The use of uncemented extensively porous-coated femoral components in the management of Vancouver B2 and B3 periprosthetic femoral fractures

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We assessed the outcome of patients with Vancouver type B2 and B3 periprosthetic fractures treated with femoral revision using an uncemented extensively porous-coated implant. A retrospective clinical and radiographic assessment of 22 patients with a mean follow-up of 33.7 months was performed. The mean time from the index procedure to fracture was 10.8 years. There were 17 patients with a satisfactory result. Complications in four patients included subsidence in two, deep sepsis in one, and delayed union in one. Concomitant acetabular revision was required in 19 patients. Uncemented extensively porous-coated femoral stems incorporate distally allowing stable fixation. We found good early survival rates and a low incidence of nonunion using this implant.

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Intra- and post-operative fractures around hip prostheses are growing in number and complexity.¹ The ageing population, with osteoporosis, periprosthetic osteolysis and a greater susceptibility to minor trauma and falls, represent a high-risk group for fracture.²

National joint registries have identified periprosthetic fractures as the third most frequent reason for revision following primary total hip replacement, less common than aseptic loosening and sepsis and equivalent to dislocation;³ about 5% of revisions are for fracture.

According to the Mayo Clinic joint registry, the incidence of periprosthetic femoral fracture is approximately 1% after primary arthroplasty and 4% after revision surgery.⁴ The treatment depends on the site of fracture, the stability of the prosthesis, the bone stock, the patient's physiology and the surgeon's experience.⁵

The Vancouver classification of periprosthetic femoral fractures⁶ has proved to be reliable, valid and a useful guide to treatment. The site of the fracture, stability of the prosthesis and the quality of the bone stock determine the severity.⁷ B type fractures are those around the stem of the prosthesis and comprise three subtypes: in B1, the prosthesis is stable; in B2 fractures, there is a loose prosthesis but the bone stock is adequate (Fig. 1); in B3 fractures, the prosthesis is loose and there is marked proximal bone loss or damage to a degree that a standard revision component will not be supported (Fig. 2).

Porous-coated uncemented femoral stems have yielded excellent mid- to long-term results

Fig. 1

Radiograph showing a Vancouver B2 periprosthetic femoral fracture.

in revision hip arthroplasty for aseptic loosening.⁸⁻¹⁰ In the treatment of periprosthetic femoral fractures, these stems provide intramedullary fixation of the fracture fragments with

Fig. 2

Radiograph showing a Vancouver B3 periprosthetic femoral fracture.

Fig. 3

Radiograph showing uncemented femoral and acetabular revision with femoral cortical onlay strut allografts.

concurrent distal diaphyseal stability through contact. The fracture and any cortical deficiencies are bypassed. There is no issue with cement inhibition or interposition of fracture healing and there is the potential to achieve biological ingrowth and long-term stability.

The aim of this study was to examine femoral revision using an uncemented extensively porous-coated implant (Solution; Depuy, Leeds, UK) in the treatment of Vancouver type B2 and B3 periprosthetic fractures.

Patients and Methods

Between July 1999 and 2003, 22 patients, 13 men and nine women, underwent revision for a femoral fracture using an uncemented extensively porous-coated stem. The fracture was a Vancouver type B2 in ten cases and B3 in 12. The mean age of the patients was 75 years (59 to 100). The mean follow-up following fracture and revision was 33.7 months (18 to 55). The mean length of time from the index procedure to fracture was 11 years (4 to 20).

In 19 cases the index procedure was a primary cemented total hip replacement, the majority of which were Howse prostheses (12 cases).¹¹ There was one fracture following a cemented hemiarthroplasty and two after a revision procedure. Concomitant acetabular revision was required in 19 cases. In seven revision was performed using an uncemented acetabular component and in five cases a standard cemented acetabular component was used. Six patients with acetabular defects had impaction grafting with a

Fig. 4

Radiograph showing complex acetabular reconstruction with impaction grafting and anti-protrusion ring in addition to uncemented porous-coated femoral revision.

cemented revision and in one pelvic discontinuity was treated with reconstruction, grafting and a cemented component. All operations were performed by one of two surgeons (OHB, DM).

Operative procedure was via a posterior approach and the proximal femur was visualised and split to the level of the fracture in a coronal manner facilitating the removal of the implant and cement. The endosteal surface of the distal femur was prepared to provide a predictable interface for the extensively porous-coated implant. It is of critical importance to use a canal fitting prosthesis in order to achieve stable contact distal to the fracture. The fracture, or the most distal defect, is bypassed by a distance of at least two cortical diameters. A prophylactic cerclage wire was placed around the femur prior to insertion of the revision stem and following insertion the proximal femur was then wrapped over the implant.

Supplementary fixation was used where required consisting of cortical strut allografts (nine cases), cerclage wires (18 cases) and additional trochanteric fixation (3 cases) (Figs 3 and 4).¹²

In cases where acetabular revision was performed, components with an internal diameter of 28 or 32 mm were used to enhance stability. In some elderly patients snap fit acetabular prostheses were employed (3 cases).

