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ORIGINAL ARTICLE

Proximal femoral reconstruction with impaction bone grafting and circumferential metal mesh

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Abstract
Introduction Impaction bone grafting (IBG) using a circumferential metal mesh is one of the options that allow restoration of the femoral bone stock and stability of the implant in revision hip arthroplasty. Here we examine the clinical and radiographic outcome of this procedure using a cemented stem, including experimental analysis of the initial stability of mesh-grafted bone-cemented stem complexes.
Methods We retrospectively reviewed six hips (six patients) that had undergone femoral revisions with a circumferential metal mesh, impacted bone allografts, and a cemented stem. The mean follow-up period was 3.9 years (range 2.4–4.8 years). Hip joint function was evaluated using the Japanese Orthopaedic Association hip score, and radiographic changes were determined from radiographs. The initial resistance of mesh-grafted bone-cemented stem complexes to axial and rotational force was measured in a composite bone model with various segmental losses of the proximal femur.
Results The hip score improved from 50 (range 10–84) preoperatively to a mean of 74 (range 67–88) at the final follow-up. The overall implant survival rate was 100 % at five years when radiological loosening or revision for any reason was used as the endpoint. No stem subsided more than 3 mm vertically within one year after implantation. Computed tomography showed reconstitution of the femoral canal in a metal mesh. In mechanical analyses, there was no relationship between IBG reconstruction rates under axial compression and stem subsidence or failure load. In contrast, under rotational load, the rotation angles of the stem to the stainless steel mesh were strongly affected by the IBG reconstruction rate.
Conclusions The short-term results show good outcomes for reconstruction of proximal bone loss with IBG and a circumferential mesh. The procedure should be applied in cases where the circumferential proximal bone loss is less than half the length of the implanted stem.

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Introduction

Recent trends towards longer population life expectancy and an increased prevalence of total hip replacement (THA) surgery in younger patients have led to a higher number of revision THAs. One of the major problems in a failed femoral prosthesis is the extensive loss of proximal femoral bone stock, which impairs stable implantation of new prosthetic components. Several surgical techniques have been advocated for reconstruction of proximal femoral bone loss and/or secure implantation, including distal fixation using

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long uncemented implants [1], massive endoprosthetic reconstruction [2], proximal femoral allograft–prosthesis composites [3], and impaction bone grafting (IBG) with circumferential metal meshes [4].

Uncemented fully porous, coated cylindrical components provide a highly successful method of femoral reconstruction [5]. Depending on the degree of femoral bone loss, this type of cementless stem is able to achieve initial axial and rotational stability. Proximal stress shielding has been a cause for concern, however, and in more extensive bone deficiency, especially with large-diameter diaphyseal canals, fully coated cylindrical femoral components have insufficient stability [6]. Another option in uncemented revision is the use of fluted, tapered grit-blasted femoral components. The flutes provide rotational stability, and the tapered geometry is designed to achieve axial stability. Regis et al. [7] reported that the cumulative implant survival rates at 15.8 years, using endpoints of femoral revision for any reason or stem failure, were 92.0 % and 96.6 %, respectively. Despite a reasonably successful outcome, most previous reports of fluted tapered monoblock stems have shown a high rate of complications, including subsidence and dislocation [8]. A massive endoprosthesis is inserted for severe proximal femoral bone loss in elderly and sedentary patients. A distal femur in good condition allows for secure fixation of the endoprosthesis with cementation. A previous study reported survival rates for massive endoprosthesis reconstruction that varied from 58 % to 84 % at 5–10 years of follow-up [9]. The most recent study, a retrospective review of 403 endoprosthetic reconstructions, reported 10- and 15-year implant survival rates of 75 % and 73 %, respectively [10]. In contrast, results have been encouraging for the use of a proximal femoral allograft with a femoral component [11]. The perceived advantages of allograft–prosthesis composites over the use of massive endoprostheses include better soft-tissue attachment and reduced loss of distal bone. Although survival rates with allograft–prosthesis composites appear to be better than those with massive endoprosthetic reconstruction, a wide range of complications have been reported [12], and the indications for this procedure have not been clearly established. In addition, in Japan, structural allografts are not commercially available and are extremely difficult to obtain [13].

IBG with morselized bone allografts, although a technically demanding procedure, is an attractive technique for restoring deficient bone stock in the proximal femur for revision hip arthroplasty, with good results reported [14]. Histologically, bone remodeling means that the allografts are largely replaced by viable cortical bone [15, 16]. Although some studies have demonstrated success in cases of more severe femoral defects, others have noted a high complication rate, including massive early stem subsidence, cement mantle inadequacies, cement mantle fracture, femoral fracture, long-term subsidence, and catastrophic stem failure [17, 18]. On the other hand, van Kleunen et al. [19] and Buttaro et al. [4] reported good outcomes for IBG and circumferential metal meshes in patients with extensive circumferential proximal cortical bone loss. Guala et al. [20] analyzed the initial stability of circumferential meshes and impacted bone allografts for massive femoral bone defects using fresh-frozen bovine femurs with complete loss of the proximal femur. This model suggested that femurs reconstructed with a circumferential mesh and impacted bone provided 50 % of the resistance to axial load and 30 % of the resistance to rotational load of an intact femur, which is enough to resist physiological load. However, the dependence of the initial stability of the reconstruction complex on the defect size has not been studied. The purpose of this study was to analyze the short-term results of revision hip arthroplasty with IBG and circumferential metal meshes in patients with circumferential proximal femoral bone loss, and to examine in vitro the initial resistance to axial and rotational forces of a composite bone model with complete loss of the proximal femur that is reconstructed with a circumferential metal mesh containing impacted bone allografts and a long polished double-tapered cemented stem.

Patients and methods

Between September 2008 and October 2011, we retrospectively reviewed six patients (six hips) who had undergone revision hip arthroplasty with IBG and circumferential metal meshes. The patients included one man and five women, with a mean age of 69 years (range 58–78 years), mean height of 153 ± 11 cm, and mean weight of 52 ± 8.4 kg at the time of the operation. The mean follow-up period was 3.9 years (range 2.4–4.8 years). The diagnoses for revision hip arthroplasty were aseptic loosening and femoral osteolysis in four hips, periprosthetic femoral fracture in one hip, and infection in one hip. The femoral defects, classified according to Paprosky [21], were Type II in three hips, Type IIIA in two hips, and Type IIIB in one hip; and Grade 2 in three hips and Grade 3 in three hips according to the Endoklinik [22] classification. All of the cases had complete circumferential bone loss or segmental cortical defect in the proximal femur. The defects were over half of the circumference, and the remaining cortices were fragile in the cases of segmental cortical defects. Institutional review board approval was obtained for publication of the study, and informed consent was provided by the patients and their families for data from their cases to be submitted for publication.

Operations were performed using a direct lateral (four hips) or posterior approach (two hips) with femoral IBG,