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Custom-Made Cement-Linked Mega Prostheses: A Salvage Solution For Complex Periprosthetic Femoral Fractures

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ABSTRACT

Periprosthetic femoral fractures with long stem implants, poor bone stock and loosening pose a considerable surgical challenge. We describe a reconstruction technique using a custom-made mega-prosthesis, cement-linked to the femoral stem of a well-fixed existing implant. Clinical and radiological outcomes were assessed at our tertiary referral centre. There were 15 patients with a periprosthetic femoral fracture: 5 proximal and 10 distal femoral arthroplasties linked to existing femoral stems. The survival rate was 93.3% at a mean follow-up of 5.3 years (0.5–19.3) with 1 revision. We present a salvage technique with good intermediate-term outcomes for highly selected patients with complex periprosthetic femoral fractures, as another option to conventional fixation methods. Specifically, it allows immediate weight bearing and avoids some of the morbidity of total femoral arthroplasty or amputation.

Whilst many revision total hip (THA) and knee arthroplasties (TKA) can be simply performed with prosthetic exchange, those with compromised femora from loosening, osteolysis and periprosthetic fracture are much more challenging [1–11].

In the presence of an ipsilateral THA and TKA with interprosthetic fracture, the scope for standard isolated revision arthroplasty or fracture fixation techniques is somewhat limited. Attempts to salvage both arthroplasties may prove impossible as fractures commonly originate in areas of osteolysis around poorly fixed components [1,12–17]. In cases with prosthetic loosening, options include revision to a long stemmed THA/TKA. However, the length of the long stems required to bypass the pathological area of bone may be limited by the presence of the ipsilateral THA/TKA femoral stem increasing the risk of fracture through a greatly concentrated stress riser. Another limb salvage option is a total femoral arthroplasty (TFA) which requires sacrifice of a stable THA/TKA, and the entire femur with its muscle and soft tissue attachments [2,11–15]. There is therefore significant associated morbidity and potential for hip and knee instability [2,11–15].

Another solution to this complex problem is a custom-made proximal or distal femoral arthroplasty (PFA or DFA). This is cement-linked to the well-fixed and functioning existing implant and only sacrifices the poor bone stock. A hollow cylindrical component is inserted over the retained femoral stem to provide a solid diaphyseal reconstruction of the sacrificed joint and allow immediate weight bearing. Retention of one component and less dissection may reduce perioperative morbidity [2–9], and maintenance of soft tissue attachments may reduce hip and knee instability, as well as improve power and rehabilitation [2–9]. This technique can also be applied in cases of progression of osteoarthritis of the ipsilateral joint proximal or distal to a long-stemmed prosthesis [10].

As the largest study of its type to date, we aim to present the technique and outcomes of a custom-made cement-linked mega prosthesis as a salvage solution for complex periprosthetic femoral fractures: a combination of ipsilateral TKA/THA and/or long stem TKA/THA, often with poor bone stock. We hope to demonstrate that it represents a valid alternative option to standard treatment which has inherent limitations and greater morbidity.

Materials and Methods

Patient Selection

Consecutive patients requiring a custom-made cement-linked femoral mega prosthesis at a tertiary referral centre between 1993 and 2012 were retrospectively reviewed. All 15 patients had a complex periprosthetic femoral fracture: 12 in between an ipsilateral THA and TKA, 2 distal to a PFA and 1 distal to a THA with ipsilateral osteoarthritis of the knee in the presence of poor bone stock. Table 1 shows the patient details.

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Table 1
Patient Details.

Patient	Age	Primary Diagnosis	Indication	Retained Implant (Linked Implant)	Blood Loss (Millilitres)	Operating Time (Minutes)	LOS (Days)	MSTS Score	Follow-Up (Years)
1	87	Osteoarthritis	Fracture	THA (DFA)	1000	170	13	15	3.9
2	74	Osteoarthritis	Fracture	THA (DFA)	500	150	14	19	3.6
3	87	Osteoarthritis	Fracture	THA (DFA)	700	150	15	28	3.9
4	60	Osteoarthritis	Fracture	THA (DFA)	1000	140	9	28	19.3[a]
5	60	Breast cancer metastases	Pathological fracture	PFA (DFA)	1500	72	19	23	4.3
6	73	Osteoarthritis, DDH	Fracture: failed internal fixation	TKA (PFA)	2000	250	21	27	3.8
7	59	Osteoarthritis	Fracture: failed internal fixation	TKA (PFA)	1300	195	19	22	3.6
8	66	Osteoarthritis	Fracture	TKA (PFA)	1000	160	13	22	4.3
9	65	Liposarcoma	Pathological fracture	PFA (DFA)	500	205	19	20	9.8
10	74	Osteoarthritis	Fracture with infection	THA (DFA)	1100	105	31	14	1.7
11	76	Osteoarthritis	Fracture: failed internal fixation	TKA (PFA)	1000	105	7	21	0.5
12	58	RA	Fracture	THA (DFA)	750	130	7	23	5.1
13	42	Osteoarthritis, Achondroplasia	Fracture: non-union	THA (DFA)	500	200	15	24	5.8
14	67	RA	Fracture	TKA (PFA)	1200	135	20	26	4.9
15	73	Osteoarthritis	Fracture	THA (DFA)	750	145	7	24	5.3[b]

