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ORIGINAL PAPER

Fourteen-year experience with short cemented stems in total hip replacement

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Abstract

Purpose The age of the population requiring total hip replacement (THR) is increasing and this may lead to a return of cemented stems. Advantages of a short cemented femoral device include preservation of metaphyseal bone, easier insertion, and easier cement removal in case of revision. The purpose of this study is to describe the rationale and assess midterm results of unique innovative short cemented double-tapered polished stem applied with contemporary cementing techniques.

Methods Our experience with this short cemented stem includes two different groups of elderly patients. Group 1 (prototype version of the short stem) from January 2005 to January 2008 counts 43 THR. Group 2 (final commercial version of the short stem) from January 2013 to January 2015 counts 54 THR. The average age in groups 1 and 2 was 79 and 75 respectively. Patients underwent clinical follow-up with the Harris Hip Score (HHS) and completed radiographic evaluation.

Results Thirty-one patients of group 1 had died for reasons unrelated to their THR. The surviving 9 hips have a follow-up of 11.2 years. In group 2, eight patients died for reasons unrelated to their THR. Follow-up for the surviving 40 patients is 4.6 years. HHS improved in both groups. In 34/43 hips of group 1 and in 41/54 of group 2 we observed a Barrack grade A cement mantle. Survival with revision of the stem for aseptic loosening as the endpoint was 100%.

Conclusions This study confirms the effectiveness of a short, polished, collarless, tapered cemented stem implanted with contemporary cementing techniques which appears as successful as the standard sized components.

Keywords Short stem · Cemented THR · Aging population · Osteoporosis · Exeter philosophy

Introduction

Total hip replacement (THR) is one of the most frequent and effective operations in orthopaedic surgery. For the standard patient with hip osteoarthritis (OA), conventional femoral cementless stems have proven to guarantee a long survivorship [1]. However, similar if not better results are reported in national registries for cemented THA [2]. Other factors, rather than surgeon preference and literature results, may influence the choice of implant fixation. Among these, unquestionably, poor bone quality plays a pre-eminent part in favouring cement fixation, at least on the femoral side [3]. Cemented techniques offer solid and immediate stability and do not demand additional time for biological fixation, even in the osteoporotic patient. In a recent survey, 100% of surgeons responded that, in case of known osteoporosis, cemented implants would be the only choice [4]. On the contrary, for standard patients without osteoporosis, cementless fixation of the stem was the first choice for 72% of surgeons. Therefore, as lifetime expectancy continues to increase and more elderly osteoporotic patients require joint replacement, it is possible to predict a return of cemented THR [5, 6].

Downsides of the use of cement on the femoral side with a conventional stem are technical difficulties, increased risk of fat embolism, and difficulties in the event of future revisions [7]. While in the area of uncemented THR, the concept of shorter anchoring length on the femoral side has gained extensive consensus, for cemented or hybrid implants, most manufacturers still produce only conventional length stems [8–15]. Theoretical advantages of a short cemented femoral device are preservation of the metaphyseal bone through a

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more proximal load transfer; easier insertion, especially through smaller direct anterior approaches; and easier cement removal in case of future revision [16, 17].

In this study, the rationale and midterm results of a unique innovative short polished stem developed by the Senior Author (FSS) and implanted with contemporary cementing technique are described.

Implant history and rationale

A standard length polished, tapered cemented stem with an original distal plug and proximal centralizer was developed back in the early nineties in our institution [18]. The idea behind this implant, which follows the established successful Exeter stem philosophy, was to offer the surgeon assistance to achieve a correct alignment (Fig. 1), a good bone cement penetration and a uniform minimal 2 mm cement mantle [19, 20].

