De-escalation exchange of loosened locked revision stems to a primary stem design: Complications, stem fixation and bone reconstruction in 15 cases

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KEYWORDS
Total hip arthroplasty revision; Femoral bone loss; Locked femoral component

Summary
Introduction: Femoral stem revision with a locked stem after total hip arthroplasties treats severe bone defects by favoring spontaneous bone reconstruction. Initially, once reconstruction was obtained, the temporary implant was to be replaced by a standard primary component. The use of locked stems has increased, but repeat revision with a short stem which is also called ‘‘de-escalation’’ has not been extensively studied.

Hypothesis: Repeat revision of a locked stem with a short stem is not associated with any specific morbidity and does not affect the quality of reconstruction obtained, or fixation of the subsequent primary length primary design stem.

Patients and methods: Fifteen patients whose locked femoral stem was exchanged due to thigh pain and/or radiographic images showing failed osteointegration were analyzed. These 15 patients were all followed-up and evaluated by the Postel Merle d’Aubigné score. Progression of bone defects was evaluated using the Hofmann cortical index.

Results: There were no difficulties extracting the locked stem and a standard length primary stem was inserted with no associated procedures or bone complications in any of the cases. At a mean follow-up of 55 months (36–84 months), thigh pain had disappeared and the Postel Merle d’Aubigné score had increased from 12.6 ± 2.9 (7–16) to 16.5 ± 0.9 (15–18) (P=0.0001). The use of a locked femoral stem resulted in bone reconstruction in all cases, the Hofmann index increased from 30.5% ± 17.9% (12–71%) before insertion of the locked stem to 43.6% ± 25.6% (19–90%) at exchange (P<0.05). Bone reconstruction was durable after the exchange with a stable Hofmann index 43.7% ± 26.2% (17–92%) at the final follow-up (P=0.9). No recurrent loosening occurred.

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Introduction
Revision total hip arthroplasties (RTHA) and the severity of bone defects which are the indication for these revisions are increasingly frequent [1,2]. The use of locked stems, developed by Pierre Vives in 1987 [3], has been widespread in France. The initial concept was to implant a temporary revision locked femoral stem to obtain bone reconstruction in order to then implant a standard primary femoral stem [3–5]. Thus the idea of “exchange” or “de-escalation” was developed which involved changing a long revision stem by a standard length primary stem.

In fact, this idea of exchange has not been consistently applied, because locked stems have produced satisfactory and long lasting results [6–10] with regular bone reconstruction methods [7–9]. The notion of a temporary implant has evolved into a definitive implant as implant designs and surface treatments have improved. For all these reasons, there are very few studies on these exchanges in the literature. We began using locked stems in 1994, and according to Pierre Vives we performed exchanges in the presence of clinical symptoms of failed osteointegration or symptomatic implant breakage (stem or screws). The aims of this study were:

- to evaluate the clinical results of locked stem revision by a shorter stem;
- to evaluate the technical difficulty of this type of exchange;
- to describe the outcome of fixation of the short stem and the durability of bone reconstruction obtained with the locked stem.

Materials and methods
Patients
We performed a retrospective analysis of a monocentric series of repeat revisions of locked stems with standard length primary stems, according to the “de-escalation” technique. Two hundred and fifty-nine locked stems (101 UltiTime™ et 158 Linea™) were implanted between 1994 and 2007 in our institution. Etiologies for RTHA with a locked stem were: aseptic loosening in 120 cases (46.3%), septic loosening in 46 cases (17.6%) and peri-prosthetic fractures in 71 (27.4%) cases, while there were specific indications in 22 cases (after tumor resection of the proximal femur, broken implants, fracture of the femur associated with osteoarthritis of the hip). Bone defects were severe: 101 (39%) stage III and IV on the Société française de chirurgie orthopédique et traumatologique (SoFCOT) score [11]. Between 2001 and 2008, 15 patients (15 stems) (9 men, 6 women) underwent de-escalation exchange or 5.7%. Mean age at exchange was 60.8 years (41–83 years), the mean delay between insertion of the locked revision stem and de-escalation exchange was 71.8 months (30–148 months). The minimum follow-up for evaluation of the repeated exchange stem was 36 months.

