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ORIGINAL STUDY

Periprosthetic femoral fractures around well fixed implants : A simple method of fixation using LC-DCP with trochanteric purchase

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Periprosthetic fractures of the femur are among the most serious complications in hip surgery. Various classifications have been suggested. At present the Vancouver classification system probably comes closest to the ideal. Most authors recommend internal fixation of the fractures in well-fixed implants (Vancouver type B1). However as the fixation to the proximal fragment has always been a problem, many types of fixation devices have been used. This retrospective study was done to evaluate the efficacy of an LC-DCP with trochanteric purchase, in the fixation of Vancouver type B1 periprosthetic femoral fractures. Our study included 12 patients, 7 male and 5 female with a mean age of 73 years (range : 57 to 91). One patient died due to complications not related to surgery and in another patient the plate was found broken with a loose implant, which was revised. All cases were primary arthroplasties. A long broad LC-DCP was used for the fixation. Purchase in the proximal fragment was obtained with screws in the greater trochanter. Ten fractures united in an average period of 7 months. The mean duration of follow-up was 6.5 years. The final results were evaluated using the Harris hip score. The mean Harris hip score was 85 with a range of 75 to 94.

Keywords : total hip arthroplasty ; periprosthetic fractures ; internal fixation.

INTRODUCTION

The incidence of fractures of the femoral shaft following primary hip replacement ranges from 0.1% to 2.5% and to 4.2% following revision hip arthroplasties (*19, 20, 31*). Various forms of treatment have been recommended, ranging from non-operative management with skeletal traction and immobilisation to various surgical techniques (*21*). Non-operative treatment is associated with well-recognised complications of prolonged bed rest, high malunion and nonunion rates and frequently need for subsequent revision (*3, 10, 16*). Attention has therefore centered on the use of internal fixation to treat periprosthetic femoral fractures (*33*).

Different classifications have been suggested for periprosthetic femoral fractures. The Vancouver classification proposed by Duncan and Masri (*8*) is becoming the standard system for assessing and reporting periprosthetic femur fractures (*30*). It is

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the only classification system that has been rigorously evaluated and its reliability and validity are acceptable with consistent agreement among different examiners (*4*). The Vancouver classification divides periprosthetic fractures into three main types based on the location of the fracture, bone stock and bone quality. The treatment recommendations are made based on this classification system. Most of the authors recommend open reduction and internal fixation of the fractures associated with well-fixed implants (Vancouver type B1). Revision with a long femoral stem and strut bone grafting is advised if the implants are loose and when there is associated osteolysis. Various methods of open reduction and internal fixation include intramedullary fixation (*15*), Ogden plate fixation (*38*), Partridge bands (*24*), Mennen plate (*26*), Dall-Miles cable and plate system (*2*), compression plates with either unicortical screws or cerclage wires or a combination (*32*).

The ideal method of fixation is yet to be determined and there is no consensus on the best surgical treatment of periprosthetic femoral fractures. The problem in most of the reported methods of fixation has been the anchorage of the plate into the proximal fracture fragment, which has the femoral implant fixed inside the medullary canal, thus reducing the possibility for a firm purchase. We used a standard broad LC-DCP extending from the greater trochanter and getting purchase into it using cancellous screws. The remaining part of the fixation into the proximal fragment is done with unicortical screws and cerclage wires. This method of fixation is simple to use and it makes use of good bone stock which is usually present in the greater trochanter. We believe that obtaining purchase into the greater trochanter can address the problem of anchorage in the proximal fragment.

PATIENTS AND METHODS

We reviewed 12 patients with Vancouver type B1 periprosthetic femoral shaft fractures which were treated between 1996 to 2001, in which this method of fixation was used, out of the various methods of fixations commonly used in our institution. There were 7 male and 5 female patients (table I). The mean age at the time of fixation was 73 years (range : 57 to 91). Seven fractures occurred in the right femur and 5 in the left. The mean time interval between the index hip arthroplasty and fracture was 8 years (range : 3 to 17). There was one case of bipolar (fig 1) and 11 cases of total hip arthroplasty, all of them cemented. All cases were primary arthroplasties ; none had undergone any revision procedure. One patient died within 3 months of surgery for reasons not related to surgical complications. In another patient the plate was found to be broken at 4 months and the femoral stem was also found to be loose, so it was revised (table I). Nine patients sustained the fracture following a major fall while the remaining three had a trivial injury.

