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ORIGINAL ARTICLE • PELVIS - FRACTURES

Early clinical and radiological outcomes for the Taperloc Complete Microplasty stem

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Abstract
The use of short stem designs in total hip arthroplasty is not a new concept, but its popularity has increased as a bone-sparing alternative to traditional stems. This study analyzed the midterm clinical and radiological results of the Taperloc Complete Microplasty stem (Zimmer Biomet® Warsaw, IN, USA). A total of 32 patients (20 men and 12 women) were retrospectively documented and received 40 stems (eight bilateral). The median patient age was 50 years (interquartile range 43–58) at the time of surgery. The median follow-up was 36.5 months (interquartile range 26.75–50.25). Indication for total hip arthroplasty was osteoarthritis (62.5% of patients), avascular necrosis (25%), and developmental dysplasia of the hip (12.5%). The Merle d'Aubigné score improved from a mean 11.5 preoperatively to a mean 17.5 at the latest follow-up. During X-ray assessment, we observed one subsidence of the stem (3 mm) and four cases of varus malalignment without clinical consequences. No cases of osteolysis were reported, and no stems were revised. According to our results, this short tapered stem shows a good early-term outcome. Prospective results and a longer follow-up are needed to assess the long-term survival of this stem fully.

Keywords Short stem · Total hip arthroplasty · Total hip replacement · Postoperative complications · Hip

Introduction

The use of short stems for total hip arthroplasty remains controversial. There are numerous possible advantages, such as easier implantation, less thigh pain, and significant preservation of bone stock [1, 2]. This is particularly interesting for younger patients. Also, short stems could reduce periprosthetic bone resorption [3]. In a recent systematic review, short stems with complete anchorage in the femoral neck did not show a satisfactory overall survival rate [4]. For the rest of short stems, known as partial collum and trochanteric sparing stems, the results are encouraging to present date, despite most of the series lack of a long follow-up. Worryingly, there are reports pointing to an increased risk of malpositioning, persistent thigh pain, loosening, migration, and/or proximal stress shielding with the use of partial collum or trochanteric sparing short stems [5–7].

In the present study, we aim to analyze the results of a trochanteric sparing short stem, named Taperloc Complete Microplasty. The published results are scant There are two series published by the same group regarding the previous design of this stem (Taperloc Complete Microplasty), with 7.3 and 29.2-month follow-up and both with 99% survival [8, 9], and there is only one series evaluating the Taperloc Complete Microplasty, also by the same group, showing satisfactory results [10].

Using a retrospective cohort of patients, this study was designed to (1) evaluate clinical and radiological outcomes and (2) evaluate midterm survivorship of the Taperloc Complete Microplasty stem.

Patients and methods

From December 2011 through October 2015, 32 patients underwent 40 primary THA procedures at our institution, receiving the Taperloc Complete Microplasty stem (Zimmer Biomet, Warsaw, IN, USA). This short stem was indicated for young adult patients; patients over 66 years old

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and patients with osteoporosis, with BMI over 35 were excluded for this implant (Table 1).

This study was performed in accordance with the ethical standards laid down in the 1964 Declaration of Helsinki and its later amendments. Specific national laws were observed as well. We obtained the approval of the ethical committee of our institution for this retrospective observational study (registered reference HCB/2018/0069). All the patients signed the corresponding informed consent document, and the data were collected anonymously. The information was downloaded from a specific database for the study, to which only the members of the research staff had access and was hosted on the hospital intranet.

We used the TraumaCad software (Brainlab Ltd., Petah Tikva, Israel) for preoperative templating. Calibration of the image was adjusted using the KingMark device (Brainlab AG, Kapellenstraße, Germany). We used a standardized protocol for digital templating [11]. The morphology of the proximal femur was assessed on the preoperative radiographs as described by Dorr et al. [12].

All patients received spinal anesthesia and antibiotic and antithrombotic prophylaxis, according to our institutional protocols. Usually, patients underwent THA with a modified Hardinge approach and, in some cases, the procedure was performed through a modified anterolateral approach (Watson–Jones mini-invasive, also called the Röttinger approach) or direct anterior approach. These different approaches were related to the preferences of the surgeon. Intraoperative radiology was used in all the cases to assess correct positioning and dimensioning of the stem and cup according to the preoperative digital template. Routine postoperative blood work and X-ray were performed the day after surgery along with early physiotherapy.

