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ORIGINAL ARTICLE

Radiographic preoperative templating of extra-offset cemented THA implants: How reliable is it and how does it affect survival?

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KEYWORDS
Cemented stem;
Offset;
Abductor muscle lever arm;
Hip abductor moment arm;
Survival

Summary
Introduction: Securing femoral offset should in theory improve hip stability and abductor muscles moment arms. As problems arise mainly in case of originally increased offset (> 40 mm), a range of extra-offset stems is available; the exact impact in terms of fixation, however, is not known.
Hypothesis: Extra-offset stems should more reliably reestablish original femoral offsets exceeding 40 mm than standard femoral components, limiting instability risk without possible adverse effect on fixation.
Objective: To compare the ability of five commonly available femoral stem designs to restitute offset exceeding 40 mm, and to assess function and cement fixation at a minimum 6 years' follow-up in a stem conceived to reproduce such offset.
Patients and methods: A continuous series of 74 total hip replacements (THR) in hips with increased (> 40 mm) femoral offset was studied. All underwent preoperative X-ray templating on Imagika™ software to assess offset reproduction by five models of stem: four standard, and one Lubinus SP2™ extra-offset stem. A retrospective clinical and X-ray study was conducted with a minimum 6 years' follow-up on the Lubinus SP2™ 117° stems used to try to reproduce offset in the 74 THRs.
Results: Apart from the increased (> 40 mm) offset, the cervicodiaphyseal angle was consistently < 135°, < 130° in 60 femurs (81%) and < 125° in 45 (60%). Planning showed the four standard stems to induce (> 5 mm femoral offset reduction in 50—83% of cases, versus only 25% with the Lubinus SP2™ 117°). All 74 hips received Lubinus SP2™

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117° stems: at a mean 78 months FU (range, 70—94 mo), their mean Postel-Merle d'Aubigné score was 17 ± 1.8 (range, 13—18). Five of the 74 THRs underwent surgical revision: three cases of loosening, in which the stem was replaced, and two of instability, without change of stem. Loosening was not related to offset reproduction quality; two of the three cases were due to initial cementing defect, and the third occurred in a femur with previous history of two osteotomies. There were four cases of dislocation (5.4%: two primary, which were not operated on, and two recurrent, managed by acetabular revision), despite good reproduction of the preoperative offset in three of the four cases. Mean 7-year implant survivorship was 95.1% (± 4.8).

Discussion and conclusion: The anatomic form of the Lubinus™ SP2 117° should in theory provide a uniform cement mantle. Survivorship, however, is less good than for regular offset versions (126° or 135°). On the other hand, it does reproduce anatomy in case of > 40 mm offset, providing extra offset of more than 51 mm. The slightly shorter survivorship requires more long-term surveillance.

Level of evidence: Level IV, retrospective study.
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Introduction

Reproduction of femoral offset (or abductor lever arm) should in theory improve implant joint stability [1,2], range of motion [3] and, above all, abductor muscle strength [1,4] and function [5]. Few studies, on the other hand, support the idea that offset reproduction should protect femoral component fixation [6—8], which remains controversial: the impact of extra offset on femoral stem fixation has not been widely validated in the literature, despite being a major issue [8,9]. X-ray assessment is imperfect, underestimating offset as compared to CT-scan [10,11], but remains the more common means of planning and thus of scheduling use of an extra-offset stem [12—14]. Thus, 2D planning in femurs showing increased offset fails to predict precise offset reproduction by standard stems.

The present study analyzed a population of increased-offset femurs, to assess:

- the ability of four standard stems and one extra-offset stem (Lubinus SP2™ 117°, Waldemar-Link, Hamburg, Germany) to reproduce offset on 2D planning;
- the evolution of hip fixation following extra-offset stem implantation, compared with Swedish registry data [15], which found standard offset versions (126° and 135°) to show the best survivorship for cemented stems;
- whether possible changes in offset influenced functional score components (gait and pain) and episodic instability.

Patients and methods

Patients

The study cohort comprised 74 THRs (in 71 patients), performed between 1999 and 2001, using the 117° cervical angle Lubinus SP2™ extra-offset stem (Waldemar Link, Hamburg, Germany) (Fig. 1). The selection criterion for use of this stem during the study period was increased (> 40 mm) femoral offset and/or a cervicodiaphyseal angle < 135°. The 40 mm threshold was set as being outside the mean offset value reported by Fessy et al. [12].

