Arthroplasty Today 8 (2021) 150–156

Contents lists available at ScienceDirect

Arthroplasty Today

journal homepage: http://www.arthroplastytoday.org/

Surgical technique

Complex Primary Total Hip Arthroplasty: Small Stems for Big Challenges

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ARTICLE INFO

Article history:
Received 7 April 2020
Received in revised form
15 February 2021
Accepted 23 February 2021
Available online xxx

Keywords:
Complex
Total hip arthroplasty
Short stems
Deformity
Retained hardware

ABSTRACT

Total hip arthroplasty is one of the most successful operations in all of medicine. Femoral deformities from malunion, prior osteotomy, and retained surgical implants all present unique challenges. Corrective osteotomy and hardware removal add significant morbidity to an operation that typically has a fast recovery. Short stems can be used in these cases to spare patients' increased morbidity. We present a case-based illustration and surgical technique for the use of short stems in complex primary total hip arthroplasty with femoral deformity and retained hardware. We discuss how these implants can spare significant morbidity, show radiographic examples of their use, and present short-term outcomes.

Introduction

Total hip arthroplasty (THA) has proven to be one of the most successful surgical procedures in all of orthopedics [1]. Most conventional uncemented hip arthroplasties use a stem that fills the proximal femur and engages the upper diaphysis to varying degrees. Proximal-distal mismatch, excessive femoral bowing, proximal femoral deformity, and retained hardware are scenarios that might prompt the surgeon to use a shorter stem. Studies have demonstrated comparable durability and similar outcomes of short and standard-length stems [2]. Short stems have advantages including preservation of bone stock, avoidance of stress shielding, lower incidence of intraoperative fractures, and decreased thigh pain [3]. In patients with diaphyseal deformity, these devices preclude the use of corrective osteotomies as fixation is achieved proximal to the majority of these deformities. When retained, proximal femoral hardware would interfere with implantation of a standard-length component, and a short-stemmed device can be used as an alternative to avoid the morbidity associated with hardware removal. The purpose of this article is to highlight the use of short stems in complex primary THA with challenging femoral anatomy.

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Surgical technique

We present a case-based illustration of short stems implanted for challenging femoral anatomy. The selected cases were performed by the 2 senior authors between February of 2015 and March of 2019. All patients consented to inclusion in this case series. Three stems were included in this series: the Microplasty Echo Bi-Metric (Zimmer Biomet, Warsaw, IN), the Short Synergy (Smith and Nephew, Memphis, TN), and the SMF (Smith and Nephew). These short stems are double tapered in the medial-lateral and anterior-posterior planes to provide more proximal fit and fill than a flat tapered wedge design. The authors prefer this design of short stem to gain additional proximal fixation because there is less diaphyseal engagement.

Compared with full-length double-tapered stems which use a ream and broach technique, these short stems are prepared only with broaches. Similar to the actual implants, the corresponding broaches are shortened compared with standard-length versions (Fig. 1). Preoperative templating is critical in cases of femoral deformity or retained hardware to ensure a short stem will fit and to prepare for alternative implants or osteotomy (Fig. 2). Intraoperative fluoroscopy can also be used to confirm broach trajectory while preparing the femur in cases of severe deformity or canal obliteration from fracture malunion (Fig. 3).

All surgical procedures in this series were performed through a posterior approach. The piriformis and short external rotators were

https://doi.org/10.1016/j.artd.2021.02.016

Figure 1. Standard length and Microplasty Echo Bimetric (Zimmer Biomet) broaches.