Patients were reviewed at 6 weeks, 6 months, 12 months, and annually thereafter. We used the Merle d'Aubigné score to assess the clinical result. The radiological analysis was carried out by means of a standard anteroposterior X-ray view of the pelvis and a lateral hip view, comparing images taken after surgery and at the final follow-up. The varus or valgus malpositioning was measured using the method described by Khalily and Lester [13]. We also checked for subsidence, migration, osteolysis, and signs of stability in the Gruen zones [14].

We used the criteria described by Engh et al. [15] to evaluate implant stability. Malpositioning was defined as a deviation of greater than 3 degrees from the longitudinal femoral axis. Subsidence, described as the vertical movement of the femoral component, leaving a radiolucent space at the most proximal aspect of the implant [2], was considered significant if greater than 2 mm, and a change of more than 2 degrees in the stem angle was considered implant migration [16].

The data were represented as absolute frequencies and percentages in the case of qualitative variables. For the quantitative variables, the mean and the median and the standard deviation (SD) or the median and the interquartile range (IQR: P25; P75) were used, according to their distribution. In the case of ordinal variables, absolute and relative frequencies (%) or the median and IQR were used, depending on the number of categories.

In all cases, a type I error of 5% bilateral was used. Given the characteristic observations of the present study, the values of p were considered descriptive, for which no correction for multiplicity was made. The statistical program SPSS version 20 was used for statistical analyses.

Results

Data were collected retrospectively from 32 patients: 20 men (62.5%) and 12 women (37.5%). The median patient age at the time of surgery was 50 years (IQR 43–58), and the median BMI was 27 kg/m^2 (IQR 24–30). The indications for total hip arthroplasty were osteoarthritis (62.5% of patients), avascular necrosis (25%), and developmental dysplasia of the hip (12.5%). When classified under the American Society of Anesthesiologists (ASA) guidelines, 55% of the patients were grade II and 42.5% were grade I. Only 2.5% were ASA III, and none were ASA IV (Fig. 1).

The median follow-up was 36.5 months (IQR 26.75–50.25), range from 26 to 68 months. One patient was lost to the final follow-up due to death secondary to melanoma.

We used 26 standard-offset stems and 14 high-offset stems. The acetabular component most commonly used was the cementless BiHAPro cup (Zimmer Biomet, Warsaw, IN, USA) in 31 of the hips. The rest of the acetabular

Table 1 Demography of the series

Age at surgery (years old): median (25th, 75th percentile)	50.0 (43.0; 58.0)
Age at surgery (years old): range	28–66
Gender female *N* (percentage) versus male *N* (percentage)	12 (37.5%) versus 20 (62.5%)
BMI: median (25th, 75th percentile)	27.0 (24.0; 30.0)
BMI: range	16.0–33.0
ASA	ASA I 17 (42.5%); II 17 (55.0%); III 1 (2.5%)

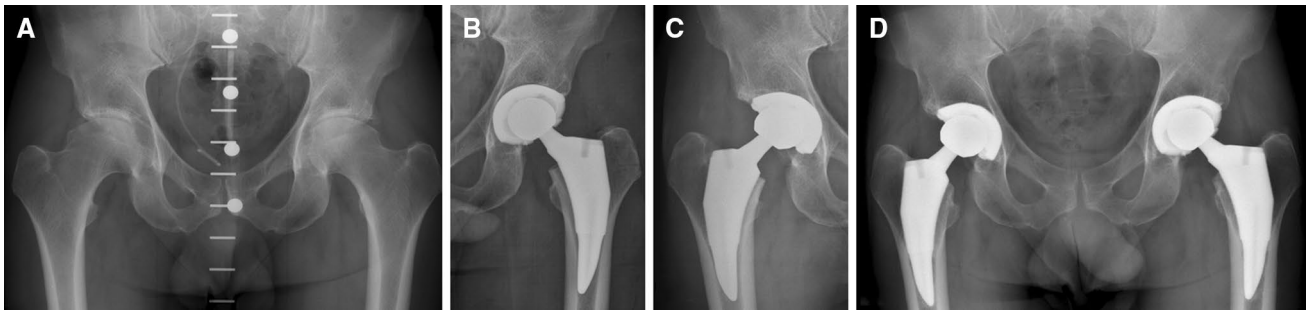

Fig. 1 An illustrative case of a bilateral total hip arthroplasty treated with Taperloc Complete Microplasty stem. **a** Preoperative radiology of a 47-year-old male depicting bilateral osteoarthritis. The patient BMI was 23.4 kg/m^2 and his medical record was relevant for having a type 2 diabetes Mellitus treated with oral antidiabetics; **b** and **c** postoperative radiological control for left and right arthroplasties on May 2014 and May 2015, respectively; **d** latest follow-up, in November 2017