Because of our increased confidence with mini cementless THR, a shortened version of the Friendly stem (Fig. 2) was developed [21, 22]. The small stem was produced in a limited series and implanted only in our institution. From January 2005 to January 2008 we performed, with the approval of the ethics committee, an initial experimental series of 43 short cemented stem THR [23]. In the meantime, a change in the European regulations occurred and an additional conformity assessment was required for the Friendly short stem to obtain the EC certificate, hence a new study was undertaken by Marega and Gnagni [22]. They performed, between June 2011 and October 2012, 100 THRs in 96 patients with the final version of the Friendly short stem. No changes occurred in the shape and texture of the stem between the first and second series whilst some

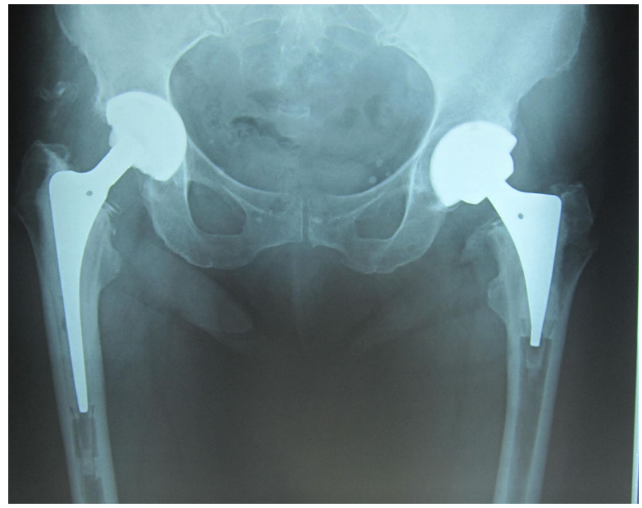

Fig. 2 Pelvis A-P X-Ray: R hip with conventional Friendly stem (cement mantle Barrack C1) and L hip with Friendly short stem (cement mantle Barrack A)

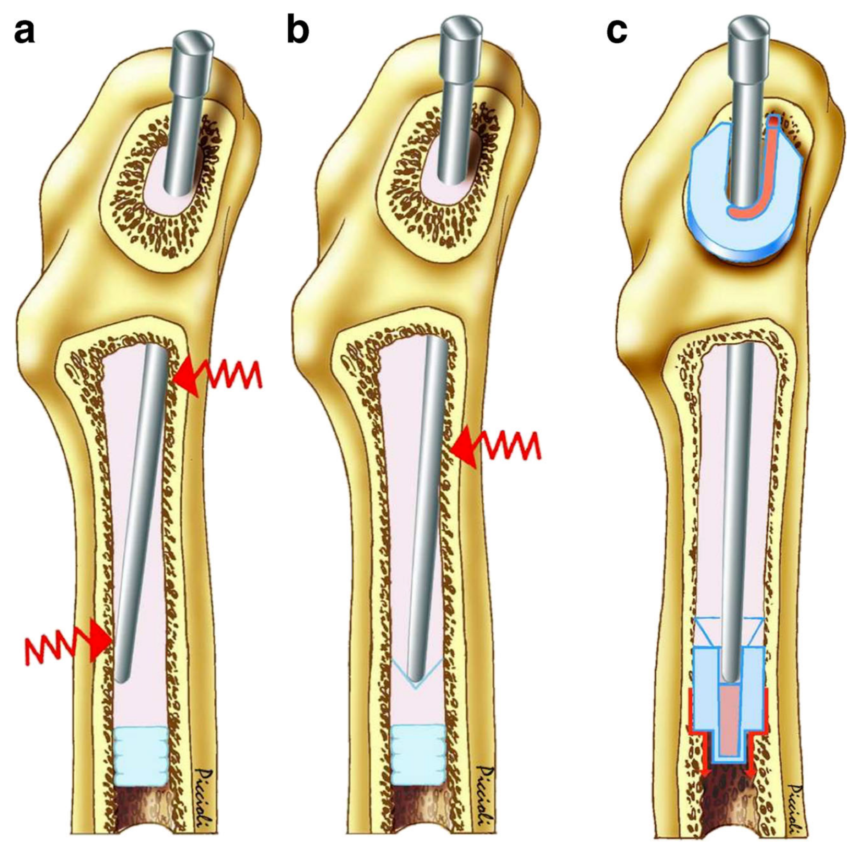

Fig. 1 Axial view of the proximal femur. **a** and **b** stem malalignment. **c** The anterior wedge of the asymmetric proximal centralizer provides correct stem alignment

minor instrument and distal plug modification, were introduced by a team of appointed surgeons.