A retrospective review of the notes and radiographs of all patients was performed. In addition, patients attended for clinical and radiographic assessment. The clinical assessment consisted of the Harris hip score,¹³ the UCLA activity score¹⁴ and the SF 36 score.¹⁵ In keeping with the views of previous investigators, we considered that a Harris hip score of greater than 80 indicated a satisfactory result and one less than that unsatisfactory.¹⁶ Plain radiographs were examined for evidence of loosening, infection, subsidence and nonunion.

The fractures were considered to have united when the patient could fully weight-bear with no pain, stressing the fracture site was painless and there was radiographic evidence of bridging callus. Osseointegration was determined using Engh, Massin and Suthers¹⁷ criteria where successful integration is indicated by increased density of bone adjacent to the porous coating, the absence of diverging radiolucent lines, the absence of prosthetic subsidence and the absence of a pedestal sign.

The outcome was graded as excellent, good or poor as classified by Beals and Tower.¹⁸ An excellent result is a stable arthroplasty with union of the fracture and minimal deformity or shortening. A good result is indicated by stable subsidence of the prosthesis or a fracture which has united with moderate deformity or shortening. If the prosthesis is loose with or without pain or if there is nonunion, sepsis, a new fracture, severe deformity or shortening the result is said to be poor.

Results

Of the 22 patients, 17 had a satisfactory outcome with a HHS > 80 (mean 82.7). The mean HHS in those with unsat-

isfactory results was 69. Of the five with an unsatisfactory outcome, one with a B3 fracture developed deep infection and required further surgery. This patient had prior infection at the time of fracture and was treated with a Solution stem as the second stage of a two-stage revision procedure. Salvage consisted of further proximal femoral replacement using a tumour endoprosthesis.

Two further patients developed radiographic evidence of subsidence which was stable in one patient with a B3 fracture and presented as painless shortening. The other who had a B2 fracture developed an unstable and painful subsidence. Although the outcome in the remaining two patients was unsatisfactory (HHS < 80), neither had any specific complication relating to their procedure. Both had B2 fractures. Multiple medical comorbidities with associated poor mobility and function accounted for the unsatisfactory outcome scores.

The mean UCLA activity score was 4.1 (1 to 7) which equates to a person regularly participating in mild activity. The mean total SF 36 score was 71.1 (19.1 to 94.8; SD 23.9). The mean Physical Component Score was 66.7 (15.7 to 91.8; SD 24.7). The mean Mental Component Score was 75.6 (22.5 to 97.8; SD 24.4).

Union of the fracture was successfully achieved in 20 of the 22 patients. Of those patients whose fractures failed to unite, one had residual infection and the other extensive proximal bone loss and although showing signs of callus formation had not yet fully united at the time of the most recent follow-up.

Using Engh et al's¹⁷ criteria, 18 femoral components were probably fixed by bone, two were classified as being stable and fibrous and two were unstable. Further criteria for radiographic stability were devised by Engh et al.¹⁹ Using these, there were 19 stable femoral components with no sign of subsidence, tilt or rotation. Two were unstable as manifested by of subsidence with or without divergent progressive lucent lines around the porous coating. The patient who underwent further revision for infection was excluded from this assessment.

The outcome was excellent in 18 cases, good in one and poor in three. These three included the patient with residual infection, one with nonunion and one with unstable subsidence of the prosthesis.

Although the sample size did not permit meaningful statistical analysis, there was no clear difference in outcome in this series between those with B2 and B3 fractures.

Discussion

In contrast to early post-operative periprosthetic femoral fractures, which are frequently related to stress risers and cortical perforations or windows, later fractures tend to occur around loose implants and are commonly associated with undiagnosed osteolytic defects. Bethea et al²⁰ found that 75% of periprosthetic femoral fractures are associated with aseptic loosening, as a result of mostly asymptomatic osteolysis. That the most common mechanism of injury is

minor trauma reinforces this assertion. Equally, up to 50% of patients report that insidious pain has been present for some time prior to fracture.²¹ Significant radiographic evidence of osteolysis around a femoral component may be seen as equivalent to impending fracture. In order to prevent such adverse events, there may be a case for longer and more frequent post-operative surveillance of patients with implants known to be prone to early failure.

Non-operative treatment is no longer acceptable in those deemed medically fit for surgery due to the problems associated with prolonged recumbence and the high incidence of mal- and nonunion.²² The best outcome is achieved when the surgeon has a thorough understanding of the principles of treatment of these fractures and access to appropriate fixation and prosthetic components in addition to allograft bone when necessary.⁷

Femoral revision using an uncemented, extensively porous-coated, long-stemmed component is a versatile treatment enabling distal as well as intramedullary fixation of these fractures.^{23,24} In addition to permitting union of the fracture, the ability to achieve biological ingrowth around the porous coating provides the potential for long-term prosthetic stability. Adequate distal fixation is essential and is secured by tight diaphyseal contact and bypassing of the fracture and cortical deficiencies. A biomechanical study of canine femora demonstrated that cortical penetration resulted in a reduction of femoral strength to 44% that of the contralateral side. Bypassing the most distal defect by a distance of two cortices increased the femoral strength to 84% of the contralateral side.²⁵ Therefore, while it is desirable to achieve a lengthy diaphyseal fit, a minimum interferential fit of two cortical diameters beyond the most distal deficiency is essential.