components were the cementless G7 PPS Limited Hole Acetabular Shell (Zimmer Biomet, Warsaw, IN, USA). All the liners were highly cross-linked vitamin E-enhanced polyethylene, and one of the liners was for a constrained system (Freedom, Zimmer Biomet, Warsaw, IN, USA). A metal head was used in 36 (90%) cases and a ceramic head in the rest. The neck length was −4, 0 or +4 in 36 cases (90%). The most common size of the stem was 5, followed by sizes 9, 10, 13, 14, and 16. The diameter of the heads is shown in Fig. 2. A direct lateral approach (Hardinge) was used in 36 (90%) THAs, a Röttinger approach was used in 2 (5%), and a direct anterior approach was used in 2 (5%).

The Merle d'Aubigné scores improved globally from a mean 11.5 preoperatively (range 11.1–12.8) to a mean 17.5 (17.2–17.9) at a minimum of 12-month follow-up, and the improvement remained constant until the final follow-up ($p < 0.05$). No patient reported thigh pain.

Interestingly, we found a statistically significant correlation between the use of a high-offset stem and osteoarthritis as the indication for surgery ($p < 0.05$), although it had no influence on the outcome. No statistically significant differences were found between the offset (standard vs. high) or between the patients who presented a radiological problem during the follow-up.

The radiographic evaluation did not show any signs of periprosthetic osteolysis. Interface buttressing was observed in 27 patients (69.2%) in Gruen zones 2, 3, and 6. There was one case of less than 1-mm radiolucency lines in Gruen zones 1 and 3, without progression, accompanied by the presence of a pedestal sign. The patient had mild, occasional hip pain but did not desire a new intervention.

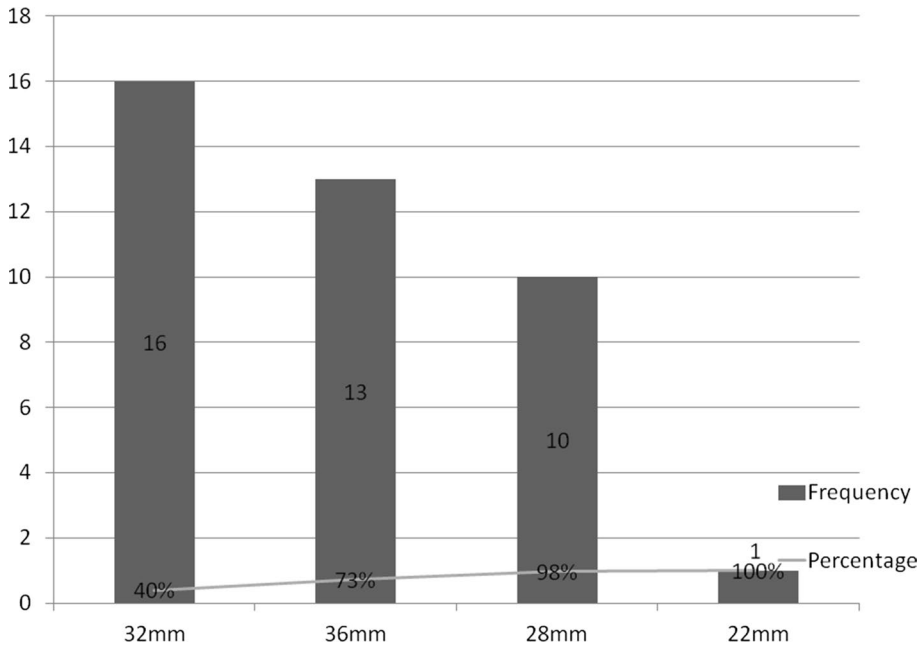

Fig. 2 Pareto chart of head size

All the radiological findings that were observed around the stem at the end of follow-up were already present after the first year, without significant changes. This rule had an exception in the case of flying buttresses. In eight cases, this image was not present at the end of the first year ($p=0.008$). We could also confirm that Gruen zone VI showed the most prevalent appearance of flying buttresses (six cases) at the end of follow-up ($p=0.031$).

Table 2 shows the different radiological observations. Significant subsidence (3 mm) was detected in one patient with a Dorr type C femur at the 1-year follow-up, with evidence of spot welds at the final follow-up. The stem was originally correctly aligned and continued to be the same throughout the follow-up. The patient was asymptomatic. There was no correlation between the Dorr type and subsidence (Pearson's r 0.23, $p=0.13$). Subsidence, migration, pedestal, or radiolucency rates were very low, which makes it difficult to evaluate possible differences between the types of Dorr. No statistically significant differences between the types of Dorr and malposition, implant presence of buttresses, or varus stem were observed.

