichrome to visualize osteoid. Normal and polarized light were used to detect woven bone.

Results

Remnants of the graft could be clearly recognized on the basis of empty osteocyte lacunae. In none of the core biopsy specimens could the host-graft interface be found.

No incorporation of the graft was found in the biopsy taken at one month (case 1). Only dead bone trabeculae were present with avital remnants of bone marrow. At the graft-cement interface, a substantial interlock was found between graft and cement. In 2 of the 3 biopsies taken at 4 months, a front of new bone was penetrating the avascular graft. At the revascularization front, which could be recognized on the basis of vital soft tissue, osteoid and woven bone had formed on the original graft trabeculae and in the interstitial space (Figure 2). There was also local osteoclastic resorption of the graft.

All of the specimens taken 8–28 months after revision showed different stages of graft incorporation. At 8 and 9 months, various amounts of graft remnants were embedded in a new trabecular structure. The newly formed bone was woven. Generally, there was an increase in the amount of woven bone towards the graft-cement interface, which suggested that, after a time, woven bone was remodeled into lamellar bone. In 4 specimens (cases 1, 5, 7, and 8), the graft-cement interface was present in the biopsy. In cases 7 and 8, no intact interface was present due to the loosening process, but there was only vital bone, without remnants of graft. In case 5, the interface was present over large areas of the reconstruction. Locally, vital bone was in direct contact with the cement, but at most locations a thin soft tissue layer interfaced with the cement (Figure 3).

In the biopsies taken 15, 22, and 28 months postoperatively, remnants of the graft were extremely

