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Vancouver Type B3 Periprosthetic Fractures: Evaluation and Treatment

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Abstract

Periprosthetic fracture with preexisting severe loss of bone stock is a challenging condition to treat. Available surgical options can be divided into three categories: complex reconstruction of the deficient proximal femur with secure distal fixation; segmental substitution of the proximal femur with a megaprosthesis or allograft/stem composite; and distally fixed replacement with a modular stem, which acts as a scaffold around which the remaining deficient proximal bone can be assembled, to unite and possibly reconstitute.

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Total hip arthroplasty (THA) is an extremely successful procedure, providing excellent pain relief while improving patient function. Complication rates are low but still represent a significant clinical and financial burden to the health care system. Periprosthetic fractures are now the third most common reason for revision THA, after osteolysis (with or without loosening) and recurrent dislocation. The reported prevalence ranges from 0.1% to 2.1%.[1-7] The increasing prevalence of periprosthetic fractures is related to several factors, including an increasing number of patients undergoing THA, an increasing number of elderly patients at risk for falls, and increasing numbers of revision procedures using techniques with distal fixation, resulting in significant stress transfer to the distal tip of the reconstruction and proximal stress shielding.[2,8-10]

The Vancouver classification of postoperative periprosthetic fractures consolidates the three most important factors: location of the fracture, fixation of the femoral stem, and the quality of the surrounding bone stock.[11-13] Type B periprosthetic fractures are those fractures around or just below the femoral stem. These fractures are subdivided depending on the stability of the femoral implant and remaining bone stock: type B1 fractures have a solidly fixed implant; type B2 fractures have a loose implant, but remaining bone stock is good; and type B3 fractures have a loose implant with severe bone stock loss (osteopenia, osteolysis, or comminution; Figure 1). The treatment of type B1 and type B2 fractures is relatively straightforward. Treatment of type B1 fractures is with retention of the component and open or indirect reduction and internal fixation of the fracture. Treatment of type B2 fractures is with component removal and reduction and fixation of the fracture, followed by revision of the femoral component. In contrast, the treatment of type B3 fractures is more complex and depends on various factors, including the age of the patient, the quality of the remaining distal host bone, and the experience and preference of the surgeon.

The surgical management of type B3 periprosthetic fractures can be divided into three broad generic groups, with some overlap: complex reconstruction of the deficient proximal femur with secure distal fixation, using either impaction allografting or strut allografts; segmental substitution of the proximal femur with a megaprosthesis or an allograft/prosthetic composite; and an extensively fixed, modular, fluted, tapered titanium implant replacement, acting as a scaffold around which the remaining proximal bone may be reassembled, with the intention that it will unite and to some extent reconstitute.

Surgical Management of Type B3 Periprosthetic Fractures

Regardless of the specific technique used in the management of a type B3

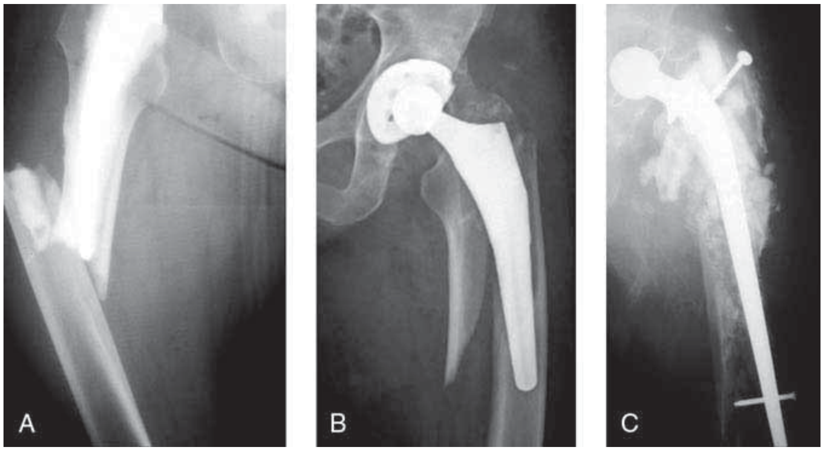

Figure 1 **A,** Vancouver type B1 periprosthetic fracture. **B,** Type B2 periprosthetic fracture. **C,** Type B3 periprosthetic fracture.

