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ORIGINAL STUDY

The complex problem of the interprosthetic femoral fracture in the elderly patient

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An ageing population and greater number of hip and knee replacements performed have led to an increasing number of patients with ipsilateral hip and knee replacements *in situ*. This often physiologically suboptimal population is at risk for periprosthetic fracture. An interprosthetic femoral fracture represents a unique challenge to the surgeon and requires a detailed multidisciplinary management strategy involving both fracture fixation and often complex revision. We have identified the largest series to our knowledge of patients presenting for surgical management of an unstable fracture between a hip and knee prosthesis. Institutional approval was granted for prospective study of these patients. We present the detailed management, outcome and review the known literature of the best practice for such a complex surgical case. We have outlined 9 fractures in 8 patients presenting to a single trauma unit. A variety of surgical options, often more than one, were employed. One patient died during the study period. All fractures progressed to union. There was a female preponderance with a mean age of 78 years. All patients had established systemic and metabolic bone morbidity. We believe this fracture pattern presents to the general orthopaedic surgeon a unique challenge , which bridges the expertise of the trauma and revision surgical spectrum. It is obvious that this will become an increasing issue with the median age of the population increasing. This case series highlights the need for ready availability of biological, arthroplasty and trauma systems to address such.

Key words : interprosthetic ; fracture ; femur.

INTRODUCTION

Total hip replacement (THR) and total knee replacement (TKR) are common orthopaedic procedures providing patients with a good level of pain relief and functional improvement. As the mean age of the population is increasing, a greater percentage of the total population now have either hip and/or knee replacements *in situ* (*7,13*). This shift in the demographic profile of patients with hip or knee prostheses therefore represents a greater 'at risk' group for prosthetic associated complications.

The risk and consequences of sustaining a periprosthetic fracture associated with a total knee or hip replacement are well known and management has been extensively discussed elsewhere (*8,11*).

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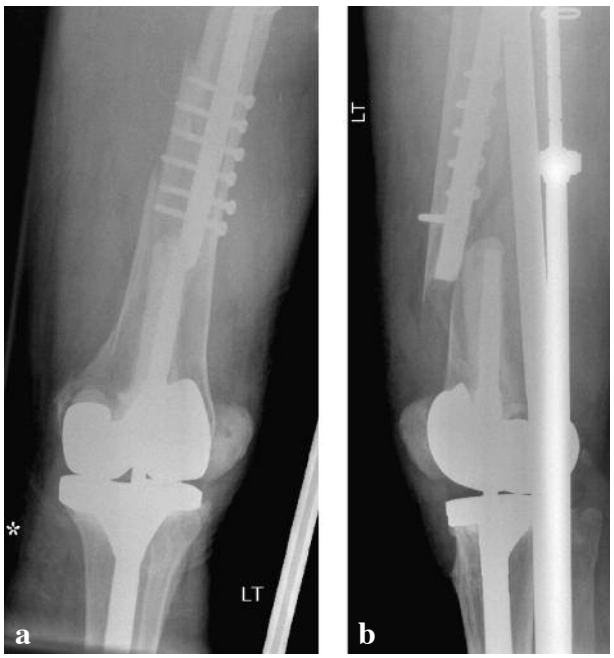

Fig. 1. — Illustrative AP (a) and lateral (b) radiographic example of a transverse fracture at junction of a stable stemmed femoral knee component and revision locked long femoral hip component.

Fig. 2. — AP (a) and lateral (b) post-operative radiograph of the mode of fixation utilising lateral plate secured with a combination of cables spread over a long distance and rotational control obtained using cancellous screw fixation. This was augmented with a distal femoral strut allograft The fracture healed allowing for full weightbearing at 4 months.

These fractures represent a surgical challenge in an often physiologically suboptimal patient. The management issues raised by an interprosthetic fracture between ipsilateral hip and knee replacements are yet more extensive. There is, however, little guidance on the surgical management of such a fracture, often comminuted, with poor bone stock, in this frail patient cohort.

This is likely to represent an increasing burden to the general orthopaedic surgeon.

We present a series of 8 patients with 9 interprosthetic femoral fractures. We believe this to be the largest series of such fractures reported to date. We also review the published literature of 16 cases in total of interprosthetic fracture management. Our aim is to highlight the issues and difficulties in the management of these fractures.