The indication for de-escalation exchange was based on thigh pain (n = 11) and/or radiological features of stem loosening (progressive radiolucent lines (n = 15), stem breakage (n = 1), or severe facing the locking screws (n = 11)).

Surgical technique
Two types of locked stems were revised:

- UltiTime™ stem (Cremascoli-Wright, Créteil, France) in 10 cases;
- Linea™ revision stem (Tornier, St.-Ismier, France) in five cases (Figs. 1 and 2).

All surgical interventions were performed by a postero-lateral approach. An additional lateral incision was made in the thigh in 14 cases to remove locking screws. The standard primary stem used for de-escalation exchange was a straight cementless Alloclassic™-SL (Zimmer, Étupes, France) in 10 cases and a cemented stem in five cases including three straight self-locking Müller™-implants (Zimmer, Étupes, France) and two Charnley Kerboul™-implants (Stryker, Pusignan, France). Postoperative full weight bearing was allowed in all cases. The choice of the stem for exchange was left up to the surgeon, however cemented stems were used in the first cases, then cementless stems were systematically used thereafter.

Methods of evaluation
Patients were evaluated by the Harris (HHS) [12] and Postel Merle d’Aubigné (PMA) scores [13] before revision surgery, at final follow-up and for intermediary follow-up visits (at 1 and 6 months, then annually). Thigh pain was investigated. Patient satisfaction was evaluated at follow-up using a 4-point scale: very satisfied, satisfied, disappointed, and dissatisfied. The etiology of failure of the locked stem, and the condition of bone, the presence of implant breakage and union of the femorotomy were investigated on anteroposterior (AP) and profile pelvic X-rays [11] (Table 1), while signs of bone regeneration were determined with the Hofmann cortical index measured 1 cm below the lesser trochanter [14] (Table 1).
During removal of the revision stem, we investigated difficulties of the surgical procedure. In cemented implants, the follow-up evaluation included identifying the presence, site and progression of radiological radiolucencies according to Gruen et al. [15] and distal or tilting migration of the femoral component. In cementless implants, the evaluation was performed using the Engh et Massin classification [16]. Finally, to avoid any differences due to X-ray film enlargement, a relationship between the diameter of the known and measured femoral head components was calculated so that all radiographic measurements could be corrected with this report. The distance between the trochanter and the lateral shoulder of the stem was systematically measured and corrected. Loosening of the exchange stem was confirmed if two elements were identified: more than 5 mm of distal migration or tilting of more than 3° and/or the development of a complete radiolucency of > 2 mm.

**Statistical methods**

Descriptions used means, standard deviations, ranges and percentages for categorical values. Non-parametric tests were used for the comparison of radiological and clinical status at different steps of clinical progress (Mann Whitney U test, Kruskall Wallis, F test). \( P < 0.05 \) was considered to be significant.

**Results**

**Morbidity and complications**

All revision locked stems were removed without perioperative fractures, the use of additional bone replacement techniques, or difficulty according to surgical reports.
Femoral preparation was performed with standard equipment without additional reaming. In one case, the acetabular component was also changed (Fig. 1). None of the patients presented with mechanical or infectious complications on the arthroplasty. In particular, there were no fracures on the former distal screw holes of the locking system.

**Clinical results**

All patients were seen at follow-up. The mean follow-up was 55 months (36–84 months). Before de-escalation exchange, the mean clinical PMA scores were 12.6 ± 2.9 (7–16), and the HHS was 67.9 ± 18.2 (25–79.5). At the final follow-up, the PMA score was 16.5 ± 0.9 (15–18) and HHS was 90.6 ± 6.9 (79–98) (P = 0.0001). At follow-up, none of the patients presented with thigh pain, and all patients were very satisfied (n = 4) or satisfied (n = 11). None of the patients required additional surgery.