The 71 patients (43 male, 27 female) had a mean age of 61 ± 10 years (range, 29—80 yrs). THR was indicated for osteoarthritis of the hip in 55 cases, osteonecrosis of the femoral head in 11 and hip inflammation in eight. Mean height was 170 ± 8 cm (range, 150—190 cm) and mean weight 79 ± 14 kg (range, 54—125 kg); mean body/mass index (BMI) was 27.1 ± 4.5 (range, 16—37), with 18 patients (24%) with BMI > 30. On the Charnley classification [16], 19 patients were grade A, 25 grade B and 27 grade C. Sixty-four hips had no history of surgery; of the other 10, six had history of femoral varization osteotomy (including three with joint stop), three of isolated joint stop, and one of osteosynthesis. The cervicodiaphyseal angle showed a mean 121.8° ± 7.6 (range, 90°—134°), and in 58 cases was ≤ 125° (78.3%). Mean preoperative offset was 45 ± 4 mm (range, 41—59 mm), with offset < 45 mm in 36 cases (48.8%).

Surgical technique

All THRs were performed by or under the supervision of four senior surgeons in vertical flux with a posterolateral approach, associating capsule and rotator repair. Stems were cemented using a second-generation technique [17] with high-viscosity cement supplemented with Gentalline® (Palacos Genta®, Schering Plough, Herouville Saint-Clair, France). Sealed polyethylene cups were used in 14 cases (including one with reinforcement ring, because of dysplasia) and cementless impacted metal-back cups in 60 cases. All femoral stems were Lubinus SP2™ with 117° cervical angle (Waldemar-Link, Hamburg, Germany). The angulation uses two cervical lengths so as to adapt limb length to the surgical data: the implant neck was 117XL in 69 cases and 117L in 15 cases (Fig. 1). Implant heads were all 28 mm caliber, in aluminum ceramic in 40 cases and chromium-cobalt in 34 cases. Head lengths were short in 10 cases, medium in 32, long in 28, and in four cases extra-long with skirt (all in CrCo).

Radiographic planning and femoral offset assessment

2D planning was based on the 74 preoperative views, taken in the same radiography room and with the same distance,

Figure 1 The chromium-cobalt Lubinus SP2™ stem has a double-curve anatomic form, providing a uniform cement mantle. The cervical angulation is 117°, with two neck lengths: standard and XL. Femoral offset and angulation are the same in all six of the sizes.

so as to limit problems of enlargement. The hip was positioned in 10° medial rotation or, in case of stiffness, in the maximal tolerated medial rotation. The consequent variations in rotation did not bias comparison between the five stems, inasmuch as they equally affected each stem. Even so, we sought to limit the impact on offset measurement by imposing a 5 mm error threshold, corresponding to a rotation variation of ± 10° [18]. Likewise, comparison between the 2D planning and the in vivo position of the 74 Lubinus SP2™ 117° stems took account only of offset errors exceeding ± 5 mm, corresponding to ± 10° variation in medial and lateral rotation [18]. The 74 images were digitized and processed by an independent (nonoperator) observer (H.A.), using the Imagika™ software package. They displayed the expected center of rotation after cup fitting: i.e., taking account of the slight medialization found in clinical practice [19,20] (Fig. 2). Two operators successively traced the five stem models onto the X-rays, at a scale of 1:15. These particular stems: Alloclassic™ (Centerpulse-Zimmer, Winterthur, Switzerland), SL-Plus Lateralized™ (Endoplus, Smith Nephew, Courbevoie, France), Kerboull-Legend™ (Stryker, Pusignan, France), Muller™ Self-locking (Centerpulse-Zimmer, Winterthur, Switzerland), and Lubinus SP2™ 117° (Waldemar-Link, Hamburg, Germany) were chosen because the surgeons were used to them and thus could foresee their behavior and how to prepare the femur in the light of the preoperative planning data. The size and position of each model were determined so as to ensure metaphyso-diaphyseal filling, and thus good stability, and reproduce offset without lengthening and with stem and diaphysis axes kept parallel (neutral position). In the preoperative planning, all joints were 28 mm diameter, using one of the three head lengths provided by the manufacturer (excluding extra-long necks). When both observers were satisfied with the positioning, images were digitized and collated for subsequent processing on the Imagika™ software (six views per patient, including one blank, showing the expected center of rotation, and five with the successive templates: i.e., 370 digitized templates for analysis). Data processing on Imagika™ was automated: location of the planned center of hip rotation on blank image, location of the femoral component head center nearest to the planned center, and measurement of X (offset error) and Y (length error) distances according to an orthonormal landmark (Fig. 3). Data were then transferred to a spreadsheet for analysis. Medialization was defined as > 5 mm negative difference between traced and theoretical centers, lateralization as > 5 mm positive difference, and no change in offset as a positive or