MATERIALS AND METHODS

We identified a cohort of 8 patients (9 fractures) treated in our unit over the last 3 years with interprosthetic femoral fractures. All underwent surgical intervention, with a variety of methods employed. We obtained written institutional approval for patient review as part of an in-house audit through the Trust R&D department. The demographics, comorbidities, fracture pattern, mode of fixation and outcome are given in table I. There were six females and two males with an age range of 53 to 92 years, median 78. The youngest patient had had longstanding polyarticular juvenile idiopathic arthropathy. All patients had documented evidence of established bone pathology prior to the herald event. In five of the eight patients there had been a major revision procedure performed prior to and unrelated to the index injury. Illustrative radiographs of differing modes of fixation are given in figures 1 and 2.

RESULTS

Seventy five percent of this cohort of patients (67% of fractures) were female and their ages ranged from 53 to 92 years. The majority of fractures were sustained due to low velocity trauma (e.g. rolling over in bed), in some cases with no history of direct trauma. Only one patient did not

Table I. — Details including demographics, fracture type, mode of treatment and outcome for our cohort.

Demographics	Comorbidity	Arthroplasty	Fracture pattern	Fracture fixation	Outcome
Female 73	Osteoporosis Osteoarthritis Cervical crush fracture COPD Hypertension	TKR >18years ago THR 15 years ago, revised 4 years ago due to periprosthetic fracture, revised 1/52 later due to recurrent dislocation	Supracondylar	Lateral 9 hole LISS plate Femoral head graft Donjoy brace	Mobile fully weight-bearing at 3 months
Female 88	Diabetes Ischaemic heart disease Previous fragility fracture Osteoarthritis Hypothyroidism	TKR 32 years ago, stable Stable THR	Supracondylar	Retrograde femoral supracondylar nail	2/12 post-op distal screws broken, fracture united Broken screws removed 13/12 post-op
Female 84	Rheumatoid arthritis Osteoporosis	TKR >15 years ago, stable Stable THR, previous intraoperative # tip THR stem managed with Dall Miles system	Supracondylar	DCS	Fracture united, mobilising with zimmer at 4/12
Female 88	Severe COPD Right heart failure Severe leg ulcers Active pneumonia	Stable THR Loose TKR	Supracondylar with gross comminution	Revision to long stemmed cemented link endoprosthetic hinge	Died postoperatively due to severe COPD and concurrent pneumonia
Female 71	Rheumatoid arthritis COPD Anaemia	Uncemented THR 16 years ago, stable Uncemented TKR 16 years ago, stable	Supracondylar	Unreamed retrograde supracondylar nail + cast brace	Mobilising independently Fracture united at 4/12
Male 69	Hypertension Raised cholesterol	Multiply revised THR, long stemmed implant 7 years ago Superstabilised revision TKR 1 year ago	Spiral diaphyseal at stress riser between implant stem Poor endosteal bone quality	Dall Miles plate plus strut graft	Fracture united at 4/12 Mobilising fully weightbearing
Female 92	Osteoporosis Pernicious anaemia	TKR 3years ago, stable THR > 25 years ago, revised 5 years ago, radiological acetabular loosening but aymptomatic	Supracondylar	Retrograde supracondylar nail	At 6/12 follow up fracture united, stable knee Mobilizing with tripod frame and weightbearing with > 90 flexion
Male 53	Juvenile Idiopathic Arthritis	Multiply revised THR bilaterally Stable TKR bilaterally	Bilateral diaphyseal fractures around loose THR stems	Left : revision THR stem, Dall Miles plate and strut graft Right :revision THR stem plus Dall Miles cables	Fractures united at 4/12 Mobilising fully weightbearing

