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Technical note

Global fit concept in revision hip arthroplasty for cementless press-fit femoral stems

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ABSTRACT

A revision stem may be required after a femoral extended trochanteric osteotomy (ETO) is made during revision hip arthroplasty. The two main complications of straight cementless femoral stems are subsidence due to inadequate osteointegration and stress-shielding. We will describe an original revision method with ETO that uses a straight cementless stem. The goal of this method was to achieve the most extensive press-fit possible during stem implantation to improve the transmission of stresses to the bone and to prevent reduction in bone density. The intramedullary preparation was done after closure and fixation of the ETO, which allows impaction of the revision stem with metaphyseal and diaphyseal press-fit. We report encouraging results with preservation of periprosthetic bone stock and good osteointegration of these revision stems at the final follow-up. Pronounced sagittal curvature or large bone defects are contraindications for this technique.

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1. Introduction

The primary stability of a straight, cementless, non-locked femoral implant during revision hip arthroplasty with a femoral extended trochanteric osteotomy (ETO) is based on the principle of distal press-fit. This applies to a 3–4 cm long contact area between the portion of the femur distal to the ETO and the straight, conical stem with fins, according to the Wagner stem principle [1]. In this technique, the ETO is closed after the femoral stem is implanted. While it leads to good clinical outcomes and osteointegration, there is a clear risk of stress-shielding [1,2]. This adverse event, which can impact the clinical outcomes, results in reduced bone density in the proximal femur due to poor transmission of the bone stresses [1–3]. We propose a modification to achieve "global fit" that improves the transmission of mechanical loads between the bone and femoral stem, and minimizes secondary bone loss. The key change is that the femoral stem is implanted after the ETO is fixed. This technical note describes revision arthroplasty using ETO with the goal of achieving global press-fit.

2. Surgical technique description

CT-based planning is essential to anticipating technical difficulties such as bone defects, cement limits, and femoral curvature. The implant was a modular, cementless straight revision stem (Revitan^{TM}, Zimmer-Biomet, Warsaw, IN, USA). A posterolateral approach was used to make the ETO flap (ETO extended distally based on local conditions such as length of cement mantle or prior cementless stem), which was pedicled to the vastus lateralis and the gluteus medius. The mean flap length was 15 cm from the top of the greater trochanter; the width was one-third of the femur's circumference. After the flap was made, a clamp was placed distal to it and held closed during the entire procedure to prevent intraoperative fracture (Fig. 1) (Global Fit.mov movie).

The existing stem, cement and granuloma were removed from the femur. The femur was prepared with cylindrical and then conical reamers distal to the flap to prepare the distal press-fit, as in the standard method (Fig. 1) (Global Fit.mov movie). A trial implant was inserted to check the quality of the distal press-fit (absence of subsidence and length of fit) and the implant length (leg length). The ETO flap was then closed after removing the trial implant (Fig. 1) (Global Fit.mov movie). The ETO was secured using two or three steel wires over its entire length. Next, the greater trochanter was meticulously prepared to avoid varus positioning of the femoral stem (three-point contact). The reamers were then inserted into the femoral canal, until the diameter matched the trial stem implanted

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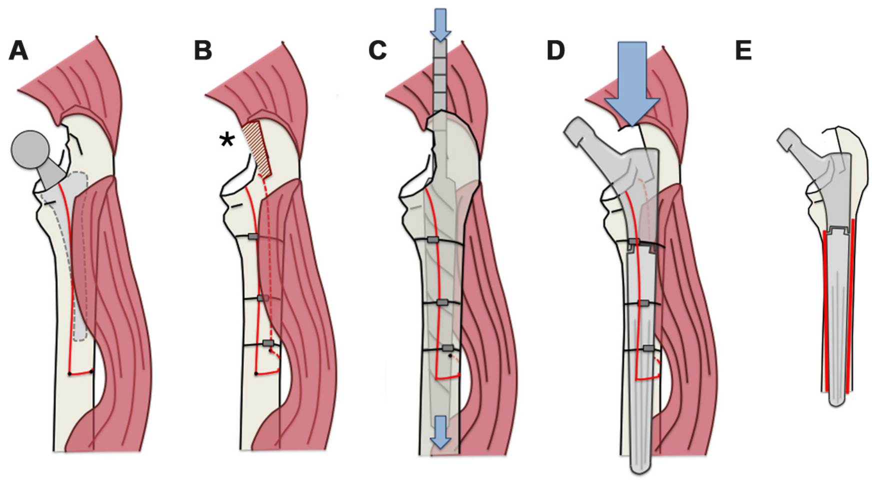

Fig. 1. The global press-fit concept. A. Making the extended trochanteric osteotomy (ETO) flap and extracting the stem. B. Resecting the trochanteric calcar (*) and flap fixation after preparation of distal press-fit. C. Intramedullary preparation with flap closed. D. Impaction of straight cementless revision stem. E. Achieving global fit.

during the "open ETO flap" phase (Fig. 1) (Global Fit.mov movie). A trial implant was inserted to assess the intramedullary preparation and leg length. The definitive revision stem was impacted with the flap closed and elevated based on the required length and anteversion (Fig. 1) (Global Fit.mov movie). Weight bearing was not allowed for the first 3 weeks when the revision involved only the femoral side.