For Vancouver B2 fractures, the principal alternatives to using an extensively-coated stem are those of a cemented revision or revision with a proximally porous-coated uncemented implant.²⁶ Following a primary cemented femoral component the proximal femur may be a poor environment for re-cementing or proximal porous on-growth.²⁷ Thus, with proximally-coated stems, although fracture healing occurs in most cases, osseointegration and hence prosthetic stability may be less reliably achieved.

With cemented femoral revision, if anatomical reduction has not been achieved, cement will extrude and interpose at the fracture site inhibiting reduction and therefore fracture healing. Cemented femoral revision of B2 fractures has been reported to yield a 31% nonunion and a 15% re-fracture rate.²⁸ In addition 15% of patients are left with persistent bony defects. This technique is probably best reserved for elderly and infirm patients with poor bone stock.

The standard treatment for B3 fractures has been either proximal femoral replacement using a tumour prosthesis or an allograft prosthesis composite. The advantage of using a porous-coated implant lies in the retention of the proximal femur. In such injuries, it is important to avoid de-vascularising proximal femoral fragments thereby preserving their

osteogenic potential. Where poor proximal fixation has been achieved because of inadequate bone stock, it may be more prudent to use a bowed rather than straight stem to achieve greater rotational and torsional stability. In addition to restoring bone stock and addressing cortical deficiencies, the use of supplementary cortical strut allografts confer the benefit of greater rotational stability.²⁹ They exhibit less stress shielding and are biologically active when compared with other means of supplementary fixation.³⁰ Although there is a theoretical inadequacy of proximally porous-coated uncemented implants where there has been extensive proximal bone loss or bone stock is poor, Berry³¹ described eight patients with B3 fractures treated by femoral revision using an uncemented modular fluted tapered implant. Seven patients had one to two years follow-up and union had occurred in all cases. Reconstitution of proximal bone stock was an invariable finding.

Springer et al⁴ recorded the Mayo clinic experience with femoral revision for the treatment of periprosthetic femoral fractures. Extensively-coated implants fared better than partially-coated prostheses, which in turn fared better than cemented revision. Uncemented extensively porous-coated implants were associated with greater survival rates, stable fixation and the lowest incidence of nonunion. Other authors have reported their experience with uncemented revision for periprosthetic fracture. Macdonald et al²⁴ described 14 periprosthetic femoral fractures treated with an extensively-coated uncemented implant. According to the classification of Johansson et al³² they consisted of ten type 1 and four type 2 fractures. There was a mean follow-up of 8.2 years with no revisions and no reported nonunion. Moran²³ described the successful treatment of four cases of periprosthetic fracture, consisting of three type B2 and one B3, using a Solution femoral component.

More recently, Tsiridis et al³³ found favourable results following cemented revision in combination with impaction bone grafting for B2 and B3 fractures, with the net effect of restoring bone stock in the younger patient with deficiency.

Uncemented femoral revision is associated with specific complications namely lack of osseointegration, thigh pain, stress shielding and late osteolysis.³⁴ Subsidence has been reported in about 10% to 15% of patients, generally in those who have not achieved bony ingrowth.³⁵ Significant thigh pain occurs in approximately 10% of patients, the main risk factors being lack of osseointegration, osteoporosis, poor bone stock and failure to achieve filling of the canal with the prosthesis. Stress shielding, in contrast, is seen only in those who have achieved bony ingrowth with proximal loss of periprosthetic bone density, a sign of successful osseointegration. To date, investigators have not found stress shielding to be of clinical significance but greater long-term follow-up may change this.⁸

The three principal complications experienced using long-stem femoral revision for periprosthetic fractures are aseptic loosening, nonunion and deep infection. Tsiridis et

al²⁷ have reported a 12% to 20% cumulative incidence of these complications. In this series there were no second revisions for mechanical prosthetic failure. One patient had severe thigh pain and shortening associated with unstable subsidence of the prosthesis but intercurrent medical problems mitigated against revision. Although osseointegration of the implant is harder to achieve in the revision than the primary setting, most series report a much higher incidence of mechanical loosening than second revisions for mechanical failure. This supports the belief that fibrous ingrowth can provide a functional base for prosthetic stability.^{34,35} There was one case of recurrent sepsis in a patient with prior MRSA prosthetic infection. In spite of the fact that at the time of follow-up, the fracture had not yet united, there was serial radiological evidence of progressive callus information and we anticipate successful union in due course. Using the described methods of outcome, not all the poor results could be accounted for by failure of fixation or technique. Indeed two patients had poor functional scores despite being considered surgical successes. While it would have been desirable to have pre-operative health scores available for these patients, the fact that they all presented as emergencies did not permit the collection of such data. We acknowledge this as a shortcoming of this study.

The majority of patients in this series required concomitant acetabular revision. A variety of techniques were employed depending on the degree of osteolysis and bony defects encountered. One cannot, therefore, view these fractures as a problem in isolation and it is important to tailor treatment to each individual patient.

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