Aspects of current management

THE MANAGEMENT OF PERIPROSTHETIC FRACTURES AROUND THE FEMORAL STEM

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Total hip replacement is the second most common elective surgical procedure performed in the UK. It is estimated that by 2010 Europe will have more people over 60 years of age than under 20 years. The number of total hip replacements will therefore continue to rise in an ageing population, as will the frequency of occurrence of periprosthetic fractures. These injuries may occur during or after operation. The incidence of post-operative periprosthetic fractures has remained relatively constant, ranging from 0.6% after primary arthroplasty to 2.4% after revisions.1

This article deals only with post-operative fractures, and seeks to review the available surgical techniques and to develop a management algorithm.

Predisposing factors

Fractures may arise at the site of a stress-riser, particularly at the tip of the stem itself or at any regional cortical defect such as a screw hole or where perforation of the cortex has occurred. Osteolysis associated with aseptic loosening of the implant is probably the single most common cause of a periprosthetic fracture, although any pathological process which weakens bone, such as osteoporosis, may be a contributory factor.

Classification

Several classifications of periprosthetic femoral fractures have been described. Many are descriptive2,3 and give information about the site of the fracture, but are of little value in formulating a strategy for management. That of Duncan and Masri4 (Fig. 1) provides the best assistance in developing such a plan and will be used in this article. The most important factor influencing treatment is whether or not the femoral stem remains well fixed.

Management options

Non-operative treatment is only indicated when the fracture is stable, such as in undisplaced trochanteric fractures, or in a patient whose general medical condition precludes surgery. Type A_G and A_L. Displaced proximal femoral fractures (A_G, greater trochanter; A_L, lesser trochanter) are commonly related to osteopenia and can usually be fixed adequately by cerclage wires supplemented by screws or plates if required (Fig. 2). These fractures are often associated with osteolysis in the proximal femur, and this should be grafted, usually with morsellised allograft, at the time of fixation of the injury.

Type B

B_1. This occurs in the region of the tip of a well-fixed stem. Long oblique or spiral fractures can be fixed by cerclage wires or cables and crimpsleeves. However, supplementary fixation by an onlay cortical strut graft or by a plate provides the facility for fixation both with screws placed distal to the implant and cerclage wires or cables located proximally. If the fracture is short, oblique or transverse, biplanar fixation on the anterior and lateral aspects can be provided by any combination of plates and cortical onlay grafts. The latter are sculpted with a burr to provide intimate contact with the underlying cortex, which is also roughened.5 Juncational grafting with morsellised allograft or bone slurry probably accelerates union. In rotationally unstable transverse fractures it is necessary to achieve unicortical fixation proximally to provide stability.

Short oblique and transverse fractures tend to be slow to unite and it is desirable to place autograft at these sites during the operation.

B_2. These fractures occur at the tip of the stem and are associated with a loose implant but reasonable proximal bone stock. Revision of the stem is needed with adequate fixation of the fracture. The best method is to use a revision stem which bypasses the site of the fracture by at least 5 cm, or twice the outer diameter of the diaphysis. A long cemented stem can provide good fixation and will not prevent healing of bone provided that cement is not allowed to intrude into the site of the fracture. This option should probably be reserved for infirm elderly patients with poor bone stock.6 Long cementless stems which achieve good diaphyseal fixa-
tion, with or without interlocking screws, provide the most effective contemporary method for managing these patients. The pattern of the fracture will then determine what further fixation is required. Cerclage cables, wires or straps can be used in long oblique or spiral fractures. Plates which are suitable for both cerclage and screw fixation and/or onlay grafts are used to provide further stability in short oblique or transverse fractures.

The use of ancillary bone graft with either autograft or allogenic bone is recommended to facilitate bony union in all of these fractures. It is important to recognise that the bone loss encountered at the time of surgery is likely to be much greater than that predicted from the radiographs.