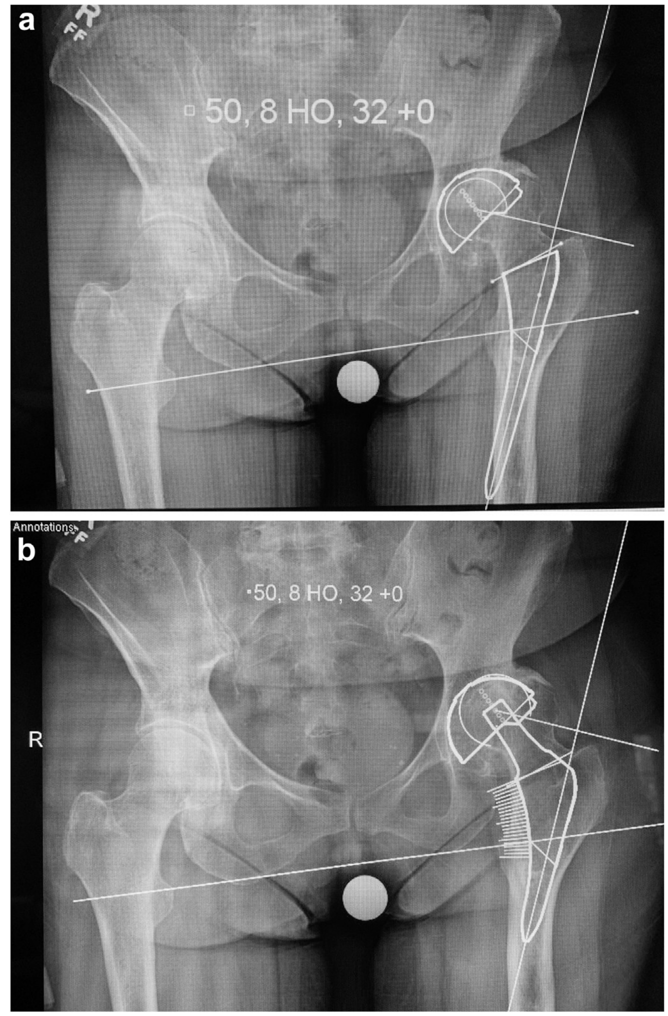

Figure 2. Preoperative templates of a standard length (a) and Microplasty (b) Echo Bimetric stems. Note that a standard-length implant would not fit in this patient with a proximal femoral malunion and would require a corrective osteotomy.

released followed by an L-shaped capsulotomy to expose the hip. The starting site for femoral preparation is the same as that with standard-length stems. Stem version is dictated by the posterior cortex of the femoral neck and the axis of the lower leg. Severe torsional malunion of a fracture or osteotomy may require the surgeon to add more version with the short stem vs switching to an alternative implant. A direct capsular repair followed by soft tissue repair of the piriformis and short external rotators to the gluteus medius tendon was performed in each case. Each patient was allowed to immediately bear weight as tolerated with standard posterior hip precautions for 6 weeks.

Case 1

A 56-year-old male presented with 3 years of right hip pain secondary to osteoarthritis. He had failed multiple nonoperative treatments and elected to undergo THA. His femoral anatomy was complicated by a remote femur fracture treated with traction, intramedullary nailing, and subsequent nail removal. His fracture malunion resulted in deformity and obstruction of his canal due to abundant secondary healing (Fig. 4). A short stem (Microplasty Echo Bi-Metric, Zimmer Biomet) was used successfully to avoid corrective osteotomy (Fig. 4). The patient's immediate postoperative course was uneventful; he has made a full recovery and is now 1 year postoperative. His preoperative pain resolved after the THA, and he has returned to moderate labor employment and light recreational activities.

Case 2

A 70-year-old male presented with 5 years of right hip pain due to osteoarthritis. He failed multiple nonoperative treatments and elected to undergo THA. His femoral anatomy was complicated by a remote femur fracture treated with traction. His fracture malunion resulted in a coronal plane deformity (Fig. 5). To avoid corrective osteotomy, a short stem (Short Synergy; Smith and Nephew) was used (Fig. 5). The patient's immediate postoperative course was uneventful. He has made a full recovery and is now 16 months from his surgery. His preoperative pain was resolved with the operation, and he has returned to light to moderate recreational activities.

Case 3

A 60-year-old female presented with 8 years of left hip pain secondary to hip dysplasia and secondary osteoarthritis. She failed multiple nonoperative treatments and decided to undergo THA. Her femoral anatomy was complicated by a history of a pathologic femur fracture from a benign bone cyst treated with traction and casting. Her fracture malunion resulted in a coronal plane deformity and a narrow canal at the metaphyseal-diaphyseal junction (Fig. 6). A short stem (Microplasty Echo Bi-Metric; Zimmer Biomet) was used thus avoiding corrective osteotomy. A prophylactic cable was placed before broaching to protect against unpredictable hoop stresses (Fig. 6). The patient's immediate recovery was uneventful; she has made a full recovery and is now 2 years postsurgery. Her preoperative pain was resolved with the THA, and she has returned to light labor employment and moderate recreational activities.