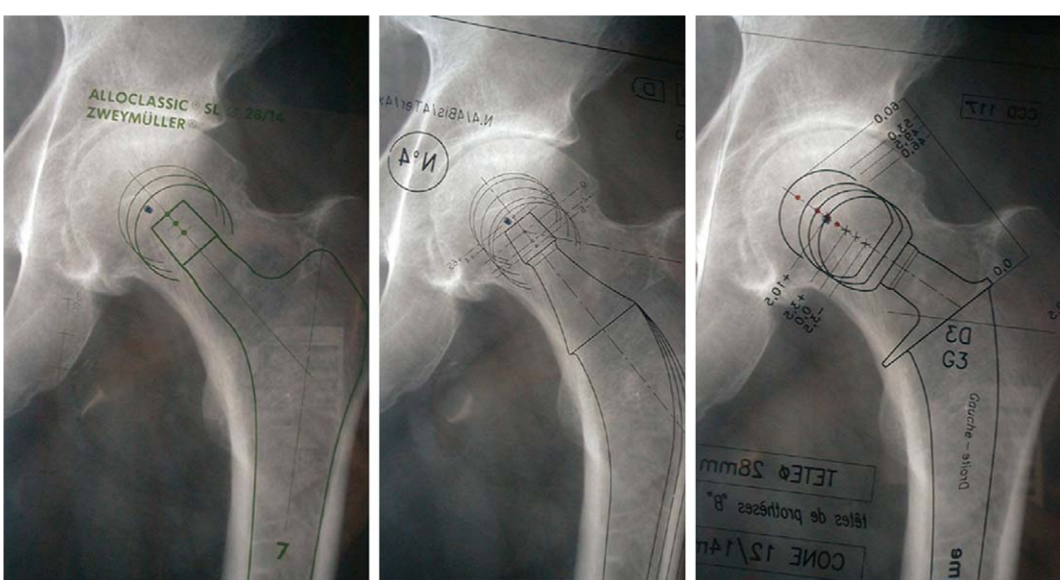

Figure 2 Templates for the Alloclassic-Zweymuller, Kerboull-Legend™ and Lubinus SP2™ 117° stems on a femur with 55 mm preoperative offset. Only the Lubinus SP2™ 117° stem reproduces this offset.

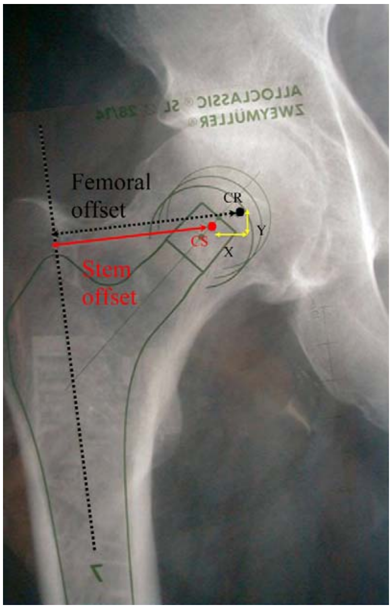

Figure 3 Template on X-ray showing the method of measuring variation in offset (X vector) and in limb length (Y vector) between the center of rotation of the hip (CR) and the center of the femoral head of the stem (CS). The center of rotation of the hip was determined taking account of the usual slight medialization of the cup [19,20]. Templates for the five kinds of stem were successively applied and digitized. Stem size and position were chosen so as to fill the femoral canal while conserving offset and limb length so far as possible. An independent observer (H.A.) measured variations in length and offset, using Imagika™ software on the digitized views.

negative difference not exceeding 5 mm. The same thresholds applied to any length variation with respect to normal Y-vector values.

