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Case Report

Impaction Bone Grafting in Revision Total Knee Arthroplasty—Using Mesh and Cone to Contain the Defect: A Report of 3 Cases

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ABSTRACT

Uncontained tibial bone defects are a challenge in revision total knee arthroplasty. The present study reports on the results of a modified surgical technique for impaction bone grafting using metaphyseal cones and wire mesh. Three patients (2 male, 1 female; average age: 71.3 years) underwent revision total knee arthroplasty. All patients presented with uncontained medial tibial bone defects, one of the patients with an additional posterior cortical tibial split fracture. All cases were treated with a metaphyseal cone and outside mesh to create a contained defect. Between the mesh and cone, fresh frozen cancellous chips mixed with β-tricalcium phosphate were impacted. No evidence of loosening or osteolysis was present at 3.6-year follow-up. Impaction bone grafting using an outside mesh and inside cone for defect containment provides a durable reconstruction of tibial bone defects.

Introduction

Revision total knee arthroplasty (TKA) in the presence of uncontained bone defects remains challenging. Possible treatment options include porous metal cones or sleeves with the use of medial augments and structural allograft reconstruction. Additional treatment options to address large bone defects are impaction bone grafting or filling the defect with cement [1-4].

Structural allografts have been shown to provide a stable and durable reconstruction in tibial bone defects [3,5]. Complications are graft nonunion, graft fractures, aseptic loosening, or infection [6-8].

Trabecular metal cones (Zimmer Biomet, Warsaw, IN) are also associated with a good outcome and show a survivorship of 91% at a mean of 5-year follow-up [9,10].

The technique used in this study was first described by Lonner et al [11]. They first reported the use of impaction of morselized allograft and wire mesh for large uncontained defects around the knee with good results in 17 revision TKAs.

The present study reports on a variation of this technique using both outside mesh support and metaphyseal cones to convert large uncontained defects into a contained defect amenable for impaction bone grafting.

Case history

This study was approved by the institutional review board at the author's institution.

Between December 2015 and April 2016, 3 patients (2 male and 1 female) underwent revision TKA in the presence of an uncontained tibial bone defect and loosening of the tibial component. Informed consent for surgery was obtained from all patients. Inclusion criteria were patients with loosening of the tibial component after TKA with a large uncontained medial tibia defect not amenable to reconstruction with a medial augment. Alternative treatment options included medial metal augments in combination with a thick tibial base plate, metaphyseal sleeve fixation without medial defect reconstruction, or medial cement augmentation.

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Figure 1. Case 1: Preoperative radiographs showing loosening of the tibial component and consecutive varus malalignment.

Besides anteroposterior (AP), lateral, and merchant radiographs of the knee, all patients underwent hip to ankle standing radiographs. Case 2 also underwent preoperative computed tomography imaging. The mean age at the time of surgery was 71.3 years (range: 63-80 years), and the right side was affected in 2 patients and the left side in one patient. The average body mass index was 31.7 kg/m^2 (range: 28.7-36 kg/m^2). The mean time from

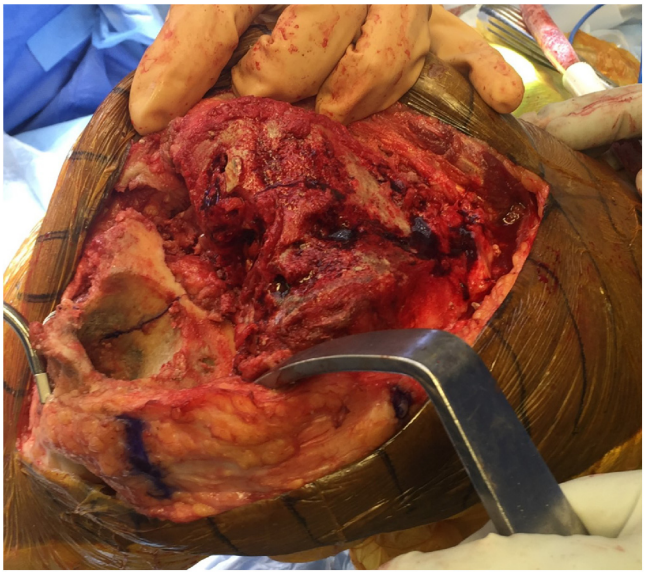

Figure 2. Intraoperative image showing an uncontained defect of the medial tibia and a split fracture in the posterior cortical bone.