One patient had a varus migration of the femoral stem. She had a previous diagnosis of schizoaffective disorder, in treatment with electroconvulsive therapy. She received a constrained acetabular cup due to the high risk of dislocation. She referred an occasional pain in her hip with a Merle d'Aubigné at the final follow-up of 17. Four stems (10%) were implanted with varus malalignment without migration during follow-up and with no detrimental effect on clinical outcome. There was no correlation between the Dorr type of femur and the initial alignment of the femoral component (Pearson's r −0.31, $p=0.04$). No stems required revision; therefore, the Kaplan–Meier method could not be used.

Table 2 Correlation between radiographic findings and Dorr type

	Dorr type				
	Total	A	B	C	*p* value
Subsidence					
No	39 (97.5%)	12(100%)	18 (94.7%)	9 (100%)	1.000
Yes	1 (2.5%)	0 (0%)	1 (5 3%)	0 (0%)	
Migration					
No	39 (97.5%)	11 (91.7%)	19 (100%)	9 (100%)	1.000
Yes	1 (2.5%)	1 (8.3%)	0 (0%)	0 (0%)	
Spot welds					
No	12 (30.8%)	2 (18.2%)	6 (31.6%)	4 (44.4%)	0.478
Yes	27 (69.2%)	9 (81.8%)	13 (68.4%)	5 (55.6%)	
Varus malalignment					
No	36 (90.0%)	9 (75.0%)	18 (94.7%)	9 (100%)	0.278
Yes	4 (100%)	3 (25.0%)	1 (5.3%)	0 (0%)	
Pedestal					
No	39 (97.5%)	11 (91.7%)	19 (100%)	9 (100%)	1.000
Yes	1 (2.5%)	1 (8.3%)	0 (0%)	0 (0%)	
Radiolucency lines					
No	39 (97.5%)	11 (91.7%)	19 (100%)	9 (100%)	1.000
Yes	1 (2.5%)	1 (8.3%)	0 (0%)	0 (0%)	

There were three complications. One intraoperative complication occurred, a posterior femoral cortical perforation during reaming, which was detected using routine intraoperative radiology; the definitive stem was adequately oriented and increased in size compared to the broach that performed the perforation. The stem was stable immediately, and the patient was asked to maintain partial weight bearing with the aid of two crutches for 6 weeks, and the stem maintained stability; the clinical result was satisfactory with a Merle d´Aubigné score of 18 at the final follow-up (Fig. 3). Two early postoperative complications occurred: one acute infection a month after the primary surgery, which was successfully managed with debridement, antibiotics, and implant retention, and one anterior dislocation within hours after the index procedure, which required open reduction and an increase in neck length to achieve stability.

Discussion

Young patients present a demand for additional activity, which makes them a serious challenge for the survivorship of the implants. In addition, most of them are exposed to modern information technology, which includes social media [17]; this provides much information that has to be validated or weighed during their visit with the surgeons, in subjects such as the type of fixation of the implant, the bearing surface, or the size of the components. Maintaining the quality of life, preserving bone and soft tissues, and achieving a completely stable implant are the objectives that all hip orthopedic surgeons pursue this type of patient. Both the fixation of the implant and the bearing surface remain controversial issues, but these options nowadays are well studied and documented. However, bone preservation is still an area needing improvement, and new designs of short stems need to be validated because most of them do have medium or short follow-up and some others do not succeed [4].

The results presented in the present series show satisfactory clinical results for the Taperloc Complete Microplasty stem. The Merle d'Aubigné score improved satisfactorily after surgery, and the values remained unaltered until the last checkup. These results are consistent with those published by Lombardi et al. [10]. In addition, a recent article by Hossain et al. [2] found that a short stem with a coated, proximally porous, flattened taper wedge design had a very favorable result in comparison with a non-cemented component of conventional standard length, in terms of functional results perceived by patients. We also found an absence of thigh pain. This complication is expected to occur more

