Uncemented revision stem for biological osteosynthesis in periprosthetic femoral fractures

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Summary. *Fractures around a femoral prosthesis have been treated with plating and additional cement, but this leads to further reduction of bone stock in the proximal femur. Since February 1992, we have dealt with this problem in 12 patients by revision using a long uncemented stem and distal interlocking combined with homologous bone grafting. Bony ingrowth and remodelling led to restoration of the proximal femur. After bone healing, removal of the distal interlocking screws converts the distal load transfer to the proximal anchoring of the revision stem so that osteointegration can occur in the trochanteric region. The clinical results were good in all the patients after a mean follow up of 23.5 months. This is a method which provides biological osteosynthesis and is especially indicated in younger patients.*

Résumé. *Les fractures fémorales périprothétiques constituent en chirurgie orthopédique un problème majeur. Les traitements conventionnels, pose d'une plaque et/ou de ciment, accentuent la diminution de la masse osseuse dans le fémur proximal. Une méthode de conception différente a été employée chez 12 sujets depuis février 1992. Cette intervention de reprise sans utilisation de ciment consiste à implanter une longue tige de reprise avec un verrouillage distal pour la stabilité initiale et une allogreffe osseuse. La formation et le remodelage osseux ont permis une excellente restauration du fémur proximal. L'ablation des vis distales*

(dynamisation) après remodelage de l'os convertit le transfert distal de charges en ancrage proximal de la tige de reprise et favorise l'Osteointegration dans la région intertrochanterienne. De bons résultats cliniques ont été obtenus chez tous les sujets au terme d'une période de suivi de 6 à 39 mois (23,5 mois en moyenne). La reprise prothétique sans utilisation de ciment, avec greffe osseuse et dynamisation, est considérée comme une ostéosynthèse biologique convenant surtout aux sujets assez jeunes.

Introduction

Fractures of the femoral shaft after total hip replacement (THR) are a major problem [3]. The accumulated postoperative risk during a period of 15 years has been calculated as 2.5% [14] and 2.3% [30]. Predisposing factors are loosening of the femoral implant, defects in the cortex from screw holes or misdirected reaming, stress concentration, and severe osteoporosis [4, 15, 30]. Bone loss after excessive use of cement is common [2].

Different procedures for treating femoral fractures after THR have been reported, including casting or skeletal traction, plating or cerclage wiring with or without bone grafting, and implantation of long stemmed prostheses [1, 3, 15, 18, 19]. When the prosthesis is loose and there are bony defects, the implantation of cemented long stemmed components combined with plating may be needed to achieve stability. This may be followed by progressive bone loss in the proximal femoral shaft caused by the toxic effects of the

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Fig. 1. **a** Micromovement of the proximal part of the revision stem due to instability at the fracture site, bone loss in the proximal femur and the mechanical properties of the stem. **b** Bone formation and healing restores the proximal femur; micromovement still occurs and impedes osteointegration (*small arrows*). **c** Removal of the interlocking screws leads to slight sinkage of the stem and load is transferred to the trochanteric region. Micro-movement is minimised and osteointegration can take place

bone cement, and plating may compromise the blood supply of the femur [28]. Instability and refracture have occurred in our patients.

We now report a different concept in which a long stem prosthesis, developed for uncemented THR revisions, is used. The prosthesis is temporarily fixed in the distal part of the femur by distal interlocking screws and supplemented by homologous bone grafting. After bone healing and remodelling of the proximal femur, proximal load transfer is achieved by removal of the distal screws.

Patients and methods

All patients with periprosthetic fractures admitted to our hospital are operated on. Since February 1992, 12 patients were included in this study. Others were excluded because of general disorders and were treated by conventional plating. There were 5 men and 7 women with a mean age of 69.5 years (range 43 to 81 years). The primary THR had been carried out a mean of 8.7 years (range 1 to 17 years) before fracture. In one patient, the THR had been revised. In 5 patients, the stem was loose before the fracture.

A revision stem has been designed based on the uncemented BiContact™ stem system (Aesculap, Tuttlingen, Germany) [24]. The distal part is a straight loosely fitting stem resembling a solid intramedullary nail. Two holes are provided for distal interlocking. There are two lengths needed for different amounts of bone loss, one extending to the midshaft.

Primary distal fixation is obtained by distal interlocking, and supplemented by bone grafting. Bone ingrowth, together with fracture healing, restores the bone stock of the proximal femur. Micromovement occurs which further stimulate bone growth. Secondary stability and proximal load transfer is

Table 1. Results at follow-up

Pain	No pain		6/12
	Slight pain while walking		6/12
	Severe pain		0/12
Gait	Normal		4/12
	Limp		8/12
Joint mobility	Extension deficit	None	8/12
		< 10°	4/12
		> 10°	0/12
	Flexion	< 60°	3/12
		60°	5/12
		80°	
		≥90°	4/12
	Internal rotation	0°	2/12
		≤10°	6/12
		≥15°	4/12
Radiological result	Fracture healed, no loosening, prosthesis stem correct		11/12
	Fracture healed, axial shortening 3 cm		1/12

accomplished by removal of the distal screws 6 to 9 months after operation, so that the stem can sink a short distance and become stabilised in the proximal femur. Micromovement is now reduced and osteointegration takes place in the trochanteric region (Fig. 1); this is further encouraged by using a microporous surfaced titanium [5].