3. Results

We used this technique in a pilot study of 5 patients (4 men, 1 woman) operated for aseptic cup and stem revision of total hip arthroplasty within a larger set of 90 revisions (mean age 66.5 years, range 55–88). These patients improved clinically after the revision procedure, with the Harris Hip score going from 42.2 points (38–53) to 83.8 points (52–95) at the final follow-up. The stem's osteointegration and bone density at the last follow-up were evaluated using specific outcome scores [2–6]. The periprosthetic femoral bone density was evaluated through the appearance of osteolysis [3]. The bone stock was evaluated through the cortical thickness, quality of the cortical trabecular bone and the presence of osteolysis [3]. Lastly, the osteointegration and secondary stability (O-SS) score consisted of the assessment of a clear periprosthetic radiolucent line [5,6]. There was little migration of the femoral stem, good preservation of the bone stock and osteointegration at the final follow-up (Table 1). Fig. 2 is an example case (No. 3).

4. Discussion

Bone integration of the revision stem is a prognostic factor for implant survival. Reduction of the bone density in contact with the revision stem can be observed during the follow-up period. This impacts not only the implant's survival, but also the functional outcomes [3,4]. In this context, the concept of metaphyseal and diaphyseal fit over the entire stem aims to improve the transmission of stresses to the bone and in the end, the stem's integration.

Several parameters must be evaluated during the follow-up of a cementless femoral stem: change in the bone stock and its regeneration, along with assessment of clear periprosthetic radiolucent lines. This assessment is particularly relevant for implants with a porous surface coating [6]. Hence, during the radiological monitoring, reduction in bone density is typically reported in published studies. This assessment is vital for understanding the extent of the femoral stem's fixation [3–5,7]. Several methods have been described to assess this change over time. Recently, Canovas et al. [2,3] published a radiological assessment method that is used to classify the changes in bone density and periprosthetic bone stock in the Gruen zones. These changes were correlated to the cortical index ($p < 0.02$). In a study of 183 revision cases after a mean follow-up of 6.3 years (2–15), bone density was reduced in 32 cases (21%) and there were 13 cases of cortical atrophy [4]. In our case series, the femoral periprosthetic bone stock was well-preserved, especially in Gruen zones 1 and 2, corresponding to those of the usual ETO flap length.

There are certain technical limitations: a medial osteotomy is needed when the femur is curved in the sagittal plane, which makes it a contraindication for this technique [5]. Massive femoral bone defects (SOFCOT stage 3, 4) are also a contraindication. A failure is likely with 3-point fixation due to varus shifting of the stem. The "global fit" concept needs to be evaluated prospectively over the long-term to compare the changes in the bone density and osteointegration in contact with the revision stem.

Table 1
Radiological outcomes of revision hip arthroplasty cases using the global fit technique.

	Follow-up (months)	Flap healing (months)	Bone density[a] [3]	Cortical index[a] [3]	Stem migration[a] (mm)	Bone stock Preoperative /Follow-up (/20) [2,4]	Score O-SS[a] (/20) [4]
Case 1	76	3	Stage 1	0.40	1	18/16	14
Case 2	74	5	Stage 1	0.52	1	14/14	18
Case 3	62	3	Stage 1	0.56	2	16/14	20
Case 4	72	3	Stage 1	0.56	3	20/18	20
Case 5	64	5	Stage 1	0.48	1	16/16	20

Bone stock [2,4]: analysis of extent of periprosthetic osteolysis; O-SS score [4]: osteointegration–secondary stability based on extent of periprosthetic radiolucent lines; bone density [3]: localized reduction in bone density over at least two Gruen zones (stage 1); reduction of more than two zones (stage 2).

[a] Assessment at last follow-up.

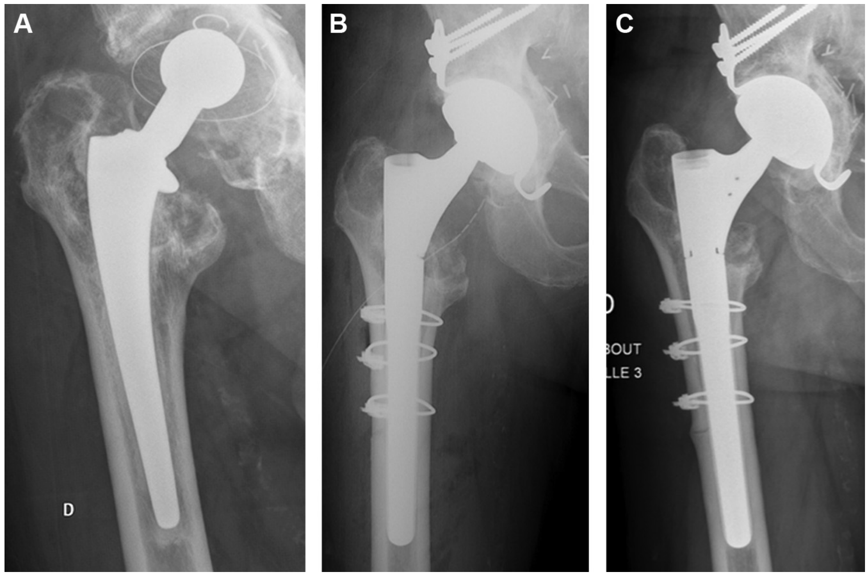

Fig. 2. Example of global fit in case No. 3. A. Indication for cup and stem revision in an 88-year-old patient. B. Postoperative radiographs with global fit. C. Review after 62 months with good osteointegration and secondary stability (moderate osteolysis in Gruen zone 2 and absence of periprosthetic radiolucent lines).

Disclosure of interest

François Canovas is an educational consultant for Zimmer GmbH, Pierre LeBeguec has financial links with Zimmer GmbH. Louis Dagneaux received a research scholarship from the SOFCOT in 2013, that is not related to this work.

Julien Batard and Florent Gaillard declare that they have no competing interest.

Appendix A. Supplementary data

Supplementary data associated with this article can be found, in the online version, at http://dx.doi.org/10.1016/j.otsr.2017.01.015.

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