Periprosthetic fractures in the presence of grossly deficient proximal femoral bone stock and loose stems are the most difficult to treat. If adequate distal fixation in the diaphysis can be achieved, the proximal femur can be collapsed down to embrace the underlying stem. The fixation and bone stock can then be supplemented by two cortical onlay grafts. Cancellous allograft is used to augment the bone stock further. If this solution is not feasible, it may be necessary to replace the proximal femur with a customised prosthesis in elderly patients or with an allograft-prosthetic composite in the younger age group. This has the advantage of allowing the remnants of the proximal femur to be wrapped around the allograft, which potentially contributes to regional soft-tissue attachment and thus stability and function.

C. These fractures are sufficiently distal in the femur such that, while some forms of intramedullary fixation are obviously excluded, their further management can be undertaken without consideration of the proximally placed prosthesis.

Overview of results obtained

The use of different systems for classification and the variety of methods of treatment which have been used make it difficult to identify the ideal management for any specific periprosthetic fracture. Mont and Maar reviewed 26 pub-

Diagrams showing the classification of femoral periprosthetic fractures according to Duncan and Masri. Figure 1a – Type-A with fracture at the lesser trochanter A, and at the greater trochanter, A. Figure 1b – Type-B with fracture around or just below a well-fixed stem (B), around or just below a loose stem with adequate bone (B), at or just below a loose stem with poor proximal bone stock (B). Figure 1c – Type-C fracture well below the stem.
Radiographs showing a) a widely displaced detachment of the lesser trochanter (A₂) after a fall and b) reduction and stabilisation by two cerclage cables and crimpsleeves.

Radiographs showing a) a transverse fracture just distal to the tip of a well-fixed stem, b) stabilisation by a plate fixed with screws and cables and crimpsleeves and c) solid union at three years.
lished reports with a total of 487 periprosthetic fractures. They noted that the most significant obstacle in obtaining guidance for treatment was the small number of patients in any one study.

Most type A fractures which require stabilisation can be adequately managed by cerclage fixation (Fig. 2). Adjuvant cancellous allografting to fill osteolytic defects is usually well incorporated.

Type-B1 fractures require internal fixation. Stabilisation by cerclage cables may be sufficient for spiral or long oblique fractures, but additional fixation is usually required. Noorda and Wuisman8 reviewed 36 type-B1 periprosthetic fractures in which the Mennen paraskeletal clamp had been used for fixation. When reviewed after 27 months 28% of the fractures had progressed to nonunion with 20° to 30° of varus. In 22% the plate had fractured. They concluded that the use of the Mennen plate was not recommended for the treatment of periprosthetic fractures. Other recent publications have shared this view.9,10

Tadross et al11 described the use of the Dall-Miles plating system in seven hips, four of which were considered to be failures. They observed that the femoral stems were in varus in all the cases which failed. Mont and Maar7 also reported poor results, with only 48% satisfactory, when treating these fractures by plates and screws. Tsiridis, Haddad and Gie12 reviewed 13 cases of fracture around a femoral prosthesis, in which the Dall-Miles plate had been used. They reported breakage of the plate in four of the 13 (31%) and concluded that the Dall-Miles plates and cable system alone was insufficient for the treatment of periprosthetic fractures.

We reviewed 12 patients with type-B1 fractures who had been treated by the Dall-Miles system.13 The minimum follow-up was for two years. Eleven of the fractures (92%) had united in a good position, irrespective of the quality of bone stock, the pattern of the fracture or the degree of comminution (Fig. 3). In one case the fixation failed with loosening of the plate and breakage of a cable (Fig. 4). This type of fixation is a useful adjunct to the choice of management of these fractures but it is essential to obtain good cable or screw fixation on the plate distally and proximally. These favourable results are in accordance with those reported by Venu et al14 who reviewed 13 periprosthetic femoral fractures which had been fixed using this system. However, they indicated that this method was not suitable on its own if the femoral component was loose or was in more than 6° of varus.

Haddad et al,15 in a multicentre study, reviewed 40 patients with a fracture around a well-fixed femoral stem (B1) in which the stem was not revised. Nineteen were treated by cortical strut onlay grafts alone, while 21 were managed by a plate and one or two cortical struts. Union occurred in 98% of the fractures. There were four malunions, but all had less than 10° of malignment. The authors suggest that cortical strut grafts should be routinely used in the treatment of these periprosthetic fractures.
Type-B₂ fractures require revision of the femoral stem. Macdonald et al ¹⁶ reviewed 14 proximal femoral fractures which had been treated by long-stem extensively porous-coated femoral components with a mean follow-up of 8.2 years. Supplemental cortical strut grafts were used when required. All the fractures united and the only unstable component did not give sufficient symptoms to warrant revision. Sledge and Abiri ¹⁷ achieved equally favourable results in seven type-B₂ fractures using a similar method.