At an average two year follow-up, Marega and Gnagni, reported good clinical results and no revision or implant failures hence, in 2016, this device became commercially available [22].

Presently, the Friendly short stem, is offered in four sizes with two different offsets. The stem is straight, polished, double tapered with a rectangular section and rounded edges. As it was for the longer version, the short stem is implanted with a dedicated instrument set and with proximal and distal centralizers (Fig. 3). The plug, acts as a guide and, together with the asymmetric proximal centralizer, ensures a perfect stem position and a uniform thickness of the cement mantle. A precise cementing technique is crucial for long-term survival of a cemented THR and this is even more important if a short device is used. The fourth-generation cementing technique intended for this stem includes a dedicated highly stable distal plug, endosteal bone lavage, vacuum mixing, cement gun retrograde delivery, maintenance of pressurization with a rubber seal and a proximal asymmetrical centralizer. In our institution we selected to use the low viscosity cement provided by the manufacturer and a high neck cut.

Material and methods

Our experience with the Friendly short stem (LimaCorporate, San Daniele Friuli, Italy) includes two different groups of patients. The first, between January 2005 and January 2008, consist of 43 stems in 40 patients (Group 1). Primary diagnosis was displaced femoral neck fracture in 11 and osteoarthritis in 29 patients. All surgical procedures were performed by the author (FSS). Anterolateral and posterior approaches were used in ten and 33 cases respectively. In 40 cases a cementless and, in three, a cemented acetabular cup was used. Mean age at the time of surgery was 79 years (71 to 86), 14 men and 26 women. Patients underwent standardized clinical follow-up with the Harris Hip Score (HHS) and radiographic evaluation at four and 12 weeks, and every year thereafter. Correction for magnification was completed by standardizing all measurements against the known size of the femoral head [23]. A single observer reviewed all X-rays. Radiolucencies and osteolysis were recorded in each Gruen zone [24]. Femoral loosening was defined as more than 5 mm of subsidence at the cement bone interface. Stem within cement subsidence was measured at the shoulder of the prosthesis. Quality of cement mantle on X-rays was classified according to the Barrack system modified by Mulroy (Table 1) [25]. Complete data on stem alignment, subsidence, cortical hypertrophy, and calcar resorption were recorded. Post-operative femoral fractures were classified using the Vancouver system [26]. Patients unable to come to the clinic due to infirmity were followed up by phone interview and remote X-rays. Five to seven years results were presented at the Combined 33rd SICOT & 17th PAOA Orthopaedic World Conference of Dubai in 2012 [27].

From Jan 2013 to Jan 2015, we performed a second series of 54 THR in 48 patients using the final commercial version of the Friendly short stem (Group 2). Fourteen patients were treated for femoral neck fractures and 34 for osteoarthritis. A mini posterolateral surgical approach with capsular closure was used in all cases. Cementless acetabular cup fixation was used in all but one case. Mean age was 75 years (64 to 87), 21 men and 27 women. The same clinical and