Results assessment

The 71 patients (74 Lubinus SP2™ stems) were retrospectively assessed clinically and radiologically by an independent (nonoperator) observer (E.M.). Clinical results were assessed on Harris score [21] and Postel-Merle d'Aubigné [22] (PMA) score weighted according to Charnley [16]. Activity level was assessed on Witvoet's classification [23]. Follow-up X-rays were compared to immediate postoperative views, and stem fixation was assessed in terms of the seven zones defined by Gruen et al. [24]. Likewise, cementation quality was assessed on Barrack et al.'s classification [25]. Ossification was examined on FU views and categorized following Brooker et al. [26]. Offset reproduction on digitized postoperative images was assessed by the Imagika™ software, taking account of enlargement and using the same procedure as for template analysis. The operator performing the measurements on the postoperative images (H.A.) was blind to the clinical result and to the quality of offset reproduction with respect to the preoperative aspect. Variations in rotation center were assessed on the Imagika™ software, with respect to an orthonormal landmark determined by the tear-drop line, determining variations in medialization or lateralization of the rotation center, after correction for magnification, before and after implantation of the cup.

Survivorship was analyzed, with 985% confidence intervals, following Kaplan-Meier, with failure defined as stem replacement for whatever reason. Statistical tests comprised Chi^2 to compare categoric variables, analysis of variance to compare means, and correlation tests to compare continuous variables. The significance threshold was set at $p < 0.05$.

Results

Comparison of planning for the five stems

One objective of the 2D planned templates was to avoid change in limb length. Variations on the Y-vector with respect to the norm were slight overall, which provided partial validation for our planning technique. For the 370 templates analyzed, variations in limb length with respect to the normal Y value were < 5 mm in 29 cases (78.3%), exceeded 10 mm in only 18 (4%), and never exceeded 17 mm. Likewise, length variations did not significantly differ between the five stem models: 3.7 mm ± 3.5 for Alloclassic™, 2.4 mm ± 3 mm for SL-Plus Lateralized™, 3.7 mm ± 3.4 for Muller Lateralized™, 3.1 mm ± 3.7 for Lubinus SP2™, and 3 mm ± 3.3 for Kerboull-Legend™.

Greater variations were, on the other hand, observed between the 370 digitized templates with respect to the X-vector norm for the offset induced by the stem: the mean value was −2.45 mm ± 6 mm (range, −22 to + 23 mm); it was < 5 mm in 229 cases (61%), and exceeded 10 mm in 52 (14%) (42 cases of > 10 mm medialization and 10 of > 10 mm lateralization). Variation in offset with respect to the norm differed significantly between stem models ($p = 0.0001$): −5.5 mm ± 6.3 for Alloclassic™, −0.7 mm ± 5.7 for SL-Plus Lateralized™, −3.9 mm ± 6 for Muller Lateralized™, 0.48 mm ± 3.2 for Lubinus SP2™, and −2.6 mm ± 6.1 for Kerboull-Legend™. The Lubinus SP2™ stem showed the best femoral offset reproduction, the other models inducing medialization in 50 to 84% of cases (Table 1) ($p = 0.0001$).

Clinical results

Fifty-eight of the initial cohort of 71 patients were seen at a mean 78 months' follow-up (range, 70—94 mo); three had died and nine were lost to follow-up but their clinical and X-ray results could be included at a minimum FU of 24 months. Mean Harris score [21] rose from 56.6 ± 10.5 (range, 24 to 79) preoperatively to 93.6 ± 12.2 (range, 53—100) at FU ($p = 0.0001$). Mean PMA score [22] rose from 10.7 ± 2.2 (range, 6 to 15) to 17 ± 1.8 (range, 13—18) ($p = 0.0001$). Preoperative mean Harris and PMA scores did not significantly differ according to Charnley grade; at follow-up, on the other hand, the mean Harris score was 89.7 ± 12 for grade-C hips, 94 ± 16 for grade B and 98.5 ± 3.6 for grade A ($p = 0.03$), and mean PMA score 16.5 ± 1.6 for grade C, 17 ± 2.5 for grade B and 17.7 ± 0.5 for grade A ($p = 0.04$). On the Witvoet classification [23], five patients were heavy manual workers, nine light manual workers, six office workers, 47 active retired and four sedentary retired.