DDH: Developmental Dysplasia of the Hip, RA: Rheumatoid Arthritis, LOS: Length of Stay, MSTS: Musculo-Skeletal Tumour Society.
[a] Patient died from a medically unrelated cause.
[b] Patient underwent revision for failed linkage.

Implant Design

Pre-operative long leg calibrated measurement radiographs were performed in all patients with assessment of femoral length. These were used to produce the custom-made PFA or DFA prosthesis (Stanmore Implants Worldwide, Stanmore, UK), using computer-aided design and computer-aided manufacture (CADCAM) techniques within approximately week in the UK (Fig. 1).

The cement-linked prosthesis is made from titanium alloy (Ti 6Al 4V) and has a hollow sleeve at the non-articulating end to allow direct attachment to the existing stem of the retained prosthesis using polymethylmethacrylate (PMMA) cement. This sleeve contains internal circumferential and longitudinal grooves designed to resist pull-out and torsional forces respectively. It can therefore accommodate smooth and matte finish stems. The sleeve diameter incorporated a taper between 8 and 10 mm greater than the retained stem diameter with typically 4 grooves parallel to the bone. The sleeve length was determined by the retained stem profile with a minimum 55 mm overlap. There is hydroxyapatite coating of the sleeve collar and the shaft of the prosthesis to promote biological fixation by retained cortical bone sleeves [16–18].

Surgical Technique and Post-Operative Management

The technique varied according to each individual case: the patient was positioned laterally with a posterior approach for PFAs, and supine with a medial parapatellar approach for DFAs. The existing loose components with associated cement and fibrous tissue were removed with appropriate longitudinal osteotomies to preserve bone and soft tissue attachments. A transverse femoral osteotomy was performed at a level allowing least 55 mm of the retained stem to be uncovered whilst being conservative as possible. The cement-linked prosthesis was inserted onto the stem with careful restoration of length, rotation and version. Of those patients requiring a PFA, the acetabular components were revised for significant loosening, wear or osteolysis. Based on the surgeon's discretion, either a cemented or uncemented press-fit cup was used. Of those requiring a DFA, a SMILES hinged rotating platform TKA (Stanmore Implants Worldwide) was used in all patients. Finally, the retained cortical bone was wrapped around the prosthesis to maintain muscle and soft tissue attachments where possible.

All patients received prophylactic intravenous cephalosporin antibiotic on induction and 2 further doses post-operatively, with intra-operative calf pumps, thromboembolic deterrent stockings and low molecular weight heparin for venous thromboprophylaxis. All patients were fully weight bearing post-operatively.

Medical records were reviewed for intra-operative data including implant details, operating time and estimated blood loss.

Clinical and Radiological Evaluation

Patients were followed up clinically at 6 weeks, 6 months and 12 months postoperatively with subsequent annual/biannual reviews. Early and late post-operative complications were recorded, including the need for revision. Post-operative function was assessed using the Musculo-Skeletal Tumour Society (MSTS) score [19] at the latest follow-up. Pain, functional capacity, emotional acceptance, walking distance, use of a support and gait are each evaluated on a 5-point scale, with a maximum total score of 30.

Anteroposterior (AP) and lateral radiographs of the femur were taken post-operatively and then annually to assess for any change in implant position, linear polyethylene wear (modified Livermore technique) [20], femoral and acetabular defects (Paprosky classification) [21,22], radiolucent lines (>2 mm at the bone-implant/cement interface) (according to Delee and Charnley [23] and Gruen [24] zones for THA and Modified Radiographic Evaluation System [25] for TKA).

Results

Baseline Characteristics

Fifteen patients had a cement-linked femoral prosthesis (12 female and 3 male) with a mean age of 68 years (42–87). The mean length of clinical and radiological follow-up in clinic for all 15 patients was 5.3 years (0.5–19.3).