A long broad LC-DCP extending from the tip of the greater trochanter and spanning the fracture site, so as to get at least 8 cortices hold distal to the tip of the femoral implant, was used. Proximally the plate was contoured onto the greater trochanter (fig 1, 2) so that at least one large fragment cancellous screw could be placed into the trochanter, and care was taken to avoid breaching of the cement mantle by the screws. The remaining part of the plate was fixed with unicortical screws and cerclage wires around the stem of the femoral implant, and distally 4 to 5 cortical screws were used to fix the plate below the tip of the femoral stem. Care was taken to maintain the biology of the fracture fragments by avoiding soft tissue stripping and using indirect reduction techniques. Autogenous bone grafting from the iliac crest was used, if any significant comminution was found (graft was used in 6 cases). Partial weight bearing crutch walking was encouraged soon after the surgery and as soon as pain allowed. Postoperative rehabilitation was uneventful in all except one patient who developed deep venous thrombosis which was treated effectively ; no patient had infection of the operated wound.

The patients were reviewed clinically and radiologically. The mean duration of follow-up was 6.5 yrs (range : 4 to 9). Fracture union was deemed to have occurred when the patient was able to fully weight bear without pain and there was radiographic evidence of bridging callus across the fracture. The clinical outcomes were assessed using the Harris Hip score.

RESULTS

One patient died within 3 months of surgery for reasons not related to surgical complications. In another patient the plate was found to be broken at 4 months and the femoral stem was also found to be loose, so it was revised (table I).

Table I. — Clinical profile of patients

	M/F	Age	Side	Interval between surgery and fracture	Autograft	Time to union in months	Prosthesis alignment at union	Follow-up in months	Harris Hip score	Complications
1	M	62	Right	7 yr 6 mo	No	6	Neutral	62	86	None
2	M	75	Right	9 yr	Yes	9	Neutral	70	94	None
3	M	73	Left	13 yr	No	7	Varus	58	76	None
4	F	72	Right	9 yr 4 mo	Yes	7	Neutral	96	92	DVT
5	M	57	Left	4 yr	No	6	Neutral	46	90	None
6	F	68	Left	8 yr 2 mo	No	8	Varus	82	86	None
7	F	81	Right	7 yr	Yes	10	Neutral	108	82	None
8	M	91	Right	17 yrs	yes	PATIENT DIED 3 MONTHS POST SURGERY				
9	F	82	Right	8 yrs 2 mo	No	6	Neutral	64	83	None
10	M	65	Left	6	Yes	5	Varus	76	75	None
11	M	73	Left	3	Yes	Plate broken, revision THA done				
12	F	80	Right	5	No	6	Neutral	56	88	None

Fig. 1. — A 62-year-old male who had undergone THA 7 years before for OA of the left hip ; he sustained a type B1 periprosthetic fracture. He was treated with a broad LC-DCP with trochanteric purchase. The fracture united in 6 months.

Fig. 2. — A 72-year-old female who had undergone hemi-arthroplasty 9 years before for fracture of the neck of the femur, presented a type B1 periprosthetic fracture. She was treated with a broad LC-DCP with trochanteric purchase. The fracture united in 7 months.

The other 10 fractures united in an average period of 7 months (range : 5 to 10). The final results were evaluated using the Harris hip score. A satisfactory result was one in which the Harris Hip score was 80 points and above and the fracture had united. An unsatisfactory result was one in which the Harris hip score was less than 80 points or the fracture had not united or malunited (*26*). The mean Harris hip score was 85 with a range of 75 to 94 (table I). The Harris hip score was satisfactory (> 80) in 8 patients and unsatisfactory (< 80) in 2 patients. These two patients were found to have a varus malunion of less than 10°. In another patient a satisfactory Harris Hip score of 86 was noted in spite of a varus malunion of 8°. Prefracture Harris

Hip scores were not available in most of our patients. In our series of 12 patients, there was one failure, one patient died 3 months post-operatively, the remaining 10 had union of fracture and no patient had varus malunion > 10°.

DISCUSSION

Fracture of the femoral shaft is not a rare complication following total hip arthroplasty or hemiarthroplasty. Various treatment modalities have been described depending on the fracture location, fracture type and quality of bone. In cases with a loose femoral prosthesis (Vancouver type B2 and B3), most authors would recommend revision with a long stem prosthesis (*6, 8*) with strut grafts. Open reduction and internal fixation is advised for the fractures around well fixed implants (i.e. Vancouver type B1 fractures).

Various internal fixation methods have been described in the literature, like cerclage fixation using stainless steel wires, multi filament cables or wide bands as the Parham and Partridge bands (*24*). Clinical studies however, have shown that the cerclage fixation alone does not achieve rigid fixation and should be supplemented with other methods of internal fixation or cortical onlay grafts (*11*).