Table 1 Variation from the norm in vector X, indicating medialization (< 0) or lateralization (> 0), for the five models of stems analyzed on template.

	Alloclassic™[a]	SL-plus Lateralized™	Muller Lateralized™[a]	Kerboull-Legend™[a]	Lubinus SP2™	Lubinus SP2™ in vivo[b]
Medialization	61 (82.4%)	37 (50%)	59 (79.7%)	48 (64.8%)	26 (35.1%)	9 (12.1%)
No variation at ± 5 mm	4 (5.4%)	11 (14.8%)	2 (2.7%)	5 (6.7%)	17 (22.9%)	55 (74.3%)
Lateralization	9 (12.1%)	26 (35.1%)	13 (17.5%)	21 (28.3%)	31 (41.9%)	10 (13.5%)
P-value compared to Lubinus SP2™	$p = 0.0001$	$p = 0.1$	$p = 0.0001$	$p = 0.0006$		
P-value compared to SL-Plus lateralized	$p = 0.002$		$p = 0.004$	$p = 0.1$	$p = 0.1$	

[a] No difference in offset reproduction on digitized templates between Kerboull-Legend™, Alloclassic™ and Muller Lateralized™ stems.
[b] Conservation of femoral offset by the Lubinus SP2™ stem differed between planning and in vivo ($p = 0.0001$).

Conserved femoral offset with the Lubinus SP2™ stem affected functional results:

- FU values on the Harris score were significantly poorer in case of increased (85.3 ± 23.3) than of conserved offset (95.6 ± 8.3) (Table 2) ($p = 0.03$);
- likewise, mean PMA scores: 15.7 ± 3.6 in case of increased offset, versus 17.3 ± 1.1 (Table 2) ($p = 0.01$);
- in the detailed PMA subscores, reduced offset did not affect pain but did significantly impact gait (Table 2);
- increased offset, in contrast, did not significantly impact PMA pain or gait scores (Table 2).

Preoperatively, 52 hips showed no length difference at the 5 mm threshold; seven were > 5 mm longer (by a mean 1.1 cm; range, 0.7 cm to 1.5 cm); and 15 were > 5 mm shorter (by a mean 1.3 cm; range, 0.8 cm to 3 cm). At follow-up, length inequality had improved: 57 hips showed no length difference at the 5 mm threshold; 14 were > 5 mm longer (by a mean 1.3 cm; range, 0.7 cm to 3.5 cm); and three were > 5 mm shorter (2 by 0.7 cm and one by 1 cm) ($p = 0.001$).

X-ray results

The Lubinus SP2™ stem showed better in vivo conservation of femoral offset than expected from the digitized planning templates. Using the same threshold as in the template study (reproduction to within 5 mm), offset was unchanged in 55 hips (74.3%) versus 17 (22.9%) according to the digitized planning ($p = 0.0001$). Likewise, offset was less often increased in vivo (10 vs. 31 lateralizations expected) and above all there were fewer cases of medialization (nine vs. 26) (Table 1). In absolute terms, pre- to postoperative variation in femoral offset was less than predicted: mean X-vector variation from the norm, −0.01 mm ± 4.3 mm (range, −14 to 8.8 mm) in vivo vs. 0.48 mm ± 3.2 mm (range, −9.1 to 12.1 mm) on planning templates ($p = 0.4$). Variations in hip rotation center were not taken into account in calculating overall offset, being slight: mean −1 mm ± 4 mm (range, −10 to 8 mm). Fifty-eight hips showed < 5 mm rotation center variation, and 19 (> 5 mm) (15 medializations of a mean −7 mm ± 1 mm (range, −5 to 10 mm) and four lateralizations (3 of 6 mm and one of 8 mm)).

On the Brooker classification [26], 55 hips (74.3%) were free of ossification, six (8.1%) showed grade-1 ossification, five (6.7%) grade 2, seven (9.4%) grade 3, and one had complete grade-4 type bridges. Presence and severity of ossification did not influence mobility as assessed by the PMA mobility score.

On the Barrack classification [25], 58 hips (78.3%) showed grade-A femoral cement fixation, 14 (18.9%) grade B, and two (2.7%) grade C.

