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Periprosthetic fractures with extensive bone loss treated with onlay strut allografts

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Abstract We reviewed a consecutive series of 19 patients with comminuted periprosthetic fractures, loosening of the femoral stem (Vancouver type B3) and significant loss of bone stock (Paprosky type III and IV). Sixteen porous-coated long stems and three Exeter stems, all with impaction grafting, were used. Large femoral onlay strut allografts were applied to maintain fracture reduction and improve stability. There was one early re-fracture at the tip of the femoral stem. Eighteen fractures healed without deformity and shortening. At the last follow-up at mean 3.7 (2.0–7.5) years, the mean Harris hip score was 76.4 (57.5–92.0). There was ingrowth of all strut grafts and significant augmentation of periprosthetic bone.

Résumé Nous avons examiné une série consécutive de 19 malades présentant une fracture comminutive périprothétique, un descellement de la tige fémorale (type Vancouver B3) et une perte du stock de osseux (type Paprosky III et IV). Seize longues tiges à revêtement poreux et trois tiges Exeter, toutes avec greffes impactées ont été utilisé. Des baguettes d'allogreffes ont été appliqués pour maintenir la réduction de la fracture et améliorer la stabilité. Il y avait, précocement, une re-fracture à la pointe de la tige fémorale. Dix-huit fractures ont guéri sans déformation ni raccourcissement. Au dernier suivi, en moyenne 3.7 (2.0–7.5) années le score moyen de Harris était 76.4 (57.5–92.0). Il y avait incorporation de toutes les greffes et augmentation notable de l'os périprothétique.

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Table 1 Vancouver classification of periprosthetic femoral fractures

Type	Location	Subtype
A	Trochanteric region	AG: greater trochanter AL: lesser trochanter
B	Around or just distal to the stem	B1: prosthesis stable B2: prosthesis unstable B3: bone stock inadequate + B2
C	Well below the stem	

Introduction

The incidence of periprosthetic femoral fractures is low but has significantly increased during the last decade [16]. The management of complex periprosthetic femoral fractures is challenging and the clinical outcome often unsatisfying due to deformity, shortening, non-union and implant loosening [1, 5]. According to the Vancouver classification of periprosthetic fractures [6] (Table 1), type B3 is the most severe category. It is a complex fracture with shattering around the prosthesis stem. The femoral component is always loose, the fracture inherently unstable and the femoral bone stock severely deficient (Fig. 1a). Intramedullary fixation of the fracture by bridging with a long revision stem and extramedullary osteosynthesis with cerclage wires, screws or plates can be unreliable, as the cortical host bone does not provide adequate stability for anchorage. Therefore, reconstruction with cortical onlay strut allografts has been recommended [4, 5, 6, 9, 10, 16]. The aim of this study is to present a series of type B3 periprosthetic fractures with loose femoral components and extensive bone loss treated with supportive femoral strut allografts.

Patients and methods

A consecutive series of 19 patients with B3 periprosthetic fractures underwent fixation with fresh-frozen extensive femoral strut

Fig. 1a–c Periprosthetic fracture (Vancouver type B3) following cemented revision. **a** Fracture with eggshell-like bone stock and loosening of the stem cement composite. **b** Postoperative result: large anteromedial and anterolateral strut allografts provide fixation of the cementless revision stem by tightening the proximal and more distal remnants of the host bone against the prosthesis. **c** Bony bridging of the strut grafts 2.9 years after surgery, which show cancellisation. No deformity or shortening of the femur. The stem appears ingrown

allografts from January 1992 to April 1999. The patients' mean age at the time of fracture was 67.4 (43–87) years. There were 14 women and five men. The preceding procedure had been a cemented stem in 16 patients and a cementless stem in three patients. Femoral component revision had already been performed in 11 cases before the index operation. Seven stems were standard length, and 12 stems were long revision components. All fractures

Table 2 Paprosky classification of periprosthetic bone loss

Type	Definition
I	Minimal
II	Metaphyseal
III	Metaphyseal + diaphyseal
IIIA	>4 cm of diaphysis available for fixation
IIIB	<4 cm of diaphysis available for fixation
IV	Complete diaphyseal, thin cortices and widened canal

were associated with minor trauma and were categorised as type B3 (Table 1) with stem loosening and severe bone loss. Bone damage was classified according to Paprosky [2] (Table 2). There were two category IIIA, 14 category IIIB and three category IV. All patients had severe local and general osteoporosis.

The fresh-frozen femoral strut allografts had varying distal and proximal metaphyseal parts. They were selected to fit the host bone according to preoperative radiographs. During surgery, all patients were placed in the supine position and an anterolateral approach to the hip joint with lateral extension for fixation of the strut allografts was performed. In seven patients one, in 11 patients two and in one patient three struts were fixed with 1.5 mm cerclage wires. A minimum of three wires were applied distally to the fracture. Supplementary plate fixation was not used. The number of strut allografts was affected by the width of defects at the fracture sites, the thickness of the opposing cortex, the length of stem fixation distally to the fracture and the diameter of the native femur. All revision stems bypassed the fracture, but tight stem fixation could not be achieved with the trial prosthesis alone. The length of the strut allograft was therefore chosen to bridge the fracture for at least 10 cm proximally and distally [5]. During removal of the loose implant, fracture reduction was achieved by manual traction, cerclage wires and strut allografts preliminarily fixed to the host bone. To avoid obliteration of the femoral canal and in order to gain final stability, tightening of the cerclage wires was accomplished during stepwise insertion of the femoral stem.

