Management of Vancouver B2 and B3 femoral periprosthetic fractures using a modular cementless stem without allografting

Daniel Neumann · Christoph Thaler · Ulrich Dorn

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Abstract

Purpose We reviewed our experience with the management of B2 and B3 femoral periprosthetic fractures using a distally fixed modular femoral stem in 55 patients.

Methods All periprosthetic fractures were managed immediately after injury without using allograft; 53 hips were available for a mean follow up of 67 months.

Results All fractures united, and the mean Harris hip score at the last follow up was 72. Subsidence was noted in two patients (4%) within six months postoperatively and required revision surgery. One patient developed peroneal nerve palsy. Two hips dislocated and were managed by closed reduction.

Conclusion In these severe cases of periprosthetic fracture, the technique reviewed here proved to be reliable.

Introduction

The incidence of postoperative periprosthetic fractures of the femur has been estimated to be between 1.5% and 4% [1, 2]. They are a major complication of hip arthroplasty that pose a big challenge to reconstructive orthopaedic surgeons. Both nonsurgical and surgical management options have been described in the literature [1–11]. These fractures must be treated according to their individual characteristics, implant status, associated medical conditions, and each patient's level of physical activity [1, 2, 12]. Several classifications have been used in the literature

[1, 2, 4, 5, 12–14]. For us, the Vancouver classification [2] is the most useful for predicting the required management, incorporating fracture site, implant stability and surrounding bone-stock quality. Type A fractures involve either the greater (AG) or lesser (AL) trochanter. Type B fractures occur around the stem or just distal to it. Type C fractures occur distal to the tip of the stem. Type B1 fractures are associated with a solidly fixed stem and type B2 fractures with a loose stem. If the stem is loose and there is severe bone loss, the fracture is classified as type B3. Treatment strategies depend on the nature of a fracture, implant stability, bone-stock quality, patient age and the surgeon's experience.

Although there are many reports dealing with the treatment of types B2 and B3 fractures, the numbers of cases in the different series are small and there is no agreement concerning the optimal therapeutic approach. We therefore reviewed the results of our management of B2 and B3 fractures using a distally fixed modular femoral stem without distal transverse screw fixation or allografting. We wanted to determine the percentage of united fractures, the stability of the implants and whether there was a difference in outcome between the two fracture types. Furthermore, the incidence of subsidence, revision rate and value of this method in comparison with studies dealing with other straight cementless revision stems was of interest.

Materials and methods

Since 1998, we have used a cementless modular tapered revision femoral component (Modular Plus System, Smith

D. Neumann (✉) · C. Thaler · U. Dorn
PMU Salzburg, Orthopedic University Clinic,
Salzburg, Austria
e-mail: dr.daniel.neumann@gmail.com

and Nephew, UK) in Vancouver types B2 and B3 periprosthetic fractures. This system obtains axial and rotational stability in the area of the femoral isthmus by bypassing the areas of insufficient bone. The base module is curved, tapered and has a rectangular cross-section combined with double contoured edges. For each implanted base module chosen, three proximal modules of increasing length are available. Those modules offer the possibility of antetorsion adjustment; the CCD angle is standardised (126°). (Fig. 1a and b)

We reviewed 55 consecutive patients (55 hips; 27 men and 28 women) with an average age of 74 (range 45–84) years. The average follow-up period was 67 (range 60–144) months. Thirty-five fractures were classified as Vancouver type B2 and 20 as type B3 periprosthetic fractures. The average interval between the procedure and the index operation was 9.7 (range three to 15) years. The index operation involved a variety of prostheses, of which six were cemented and 49 were uncemented. Four patients had had more than one previous implant. Before surgery, templated radiographs of the femur were obtained.

Surgical technique

All these periprosthetic fractures were managed immediately after the injury occurred, without using allograft. The operation was performed with the patient placed in the supine position. A direct lateral transgluteal approach to the proximal femur was used. All procedures were performed by the first or senior author. When cement removal was difficult, we extended the fracture line with an osteotomy (four hips). Fracture-site reposition was achieved using two or three bone clamps without using additional screws. Then