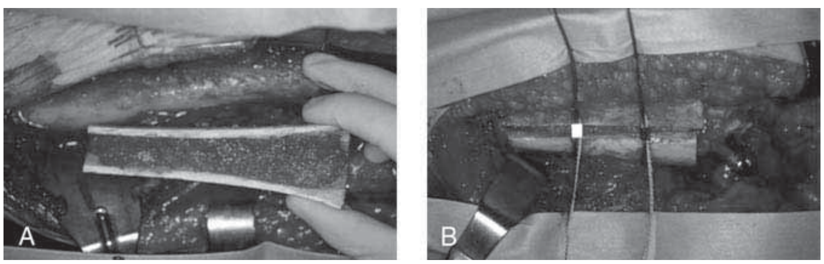

Figure 2 **A** and **B,** Preparation and fixation of strut allograft.

periprosthetic fracture, the surgeon should be familiar with various extensile approaches to the hip and femur. After removal of the loose implant, the fracture is identified and often can be separated to enhance canal débridement and facilitate femoral reaming. Intraoperative tissue cultures should be obtained and intraoperative prophylactic antibiotics administered. Intraoperative radiographs can be an important adjunct for confirmation of construct integrity before wound closure.

Complex Reconstruction of the Deficient Proximal Femur With Secure Distal Fixation

Strut Allografting With Distally Fixed Stem

Following removal of the prosthesis and cement, the intact distal femur is prepared for a cementless prosthesis. The proximal deficient bone is reduced around the prosthesis and augmented with onlay strut allografts. The use of a whole segmental femoral allograft allows for optimal preparation of the strut graft, if available. The medullary cavity of the allograft femur can be reamed before it is bivalved, to allow good apposition against the host femur. The grafts, 15 cm in length, are secured laterally and anteriorly with at least four multifilament cables and morcellized allograft is spread along the concavity of the strut[14] (Figure 2).

There has been some interest in the reconstruction of femoral defects with cortical strut grafts in the revision setting for aseptic loosening.[15] There are no published reports evaluating their use in the treatment of periprosthetic fractures alone. Emerson and associates[16] have demonstrated that cortical struts unite consistently by 8 months, with a union rate of 96%.

Circumferential Mesh With Impaction Allografting

Following removal of the prosthesis and cement, the fracture is reduced and fixation is achieved or augmented with cerclage wires, cables, plates, or strut allografts. Segmental defects in the femur are reconstructed using wire mesh secured with cerclage wires. A large cement restrictor is inserted. The canal is then packed with allograft bone chips over a central guidewire. The distal canal is impacted until filled to the level of the distal tip of the femoral phantom impactor. The canal is then repeatedly filled and impacted with a femoral phantom impactor until a neomedullary canal is formed. The new canal is then filled with bone cement and pressurized. A polished, collarless, tapered stem is then inserted. Postoperatively, patients are restricted to toe-touch weight bearing for 3 months.[17]

Tsiridis and associates[17] reviewed 89 Vancouver type B2 and B3 fractures treated with impaction allografting and cemented stem fixation. Seventy-four (83%) of the fractures united, with improved results for patients treated with a long stem prosthesis that bypassed the fracture (66 of 75 fractures [88%]).

Resection of the Proximal Femur With Simple Substitution

Allograft Prosthetic Composite

To ensure adequate fixation of the host greater trochanter to the allograft femur, an extended trochanteric osteotomy or trochanteric slide is favored instead of a classic tro-

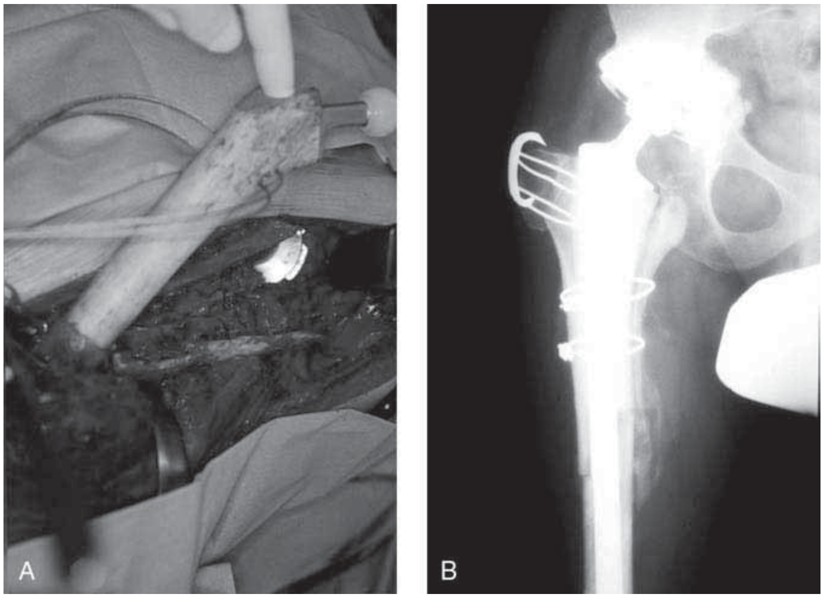

Figure 3 **A,** Insertion of an allograft prosthetic composite. **B,** Postoperative radiograph of the allograft prosthetic composite technique.