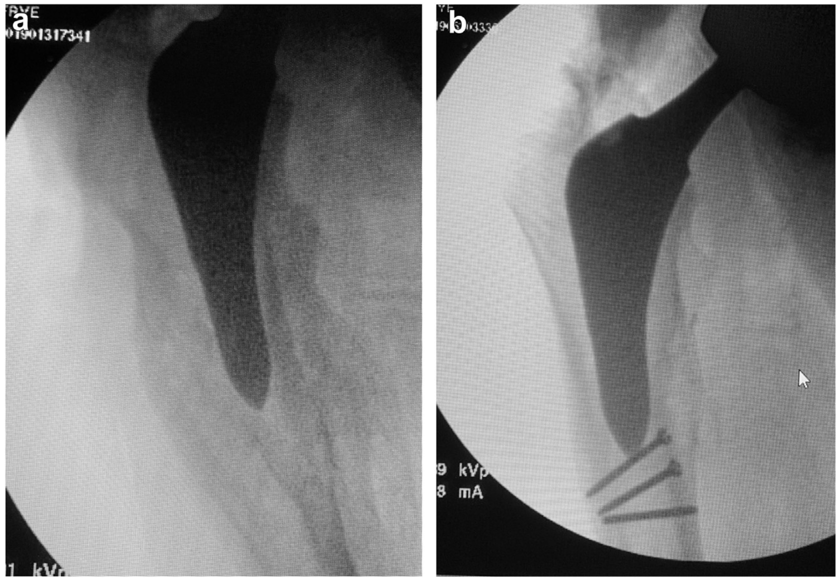

Figure 3. Intraoperative fluoroscopy used to aid in placement of a short stem in a femur with (a) complex anatomy and (b) retained shaft screws.

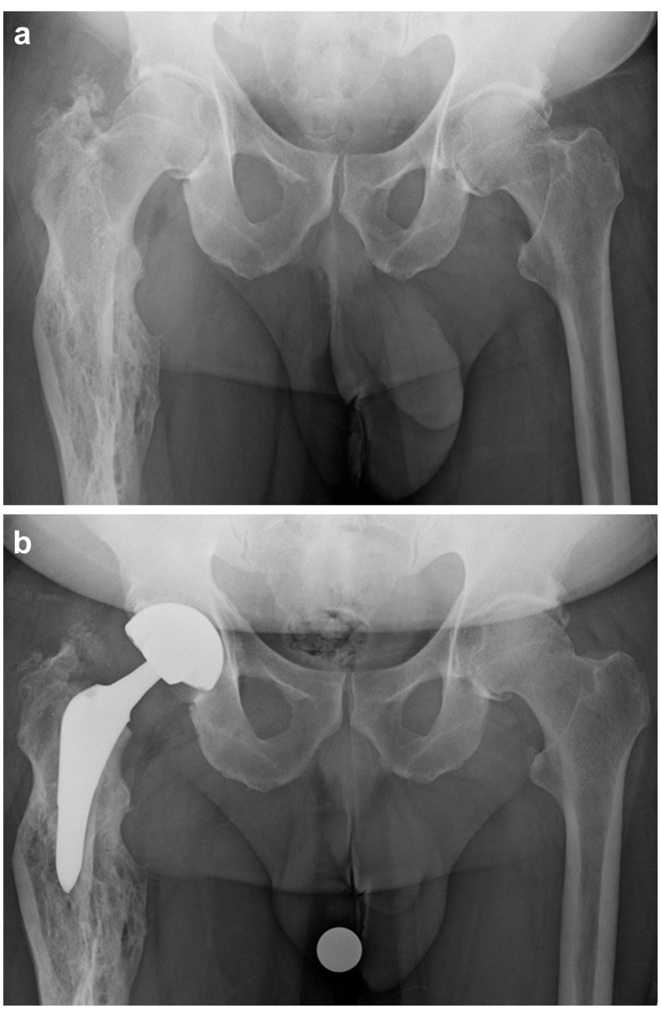

Figure 4. Preoperative (a) and 12-month postoperative (b) anteroposterior (AP) pelvis views.