In 16 operations, a long intramedullary locking stem with extensive porous coating was used (Solution, Johnson & Johnson/DePuy, Warsaw, IL, USA). In three patients with a diameter of the femoral canal exceeding 20 mm (Paprosky IV), a long cemented Exeter revision stem (Stryker, Howmedica Osteonics, Allendale, NJ, USA) was used with impaction grafting, as recommended by Aribindi et al. [2]. In 13 patients, additional autogenous and allogeneic cancellous bone grafts were placed along the allograft-host junction [8].

Postoperatively, 18 patients started standing with partial weight bearing between 1 day and 2 weeks after surgery. One patient with severe general disability was first mobilised after 8 weeks. No braces were used. Full weight bearing was allowed 3–7 months after surgery. Clinical and radiographic follow-up was performed 3 months postoperatively and then annually. For postoperative clinical evaluation, the Harris hip score [11] was used. The extensive bone grafts and prostheses stems made radiographic evaluation of fracture healing difficult. Healing was therefore assessed indirectly by looking at strut allograft stability and ingrowth according to Emerson et al. [7]. Implant subsidence was measured using constant reference points for each patient.

Results

All fractures finally healed without deformity and shortening. One patient had a fracture at the tip of the prosthesis stem with loosening of the strut grafts 4 weeks after the index operation. The well-fixed cemented stem was left in situ and the fracture stabilised using two additional femoral strut grafts. Nineteen months later, the

Fig. 2a–c Strut allograft incorporation. **a** Immediately after surgery, the border between onlay strut and host femur is clearly visible. **b** Two years after surgery, the strut shows round-off with extensive bridging and minor cancellisation. **c** The strut is entirely integrated with cancellisation and longitudinal trabeculae 7.5 years after surgery. No graft resorption

fracture was completely healed, and the strut grafts showed adequate ingrowth.

Further complications included one incomplete sciatic nerve palsy with total recovery after 1 year, one urinary tract infection and one deep-venous thrombosis.

At a mean follow-up of 3.7 (2.0–7.5) years, the mean Harris hip score for all patients was 76.4 (57.5–92.0). Two were graded as excellent, four as good, 12 as fair and one as poor. In the patients with fair and poor results, the reduction of the total score was mainly due to a low activity score caused by concomitant diseases. Neither functionally relevant ossifications nor painful local irritations occurred at the grafts.

Adequate radiographic incorporation of the grafts was seen in all patients according to the categories of Emerson et al. [7]. Partial bridging – greater than 50% of the contact area – was visible in six patients at a mean follow-up of 2.3 (2.0–3.6) years. At a mean follow-up of 2.7 (2.2–4.3) years, five patients had an extensive bony bridging between graft and host. Compared to the immediate postoperative radiographs, the graft could, however, still be clearly identified (Fig. 1). In eight patients, the strut grafts showed complete bony union with graft remodelling at a mean follow-up of 6.3 (2.1–7.5) years (Fig. 2).

Discussion

In the treatment of periprosthetic femoral B3 fractures, additional fixation is frequently necessary. A large variety of treatment options has been proposed: standard plates, plates with unicortical screws [20], clamp-on plates [15] and metal or elevated nylon plate and cable

systems [15]. Partial or total resection of the femur and treatment with proximal femoral allografts or use of megaprotheses have been reported. However, systematic restoration of the periprosthetic bone stock is the key to a durable success [10].

Although femoral reconstruction with strut allografts is costly and carries a potential risk of disease transmission, it appears to be a reliable option, especially for B3 fractures. In recent reports on periprosthetic fracture management [4, 6, 9, 14, 16, 19], femoral strut allografts are especially recommended for B3 fractures with bone loss, but only sporadic clinical results have been reported. Pak et al. [18] published 95 revisions with 14 periprosthetic femoral fractures necessitating femoral strut allografts. The specific results of strut graft treatment have, however, not been presented. Incavo et al [14] reported on seven periprosthetic fractures, which all healed following treatment with cementless long revision stems and strut allografts. One implant loosening occurred after 12 months. The component re-exchange was facilitated, because the bone stock had been restored by the strut grafts.

In the current series of 19 B3 periprosthetic fractures with loose femoral stems and severe bone defects, all fractures eventually healed and all struts both clinically and radiographically reinforced host bone stability. Comparable successful clinical results have been reported on augmentative strut allografts after tight proximal or diaphyseal fixation of the stem in revision surgery without fracture, or in periprosthetic fractures without loosening of the femoral stems [7, 12, 13, 18].

For severe diaphyseal bone defects, supportive strut grafts led to restoration of bone stock in all 19 stem revisions with a mean follow-up of 4.7 years [3]. Additionally, finite element analysis, biomechanical cyclic loading tests and animal studies have shown the usefulness of strut allograft reconstruction in periprosthetic fractures [7, 17, 18]. However, if it is impossible to bridge the periprosthetic fracture adequately by the prosthesis stem, a combination of lateral blade plates and medial strut allografts has been proposed [5].

In this series of complex periprosthetic fractures with shattering and deficient bone stock, strut grafts in combination with stem revision proved a reliable method for fracture healing and bone restoration.

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