Figure 4 Postoperative radiograph of the proximal femoral replacement technique.

chanteric osteotomy. Subsequently, the prosthesis and cement are removed, and a step-cut osteotomy of the host femur at the proximal end of the distal fragment is made. A step-cut is used to maximize stability at the graft-host junction. The structural allograft and femoral stem are selected based on preoperative radiographic templating. The femoral component must bypass the allograft-host bone junction by at least four cortical diameters. The structural allograft should be large enough to ensure a 2-mm cement mantle after the appropriate reaming and broaching. The femoral component is cemented into the allograft on the back table. Once the cement has hardened, the allograft-prosthesis composite is secured to the distal fragment via the step-cut osteotomy. The allograft-host bone junction is secured with Luque wires to ensure rotational stability. If the allograft-host bone junction cannot be adequately secured, a cortical onlay allograft may be used. The remaining osteotomized proximal host bone and autograft reaming from the canal preparation are used to augment the allograft-host bone junction. The host-extended greater trochanteric fragment and remaining host bone are attached to the allograft (Figure 3). Postoperatively, patients are not allowed to bear weight until there is radiographic evidence of allograft-host union, typically after 3 to 6 months.[18]

Maury and associates[19] reported good results in 25 patients with type B3 fractures treated with proximal femoral allograft followed for a minimum of 2 years. Twenty-three of 24 patients were able to walk, and allograft united with host bone in 20 patients. Subsequent union occurred in the four patients requiring repeat allografts. Wong and Gross[20] described using a proximal structural allograft in 15 patients with periprosthetic fracture accompanied by severe host bone loss. Good results were reported in 13 of 15 patients reviewed.

Proximal Femoral Replacement

After removal of the prosthesis and cement, a transverse osteotomy is made at the distal end of the proximal deficient femoral bone for seating of the implant. The distal femur is then prepared in the standard fashion for a proximal femoral replacement prosthesis. When possible, the remaining host bone is attached to the prosthesis with cerclage fixation. Intraoperative hip instability with adequately positioned components is addressed with constrained liners (Figure 4). It is important that the abductors are securely sutured to the implant. The abductors, if still available, promote healing of a soft-tissue envelope to optimize function and stability.

Malkani and associates[21] reported a 64% survivorship at 12 years for 50 patients undergoing proximal

Figure 5 Postoperative radiograph of the scaffold technique with standard unipolar articulation.

femoral replacement for nonneoplastic disorders. Parvizi and associates[22] reported on 43 patients undergoing proximal femoral replacement for nonneoplastic disorders (20 periprosthetic fractures). They found good to excellent results in 22 of 43 patients at a mean follow-up of 36.5 months.

Distally Fixed Replacement That Acts as a Scaffold for the Remaining Proximal Host Bone

Following removal of the prosthesis and cement, a transverse osteotomy is made at the distal end of the deficient femoral bone. The osteotomized proximal portion is split longitudinally, maintaining soft-tissue attachment to the bone fragments. The intact distal femur is then prepared for a cementless modular femoral component, ideally of a tapered and fluted design. The modular body of the stem system is selected next, as well as its length, version, and offset, to achieve satisfactory soft-tissue tension and limb length. Modular body selection is accomplished independent of the native proximal femur that is retracted, with its soft tissues still attached, during this step in the reconstruction.

The remaining fragments of the deficient proximal femur are then wrapped around the proximal part of the stem and secured in place with cerclage fixation, with particular attention paid to the greater trochanter. Joint stability is achieved with attention to soft-tissue tension, leg length, and offset, augmented with large-head components, enhanced offset liners, or a constrained articulation when necessary (Figure 5). Postoperatively, patients are usually managed with limited weight bearing for 12 weeks or until there is clinical and radiographic evidence of union.[23]

Klein and associates[23] reported on a series of 21 patients with type B3 fractures treated with this distally secured, proximal scaffold technique. Twenty of 21 patients were able to ambulate and had minimal to no pain. Berry[24] successfully treated eight patients using a modular, fluted, tapered cementless stem with retention of the proximal femur. At a mean follow-up of 1.5 years, all patients had stable implants, and all acute fractures were healed.

Summary

Periprosthetic femoral fractures with associated severe bone loss remains a difficult treatment challenge. A failure rate of approximately 25% is reported throughout the literature for the various options. The newly introduced scaffold technique has had early promising results (95% success), but additional long-term data are required. The treatment protocol for Vancouver type B3 periprosthetic fractures has evolved over the years. The distally fixed, proximally reassembled scaffold technique is preferable because it is a rapid procedure with reduced blood loss, high versatility, and facilitation of early mobilization.

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