We reviewed 22 fractures which had occurred around unstable femoral implants. All the patients had been treated by Bicontact revision stems with two distal interlocking screws. ¹⁸ Fourteen had had supplemental allografting. The mean follow-up was for two years. The distal screws in the Bicontact stem provide early rotational and axial stability. Loading of the proximal bone reputedly provokes restoration of bone stock with secondary proximal fixation. The fractures united in all patients (Fig. 5), but subsidence of more than 5 mm with fracture of the screws occurred in five (Fig. 6). While this prosthesis achieved adequate fixation of the fracture it does not always provide sufficiently stable fixation of the implant. We have discontinued its use.

There are no major series of type-B₃ fractures in the literature. However, these are challenging cases with a high rate of complications. It is essential that the implant obtains adequate distal fixation to provide axial and rotational stability as the proximal bone does not usually give sufficient support.
The results for type-C fractures are similar to those of any other distal femoral fractures.

Summary

The management of nonunion of femoral fractures around a total hip prosthesis is difficult. It is associated with a high risk of complications and a relatively poor outcome.19 Prevention of the nonunion by appropriate treatment of the initial fracture is mandatory.

Most peritrochanteric periprosthetic fractures can be treated conservatively. Markedly displaced fractures and those associated with osteolysis require surgery. This usually involves removing the cause of the osteolysis followed by appropriate bone grafting and cerclage fixation.

The excellent results of the treatment of type-B1 fractures reported by Haddad et al15 from a multicentre review are encouraging. Of interest, however, are two studies which compared various different configurations of fixation of periprosthetic fractures biomechanically. Dennis et al20,21 showed that a plate, proximal cables and distal bicortical screws gave a stronger and more rigid fixation than that provided by two cortical allograft struts fixed by cables. In a similar model with a transverse fracture, Schmotzer, Tchejeyan and Dall22 demonstrated that allograft struts fixed by wires did not provide adequate strength and stability. However, the use of cerclage cables and crimpsleeves increased the interfragmentary compression and thus the frictional resistance between graft and bone, which resulted in a marked improvement of the strength and stability of the fixation. Strut grafts should not make contact with each other since tensioning of any cerclage device will result in compression of one strut against the other rather than that of the strut against host bone.

Cortical strut grafts are invaded by osteoclast cutting cones and subsequent revascularisation renders the graft at its weakest at four to six months.23 It would therefore seem logical to combine a plate, with distal bicortical screw fixation and proximal unicortical screw fixation supplemented by cables, with an onlay cortical strut allograft fixed by cables. This provides the biological benefit of a strut allograft with enhanced fixation which is not potentially compromised during revascularisation and remodelling of the graft. It is appropriate to apply the plate and strut graft at

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**Fig. 7**
Algorithm showing the management of type-A fractures.

**Fig. 8**
Algorithm showing the management of type-B fractures.
right angles to each other, usually anterior and lateral, in order to resist the forces in both planes.

Type-B$_2$ fractures should be treated by revision to a long stem with adequate distal fixation and supplemental proximal grafting as required. In type-B$_3$ fractures the osteogenic potential of vascularised fragments of the proximal femur should be carefully preserved in order to augment whatever proximal femoral reconstruction is carried out.

Figures 7 and 8 give management algorithms for type-A and type-B fractures.

Type-C fractures should be treated in the same manner as any other fracture in the distal femur.

Periprosthetic fractures are difficult to treat. The vascularity of the involved limb has often been compromised by previous surgery. Autograft or allograft should be freely used. The radiographs will often underestimate the extent of bone loss. The surgeon should be prepared to consider and to cater for all alternatives in reconstruction since the definitive treatment often depends on the findings at operation.

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References