Morsellized bone allografting in revision total knee replacement—a case report with a 4-year histological follow-up

Corné J M van Loon, Pieter Buma, Maarten C de Waal Malefijt, Albert van Kampen and René P H Veth

Department of Orthopaedics and Orthopaedic Research Laboratory, University Hospital, P.O. Box 9101, NL-6500 HB Nijmegen, The Netherlands. Tel +31 24–3614480. Fax –3540230. E-mail: P. Buma@orthp.azn
Submitted 99-02-08. Accepted 99-09-20

A 61-year-old woman underwent a revision total knee replacement (TKR) for polyethylene wear of the tibial insert. Large uncontained femoral and tibial bone defects were encountered (Figure 1). According to the Engh and Parks' (1994) classification of bone defects in revision knee surgery, the bone defects were classified as type F2B (content medial femoral condyle: 9 cm^3, content lateral femoral condyle: 10 cm^3), and type T2B (content medial tibial plateau: 10 cm^3, content lateral tibial plateau: 10 cm^3). The femoral and tibial bone loss in the intramedullary canal was reconstructed by impaction of morsellized allograft similarly to the technique described by Ullmark and Hovelius (1996). The allografts were taken from fresh-frozen femoral heads and morsellized into chips of about 1/2 cm^3 with a rongeur.

The uncontained femoral bone defects were reconstructed by morsellized allograft impacted with a punch into the distal femoral areas adjacent to the trial component, without coverage by soft tissue or support by solid graft (van Loon et al. 1999).

Meshes were applied at the proximal tibia to create containment for the grafts (Figure 1). The proximal tibia was built up to the joint line by impaction of grafts towards the meshes and centrally around the trial tibial component without additional solid graft. The trial components were carefully removed without disturbance of the grafts and cemented, stemmed femoral and tibial components were inserted (Press-Fit-Condylar, Johnson & Johnson, Raynham, MA; Figure 2).

The patellar component was revised twice for

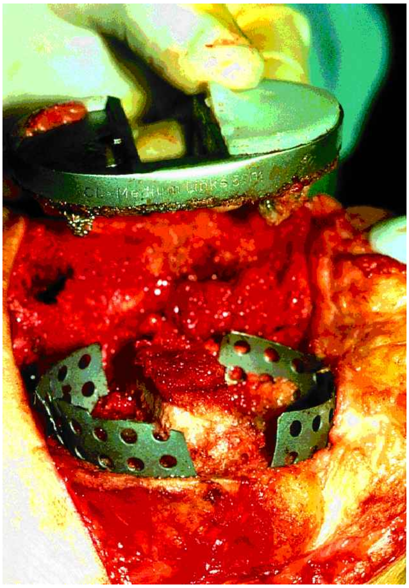

Figure 1. Intraoperative anterior view of the proximal tibia during revision TKR after removal of the tibial component and endosteal application of meshes.

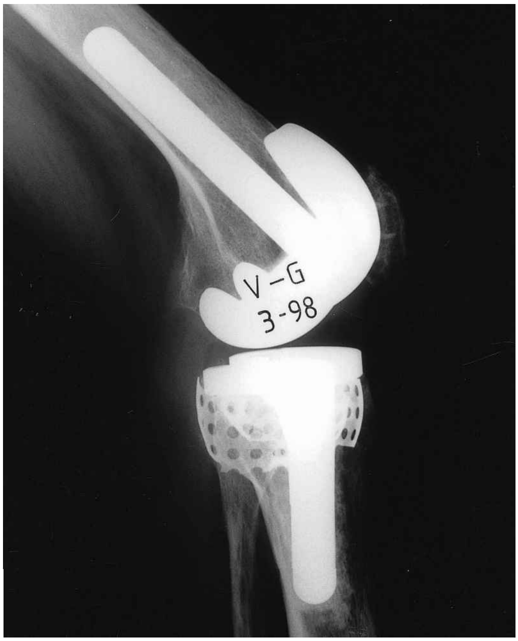

Figure 2. The reconstruction 4 years after revision.