Table 2 Functional results according to evolution of femoral offset after implantation of Lubinus SP2™ stem ($n = 74$ hips)..

	Global Harris score	Global PMA score	PMA pain	PMA gait
> 5 mm increased offset ($n = 10$)	85.64 ± 23.3 **(a)**	15.7 ± 3.6 **(a)**	4.7 ± 1.8 **(a)**	4.3 ± 1.3 **(a)**
No change in offset at ± 5 mm ($n = 55$)	95.6 ± 8.3 **(b)**	17.3 ± 1.1 **(b)**	5.5 ± 0.8 **(b)**	5.8 ± 0.42 **(b)**
> 5 mm reduced offset ($n = 9$)	90.4 ± 13.1 **(c)**	16.6 ± 1.6 **(c)**	5.3 ± 1 **(c)**	5.3 ± 0.7 **(c)**
Significance	$P < 0.05$ for **a** vs **b**	$P < 0.05$ for **a** vs **b**	$P < 0.05$ for **a** vs **b**	$P < 0.05$ for **a** vs **b** and **b** vs **c**

Change in offset had no significant impact on PMA mobility score. Preoperative PMA and Harris scores did not differ according to postoperative evolution of femoral offset.

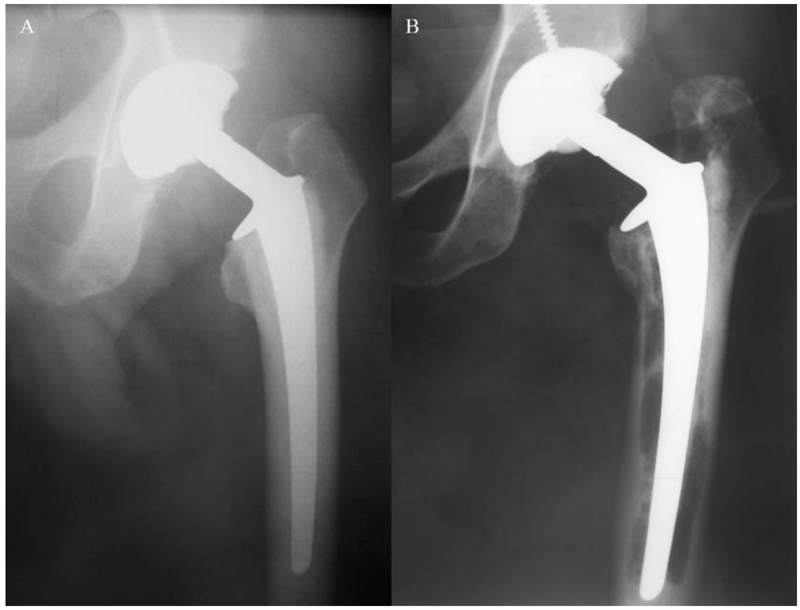

Figure 4 At 7 years, loosening (type A according to Barrack et al. [25]) of an SP2 117° XL stem which reproduced native offset (A). Osteolysis occurred and, at 7 years' FU, the stem showed subsidence (B). On revision, no mechanical explanation for such early loosening emerged. Unipolar revision, performed in a different center, used a cementless stem, but iterative revision was required 2 years later, suggesting underlying infection.

There were five cases of osteolysis, all proximal and within Gruen zone 1 in three cases and in two zones in the other two cases. Osteolysis affected patients with low-level activity (four sedentary and one light manual worker), of ages comparable to the population as a whole (mean, 63 years; range, 40—73 yrs), and concerned three cemented and two cementless cups, but four metal heads (including one with skirt) and only one ceramic head. All occurred in fixations of A-grade quality on the Barrack scale (Fig. 4) and induced no clinical effect, four PMA scores being 18 and one 16.