Fig. 1 a, b Modular Plus system disassembled (a) and assembled (b). The distal part (base module) is curved to reflect the anterior curvature of the femur and is available in 12 sizes of increasing length and width. In addition to these 12 base modules, there is a short and a long version, for a total of 24 base modules. The proximal part (module) comes in three sizes of increasing length for every base module chosen. Note that there is no interlocking screw system available

the most distal part of the fracture was identified and secured with titanium cerclage bands introduced by Gundolf [15, 16] (CCG System, PlusOrthopedics, Austria) and/or wires. Titanium bands were also applied more distally to prevent fracture propagation during reaming or stem impaction. Proximal fracture fragments were fixed by the application of titanium cerclage bands. After these repositioning manoeuvres, the distal shaft of the femur was reamed using standard intramedullary reamers, then implant-specific intramedullary reaming was begun by hand using flexible spiral reamers under fluoroscopic control. When solid cortical contact was noted and confirmed by intraoperative X-ray in two planes, the corresponding trial base module was introduced into the femoral canal and impacted thoroughly at least twice. The base module length was chosen to allow a minimum of four centimetres to be inserted into undamaged bone. Acetabular component stability was checked, and if there was any instability of the locking mechanism or if liner wear was noted in a stable metal shell, the pre-existing liner was revised at this stage. Unstable acetabular components were detected in 17 cases and treated by exchange to a hemispherical press-fit cup (Trilogy cup, Zimmer, Warsaw, IN, USA). The trial proximal component was mounted on the trial distal component of the modular stem, and the hip was reduced. After obtaining a stable hip reduction with the trial components, the original base module was impacted. In seven cases, the original base module could not be placed as deep as the trial component; therefore, the proximal trial component was re-mounted on the original base module and the trial reduction repeated. In all of these cases, the next smaller proximal module was used. In all cases, both original components were put together in situ. Component sizes used were as follows: distal module in 45 patients in group B (size 6, 28 cases; size 7, ten cases; size 8, seven cases), distal module in ten patients in group C (size 9, nine cases; size 10, one case). In 45 patients, the medium-sized proximal module was used; the remaining ten hips were treated using large module in seven cases and a small module in three cases. In all cases, a ceramic head was implanted. The neck length chosen was medium in 46 cases and long in the remaining nine. Surgical procedures took from 110 min (range 90–140) when a femoral stem was exchanged to 151 min (range 110–180 min) when both femoral and acetabular components were exchanged.

Aftertreatment

Patients were mobilised three days after operation depending on overall physical condition. Weight bearing was limited for the first six weeks for all patients, and full weight bearing was usually achieved at three months. Patients were followed up at six weeks, three months, six months and annually.

Clinical and radiological follow up

According to Park et al. [17], fracture union was defined clinically as the ability to bear weight fully with or without aids and evidence of callus bridging fracture on both anteroposterior and lateral radiographs. Radiological callus appearance determined progression to full weight bearing. Clinical evaluations were performed using the Harris hip score (HHS) [18]. Radiological evaluations were conducted using long-film radiographs of the femur. Union was defined as bony bridging across an osteotomy site or no migration of the fracture fragment on serial radiographs [17]. Stem subsidence was measured from the tip of the implant to the applied distal security cerclage (Figs. 2a–e). Definite loosening was defined as subsidence >5 mm or continuous demarcation around the stem.

Results

Two patients died in the immediate postoperative period from cardiovascular complications, leaving 53 patients (53 hips) for postoperative evaluation. The mean HHS postoperatively at the most recent follow-up was 72 (range 45–97). Sixty percent (32 patients) were completely pain free. A further 40% (21 patients) had only slight to mild pain. Fifty percent (27 patients) had a moderate limp and 14% (seven patients) a severe limp. Complete fracture union occurred in all 53 patients three to six months after surgery. Subsidence greater than 5 mm was observed in two patients and occurred within the first two to six months

postoperatively. Both stems were revised for pain and subluxation. Both femurs showed fracture union, and the stem was changed to a larger model (Figs. 2a–e).

There were no intraoperative fractures. During the study two dislocations occurred, both were managed by closed reduction and bracing without further instability. The dislocations occurred within the early postoperative period (two to six weeks postoperatively). One hip was diagnosed as late infection three years postoperatively by joint aspiration and is under permanent antibiotic suppression. The fracture united, the stem was stable at the last follow up (84 months postoperatively), the patient was pain free and able to walk without walking aids. His HSS was 95 at the last follow-up. One patient developed sciatic nerve paresis and showed weakness of the foot in dorsiflexion at the last follow-up.