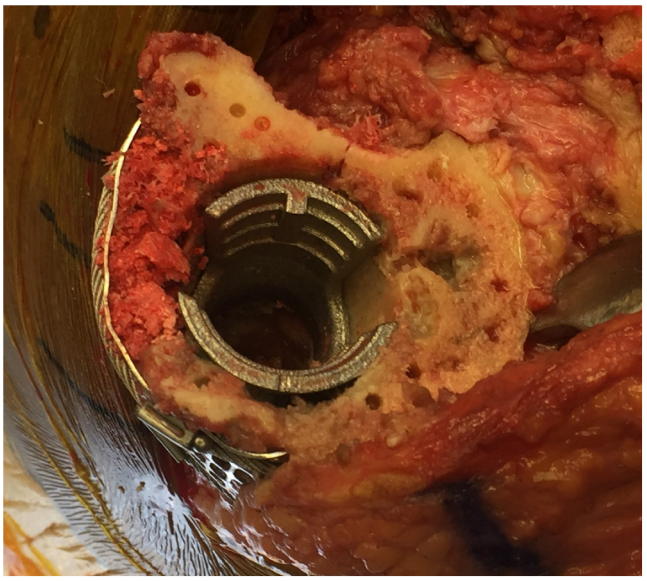

Figure 3. Intraoperative images after fixation of a mesh and compression of the fracture with Dall-Miles cables followed by graft impaction.

Figure 4. Postoperative anteroposterior radiographs 4 years after revision surgery, impaction grafting, and fixation of a mesh with Dall-Miles cables.

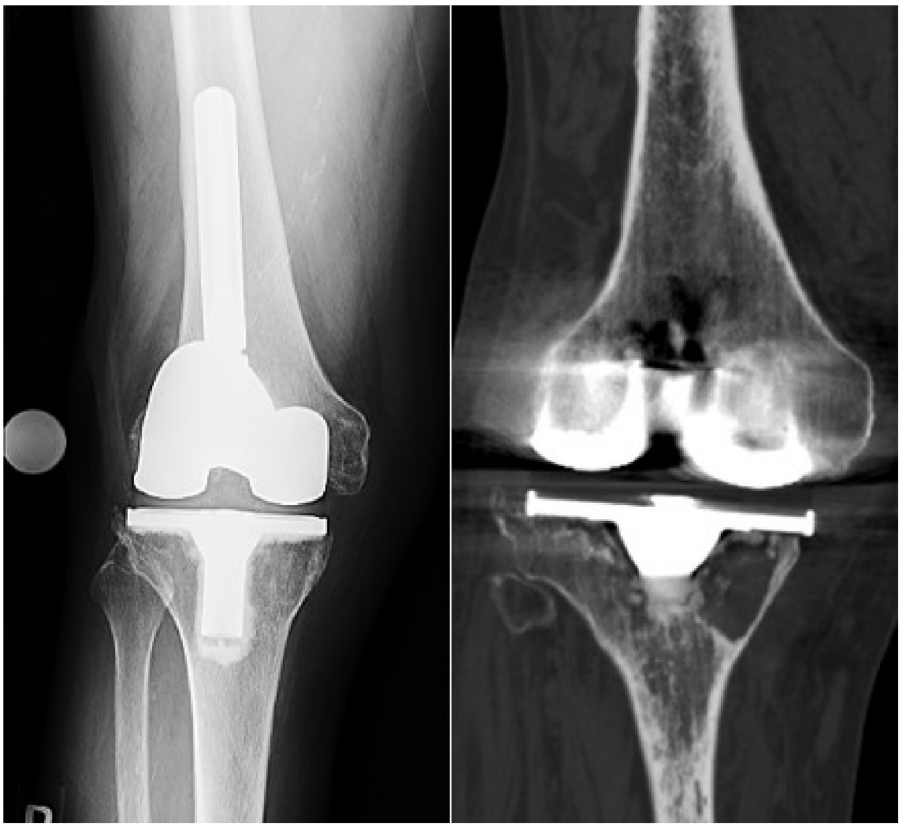

Figure 5. Case 2: Preoperative anteroposterior radiographs and coronal computed tomography images showing a defect in the proximal tibia and loosening of the tibial component.