Case 4

A 38-year-old male with a history of Legg-Calve-Perthes disease presented with over 10 years of right hip pain due to secondary osteoarthritis. He previously underwent proximal femoral osteotomy with subsequent hardware removal. He failed multiple nonoperative treatments and elected to undergo THA. His femoral anatomy was complicated by the almost 20-degree flexion deformity of the proximal femur from the osteotomy (Fig. 7). A short stem (SMF; Smith and Nephew) was used to avoid corrective osteotomy (Fig. 7). The patient's immediate postoperative course was uneventful, but he has made a full recovery and is now 6 years from his surgery. His preoperative pain was resolved with the operation, and he has returned to moderate labor employment and moderate recreational activities. He has been unable to return for clinical examinations over the years but has followed up with telemedicine check-ins.

Case 5

A 66-year-old male presented with 5 years of left hip pain secondary to osteoarthritis. He failed multiple nonoperative treatments and elected to undergo THA. Retained, now intramedullary, hardware after femur fracture repair in childhood complicated his femoral anatomy (Fig. 8). A short stem (SMF; Smith and Nephew) was used thus avoiding osteotomy and complex hardware removal (Fig. 8). The patient's immediate postoperative course was uneventful. He has made a full recovery and is now 20 months from his surgery. His preoperative pain was resolved with the operation, and he has returned to moderate labor employment and light recreational activities.

Case 6

A 70-year-old male presented with 15 years of right hip pain due to osteoarthritis. He failed multiple nonoperative treatments and elected to undergo THA. His femoral anatomy was complicated by retained, now intramedullary, hardware after femur fracture open

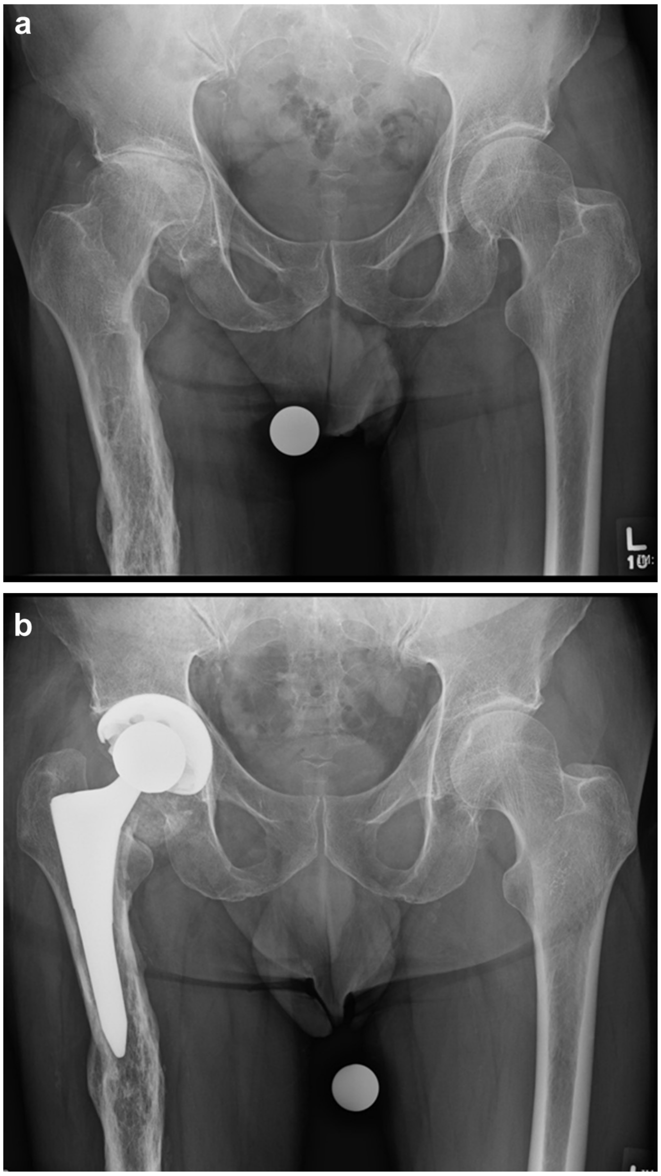

Figure 5. Preoperative (a) and 12-month postoperative (b) AP pelvis views.