Complications, revision and survivorship

There were four dislocations (5%). One was associated with defective offset reproduction (medialization), requiring cup replacement for episodic subluxation. The others were in

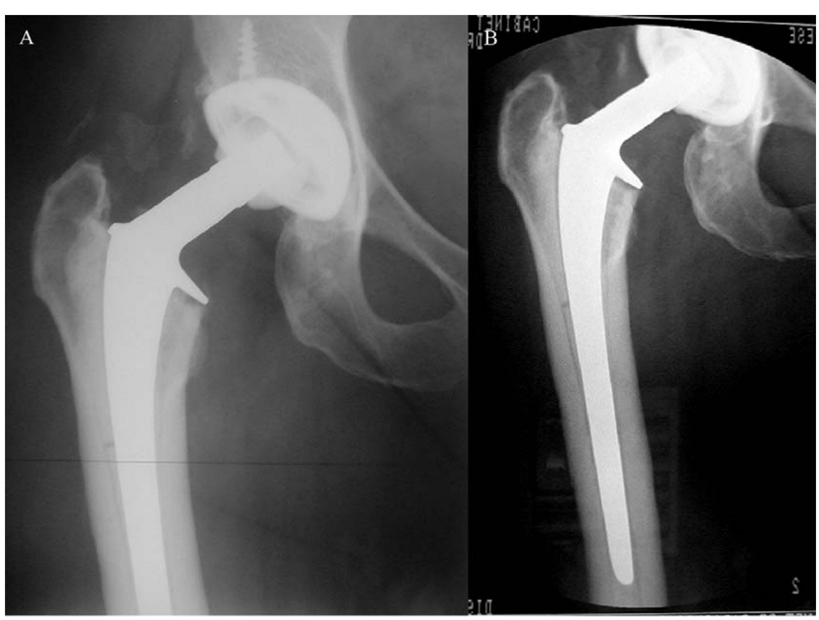

Figure 5 Mechanical loosening at 5 years' FU, secondary to initial cementing defect (type C according to Barrack et al. [25]). A: lateral cement mantle rupture at 24 months' FU. B: at 5 years' FU, the stem shows varus mobilization, with radiolucency in the mantle in zones 1 and 2.

hips in which offset was unchanged by THR:

- one dislocation recurred despite acetabular component replacement by a dual mobility cup in a patient suffering from dementia;
- one, secondary to high-energy trauma (fall from a boat mast), was free of recurrence after revision;
- one early anterior dislocation was observed during physiotherapy 3 weeks after initial surgery, and showed no recurrence.

Three cases of femoral component loosening required revision. All were in hips with unchanged offset:

- one was due to an initial Barrack-C cementing defect (Fig. 5);
- one concerned a femur with history of two osteotomies (one during adolescence and one in adulthood, associated to joint stop);
- the third had no mechanical explanation (Fig. 4), but the revision, performed in another center, needed redo 2 years later for recurrence of loosening, suggestive of an underlying infection, not confirmed on the latest revision.

In all, there were five surgical revisions, three for femoral stem loosening and two for instability. Mean 6.5-year survivorship in terms of loosening was thus 95.1 ± 4.8%. In comparison, 7-year survivorship in non-lateralized models (126° and 135°) was 98% in the Swedish registry.

Discussion

Following the comparative template study in our population of increased offset femurs, the Lubinus SP2™ 117° stem limited the medialization risk to 35%, versus 50 to 82.4% for the other models studied. These findings were confirmed in vivo, where the medialization rate was only 12.1%. Our method of measuring femoral offset is criticizable: Lecerf et al. [10] showed 2D measurement to give a mean 3.2 mm underestimation as compared to a 3D gold standard using CT scan [11]. Systematic CT ahead of THR would, however, be an unacceptable extra cost. Likewise, in theater the surgeon should be guided by 2D data [14,19,20], and template planning remains fully relevant, notably to screen for abnormal femoral morphology which may then be further explored in 3D by CT-scan [5,11] and/or be managed by a customized stem [5,27]. The precision of 2D planning is a matter of debate: Lecerf et al. [10] and Sariali et al. [11] reported errors in size selection and offset assessment, whereas for Debarge et al. [19], Unnanuntana et al. [28] and Suh et al. [29] 2D planning was accurate in regard to stem size and offset in almost 70% of cases. Errors in offset assessment are mainly related to femoral rotation on preoperative X-ray views [10]. Comparison of offset reproduction on template for the five models limited the impact of such error, as the same method was used in all models. Given that 2D planning tends to underestimate femoral offset, reproduction would probably have been poorer using a 3D technique. We sought to limit measurement error due to femoral rotation variations by considering only offset variations exceeding ± 5 mm, or a 20° error in femoral rotation, which seemed to be sufficient for clinical purposes. We cannot, however, account for the fact that the Lubinus SP2™ stem provided better reproduction of femoral offset after implantation, as the data here were obtained on the same method as used in the comparative 2D templating study. Three hypotheses may be put forward:

- peroperative adjustment of muscle tension to choose between the two neck lengths (standard and XL) and four head lengths;
- frontal stem orientation (valgus-varus), which may affect the offset value [30]; and/or;
- error inherent to our measurement method, although the method has been validated [31] and all measurements were made by an observer blind to the functional result and to the postoperative evolution of the femoral offset.