primary TKA to revision surgery was 117 months (range: 19-210 months). Preoperatively, all patients presented with knee pain, inability to weight-bear, and progressive varus deformity. Case 1 presented with a flexion contracture of 10°, flexion of 100°, and grade 2 lateral ligamentous instability with varus stress. Case 2 presented with 115° of flexion and no ligamentous instability. Case 3 had 90° of flexion and full extension. All patients underwent preoperative C-reactive protein evaluation. All C-reactive protein levels were less than 1 g/dL. Routine cultures were collected at the time of surgery.

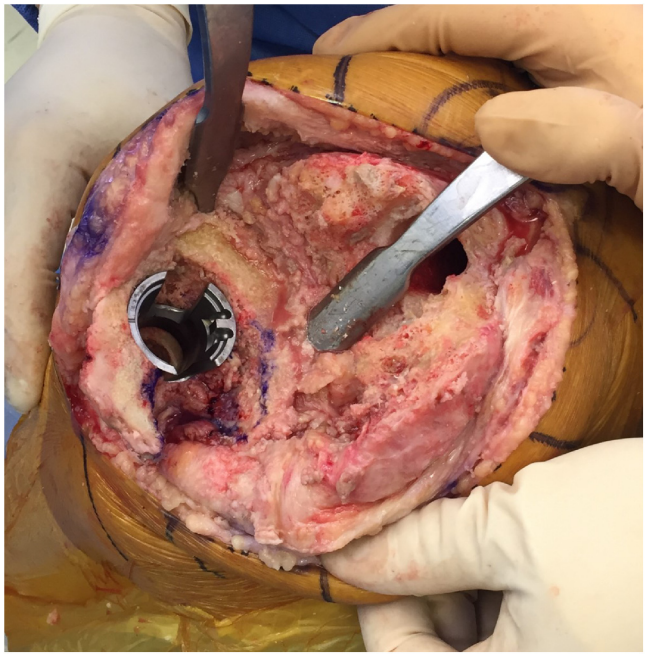

Figure 6. Intraoperative image after placement of the metaphyseal cone showing a large uncontained medial bone defect.

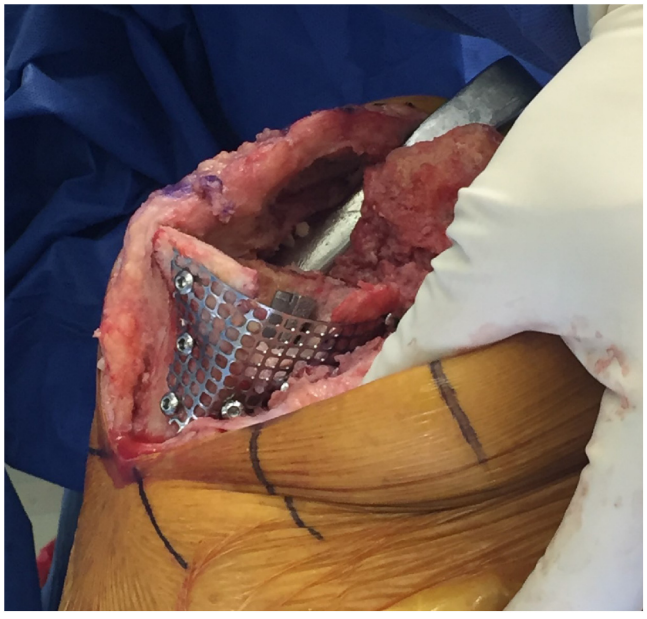

Figure 7. Intraoperative image showing the fixation of the mesh with small fragment screws.