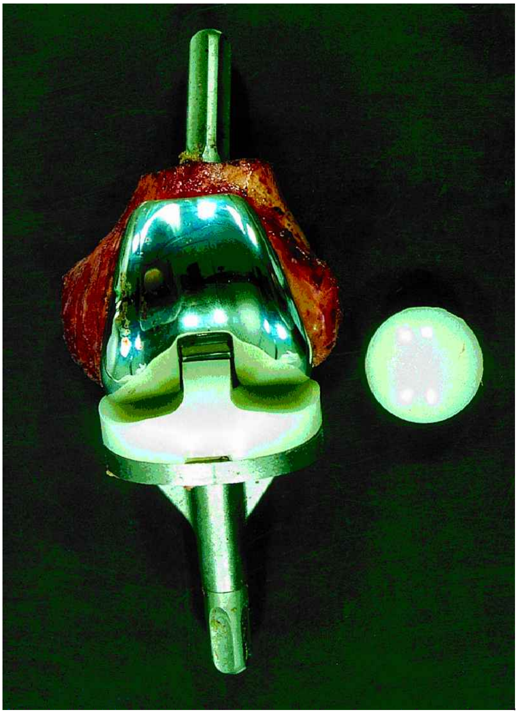

Figure 3. The retrieved knee prosthesis with attached distal femoral bone.

patellar dislocation and malposition at 1 and 3 years, respectively. 4 years after revision, an arthrodesis was performed because of persistent pain without signs of (a)septic loosening or malposition of the components. The intraoperative cultures were negative for infection. The femoral component was rigidly fixed to the bone. The entire distal femoral bone with the grafted areas was removed en bloc with the component (Figure 3). On the tibial side, part of the graft was fixed to the component, while the graft adjacent to the meshes partly crumbled on removal. The bone mineral density of the grafted medial and lateral condyles was measured by dual-energy radiographic absorptiometry, after removal of the femoral component and immersion in water. The bone was radiographed and sectioned into ca 5 mm slices for slab radiographs. Standard histological sections were made, and stained according to Goldner as well as with hematoxylin and eosin (HE).

Results

The specimen radiographs (Figure 4) and slab radiographs revealed clear differences in bone structure of the medial and lateral condyles of the grafted distal femur. The medial condyle showed signs of trabeculation of the graft up to the bone cement interface. In a part of the lateral condyle, an area with high bone-mineral density, we found no signs of trabeculation. The bone mineral density of the grafted medial and lateral condyles was 0.24 and 0.56 g/cm^2, respectively.

Histological analysis showed that the impacted graft in the medial femoral condyle was completely incorporated into new vital trabecular bone with vital fat marrow (Figures 5 and 6). No remnants of graft were found in this condyle. Most of the graft (about 90%) in the lateral femoral condyle was incorporated into new bone. Only the

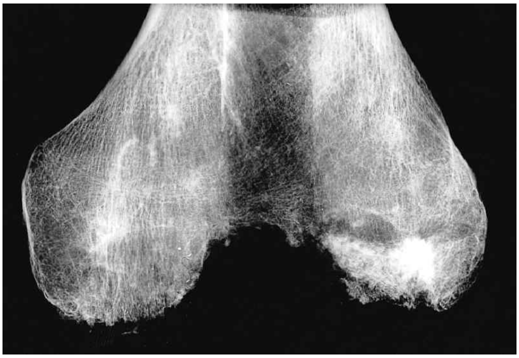

Figure 4. Radiograph of the femoral bone retrieval after removal of the femoral component. The lateral condyle shows trabeculation, but an area of high density is present in the medial condyle.

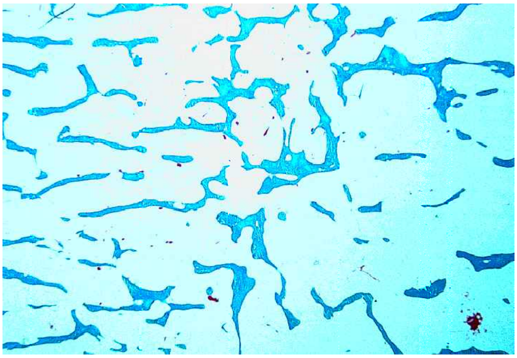

Figure 5. Low magnification of incorporated morsellized graft in the distal femur. Note that a normal trabecular structure has been formed. The lack of osteoid indicated a low level of bone remodeling (Goldner, ×10).