Discussion

To our knowledge, this paper presents one of the largest single-centre series of Vancouver types B2 and S3 fractures. We followed the guidelines of Lindahl et al. [19] for these types of fractures according to the experiences gained from the Swedish arthroplasty register. The strengths of this study are the consecutive series of hips revised using the same distal taper rectangular cross-section design in all cases, the same approach, uniform reaming and implantation techniques, the same osteosynthesis techniques without using distal interlocking screws, assessment of primary stem stability and no bone grafting (Fig. 3). The goals of

Fig. 2 **a** Anteroposterior X-ray of the right hip in a 72-year-old man after a skiing accident depicting a Vancouver B2 situation with a loosened stem due to the comminuted fracture pattern and presenting with good bone quality. **b** X-ray 3 months after revision. **c** Anteroposterior X-ray of the same patient 6 months after revision depicting subsidence in relation to the greater trochanter and the applied cerclages. At the fracture site, callus formation is clearly

visible. **d**, **e** detailed anteroposterior X-ray illustrating the distance (arrow) between the distal tip of the stem and the security cerclage 3 months after revision without subsidence (**d**). In comparison, anteroposterior X-ray (**e**) 6 months postoperatively depicting subsidence of more than 1 cm measuring the distal tip of the prosthesis in relation to the distal security cerclage (arrow)

Fig. 3 **a** Preoperative X-ray of the left hip in a male patient 55 years old suffering from a Vancouver B2 fracture. Due to the fracture pattern, the stem is loose; bone quality seems good in the more distal areas of the stem, but in the proximal areas, bone resorption due to polyethylene granuloma is evident. **b, c** X-rays obtained 120 months postoperatively of the same patient showing the Modular Plus stem in situ together with multiple titanium band cerclages. No bone resorption can be detected, especially in the mid part of the stem; the distal module has an excellent contact to the diaphyseal bone. In the proximal part of the stem, a certain amount of bone resorption is visible, probably the result of the pre-existing bone resorption and fracture pattern. The most proximally placed titanium cerclages are obviously loose

treatment of postoperative femoral periprosthetic fractures include a united fracture in near-anatomical alignment, a stable prosthesis, early mobilisation and return to prefracture function [1, 20]. Several case series have been reported in the literature, and there is little agreement on the optimum management of these fractures [20]. In the literature, most studies on this topic involve small series, are retrospective and recommend a variety of treatment methods. Mont and Maar [10] recognised the difficulty in establishing clinical guidelines from reports with small numbers of patients. Those authors did a literature survey on periprosthetic fractures and described 487 patients with periprosthetic fractures in 26 publications. Their conclusion was that patients with proximal trochanteric fractures did well with nonoperative treatment. For midstem and distal-stem fractures, cerclage cables and bone graft or revision to a longer stem were superior to screw-plate fixation or traction. Fractures below the stem tip responded well to long-stem revision or traction, with worse results from internal fixation with plates and screws and a trend toward inferior results with cerclage fixation. Comminuted fractures seemed to do better with long-stem revision; however, statistical significance was not attained in comparison with the other methods of treatment.

Lindahl et al. [19] suggest that the Vancouver type B1 fracture is the only type that can be successfully operated upon without a stem revision—i.e., can be treated with an

adequate open reduction and internal fixation. According to data obtained from the Swedish Arthroplasty Register the authors found a high frequency of repeat surgery after treatment of Vancouver type B1, B2 and C fractures with open reduction and internal fixation alone. They reported that the failure rate is probably due to an underdiagnosis of loose implants, resulting in inadequate treatment. There was no notable difference in reoperation rates between patients treated with a cemented stem and those treated with an uncemented stem in that study. However, when used to treat types B2 and B3 fractures, uncemented stems were associated with a lower reoperation rate. The authors concluded that classifying a periprosthetic femoral fracture in the Vancouver B category is difficult and inconsistent. Surgical exploration of the joint is therefore recommended for all patients with a Vancouver B fracture pattern assessed radiographically. If there is doubt regarding the fixation status of the stem, revision of the femoral implant and open reduction and internal fixation of the fracture are recommended. In our series, every stem was assessed for stability, and all were loose, which necessitated exchanging the stem for a longer version.

Zhao et al. [21] reviewed data to determine outcomes for 21 consecutive Vancouver types B1 or C periprosthetic fractures using a nickel–titanium shape-memory sawtooth-arm embracing fixator. The average duration of follow-up was 39.7 months. Bone union was achieved in all 20 cases and available for follow-up within an average of 5.25 months. No implant failures or malunions occurred. Fink et al. [22] reported nine successfully treated Vancouver types B2 and B3 fractures with the distal fixed modular cementless revision stem with a Revitan curve (Zimmer, Winterthur, Switzerland). In cases where the femoral isthmus was disturbed by the fracture or fixation length was less than three centimetres, additional interlocking screws were used for fixation. In this way, there was no sinking over five millimetres or stem loosening in a follow-up of at least two years. Mulay et al. [1] reported an average radiological subsidence of 5 mm (range 2–10 mm) in 17 of 22 patients with Vancouver types B2 or B3 fracture when using the Link MP modular stem (Waldemar Link GmbH, Hamburg, Germany). In 15 of the 17 patients, subsidence occurred within the first four to six months of the operation, with no further subsidence. Springer et al. [23] reported on seven B1 fractures, 76 B2 fractures and 35 B3 fractures. The femoral implant used at the time of the index procedure was a cemented stem in 42 hips, an extensively porous-coated uncemented stem in 30, a proximal porous-coated uncemented stem in 28, an allograft–prosthesis composite in 14 and a tumour prosthesis in four. At the time of the most recent follow-up, 22 femoral components had been re-revised (16 hips) or resected (six hips). Ten re-revisions were performed for