have a pre-existing diagnosis of osteoporosis, rheumatoid arthritis, previous fragility fracture or steroid use. Indeed one patient sustained an intraoperative fracture at the time of primary THR due to poor bone quality. Implants had been *in situ* for up to 32 years and had required previous single revision in 2 cases, once due to periprosthetic fracture. The two males in the series had both undergone multiple revision arthroplasty. One of the knee implants was loose at the time of fracture, requiring revision to a linked rotating hinge implant. Two of the hip stems were loose, in the same patient, requiring revision at the time of initial fracture fixation. One was revised and augmented with a Dall-Miles plate and strut graft, the other managed with revision and Dall-Miles cables. Three fractures were managed with retrograde femoral nailing, one with lateral LISS plating, one with a Dall-Miles system and one with a DCS plate. Eight fractures (7 patients) healed following the initial fixation, allowing the patients to mobilise fully weightbearing. Radiographic and clinical evidence of fracture consolidation was evident in these cases by no later than 6 months after initial presentation. The eighth patient in this series was initially making good progress but died prior to discharge due to her severe airways disease and concurrent pneumonia.

DISCUSSION

Despite the increasing interest in the epidemiology, management and outcome from periprosthetic fracture involving either the hip or knee, very little information exists on femoral fracture between an ipsilateral hip and knee replacement. We expect that this will become an increasing problem with the increasing numbers of lower limb joint replacements being performed. Coupled with the rapid increase in the numbers of elderly people, the 'at risk' population for this type of fracture will expand greatly in the next decade. This is despite measures being actively taken to identify and prophylactically treat reduced bone densitometry in such populations (*4*).

Our literature review identified only 16 cases, described by 9 authors (*3,5,6,9,10,12,15,16,18*), details of which are summarised in table II. Of those where details were given, 85% were female, with an age range of 61-86 years. Seven patients had a diagnosis of rheumatoid arthritis (one plus osteoporosis), and one of Paget's disease. Kenny *et al*'s series (*12*) of four elderly patients, three with rheumatoid arthritis and one with Paget's disease, was managed with open reduction and internal fixation. A variety of plates were used supplemented with bone graft in one case. All fixation methods initially failed and were revised in two cases supplemented with bone graft. Of these two revisions, one healed but the second patient underwent amputation after a failed total femoral arthroplasty. Of the remaining two patients one was reported to be mobilising in an orthosis and the other underwent amputation after a failed trial of bracing, giving an overall amputation rate of 50%. Della Valle *et al* (*6*) described the use of a percutaneous DCS in a 66-year-old with rheumatoid arthritis and demonstrated fracture healing at 5 months. Fulkerson *et al* (*10*), described three patients treated with LISS plating, of which two united after the initial surgery and a third required revision to a long stem TKR secondary to implant loosening. Zuurmond *et al* (*18*) described one case of interprosthetic fracture as part of a series of periprosthetic femoral fractures. They used closed AO nailing plus allograft struts and demonstrated fracture consolidation within 12 months. Dave *et al* (*5*) described a single case of interprosthetic fracture in a 75-year-old with rheumatoid arthritis managed with a Mennen plate and bone graft. Post-operatively the patient was mobile but a broken interfragmentary screw was noted. Walker *et al* (*16*) described a single patient with loose knee and hip replacements. Fixation was initially attempted with a Mennen plate but following rapid plate failure, combined revision of both prostheses was performed, with good results. Urch *et al* (*15*) described an alternate scenario of a patient with multiple THR revisions and a subsequent periprosthetic fracture requiring salvage TKR after joint damage sustained from the fracture fixation. This created the situation of interprosthetic non-union. This was managed with entire femoral allograft and simultaneous revision of both prostheses, allowing the patient to return to previous function in time. Chakravarthy *et al* (*3*) described a patient who had

Table II. — Review of current literature with outcome by mode of fixation.