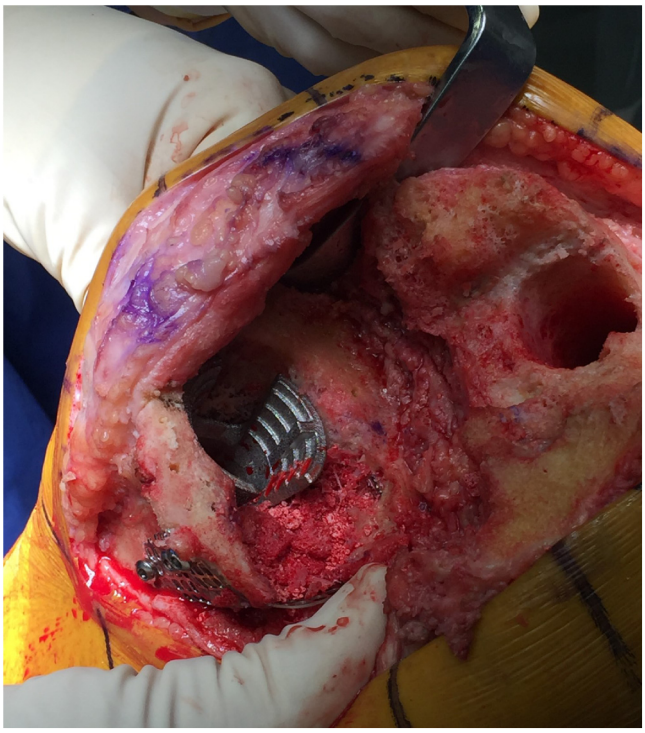

Figure 8. Intraoperative image showing impaction bone grafting between the mesh and metaphyseal cone.

All patients were treated by the senior author, a fellowship-trained high-volume surgeon. A midline incision and medial parapatellar approach was performed in all patients. A medial soft-tissue release is carried out around the tibia, and the components are removed in the usual fashion. The tibial and femoral canals were prepared with intramedullary reamers. Then, the proximal tibia metaphysis was prepared for metaphyseal cones (Triathlon Tritanium tibial cones, Stryker Orthopaedics, Stryker, Mahwah, NJ).

The wire mesh (Stryker Reconstruction Mesh, Stryker Orthopaedics, Stryker, Mahwah, NJ) was molded to the contour of the medial tibia and fixed using either Dall-Miles cables (Stryker Orthopaedics, Stryker, Mahwah, NJ) in case of fracture (case 1 (Figs. 1-4) or small fragment screws (case 2 (Figs. 5-9) and case 3 (Figs. 10 and 11). After fixation of the cone and mesh, fresh frozen cancellous chips were mixed with beta-tricalcium phosphate (Vitoss®, Stryker Orthopaedics, Stryker, Mahwah, NJ) and impacted into the medial bone defect. The cone is used for medial defect containment to improve the impaction density of the graft and avoid the graft bone from being dislodged into the medullary canal.

After bone grafting is completed, a revision TKA is fixed using a cemented (case 1) or hybrid cement fixation (cases 2 and 3) with Simplex bone cement (Stryker Orthopaedics, Stryker, Mahwah, NJ) containing tobramycin. Cementation was necessary in case 1 owing to a fracture of the posterior aspect of the tibia after removal of the tibial component. In cases with large medial bone defects, the authors in general prefer longer hybrid fixation stems to guide the alignment of the tibial component. No tibial augments were used. Initial stability for the tibial component was achieved by a combination of intramedullary stem press fit, press-fit cone fixation, intact lateral tibia bone, and impacted bone graft medially.

In cases 2 and 3, the TC-3 revision knee system (DePuy, Warsaw, IN) and in case 1, the Legion revision TKA system (Smith and Nephew, Memphis, TN) were used.