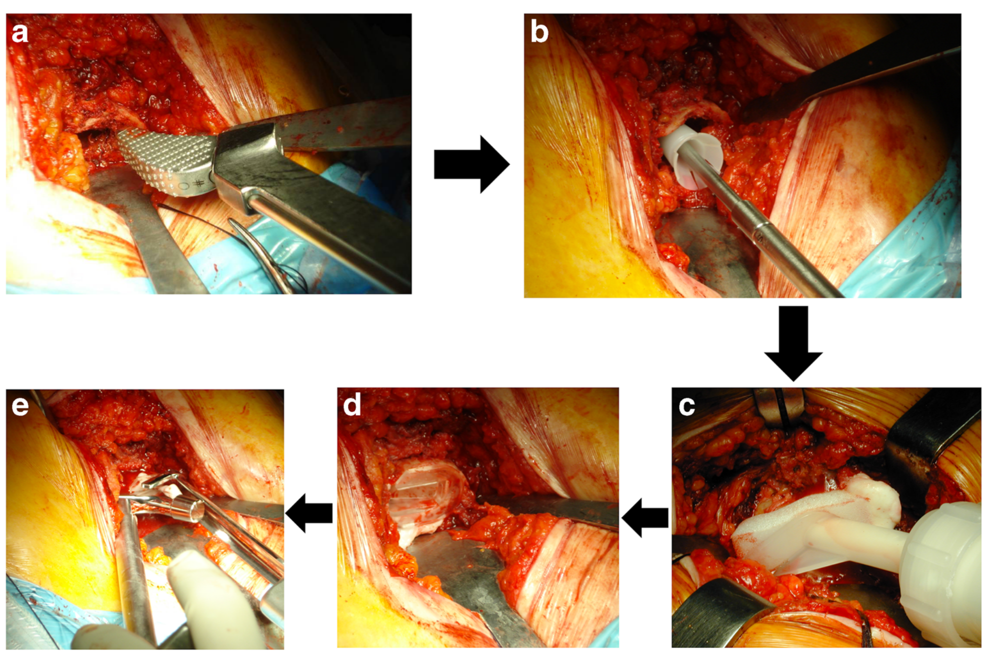

Fig. 3 Friendly short surgical technique. **a** canal preparation; **b** distal plug; **c** cement pressurization; **d** proximal asymmetric centralizer positioning; **e** short stem introduction

Table 1 Barrack's cement grading system modified by Mulroy et al.

Grade A	Complete filling of the proximal portion medullary canal of the diaphysis. Distinction between cortical bone and bone cement cannot be made (so-called white-out).
Grade B	Distribution of cement is nearly complete, but it is possible to distinguish cortical bone from cement in some areas.
Grade C1	Extensive radiolucent line (along more than 50% of the cement-bone interface) or voids in the cement.
Grade C2	Thin (less than 1 mm) cement mantle at any site or a defect in the mantle of cement with the metal in direct contact with cortical bone.
Grade D	Gross deficiencies in the mantle of cement, such as no cement distal to the tip of the stem, major defects in the mantle of cement or multiple large voids.

radiological data were recorded. All patients received a ceramic on polyethylene coupling.

In both groups, patients were allowed immediate partial weight bearing as tolerated.

Results

At the latest review, 31 patients (34 THR) of group 1 and eight patients of group 2 had died for reasons unrelated to their THR. None of them had undergone revision surgery before their death.

The surviving nine hips of group1 (average age 89.9 years) have an average follow-up of 11.2 years. (10 to 14). Mean HHS improved from 45.0 ± 16 (29–61) pre-operatively, to 93 ± 9 (84–100). One patient had a traumatic Vancouver B1 femoral fracture four years after THR and was initially treated with ORIF but one year later required revision with a standard cemented stem.

In group 2, median follow-up for the surviving 40 patients (45 THR) is 4.6 years (3 to 5 years). HHS improved from 40.0 ± 11 (29–51) to 96 ± 7 (89–100). One of the remaining 40 patients had a traumatic Vancouver B2 fracture two months after surgery and required revision to a long porous-coated cementless stem. None of the acetabular components in both groups required revision. Survival with revision of the stem for aseptic loosening as the endpoint was 100%.

In 34/43 hips (79%) of group 1, we observed a Barrack grade A (Fig. 4) and in 9/43 (21%) a grade B cement mantle. In 41/54 (76%) of group 2 the bone-cement interface was graded A and in 13/54 (24%) B. In both groups, the cement mantle remained stable over time. In ten cases of the first series and in 13 of the second, a physiologic stem subsidence within the cement mantle of less than 2 mm was observed during the first two years after surgery (Fig. 5). Calcar rounding was observed in ten cases of the first and six of the second series. No bone-cement radiolucent lines > 2 mm, cement fractures, osteolysis, cortical hypertrophy, and calcar resorption were detected. Similarly, we did not observe plug migration, axial malalignment (> 3°) or cement leakage through the plug. No patients complained of tight pain.