Surgical technique

On admission, the injured leg is immobilised by traction through the tibial tuberosity. The procedure is planned and a preoperative drawing made. The transfemoral approach is used [9, 25] with some modifications. A long lateral incision is

Fig. 2. a–f A man, 78 years of age, with a periprosthetic fracture. **a** Radiograph after the fracture. **b** Revision with a long uncemented stem with distal interlocking and homologous bone grafting. **c** The proximal femoral region is consolidating 3 months after operation. **d** A bone sample is being taken from the proximal femur under radiographic control. **e** Histology demonstrates normal bony structure with viable osteocytes next to fibrous tissue (HE, $\times 150$). **f** Follow up at 1½ years. The interlocking screws have been removed. The trochanteric wires have broken and the stem has sunk. Complete restoration of the proximal femur

made and, after exposing the femur, holes are drilled at the tip of the stem, depending on the fracture. The holes and the fracture are connected by opening the femoral shaft with an oscillating saw and a chisel so that the proximal femur is split. Care must be taken not to separate the fragments from the soft tissues because of the risk of damage to their blood supply. The stem can be exposed through this transfemoral approach and cement is carefully removed. The acetabular cup is checked for stability at this stage and revised if it is loose. The appropriate revision stem is next inserted into the distal femoral shaft and fixed by 2 interlocking screws, using a radiolucent device to site the drill holes correctly. The fragments of the femoral stem are attached to the prosthetic stem by cerclage wires. Massive deep frozen homologous bone grafts are packed around the site. The wound is drained and closed. Antibiotics are given perioperatively.

Partial weightbearing (20 kg) is allowed on the seventh day after operation and this is continued until the twelfth week. Full weightbearing is then allowed if the radiographs are satisfactory. The interlocking screws are removed 6 to 9 months later. Bone biopsies are taken at this time.

Each patient was followed closely and data recorded about mobilisation, gait and pain. A detailed clinical examination included the state of the soft tissues, leg lengths and joint mobility. Anteroposterior and axial radiographs were taken.

Results

The operations were carried out as planned in every case, and there were no intraoperative complications, except for one fracture of the femur which did not affect subsequent management. In 5 patients the acetabular component was also revised, using bone graft and a support ring. There were no serious postoperative complications and no infections.

The patients were followed for a mean of 23.5 months (range 6 to 39 months (Table 1)). They were all fully mobile, as good or better than before the revision; 6 needed a single crutch, but the remainder could walk without support. Most patients limped to a variable extent. No patient had severe pain, 6 had slight pain when walking. Shortening was present in 7. Hip movements were limited in most patients. Radiographs confirmed that all the fractures were united and there were no signs of loosening. The position of the prosthesis was correct in all except one patient, in whom 3 cm of distal displacement of the stem had occurred. The diagrams in Fig. 2 illustrate the sequence of events.

Histology

Bone samples were taken from the region of the grafted bone in the proximal femur under radiographic control (Fig. 2d). A highly differentiated osseous structure of normal bone with viable osteocytes was found in all but one case (Fig. 2e).

Discussion

Conservative treatment of periprosthetic fracture is recommended by several authors in order to avoid damaging the periosteal blood supply and to avoid operative trauma [1, 11, 15]. Some surgeons achieve stabilisation by using plates, cerclage wiring or Parham bands [4], and this may be suitable when there is no loosening of the femoral stem and no comminution [3]. These methods have been advised even when there is loosening and revision is performed later [11]. Comminuted fractures around the stem and prior loosening can be treated by revision [4, 21]. Special revision stems are widely used, mostly with cement [20, 21, 30], and stability gained by additional plating, often with 2 plates and additional cement [30]. The combination of a Charnley stem and a Küntscher nail with cement has been reported [18, 29]. In a small number of cases, THR is used without cement [13, 26, 30].

Bone grafting, either homologous or autologous, used increasingly in revision operations [10, 16, 17, 27] and in periprosthetic fractures is capable of building up bone stock in the proximal femur. The histology in our cases demonstrated the presence of normal bone.

Bone formation is stimulated by our type of revision stem with distal interlocking because its elastic properties allow the long stem to 'swing' in the proximal region, providing favourable conditions for new bone formation. The positive effects of a small amount of movement for bone healing have been demonstrated in many experimental studies [8, 22]. This has altered the principle of rigid internal fixation towards more biological procedures, such as interlocked nailing [6, 7, 13].

The concept of the BiContact™ stem for uncemented implantation is of proximal load transfer to the trochanteric region. The stem is fixed temporarily by distal interlocking when osteointegration of the proximal stem is impeded by micro-movements. Proximal load transfer cannot be achieved in other types of uncemented revision [9]. Further weakening of the proximal femur can occur due to stress shielding. Early re-revision and the insertion of a stem with a press-fit could solve this problem. A simpler alternative is the removal of the interlocking screws after restoration of the proximal shaft which allows the stem to sink slightly and produce a press-fit in the trochanteric region. Primary distal anchorage is thus converted to proximal load transfer. Rotational stability is obtained by the antirotation wing. Osteointegration

is further encouraged by the stem coating of microporous titanium [5].

The short-term results with our method of dealing with periprosthetic fractures have been encouraging.

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