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Review

Periprosthetic fractures in the distal femur following total knee replacement: A review and guide to management

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ABSTRACT

The management of distal femoral fractures following a total knee replacement can be complex and requires the equipment, perioperative support and surgical skills of both trauma and revision arthroplasty services. Recent advances in implant technology have changed the management options of these difficult fractures. This article describes the options available and discusses the latest evidence.

Contents

1. Introduction

More than 75,000 total knee replacement (TKR) operations are undertaken annually in the UK. This figure continues to rise and has already exceeded the number of total hip replacements implanted [1,2]. It is difficult to ascertain an accurate estimate of the incidence of distal femoral fractures following TKR. The largest reported series from the Mayo Clinic joint registry (19,810 patients) suggests a femoral fracture rate of 1.3% following TKR [3]. Other studies have reported a varying incidence from 0.2% at an average of 5.1 years follow-up [4] to 2% [5] following primary TKR and a significantly higher rate following revision surgery of up to 38% [6]. As more procedures are undertaken in younger, active patients with increased life expectancy, there will be an inevitable increase in the number of patients presenting with distal femoral periprosthetic fractures.

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Management of patients with distal femoral periprosthetic fractures can often be difficult due to the complexity of their injuries and the requirement for technical expertise in both trauma and knee revision surgery. In addition there is a lack of robust evidence in the literature to help guide decision making. With the introduction of locking plates over the last decade, treatment algorithms have changed and there is a greater emphasis on surgical rather than conservative management in the majority of these fractures. This paper reviews the current management of distal femoral periprosthetic fractures around the knee and gives guidance to the best options currently available for these increasingly common complex injuries.

2. Predisposing factors

Although periprosthetic fractures can occur in any patient during or following a knee replacement, several risk factors have been implicated (Table 1). Osteopenia appears to be the greatest risk factor and can occur secondary to a variety of conditions including inflammatory arthritis and chronic use of steroids [7]. It is also associated with increasing age and female sex. Around 80% of periprosthetic fractures occur in females [3] and most occur after a low energy fall [8]. There is debate as to the fracture risk attributable to anterior femoral notching. Lesh [9] used biomechanical studies in cadaveric femora to establish that notching the anterior femoral cortex by 3 mm significantly reduced both the bending and torsional loads to failure following TKR by means of 18% and 39% respectively. This study is supported by a finite element analysis model undertaken by Zalzal [10] and a case series by Aaron [5]. However in a retrospective clinical study of 1089 consecutive TKRs, Ritter [4] found that the only two supracondylar fractures which occurred during an average follow up of 5.1 years were in patients without anterior femoral notching, despite a notching incidence of almost 30%.

3. Assessment and planning

Pre-operative assessment and planning is an essential part in the management of patients sustaining periprosthetic fractures. A comprehensive history should be taken from the patient regarding the function of the TKR prior to fracture. Pre-fracture knee pain should raise the suspicion of a loose or infected implant. Pre-operative investigations should be tailored towards determining fracture configuration and bone quality, and excluding infection or pathological fracture. Consideration should also be given to any ipsilateral hip implants in situ. Full length antero-posterior and lateral radiographs of the femur and knee should be obtained. CT scanning and serial review of older radiographs may provide evidence of pre-fracture loosening. Particular attention needs to be paid to the assessment of bone stock in the distal part of the fracture to judge whether it is sufficient to allow screw fixation. Inflammatory markers including ESR, CRP, white cell count and platelets should be routinely checked [11].

Table 1
Risk factors associated with periprosthetic fractures around the knee.

- Osteopenia
  - Female sex
  - Chronic steroid use
  - Increasing age
- Osteolysis
  - Infection
  - Implant wear/loosening
- Stiff knee
- Anterior femoral notching
- Neurological abnormalities
- Revision knee arthroplasty

Once the fracture has been evaluated and the provisional method of treatment chosen, consideration needs to be given to the surgical team undertaking the operation. Ideally a surgeon trained in both trauma and revision arthroplasty should undertake these procedures in a setting where conversion from fixation to revision is possible, so that if the unexpected is met, they have the skills and implant systems to deal with the scenario. If at all possible the femoral alignment, knee implant position and balance should remain intact in an attempt to avoid axial or coronal deformities; these may influence post-operative knee function and thereby the overall success of the procedure [12].

4. Classification

Many classification systems exist [13–17]. Those which take into account fracture displacement, bone stock, distance of fracture from the prosthesis and the stability of the prosthesis tend to be the most useful as they can direct treatment algorithms. Purely anatomical classifications are less helpful. The most widely used classification system in the literature for supracondylar periprosthetic fractures is that of Lewis and Rorabeck [13] (Table 2). However this classification system does not take into account the distance of the fracture from the prosthesis — an important factor when considering the use of retrograde supracondylar nails or locking plates. The classifications suggested by Backstein [14] and Su [15] are more helpful in this respect, whilst remaining simple enough to provide good inter-observer reliability (Tables 3 and 4).

5. Management options

Historically most supracondylar periprosthetic fractures were treated conservatively, with or without a period of skeletal traction [18–21]. For those that were significantly displaced or progressed to non-union, internal fixation with plate and screws was employed [19–22]. Although reasonable results were obtained, there was a significant incidence of malunion and mechanical failure [19,22]. This was probably in part due to the vascular disruption caused by conventional open plating [23] and the inability to obtain secure fixation in osteoporotic bone. Modern treatment methods have addressed these problems by reducing the soft tissue dissection required to achieve fixation and by utilising stronger constructs.

The two commonest fixation techniques now used in the management of Lewis and Rorabeck Types I and II supracondylar periprosthetic fractures are retrograde intramedullary nailing and locked plating. A systematic review of 415 cases by Herrera [8] suggested that both of these techniques resulted in significantly lower non-union rates and requirement for further surgery when compared to non-operative management or conventional plating. Insufficient evidence exists regarding the use of fine-wire frames and their placement. Treatment with frames either spanning or located entirely above the knee joint has been reported, the latter enabling early knee movement [19,24,25]. However, concern has been raised regarding the risk of pin site sepsis and potential contamination of the TKR [26]. Techniques such as fibular strut grafting [27] and distal femoral allograft [28,29] may be useful in certain situations such as massive bone loss. Mechanical testing has shown that retrograde nailing tends to confer a greater initial ability to withstand axial and rotational forces than locked plating (Clive Lee, personal communication). However there is no published evidence which clearly favours either

Table 2
Lewis and Rorabeck [12,13] classification of supracondylar periprosthetic fractures.

Type I	Undisplaced fracture; prosthesis intact.
Type II	Displaced fracture; prosthesis intact.
Type III	Displaced or undisplaced fracture; prosthesis loose or failing.