Dynamic compression plates alone or with onlay strut grafts are used for the treatment of fractures with stable implants. The problem arises with the treatment of fractures proximal to the tip of the femoral stem, in which screws may violate the cement mantle or in the case of uncemented implants screws may fail to gain sufficient purchase. This was the rationale behind the development of plates allowing proximal cerclage fixation. The first such device was the Ogden plate. Ogden and Rendall (*22*) in 1978 treated 10 patients with the Ogden plate, in which an AO plate was fixed proximally with Parham's bands or cerclage wires and distally with screws. Zenni *et al* (*38*) in 1988 reported the results of 19 periprosthetic fractures treated with Ogden plates. Sixteen of the fractures healed in an average of 3.5 months. Two developed delayed union and one resulted in nonunion. Although this type of fixation of the proximal fragment with Parham bands provided good fixation, it is not biomechanically as strong as a fixation with trochanteric purchase.

Serocki *et al* (*32*) in 1992 reported the results of 10 patients treated with compression plating (DCP) achieving a minimum of eight cortices of fixation on each side of the fracture. Nine of the 10 fractures united in an average of 5 months. Park *et al* (*23*) in 2003 used plate fixation in 13 out of their 37 patients. Two cases showed nonunion and 3 resulted in repeat fractures after plate removal, which was caused by empty screw holes in the area of the stem tip. The cause of nonunion was inadequate plate fixation in the proximal fracture fragment and early weight bearing. Haider *et al* (*13*) in 2005 used DCP plates for the treatment of periprosthetic fractures of the femur. Out of the 27 cases, 18 were type B1, 6 type B2 and 3 type B3. There were three fixation failures and one nonunion. They concluded that DCP fixation is sufficient for type B1 and some selected B2 fractures. Tsiridis *et al* (*35*) in 2005 used the DCP for the treatment of type B periprosthetic fractures. There were 7 type B1, 2 type B2 and 9 type B3. In addition to a DCP, all type B2 and B3 were revised to a cemented prosthesis. Five of the fractures failed to heal. The authors were of the opinion that DCP fixation seems to be a valid method of treatment for periprosthetic femoral fractures with well-fixed implants.

Ricci *et al* (*27*) in 2005 reported the use of indirect reduction and plate fixation, without grafting for periprosthetic femoral shaft fractures about stable intramedullary implants. Fifty Vancouver type B1 fractures were treated with the protocol which included open reduction with the use of indirect reduction technique and internal fixation with a single lateral plate without any grafting. Forty one of them had adequate follow-up and all of them healed in 3 months and without evidence of implant loosening or malalignment.

Robinson and Garcia (*28*) in 1995 reported the results of periprosthetic fractures of the femur treated with a Mennen plate in conjunction with a cast brace. Of the 14 patients, 12 survived to follow-up, of whom 11 went on to unite at an average of 14 weeks. One patient had nonunion with breakage of two plates. Radcliffe and Smith (*26*) reported success in review of five patients treated with

Mennen plates (Clamp plates) who were unfit for a prolonged surgical procedure like revision hip replacement. Mennen plates require less dissection and they were found superior for use in frail patients when compared with long-term traction. Kamineni and Ware (*17*) in 1999 reported results of Mennen plate fixation in 5 patients. All the 5 cases failed in an average of 32 days. Two of them underwent revision hip replacement and the remaining underwent revision fixation with a cable and plate system. The authors were of the opinion that femoral shaft fractures were not adequately stabilised with a Mennen plate and prolonged recumbency in such elderly patients further worsened the pre-existing medical problems. They advocated the use of a cable and plate system.

Cortical onlay grafts for the treatment of femoral periprosthetic fractures are attractive because they provide fixation with a potential to restore the bone stock and increase the cortical strength (*14, 25*). Chandler and Tigges (*5*) described the results of cortical onlay allograft struts in the treatment of periprosthetic fractures. In a well-fixed femoral component a femoral allograft may be split into two equal pieces and clam-shelled about the fracture side with cerclage wiring. Emerson *et al* (*9*) have shown that cortical strut allografts unite consistently and reliably by 8.4 months with a union rate of 96.6%. Haddad *et al* (*12*) in 2002 reported the use of cortical onlay allografts with or without a plate in the treatment of fractures around well fixed implants. There were 40 patients from 4 centres with a well-fixed femoral stem. Nineteen were treated with cortical allograft alone and 21 were managed with plate and cortical strut grafts. Thirty-nine (98%) of the 40 patients united. There were 4 malunions, all $< 10°$. Theauthors were of the opinion that cortical allografts should be used routinely to augment the fixation and encourage healing in periprosthetic fractures. Wilson *et al* (*37*) in 2005 reported a biomechanical study comparing cortical onlay allograft struts and plates in the treatment of periprosthetic femoral fractures around well-fixed implants. The study was done using cadaveric femur models. They were of the opinion that the best fracture fixation was achieved with the combined plate and strut graft constructs.