**Radiological results**

Before de-escalation exchange, there were no SoFCOT stage 3 or 4 defects, compared to nine out of 15 cases before implantation of the locked stem (Table 1). Union of the femorotomy was successful in all cases before de-escalation exchange on X-ray and this was also confirmed in the surgical reports. The locked stem favored bone reconstruction because the Hofmann index went from 30.5% ± 17.9% (12–71%) before implantation of the locked stem to 43.6 ± 25.6% (19–90%) at de-escalation exchange (P < 0.05). Bone reconstruction provided by the locked stem was durable after de-escalation exchange because there was very little change in the Hofmann cortical index at the final follow-up: from 43.6% ± 25.6% (19–90%) to 43.7% ± 26.2% (17–92%) at final follow-up (P = 0.9). Migration of more than 5 mm, tilting of more than 3° or radiolucent lines of more than 2 mm were not observed in any of the stems used for de-escalation exchange suggesting that osteointegration of the cementless femoral implants had occurred [16] and cemented stems had not loosened [15].

**Discussion**

In most cases, locked stems definitively treat femoral loosening of THA with bone defects because in our series of 259 cases, the rate of exchange due to incomplete osteointegration was only 5.7%. When fixation fails in a locked stem, revision by a standard stem is possible and does not result in significant morbidity (no bone defects, no postoperative fractures or failure of the standard stem, no additional bone reconstruction technique). After this exchange procedure, all thigh pain disappeared at a mean follow-up of 4.5 years without any current loosening.

The results of our series are similar to those observed during revision THA with moderate bone defects [17–22]. Thus Thorey et al. [17] found a significant improvement in clinical scores with the HHS increasing from 42.2 ± 20.8 to 78.9 ± 12.5 after a mean 6.8 years of follow-up with revision by standard cementless femoral stems. Our radiological results are also encouraging and similar to results

### Table 1: Etiologies for revisions, stage of bone defects and their progression according to the Hofmann index before de-escalation exchange and at follow-up.

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<tr>
<td>Mrs. Lo</td>
<td>Implant breakage</td>
<td>1 T0 N N</td>
<td>25</td>
</tr>
<tr>
<td>Mrs. Al</td>
<td>Aseptic loosening</td>
<td>1 T1 N N</td>
<td>30</td>
</tr>
<tr>
<td>Mrs. Hu</td>
<td>Aseptic loosening</td>
<td>1 T1 N N</td>
<td>32</td>
</tr>
<tr>
<td>Mr. Kr</td>
<td>Implant breakage</td>
<td>2 T2 N N</td>
<td>26</td>
</tr>
<tr>
<td>Mrs. An</td>
<td>Septic loosening</td>
<td>1 T0 N N</td>
<td>51</td>
</tr>
<tr>
<td>Mr. Be</td>
<td>Aseptic loosening</td>
<td>2 T1 N N</td>
<td>19</td>
</tr>
<tr>
<td>Mr. De</td>
<td>Aseptic loosening</td>
<td>2 T0 N N</td>
<td>31</td>
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<tr>
<td>Mrs. Do</td>
<td>Aseptic loosening</td>
<td>1 T0 N N</td>
<td>48</td>
</tr>
<tr>
<td>Mrs. Fa</td>
<td>Aseptic loosening</td>
<td>1 T1 N N</td>
<td>39</td>
</tr>
<tr>
<td>Mr. Le</td>
<td>Peri-prosth. fracture</td>
<td>2 T0 N N</td>
<td>90</td>
</tr>
<tr>
<td>Mr. No</td>
<td>Septic loosening</td>
<td>1 T0 N N</td>
<td>91</td>
</tr>
<tr>
<td>Mrs. Pe</td>
<td>Aseptic loosening</td>
<td>2 T0 N N</td>
<td>26</td>
</tr>
<tr>
<td>Mr. Pi</td>
<td>Aseptic loosening</td>
<td>2 T2 N N</td>
<td>31</td>
</tr>
<tr>
<td>Mr. Bi</td>
<td>Septic loosening</td>
<td>1 T0 N N</td>
<td>25</td>
</tr>
<tr>
<td>Mr. Go</td>
<td>Septic loosening</td>
<td>2 T1 N N</td>
<td>90</td>
</tr>
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Peri-prosth. fracture: peri-prosthetic fracture. SoFCOT staging of bone loss [11]: the first figure indicates bone loss stages. Stage 0: no bone defects; Stage 1: thin but acceptable cortex with more or less significant calcar osteolysis; Stage 2: thin lateral cortex, good medial cortex; Stage 3: thin lateral cortex, medial cortex partially destroyed under the lesser trochanter; Stage 4: proximal femur translucent or disappeared. Second letter: damage to the greater trochanter T; T0: intact trochanter T1: altered trochanter; T2: fractured or non-united trochanter. Third letter: (Y or N) extension of bone loss to the femoral diaphysis; Fourth letter (Y or N): fracture of the femoral diaphysis. Method of calculating the cortical index by Hofmann et al. [14] 1 cm below the lesser trochanter = (thickness of the lateral cortex + thickness of the medial cortex)/width of the femur) × 100.
for revisions with limited bone defects [17–22]. Pinaroli et al. [22] reported 100% osteointegration with standard length cementless femoral stems for revision THA when bone defects were limited to stages 1 and 2 on the Paprosky scale [23]. Thus most severe bone defects (9/15) became moderate defects after using locked revision stems, allowing for de-escalation exchange and the use of standard primary stems as in the series by Pinaroli et al. [22]. Our series shows that a standard stem can be used in repeat revision when initial bone reconstruction is obtained with locked revision stems. In the literature, the use of primary stems for RTHA is only possible under certain conditions [17–23]: mild bone defects [19,23], an implant that is easy to extract with no iatrogenic bone loss during removal [24–26], the necessity of obtaining perfect primary stability [20,22]. These conditions were met in our series because all bone defects before exchange were stages I or II on the SOFCOT score and removal of the former locked stems was simple with no additional bone lesions or additional procedures.