loosening of the femoral component: three for femoral loosening in association with a fracture nonunion; two, for recurrent dislocation; one for a second, separate periprosthetic femoral fracture. Five of the six resection arthroplasties were performed for a deep infection. The greatest long-term problems were prosthetic loosening and fracture nonunion. Better results were seen when an uncemented, extensively porous-coated stem was used. Berry [24] reported on eight patients with Vancouver type B3 fractures treated by revision using a long modular fluted tapered uncemented stem (Link MP, Waldemar Link, Germany) with retention of the proximal femur. There were no cases of stem subsidence, and no patients had radiographic evidence of implant loosening. No stems were revised for any reason. Kolstad [25] reported on 23 consecutive proximal femoral fractures in 22 patients treated with long revision stems. At the time of fracture, 21 stems were loose. An uncemented Wagner revision stem was used in nine cases, and different conventional revision stems in the others. All fractures healed, but seven of the conventional revision implants rapidly loosened, whereas so far, none of the Wagner stems have loosened. Ko et al. [26] reviewed the results of treatment with Wagner revision stems in geriatric patients with 14 Vancouver type B2 periprosthetic fractures. Twelve patients were available for assessment; all 12 reconstructions showed a stable prosthesis and solid fracture union. Two stems showed five millimetres of stem subsidence. Furthermore, the authors stated that in the literature, 20–25% of Wagner revision stems show over ten millimetres of subsidence. Park et al. [17] evaluated 27 types B2 and B3 fractures managed with a distally fixed and fluted modular femoral stem (MP Waldemar Link, Hamburg, Germany; Reconstructive modular stem, Lima-Lto, Udine, Italy). Subsidence was noted in two patients within six months postoperatively, but despite the subsidence, one achieved union. Two hips were defined as failures: one nonunion was associated with infection, and the other had another ten mm subsidence. Mertl et al. [27] retrospectively reviewed 725 revisions using interlocking stems from 14 French orthopaedic departments. Indications were 482 aseptic loosening, 150 periprosthetic fractures and 93 septic loosening. The majority of periprosthetic fractures (70%) were Vancouver B2 or B3 fractures. Seven different distal locked stems were used: 205 straight modular stems with partial hydroxyapatite (HAP) coating, 405 curved modular stems with partial HAP coating and 115 curved modular stems with total HAP coating. Average follow-up was 4.5 years. Radiologically, 637 implants were stable, and 40 demonstrated subsidence. overall 48 implants were revised. In cases of periprosthetic fractures, union was obtained in 95% of cases, but thigh pain was present in 20% of patients. Those authors stated that the advantages of the locking stem in periprosthetic fractures are the high rate

of healing, with immediate weight bearing and no detectable stem subsidence of the stem.

The use of a long cemented stem across the fracture is unlikely to be successful if femoral fragments are kept apart either by the implant or by acrylic cement, and this is associated with a high risk of nonunion and implant failure [28, 29]. We prefer cementless and distally fixed modular stems for revision surgery in B2/B3 situations because the surgical technique required is simple and the technique provides initial stable diaphyseal fixation and control of version change. Furthermore, these stems may provide reliable osteointegration in cases with a damaged proximal metaphysis [17, 30, 31]. Sporer and Paprosky [31] reported excellent early success using distally fixed modular femoral-stem designs in patients with severe femoral deficiency (types IIIB and IV). their studies show the potential benefits of managing Vancouver B3 fractures with distal tapered modular femoral stems.

In our study, most patients had a satisfactory functional outcome, and complete radiological fracture union occurred in all available hips within three months of revision. Stem subsidence was observed in two hips during the early postoperative period and had to be revised. Clinical failure occurred in another hip because of late infection without stem subsidence or nonunion.

Managing type B2/B3 fractures using a distally fixed modular femoral stem offers the advantage of providing early mobilisation and rehabilitation after injury. The technique described proved to be reliable for treating difficult periprosthetic fractures; as the two cases of subsidence occurred within the first six months, subsidence should not be a problem in the long-term follow-up. However, loose titanium cerclage, especially in the proximal part of the femur, with or without contact to the stem may cause a problem of titanium wear in the long run.

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