The Dall-Miles stainless steel cable system has been proven superior to monofilament wire in resisting breakage (*2*). Dennis *et al* (*7*) in a biomechanical study of 5 design techniques currently used for periprosthetic fracture fixation technique suggested that the plate construct with proximal unicortical screws and cables and distal bicortical screws (the design similar to Dall-Miles plate) is superior to other methods of fixation in axial compression, lateral bending and torsional loading.

Badhe and Howrad (*2*) in 2001 reported the use of the Dall-Miles cable grip system in 21 fractures with well-fixed implants. Twenty of the 21 healed in an average of 5.5 months. One patient died postoperatively due to deep infection. Shah and McCabe (*33*) in 2002 used the Dall-Miles cable and plate system for 9 periprosthetic femoral fractures. All the 9 cases united without any evidence of malunion. They recommend cable with plate fixation of type 3 (Beals and Tower) periprosthetic fractures. Tsiridis and Haddad (*36*) in 2003 reported their results of Dall-Miles plate fixation in 16 cases. There were 10 Vancouver B3, three B1 and three C fractures. In addition to Dall-Miles plate, two of the fractures were also stabilised with strut graft and nine B3 fractures were revised with impaction grafting. Of the three B1 fractures, two failed through fracture of the plate. A further two patients with B3 fractures treated with plates also failed with fracture of the plate. Failure of these plates occurred with in 6 months of surgery. They concluded that the Dall-Miles plate alone is insufficient and it must be supplemented with additional intramedullary or extramedullary fixation.

Tadross *et al* (*34*) in 2000 used Dall-Miles plate in eight patients (9 fractures) for ipsilateral type B1 periprosthetic fractures around the total hip (7 cases) and total knee replacements (2 cases). The final result was unsatisfactory in 6 patients in whom the femoral stem was in varus position. They were of the opinion that Dall-miles plates were not appropriate in periprosthetic fracture with femoral stem in varus. Sandhu *et al* (*29*) in 2005 used Dall-Miles cable and plate system for the treatment of periprosthetic femoral fractures in 20 patients. Fifteen of them were type B1 and 4 were type C. All the fractures united in an average period of

3.9 months. They were of the opinion that Dall-Miles cable and plate system alone is sufficient for the treatment of most periprosthetic fractures. Agarwal *et al* (*1*) in 2005 reported the use of cable grip plating system for the stabilisation of type B1 periprosthetic femoral fractures. Fourteen were managed with cable grip plating, one by DCP and one had insertion of cables only. Four had major complications : 2 had deep infection : 1 had nonunion requiring amputation. The Harris hip score dropped from 86.8 preoperatively to 73.4 on last follow-up.

Kaab *et al* (*18*) in 2006 reported the results of fixation of 13 periprosthetic fractures with less invasive stabilisation system (LISS). Ten of them were around total hip replacements. All fractures showed radiological fracture healing without implant loosening. There was one case of implant failure after 4 months and 2 cases of malunion. These cases showed the internal fixator to be effective for the stabilisation of periprosthetic fractures even in cases of poor bone quality.

In all those fixations in which fixation in the proximal fragment (around the implant) was with only unicortical screws with or without simple wires, the stability of fixation is not good unlike in a system wherein cables are used, which give a stronger fixation. The fixation in our cases included a broad LC-DCP extending from the tip of the greater trochanter, unlike in all of the other plate fixation systems, which we reviewed, in which the plates extended from the subtrochanteric region. We were able to place at least one fully threaded cancellous screw into the trochanter and the remaining part of the plate in the proximal fragment was fixed with unicortical screws and cerclage wires. It is expected that, by obtaining fixation into the greater trochanter, which contains good bone stock, the stability of fixation into the proximal fragment is significantly improved and the stresses are distributed more uniformly starting from the trochanter itself, thereby offloading the plate from abnormal stresses, which decreases the chances of implant failure. Trochanteric purchase makes this construct biomechanically stronger than the plates starting from the subtrochanteric region. Though there are some implants available in the market (Trochanteric cable plate, Ally trochanteric plate, Biomet), we did not find any series in the literature in which in this method of fixation has been used.

In our series of 12 cases, 10 fractures treated with this method united in an average of 7 months. There was one failure at 4 months post-op with loss of fixation and loosening of the prosthesis. It was revised with a long stem prosthesis. None of the remaining 10 cases which went in for a satisfactory union, had loss of fixation till date. Although a further study with a larger number of patients and with biomechanical models may help to clear up the exact extent of use of this method of fixation, we believe that this can be used as a simple alternative method of fixation to a plate and cable system.

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