Discussion

Primary THA with a short cemented polished stem has shown, in this study, excellent results in elderly patients at midterm follow-up. Today, a variety of uncemented short-stem femoral implants are available [28]. To our knowledge, this is the first reported series of a short cemented femoral implant. Previously, the only mention of a short cemented implant was applied to the smaller version of the Exeter stem, available for dysplastic patients with smaller femurs [29]. Just as the Exeter stem, the Friendly short was designed to facilitate subsidence within the cement mantle and, as expected, this was relatively frequent in both our groups. The cement mantle surrounding the Friendly short stem, at midterm follow-up, continues to behave properly indicating that the stress generated by a limited subsidence enhances stability, load distribution, and may contribute to preserve the cement/bone interface integrity in the long term by sealing the access of the proximal metaphysis to articular debris [20]. Recently, Petheram, at an average follow-up of 22.8 years, reported a stem survivorship of 99.0% in 382 cemented Exeter stem, confirming the efficacy of this philosophy and the insignificant value of subsidence

Fig. 4 9.5 years follow-up of R THR with Barrak grade A cement mantle

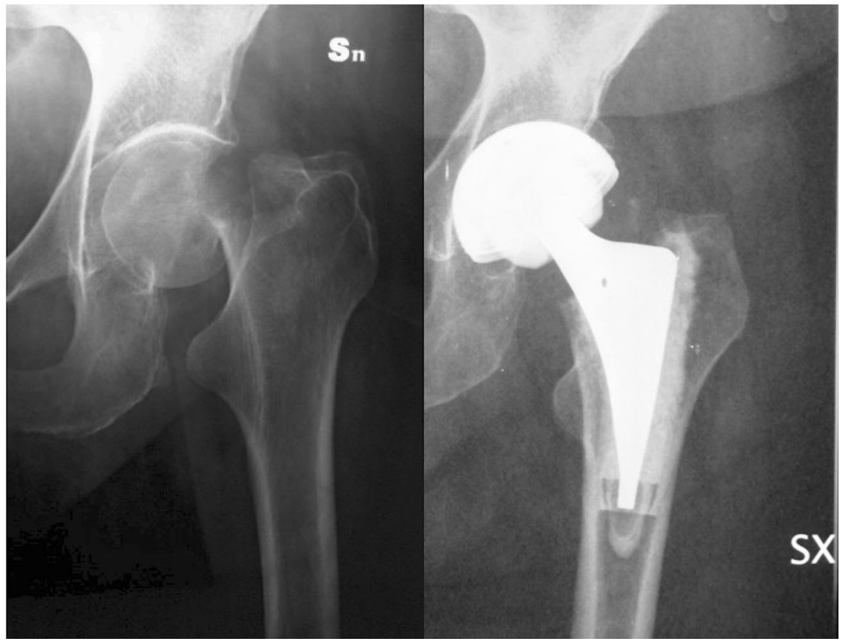

Fig. 5 **a** Displaced L femoral neck fracture treated with short cemented stem. **b** 5 years post-op X-ray shows a stem subsidence of less than 2 mm

within the cement mantle [20]. We believe that, even though our follow up is relatively short, the favourable performance of the cement mantle at up to 14 years follow-up may lead to a long-term survival as the Exeter stem.

Potential advantages of a short cemented stem are minimal bony invasiveness, a theorical decreased risk of bone-cement implantation syndrome (BCIS) and simplification of a possible future revision. Biomechanically, a short cemented stem is feasible but requires a perfect bone cement interface obtainable with contemporary cementation techniques. Kutzner has proposed the use of a line-to-line cementing technique with the idea that direct cortical contact is preferable for patients with poor bone quality [30]. This is not our in vivo experience. A precise cementing technique with the addition of proximal and distal centralizers has permitted a perfect and reproducible 2-mm cement mantle all around the stem, possibly explaining our high success rate.