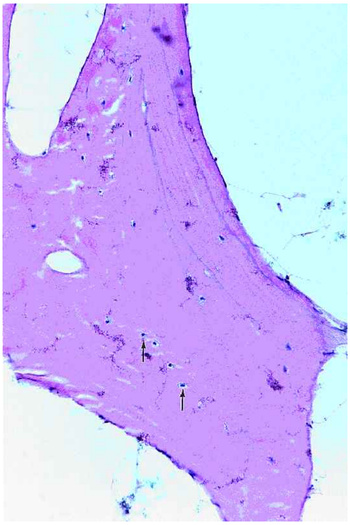

Figure 6. Enlargement of fully incorporated area with normal lamellar bone and vital osteocytes (arrows, HE ×180).

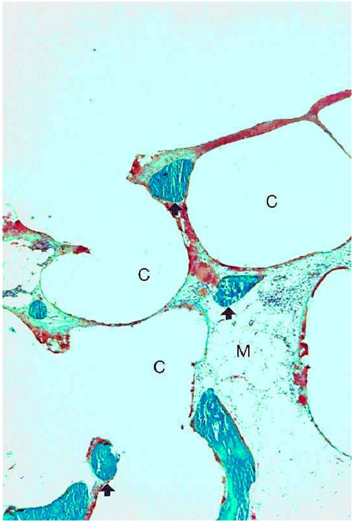

Figure 7. Interface with cement (C) around the distal femur. Note large interdigitations of the cement with vital medullary tissues (M) and scarce, thin, bone trabeculae (arrows, Goldner ×45).

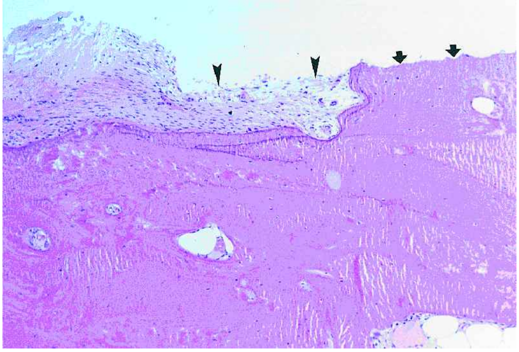

Figure 8. Outer layer of vital incorporated cortical tibial bone located directly adjacent to the mesh (removed for technical reasons). Note the direct interface of the area of the mesh with vital bone (arrows) and fibrous tissue (arrow heads, HE ×90).

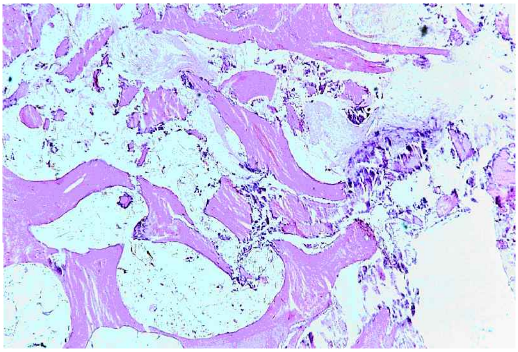

Figure 9. Non-incorporated morsellized graft in the central region of the tibial reconstruction (HE ×45).

dense area that did not show trabeculation appeared to consist of non-incorporated graft. In both condyles, the interface with the cement consisted of a thin fibrous soft tissue that alternated with local areas of direct bone-cement contact. Particularly at the posterior side of both condyles, a relatively thick vital neocortex was found. At the distal anterior interface, the bone was thinner and interrupted at many locations by fibrous tissue or medullary tissue in direct contact with cement. Around the distal part of the femoral stem, cement had penetrated deeply into the bone (Figure 7). The interface with the stem was characterized by thin osteopenic bone trabeculae, often in direct contact with the cement.

In the tibia, a vital neocortex had formed directly adjacent to the meshes (Figure 8). New vital cortical bone had formed to a depth of 4 mm inside the mesh. More centrally non-incorporated grafts predominated, with only an occasional area of vital bone. Approximately three fourths of the tibial graft consisted of non-incorporated, non-viable grafts (Figure 9).