Authors	Patients	Comorbidity	Arthroplasty	Fracture pattern	Fracture fixation	Outcome
Kenny	Female 81	Rheumatoid Arthritis	THR 8years ago TKR 4 years ago	Transverse	ORIF Mennen plate Cast brace	Plate fracture and non union at 7/12 Failed trial of ischial bearing orthotic Above knee amputation
	Female 73	Rheumatoid Arthritis	THR 12 years ago Stemmed TKR 6 years ago	Not documented	ORIF Lateral 12 hole DCP	Plate fracture and non union at 2/12 Revision anterior + lateral plates and bone graft Total femoral arthroplasty 6/12 later Multiple hip dislocations, deep infection Amputation by hip disarticulation 12/12 post injury
	Female 82	Rheumatoid Arthritis	THR 6 years ago TKR 8 years ago	Short oblique	ORIF Lateral plate and bone graft	Failed fixation Two further attempts at fixation with AO plates failed Mobilising with ischial bearing orthosis
	Female 86	Paget's disease	THR 5 years ago TKR 4 year ago	Supracondylar	ORIF Dynamic condylar screw and plate	Plate fracture and non union at 5/12 Replated plus bone graft Fracture united 4/12 later
Della Valle	Female 66	Rheumatoid Arthritis	Uncemented THR 7 years ago Uncemented TKR 15 years ago	Comminuted distal femoral shaft	Percutaneous, sub-muscuar 12 hole 95 deg dynamic condylar screw	Fracture united at 5/12
Fulkerson	Female 71	nil	THR 3.6 years ago TKR 8 years ago	Not documented	ORIF LISS plate	Fracture united at 5/12
	Female 86	nil	THR 5 years ago TKR 5 years ago	Not documented	ORIF LISS plate	Fracture united at 8/12
	Female 74	hypertension	THR 15.5 years ago TKR 15.5 years ago	Not documented	ORIF LISS plate	Non union Revision to longstem TKR (implant loose)
Zuurmond	Female 81	Not documented	Not documented	Vancouver type C	AO IM Nail	Failed at junction of nail and hip stem Allograft struts added at re-operation Fracture union at 12/12
Dave	Female 75	Rheumatoid Arthritis	THR 10 years ago TKR 5 years ago	Displaced spiral	Large Mennen plate + Bone Graft	Mobile 1 interfragmentary screw broken
Walker	Male 61	Rheumatoid Arthritis	Loose THR Loose TKR	Not documented	Mennen plate	Rapid plate failure Combined revision to cemented combined THR and TKR Patient satisfied at 15/12 post-op
Urch	Female 62	Rheumatoid Arthritis Osteoporosis	THR revised x3 Supracondylar # 3 years later – DCS + synthetic BG 2/12 post-op revision lateral fixation, medial plate, autogenous BG 3/12 later fixation failure, compression screw in intercondylar notch, arthritic knee – salvage TKR + cables	Persistent nonunion	Entire femoral allograft with simultaneous ipsilateral revision THR and TKR	2/52 post-operatively tively hip subluxation Hip spica cast for 6/52 2 years post-operatively at prefracture level of function
Chakravarthy	Male 75	Not documented	TKR 4 years ago THR 11 years ago	Around femoral stem	LCP	Union at 6/12 Sustained further fracture at stress riser between distal LCP and femoral component TKR. Managed with retrograde IM nail. Union at 6/12
Duwelius	3 patients No specific data given for each patient	No specific data given for each patient	No specific data given for each patient	Around femoral stem	Single plate Cable augmentation if poor bone stock Allograft strut at 90 degrees to plate	Post-operative fracture at stress riser between distal tip of plate and femoral component of TKR Further management not documented

sustained a fracture around the femoral component of their total hip arthroplasty, which was managed surgically using an LCP plate. This fracture healed but the patient sustained a further fracture at the stress riser between the plate and the femoral component of their knee prosthesis which was treated with a retrograde IM nail and subsequently healed. Duwelius *et al* (*9*) describe a similar scenario in three of their cohort, although they do not single out individual patient details. They do, however, describe post-operative fracture at the stress riser between a total knee replacement and a plate used to stabilise an interprosthetic fracture around a hip prosthesis. They do not comment on how this scenario was managed, but do suggest that the situation could have been avoided by using a longer, fixed angle type plate.

We believe that this current review represents the largest series, to date, of patients presenting with this particular fracture configuration. We found this to be a low velocity fracture in elderly people with no history of an external force being applied. Whilst bone densitometry could not be performed for obvious reasons prior to surgery, we do consider this to be a significant contributory component to the pathogenesis given the associated history, in many cases, of osteoporosis, rheumatoid arthritis or previous fragility fracture. As osteoporosis is the most common disease of bone, with a rapidly rising incidence as the population ages (*2*), this is likely to be the single most important contributor to this type of fracture. All but one of the patients in our series had a diagnosis of/or a history consistent with osteoporosis and of the 11 published cases with a documented past medical history, 7 had rheumatoid arthritis (one plus documented osteoporosis) and one had Paget's disease.