Twenty percent partial weight-bearing was recommended for 6 weeks after surgery. After drain removal, a continuous passive motion machine was started and advanced as tolerated, starting postoperative day 1. The range of motion was advanced as tolerated. All patients were kept at 20% partial weight-bearing on crutches for 6 weeks. After that, full weight-bearing was encouraged. Case 1 presented with postoperative wound drainage 6 weeks postoperatively, an irrigation and debridement was performed after 8 weeks, and the patient received intravenous antibiotics for 5 days followed by oral antibiotics for an additional 7 days, until the cultures were negative. Risk factors for infection in this patient were a type 2 diabetes mellitus. Case 2 was put on oral antibiotics for a superficial wound infection for a week. The patient had a chronic coronary artery disease with a previous heart attack and chronic atherosclerosis of both lower limb arteries and was treated with acetylsalicylic acid. All patients were nonsmokers. Case 3 presented with an uneventful postoperative course. Intraoperative cultures of all patients remained negative for bacteria in all cases.

Results of the individual cases are displayed in Table 1.

Figure 9. Three-year follow-up radiographs after revision surgery and fixation of a mesh with small fragment screws.

Discussion

The current case series reports a variation of the technique originally described by Lonner et al [11]. The introduction of metaphyseal cones can improve impaction grafting by providing a central buttress and in combination with a peripheral mesh

Figure 10. Case 3: Preoperative radiographs showing a fracture of the medial tibial plateau and loosening of the tibial component.

optimizes graft impaction. The mesh itself can be fixed using small fragment screws as described by Lonner et al or using Dall-Miles cables to fix concomitant fractures.

Mesh grafting in bony defects was first described by Slooff et al [12] in 43 hips with acetabular protrusion. At 2 years, all grafts seemed to be incorporated. The goal when using impaction grafting is to restore bone stock and provide lasting support for the implant. Incorporated bone graft maintains a physiological modulus of elasticity for load transfer and increases options at the time of later revision surgery [13,14]. In addition, trabecular metal material has a modulus of elasticity, which is close to that of the cancellous bone [15]. Another possibility of treating bone defects in revision arthroplasty is the use of augments. In a study by Hockman et al [16], 89% of 54 patients were treated with metal augments during revision TKA and 48% of patients needed structural allografts. Revisions with bone loss that required bulk allograft failed less often (19.2%) than revisions managed without bulk allografts. Another group found significantly better clinical outcome scores when using structural allograft in revision TKA with massive bony defects than when using revision TKA without the use of allograft [17].