Discussion

Reconstruction of uncontained bone defects in revision TKR with structural bone grafts and stemmed components yields good medium-term results (Engh et al. 1997, Ghazavi et al. 1997). However, histological evaluation of 9 retrieved structural grafts showed that revascularization and remodeling had not occurred after an average of 41 months (Parks and Engh 1997). We could not find reports of histological evaluation of morsellized grafts in revision TKR in the literature. Our findings show that the femoral grafts were mostly incorporated but had become osteopenic with very low measured bone mineral density, probably due to the stress-shielding effect of the stemmed femoral component (Willems et al. 1998). The fact that the distal area of the medial condyle had remodeled suggests that the revascularization process had reached the bone adjacent to the femoral component. The tibial mesh did not prevent incorporation of the graft and a neocortex had formed adjacent to the meshes. However, most of the tibial graft did not incorporate and the central tibial graft was necrotic. Graft failure may have been caused by a phase of relative instability of the construction, although the components were not evidently loose on removal. Ling (1997) stressed the importance of achieving absolute stability on the operating table in femoral impaction grafting in revision total hip replacement for the revascularization and incorporation process. Histological analysis of 8 retrieved acetabular morsellized allografts in revision total hip replacement revealed revascularization and incorporation of the grafts into a new trabecular structure without necrotic bone or significant graft remnants (Buma et al. 1996). Similar histological patterns were found in retrievals of morsellized allografts in the femur (Ling et al. 1993, Nelissen et al. 1995, Ullmark and Linder 1998). A neocortex was found in these retrievals as was present in the femoral condyles and proximal tibia in our case.

Based on the results of this retrieval, we conclude that impacted morsellized grafts can incorporate into new bone when applied on the femoral side in revision TKR. Reconstruction of large uncontained tibial bone defects with meshes and morsellized grafts may lead to a relative unstable reconstruction and subsequent poor graft incorporation. We therefore discourage the use of this technique on the tibial side for these large bone defects. Stability may be an important factor in the process of incorporation of impacted morsellized grafts in TKR, as was suggested in revision total hip replacement.

Buma P, Lamerigts N, Schreurs B W, Gardeniers J, Versleyen D, Slooff T J J H. Impacted graft incorporation after cemented acetabular revision. Acta Orthop Scand 1996; 67 (6): 536-40.

Engh G A, Parks NL. The classification and treatment options of bone defects in revision knee surgery. Trans AAOS 1994.

Engh G A, Herzwurm P J, Parks N L. Treatment of major defects of bone with bulk allografts and stemmed components during total knee arthroplasty. J Bone Joint Surg (Am) 1997; 79: 1030-9.

Ghazavi M T, Stockley I, Yee G, Davis, A, Gross A E. Reconstruction of massive bone defects with allograft in revision total knee arthroplasty. J Bone Joint Surg (Am) 1997; 79: 17-25.

Ling R S M. Femoral component revision using impacted morsellised cancellous graft. J Bone Joint Surg (Br) 1997; 79: 874.

Ling R S M, Timperly A J, Linder L. Histology of cancellous impacted grafting in the femur. A case report. J Bone Joint Surg (Br) 1993; 75: 693-6.

Loon C J M van, Waal Malefijt M C de, Verdonschot N, Buma P, Aa A J A M van der, Huiskes R. Morsellized bone grafting compensates for femoral bone loss in revision total knee arthroplasty. An experimental study. Biomat 1999; 20: 85-9.

Nelissen R G H H, Bauer T W, Weidenhielm L R A, LeGolvan D P, Mikhail E M. Revision hip arthroplasty with the use of bone grafting. J Bone Joint Surg (Am) 1995; 77: 412-22.

Parks N L, Engh G A. Histology of nine structural bone grafts used in total knee arthroplasty. Clin Orthop 1997; 345: 17-23.

Ullmark G, Hovelius L. Impacted morsellized allograft and cement for revision total knee arthroplasty. A preliminary report of 3 cases. Acta Orthop Scand 1996; 67: 10-2.

Ullmark G, Linder L. Histology of the femur after cancellous impaction grafting using a Charnley prosthesis. Arch Orthop Trauma Surg 1998; 117: 170-2.

Willems M M M, Lenthe G H van, Verdonschot N, Waal Malefijt M C de, Huiskes R. Fixation methods of a stemmed femoral component of a total knee replacement strongly influence eventual bone loss. Trans EORS, Amsterdam 1998.