Increased femoral offset in theory entails an increased risk of loosening due to an increase in strain on the stem [6]. Cannestra et al. [32] and Olofsson et al. [33] reported early loosening in cemented extra-offset stems, but with a straight cylindrical form. The anatomical form of the Lubinus SP2™ stem, which in theory allows a uniform cement mantle, should protect against loosening, as reported by Breusch et al. [34], even though interface strain is greater due to the extra offset [6]. The uniform cement mantle in the present series provided survivorship comparable to that of reference cemented stems with conventional offset [35,36]. Our 7-year survivorship (95.1% ± 4.8), on the other hand, was lower than that reported in the Swedish registry (98% ± 1%) for the same type of Lubinus SP2™ stem but with angulations only of 125° and 135° [15]. One of the three cases of loosening in the present series was due to an initial cementing defect (Fig. 5). Chambers et al. [37] reported that poor (Barrack C or D) initial cementing was associated with a relative risk of loosening of 9.5. For such extra-offset stems, cementing must be of the highest quality, due to the greater strain [6]. To avoid excess cement strain levels associated with extra offset, cementless fixation may be preferred, as being less sensitive to increased strain. Danesh-Clough et al. [38] reported no loosening at a mean 7 years' FU for an uncemented extra-offset stem with partial porous coating.

Our dislocation rate of 5% may be considered a failure criterion for a stem intended to reproduce increased offset. All of these dislocations, however, could be accounted for: one high-energy trauma (without recurrence), one case of dementia leading to recurrence of dislocation despite revision using a dual mobility cup, non-respect of offset in one case (with recurrence), and one case of forced maneuver in physiotherapy (without recurrence). Only two dislocations showed recurrence, the others being isolated. The dislocation rate could probably have been higher in this at-risk population in which conventional stems show significant medialization on templating in 50% of cases, with abductor tension loss, a cause of definitive instability [16,39]. Other solutions might have been considered for this population at risk of dislocation:

- trochanterotomy, to restore abductor tension, while using a standard offset stem [16,40];
- for certain patients, respecting age and degree of osteoporosis, hip resurfacing would not greatly alter femoral offset whatever its preoperative value and, combined with the effect of a large diameter, entails a minimal risk of instability [41];
- finally, certain authors recommend modular necks [42], but which have yet to be proved effective in this indication [10,42].

Polyethylene wear was not assessed in the present series, follow-up being too short for detection on conventional methods [43], although offset reproduction would seem to be desirable in order to limit wear [8,44].

The present study suggests that offset reproduction should be one objective in THR to ensure a favorable result. The extra offset of more than 5 mm provided by the Lubinus SP2™ stem significantly reduced the pain and gait scores, probably in relation to excessive soft-tissue tension. In the nine hips medialized by more than 5 mm, the reduction in functional score was non-significant but that in the gait score was significant. These results argue for femoral offset reproduction to within 5 mm, which proved feasible in 74% of cases thanks to the use of an extra-offset stem. The impact of conserved offset on the functional result was previously demonstrated by Flecher et al. [5], and on abductor strength by McGrory et al. [1] and Asayama et al. [4]. However, to the best of our knowledge, the present study is the first in which such findings have been confirmed in a population of femurs showing increased offset. Alternative solutions (modular neck, trochanterotomy for tension restoration, customized implant) have also been assessed in femurs of near-normal morphology [5,10,39,42].

Conclusion

The Lubinus SP2™ stem is a good solution where the femoral neck is long and/or the cervicodiaphyseal angle < 135°, to reproduce native femur offset. Slightly reduced survivorship compared to 126° and 135° models requires longer-term surveillance.

Prosthetically increased femoral offset impacted functional results in terms of pain and gait, whereas reduced offset did not affect the pain score but was associated with a reduced gait score.

Conflict of interest statement

None.

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