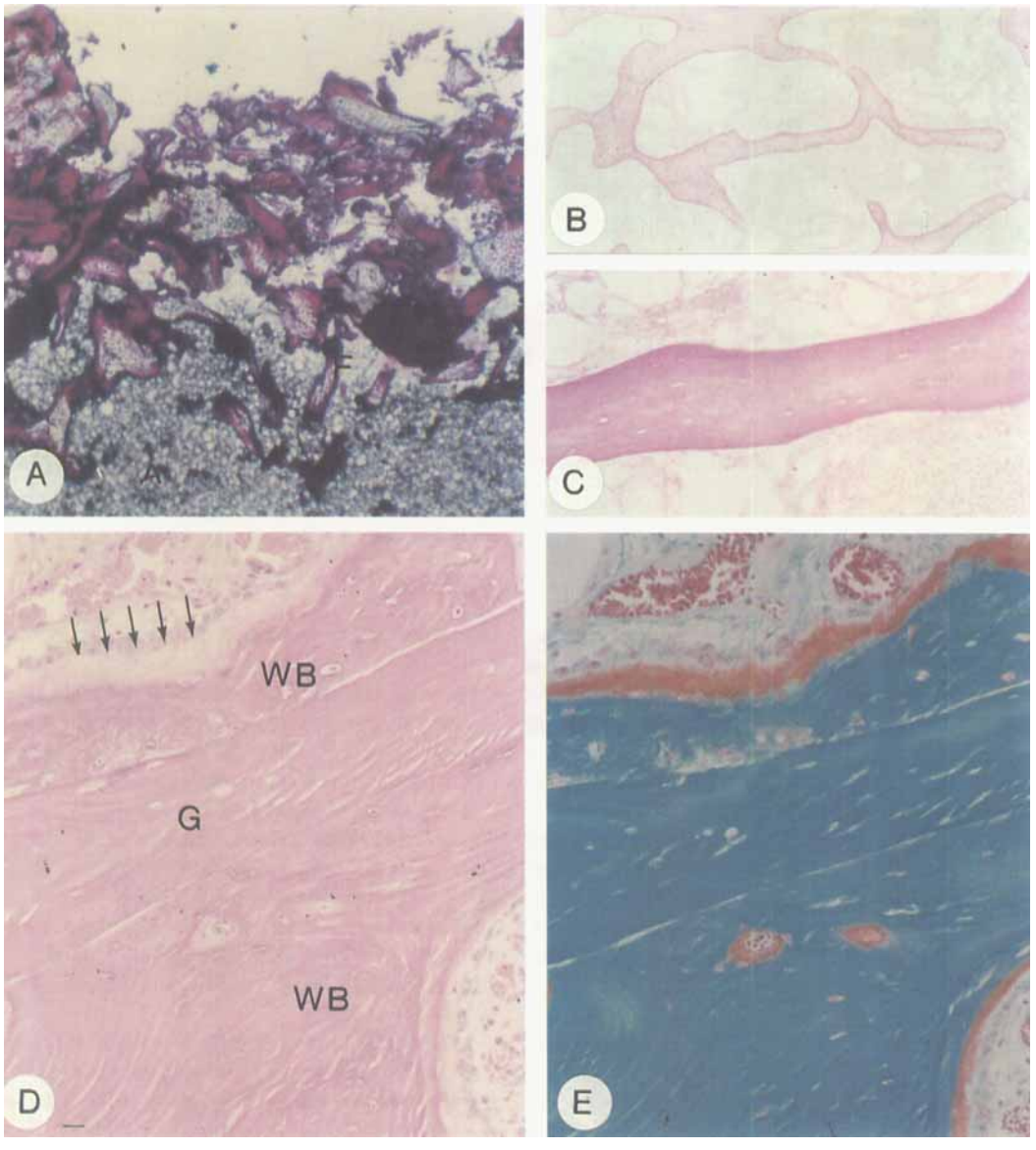

Figure 2. A–C. Case 1. 1 month postoperatively.

A. The graft-cement interface in fuchsine-stained thick section. Note penetration of cement into the graft.
B and C. No incorporation of graft in HE-stained section. Note acellular medullary tissue in C (A and B, ×20, C ×90).

D, E. Case 2. 4 months postoperatively.

New woven bone (WB) is formed on the remnants of the graft (G) by active osteoblasts (arrows). D. HE-stained section.
E. Goldner-stained adjacent section. Note red-stained osteoid indicating active bone formation (×225).

scarce. Most of the woven bone had been remodeled into lamellar bone with a normal structure and with vital, cell-rich medullary tissue. Larger bone specimens were available from case 8, because the whole reconstruction had to be moved to a higher center of rotation. All bone specimens from this patient showed normal lamellar bone with little or no graft remnants. Graft remnants and remnants of woven bone were only present at locations where a very dense trabecular structure had formed—for instance, on the margins of the new acetabular wall.