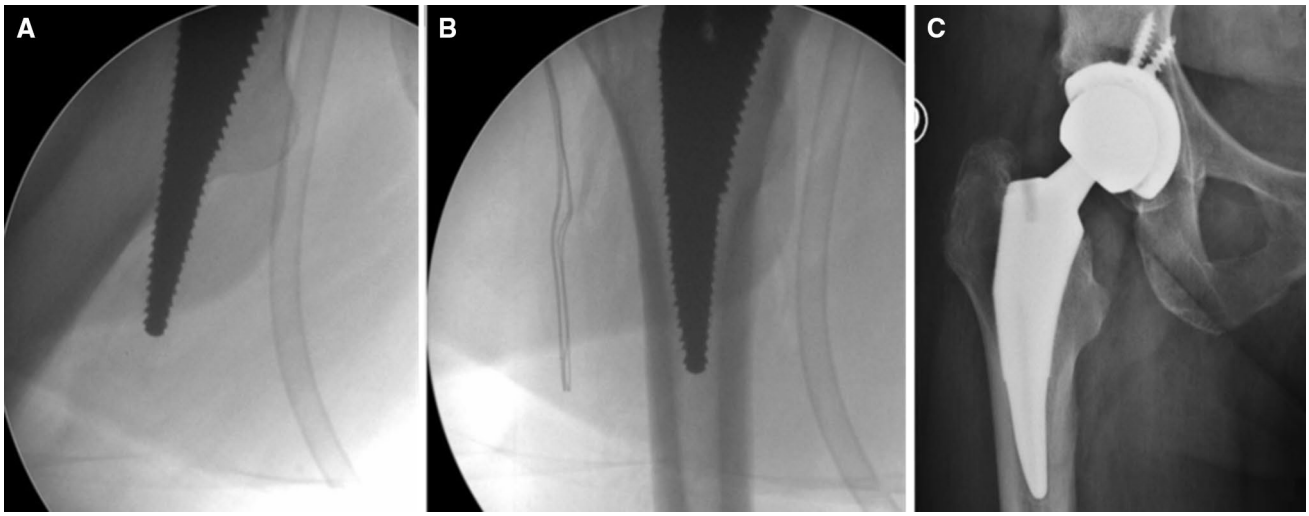

Fig. 3 **a** False reaming route; **b** correction of reamer direction; **c** AP X-ray at last follow-up

commonly in standard primary stems; in the study by Banerjee et al. [18], a low incidence of thigh pain (less than 3%) was observed with the use of short stems, and it was argued that this complication could be eliminated if the stem had an extended lateral flare.

The case that we present with the cortical perforation illustrates the value of the use of intraoperative radiology, which we consider extremely useful for all total hip arthroplasties, as published by Hambright et al. [19]. We consider that it is even more important when implanting short stems because they are technically demanding.

Regarding the radiological evaluation during follow-up, short stems seem to have a better bone remodeling on the metaphysis than standard stems, but this statement is not clearly supported by a recent meta-analysis [20], with some studies reporting bone resorption [21, 22]. We did not observe bone resorption. In the single case of subsidence reported in our series, we did observe that after initial vertical instability, the stem osseointegrated without any further complications. We want to emphasize that we did not exclude Dorr type C femurs. Some authors prefer to use cemented stems in those types of patients [2]. Nonetheless, we did not encounter findings of subsidence for uncemented stems in this type of femur with the short stem. Despite the use of intraoperative radiological control during broach trials, we found four stems placed in varus position. Those cases did not show migration, and there was no negative impact on the clinical outcome. Despite a correct alignment as the goal, a slight varus malalignment has been described by some authors as well tolerated [8, 21]. Our series had one varus migration of an initially correctly implanted stem. This could be related to undersize the stem. This has also been reported with some short stems, and it could be secondary to inadvertent varus stem malalignment [18].

In our series, no stems required revision, which coincides with the survival rate described for this type of stem in the literature [10] and the precursor design, the Taperloc Microplasty [8, 9].

The limitations of our study are its retrospective nature, its small sample size, and the short follow-up, although 75% of our patients were clinically and radiologically followed for more than 2 years. Also, this study did not evaluate the bone mineral density around the stem using dual-energy X-ray absorptiometry (DXA), which would have provide a more precise evaluation of bone remodeling around the stem. A recent systematic review evaluated fifteen studies evaluating periprosthetic bone mineral density by DXA with four short stems (CFP, Metha, Nanos, and Fitmore), comparing to two total hip arthroplasties, and observed distinctively different patterns between them [23]. To our best knowledge, this type of study is yet to be performed with the short stem reported in this series.

This series is one of the few illustrating the results of the new Taperloc Complete Microplasty stem, and it shows favorable results. Further long-term follow-up and prospective results are needed to assess this short tapered stem fully.

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Compliance with ethical standards

Conflict of interest One of the authors (XG) received royalties from and has consulting agreements with Zimmer Biomet, Inc.

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