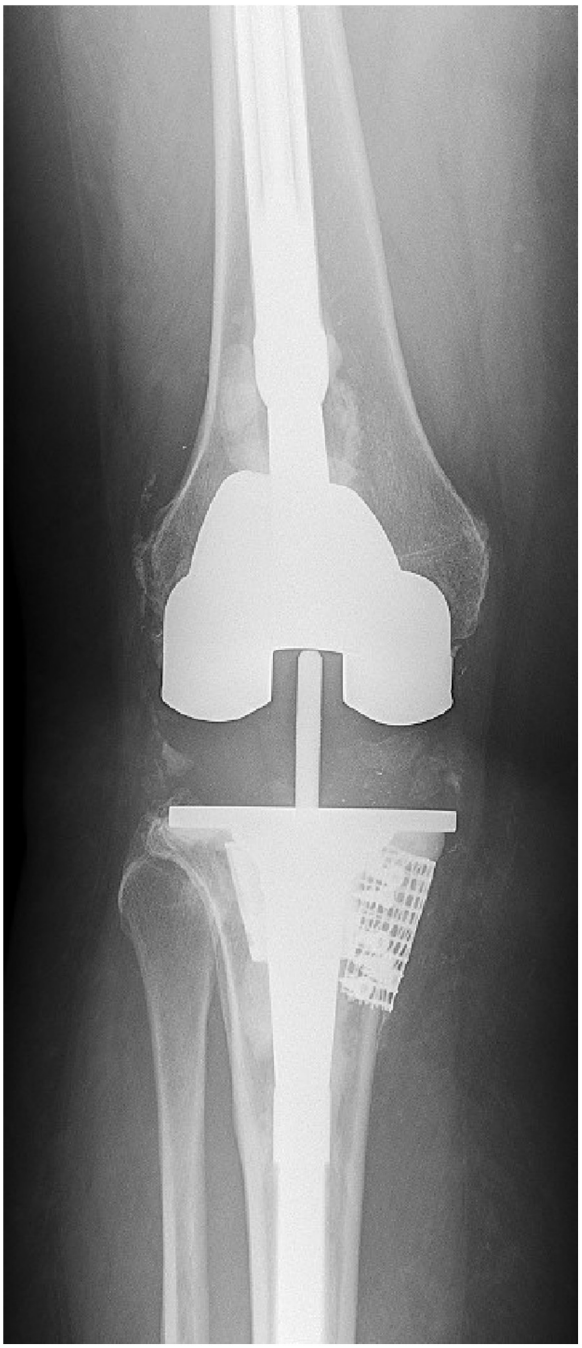

Figure 11. Two-year follow-up radiographs after revision surgery and fixation of a mesh with small fragment screws.

Contrarily, in a study by Sandiford et al, no differences in the revision rate, outcome scores, and radiographic loosening between the use of metal cones and femoral head allograft were found [10].

In addition, sleeves provide reliable fixation in revision TKA in the short-term follow-up [4].

To provide immediate stability, the graft must be sufficiently compacted. Repetitive, vigorous impaction is necessary to receive a dense and compact graft. Possible complications are intraoperative fractures [12]. To reduce the risk for an intraoperative fracture, the use of stiffer and stronger material has been recommended [18].

In addition, fat and marrow fluid play a role, and mechanical testing has been shown significantly more resistant to shearing

Table 1
Demographic data for the 3 patients including perioperative outcome data.

	Sex	Age (years)	Side	BMI (kg/m^2)	Follow-up (months)	Reason for revision	Complication	KSS preop	KSS function preop	ROM preop in degree	KSS postop	KSS function postop	ROM postop in degree
1	Male	71	Left	30.4	48	Loosening	Distal wound drainage, VAC treatment with I&D	38	30	90	90	60	100
2	Male	80	Right	28.7	32	Loosening	Distal wound infection	58	45	115	94	75	120
3	Female	63	Right	36	51	Fracture		53	45	90	93	55	110

BMI, body mass index; KSS, knee society score; VAC, vacuum-assisted closure; I&D, open irrigation and debridement; ROM, range of motion.

forces in the washed graft than fresh graft [19,20]. The graft of all patients was washed with warm water to remove fat.

Complications of revision TKA and the use of allografts are graft nonunions, graft fractures, or aseptic loosening and infection [6-8] with possible need for revision surgery. Hilgen et al reported a 10-year survival rate of only 50% after failed impaction grafting in revision surgery. After a mean time of 5 years, 19 of 29 knees had to be re-revised because of aseptic loosening and mechanical failure [21]. In a prospective study, Lotke et al report a complication rate of 14% in their prospective study at an average follow-up of 3.8 years [22].

In our cohort, 2 postoperative wound-healing problems occurred, none developed a deep infection, and the clinical and radiographic outcome was good at a follow-up period of 43.7 months. The lack of failure into varus suggests that the graft has incorporated over time. Fixation of the mesh and impaction bone grafting can be time-consuming, and the limited soft-tissue envelope on the medial tibia might increase the risk of infections. This study has several limitations. It was retrospective and has no control group. Only 3 patients were treated with this new technique of cones, wire mesh, and impaction grafting. In our opinion, a correctly applied allograft can help in the reconstruction of tibial bone defects, provides support and stability for TKA implants, and can maintain bone stock for possible re-revisions.

Summary

In this study, we report a new technique of impaction grafting with the use of mesh and cones with encouraging medium-term follow-up results after 3.6 years with no femoral or tibial component loosening and 100% implant survival.

Conflict of interest

F. Boettner reports royalties by Smith and Nephew and Ortho Development. F. Boettner has also received compensation from Smith and Nephew, Ortho Development, Medtronic, and DePuy, outside the submitted work.

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