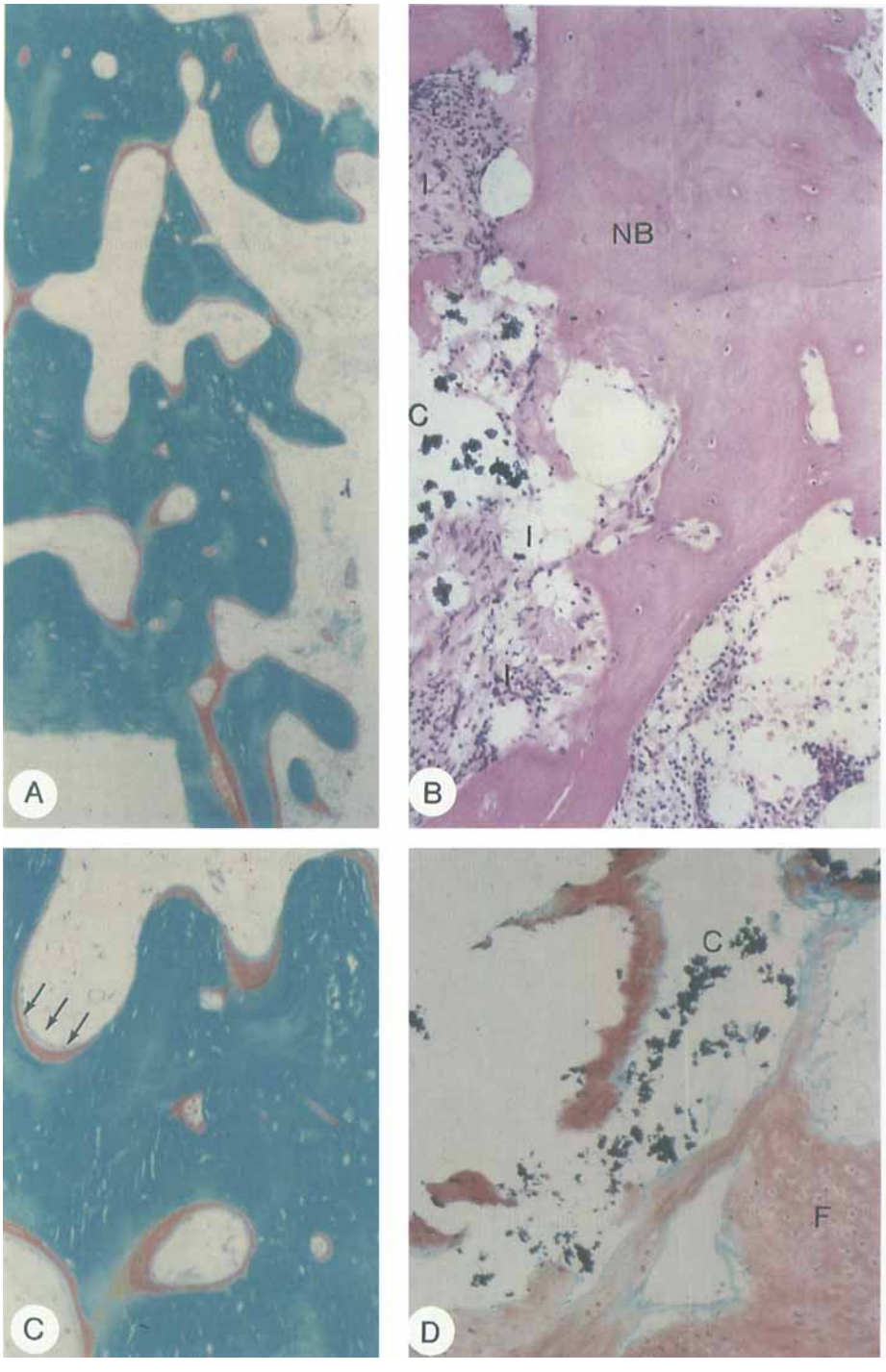

Figure 3. A and C. Case 3. 8 months postoperatively.

The graft is incorporated into a new trabecular structure. If inspected with polarized light, the structure mainly consists of woven bone, with many active bone remodeling sites indicated by the red osteoid staining (Goldner staining, ×30).
C. Magnification of part of Figure A. Note active osteoblasts (arrows) (×55).

B and D. Case 5. 28 months postoperatively.

At the graft-cement (C) interface, new bone (NB) is locally present, graft remnants are absent and locally a soft tissue interface (I) and/or fibrocartilage (F) is present (HE and Goldner staining, ×140).

Discussion

Biopsy specimens are limited as regards all the processes involved in the graft incorporation process. In most cases, only a small area of the total reconstruction can be investigated and the histology of the medullary tissues may be compromised by the biopsy procedure. Furthermore, in the case of fixed cups that were not revised, the biopsy specimens do not contain the cement-graft interface, or if the biopsies are of a mechanically failed cup, the histology of the cement-graft interface is compromised by the failure process. As a result, an intact cement-graft interface was present in only one of the biopsy specimens (case 5, 28 months).

In the specimen 1 month post-revision, no signs of graft incorporation were found. All specimens with a postoperative period of 8 months or longer showed a new trabecular structure, initially with woven bone that subsequently remodeled into lamellar bone. The bone in the specimens, with a follow-up of 15 months or longer, closely resembled normal trabecular bone, with only very few remnants of graft. Similar results were found in the proximal femur after impaction grafting (Ling et al. 1993, Nelissen et al. 1995). The sequence of events was comparable to that previously observed in experiments in the goat (Buma et al. 1992, Slooff et al. 1993, Schreurs et al. 1994, Schimmel 1995).

In conclusion, our results indicate that impacted morsellized chip graft completely incorporates into a new trabecular structure.

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