Although our series was limited by the small number of cases and the short follow-up making it difficult to draw firm conclusions on the durability of fixation, our main goal was to determine the feasibility and morbidity of this procedure. However, there were no anomalies at the final follow-up to suggest impending failures. Finally, the use of mixed cemented and cementless fixation during de-escalation exchange is a definite limitation to our study, but this also allows the possibility of revision according to the surgeon’s preferences [17–22].

Our series shows that de-escalation exchange does not modify the bone reconstruction obtained with a locked stem. The Hofmann cortical index does not decrease, and there was no recurrent osteolysis. Bone reconstruction after RTHA with a locked revision stem progresses for the first year [27]. Our series with a minimum follow-up of 30 months before exchange, as well as at least 36 months after exchange, suggests that bone reconstruction is stable. Although these repeat femoral stem revisions can also be performed with long stems, we feel that de-escalation exchange has the following advantages:

- exchange preserves bone stock obtained because it is not necessary to reami the diaphysis to use a long stem which can cause stress shielding [26];
- it simplifies any repeat revisions and prevents creating a weakened area between two components (a long stem THA and a total knee arthroplasty with a femoral extension) which may be the site of a difficult-to-treat femoral peri-prosthetic fracture [28,29].

Conclusion

Although this is a small series, our results suggest that de-escalation exchange of a loosened locked revision stem is a simple procedure which does not require additional means of extraction or repeated reconstruction. Locked stems are part of the arsenal of therapeutic options to treat significant loosening and successfully provide bone reconstruction without a graft. This study emphasizes that de-escalation exchange of a failed locked revision stem with a shorter stem is always possible without adverse effects. Fixation of standard primary stems in this reconstructed bone is stable in the short term but must be confirmed in long-term studies.

Disclosure of interest

Julien Girard and Henri Migaud have an occasional activity as consultants for education and research at Zimmer and Tornier.

B. Miletic, O. May, N. Krantz and G. Pasquier declare that they have no conflicts of interest concerning this article.

References