Bishop, in a biomechanical study, has demonstrated with an analytical model an increased risk of periprosthetic fractures (PF) after implantation of a short stem in osteoporotic bone. This evidence has not been confirmed in our clinical series [31]. Two patients (2.27%) required re-operation in both cases due to a traumatic PF. This data is congruent with what was reported for patients of similar age, sex, and bone porosity treated with conventional cemented THR. Barenius reported 3% of post-operative PF after cemented THR. Abdel, in 32.644 THRs, found a 20-year PF probability of 7.7% and a 2.1% with uncemented and cemented stems respectively [22, 23]. Only one of our PF occurred within the first year. The second occurred four years after surgery and it seems reasonable to assume that the cause was the risk of falling compatible with the age rather than by the type of stem.

The Friendly short stem requires less cement than a conventional cemented prosthesis and this may reduce the risk of BCIS, the major cause of peri-operative mortality in cemented THR. The pathophysiology of this phenomenon is poorly understood and characterized by the occurrence of sudden extreme hypotension, hypoxia, arrhythmia, and cardiac arrest [7, 32]. There are conflicting data regarding rates of BCIS in THR. Parvizi reported 23 deaths during surgery in 38,488 cemented THR and no deaths among 15,411 uncemented hip arthroplasties [7]. Of the 23 dead patients in the cemented series, 17 were treated for femoral neck fractures and only four for primary osteoroarthritis (OA). Jämsen, examining the Finnish hip registry, showed no difference in mortality rates in 4509 octogenarian patients treated for primary OA receiving cemented, uncemented, and hybrid hip replacement [6]. Hunt, in the National Joint Registry of England and Wales, reported that the use of cement was unrelated to mortality in 409.096 patients undergoing THR [33]. Finally, Costa found that overall perioperative mortality in 16.496 femoral neck fractures treated with hemiarthroplasty or THR was lower when cement was used [34]. Twenty-five (28.4%) of our 88 elderly patients were treated for femoral neck fracture without observing any BCIS. The absence of this complication, in our series, may be influenced by the limited number of implants and by the fact that most of our cases where hybrid THR. However, it is also possible that respect of the femoral canal minimizes intramedullary hypertension and, therefore, the occurrence of BCIS.

This study has limitations. Follow-up of this device is relatively short for a cemented stem, 11.2 and 4.8 years respectively for the surviving patients of groups 1 and 2. On the other hand, no patient was lost and the elderly patients who declined to take part in a complete follow-up for dementia or general health issues were reached through a family contact. The study was originally designed as two separate studies and, therefore, may seem confusing. However, the stem used was the same, and due to the limited cohort and the high mortality rate due to age, we decided to present our experience with this innovative short cemented stem in a single study. Indeed, possibly for the limited numbers, we were unable to detect any difference in survival rate, radiologic evolution, or other complications between groups 1 and 2; thus, it is not possible to state whether the minimal modifications in the surgical technique have produced any improvement. A second limitation of this study is the evaluation of all radiographic material by a single observer. Concerns on intra- and inter-observer agreement levels and the poor reproducibility of Barrack system have been reported [35]. However, we decided to use this scoring system because it is best known, most widely used and the material was reviewed by an experienced surgeon (NS).

In conclusion, this study confirms the effectiveness of a short, polished, tapered cemented stem implanted with contemporary cementing techniques which appears as successful as the standard sized components. Mild subsidence at the stem-cement interface was observed but, as for the Exeter stem, this phenomenon appears self-limiting and not associated with aseptic loosening. The femoral stem revision rate for aseptic loosening was 0%, while two patients required stem revision for PF. This PF rate, in elderly osteoporotic patients, appears in line with that reported in the literature [36].

Further studies with different surgeons, larger cohorts, and longer follow-up are needed to validate these results.

Compliance with ethical standards

Conflict of interest Author Francesco Falez receives royalties from LimaCorporate Company.

Author Francesco Saverio Santori receives royalties from LimaCorporate Company.

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