Previous work has reported a 13.1% first year mortality, 14% post-operative complication rate and 22% re-operation rate in patients sustaining periprosthetic femoral fractures (*14*), and a similar if not higher morbidity and mortality could be expected with interprosthetic fractures. In our series one patient died peri-operatively and one required removal of broken screws**.** In the literature 13 of the 16 patients experienced a complication, of which 10 required at least one further operation. This highlights the importance of stabilising these fractures at the first opportunity as multiple procedures may not be tolerated, and increase the attendant risk of complications.

Crucial to surgical planning is the status of the pre-existent prostheses. Evidence from the history or on radiographic assessment of potential requirement for revision of one or both joint replacements secondary to component loosening or polyethylene wear often mitigates against straightforward fracture fixation and should require the surgeon to consider a combination of fracture fixation and revision surgery. Distal bone stock can be an issue around even well fixed knee replacements, necessitating revision (*17*). The use of stemmed revision components potentially allows for both. This offers the attraction of early weight bearing upon a stable construct and is analogous to the management of pathological fractures. There is often concomitant medical co-morbidity requiring close interplay with a dedicated orthogeriatric team. By definition the presence of two implants implies two previous longitudinal scars. We would advise consultation with plastic surgical colleagues in advance of definitive surgical fixation. The bone quality is often poor with limited healing potential and as in many of our cases there may be significant comminution. Irrespective of mode of fixation the treating surgeon should give due consideration to augmentation of healing with allograft bone and synthetic biological agents such as BMP (*1*).

We have attempted to outline in table III the key features associated with each mode of surgical fixation. No one mode is ideally suited for a particular fracture pattern and often more than technique is required. It is crucial to bypass the fracture pattern and equally important to minimise the risk of further fracture by obliterating any stress risers. Weak bone with poor cancellous material interposed between augmented implants is a recipe for further fracture. Staggered double plating and/or allograft strut grafting may be required to offload bone by distributing stress more uniformly. The use of a stemmed intramedullary revision implant in conjunction with an external cortical plate and biological augmentation may offer a potential further level of construct stability but does necessitate increased

Table III. — Advantages and disadvantages of possible modalities of treatment.

Mode of fixation Implant Sparing	**Advantages**	**Disadvantages**	**Reference(s)**
Unicortical plating	Ease of fixation	Biomechanically unsound	Kenny Fulkerson Dave Walker Duwelius Chakravarthy
Double plating	Stronger construct Allows for use of bone graft	Difficult approach Skin healing poor laterally	Kenny
Plate and strut graft	Adjunctive support Enhanced biological ingrowth	Approach difficult Risks of allograft implantation	Our series
Retrograde intramedullary nail	Minimal exposure, biomechanically sound	Poor distal fix in osteoporotic bone Stress riser at tips Can not use bone graft	Zuurmond
Mode of fixation Implant Sacrificing	**Advantages**	**Disadvantages**	**Reference(s)**
Revision of femoral hip component + augment : plate/cables/strut graft	One stage procedure, addressing two problems Enhanced biological ingrowth	Stress riser between revision hip component and knee or plate and knee Risks of allograft implantation	Our series
Revision to stemmed femoral knee component	One stage procedure addressing two problems	Exposure of joint Stress riser between tip of knee and hip	Fulkerson
Staged procedures : fixation and then revision of arthroplasty	Preserves bone stock Reduced trauma per operation Smaller implants	2 separate operations with attendant risks	Walker
Total replacement of femur	One stage procedure	Maximally invasive Risk of loosening High infection risk	Kenny Urch

surgical dissection. There is certainly no role for non-operative intervention in this frail population. Equally we have found it useful to involve our orthogeriatric and plastic surgical teams at an early stage in the management of these patients.

We believe that this injury pattern will become more common. It is a complex surgical issue and often presents to the general orthopaedic surgeon. There is now growing awareness that periprosthetic fractures represent a frequent mode of failure of THR or TKR, with the risk being increased when there are both a THR and TKR because of stress concentration. There may be an argument for referral to dedicated surgical units with ready access to plastic surgery, familiarisation with synthetic and allograft bone material and an expert orthogeriatric service.

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