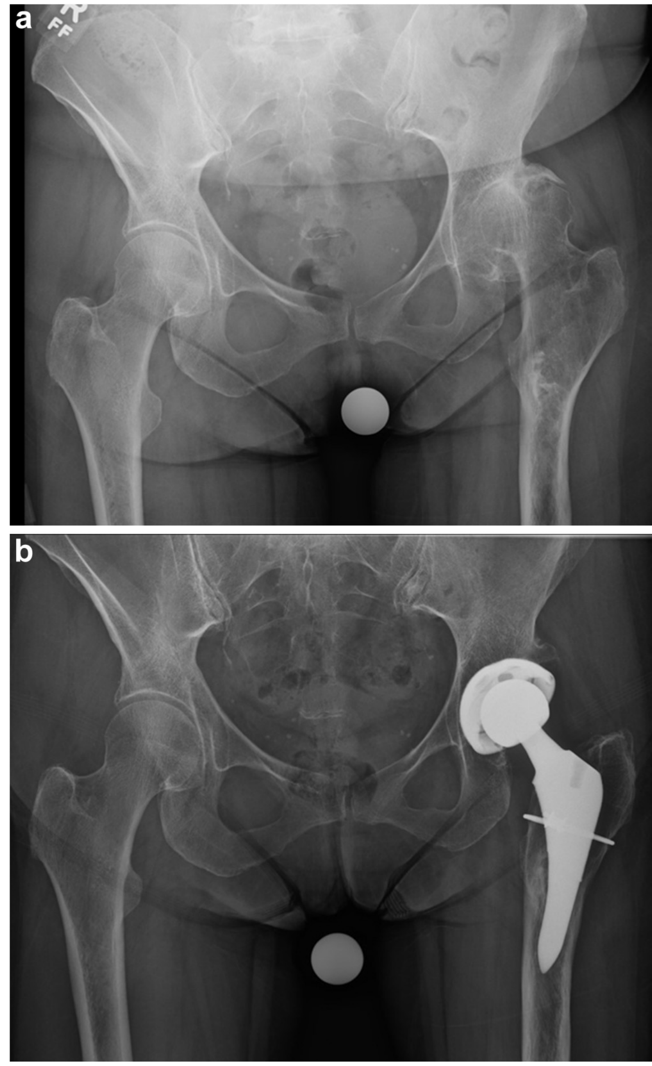

Figure 6. Preoperative (a) and 2-year postoperative (b) AP pelvis views.

reduction and internal fixation with incomplete hardware removal (Fig. 9). To avoid osteotomy and complex hardware removal, a short stem (Microplasty Echo Bi-Metric; Zimmer Biomet) was used (Fig. 9). The patient's immediate postoperative course was uneventful, but he has made a full recovery and is now 17 months from his surgery. His preoperative pain has resolved with the operation, and he has returned to light recreational activities.

Discussion

These cases highlight how short stems can help avoid significant morbidity when performing THA on patients with complex femoral anatomy. Surgeons should not compromise durable fixation and long-term survivorship to avoid more complex surgery. Long diaphyseal engaging stems should be available in case the short stem does not achieve immediate stable fixation. We present a literature review on the outcomes and durability of short stems.

Short stems have been reported in the literature since the 1980s [4,5]. Most commercially available short stems are generally 125 mm or less [5] from the top of the femoral neck to the distal part of the stem and have metaphyseal porous coating. While the location of fixation in the proximal femur can be considered similar to that of long stems in many ways, short stems do not engage the posterior cortex of the diaphysis and rely more on metaphyseal fill. This metaphyseal fill has been shown in both Sawbones models (Vashon Island, WA) and radiostereometric analysis to provide rigid stability with only small amounts of initial micromotion that do not compromise stability or clinical outcomes [6–12].

Available short- to mid-term data on short stems are encouraging. A comprehensive review by Lidder et al. identified 15 studies that reported overall survivorship of 98.6% at a mean follow-up of 12 years [13]. They noted that <2 years of survivorship was 100% (1 study); 2 to 5 years was 97.7% (6 studies); >5 to 10 years was 99.6% (5 studies); and >10 (max 17.8 years) was 97.8%.

Clinical outcome scores of patients treated using a short stem are similar to those of their long-stem counterparts. A meta-analysis by Huo et al. included 6 randomized clinical trials with 552 patients and 572 hips [14]. There was no difference in Harris hip scores between the conventional stem cohort and short-stem cohort (standard mean difference = 0.02, P = .82). WOMAC

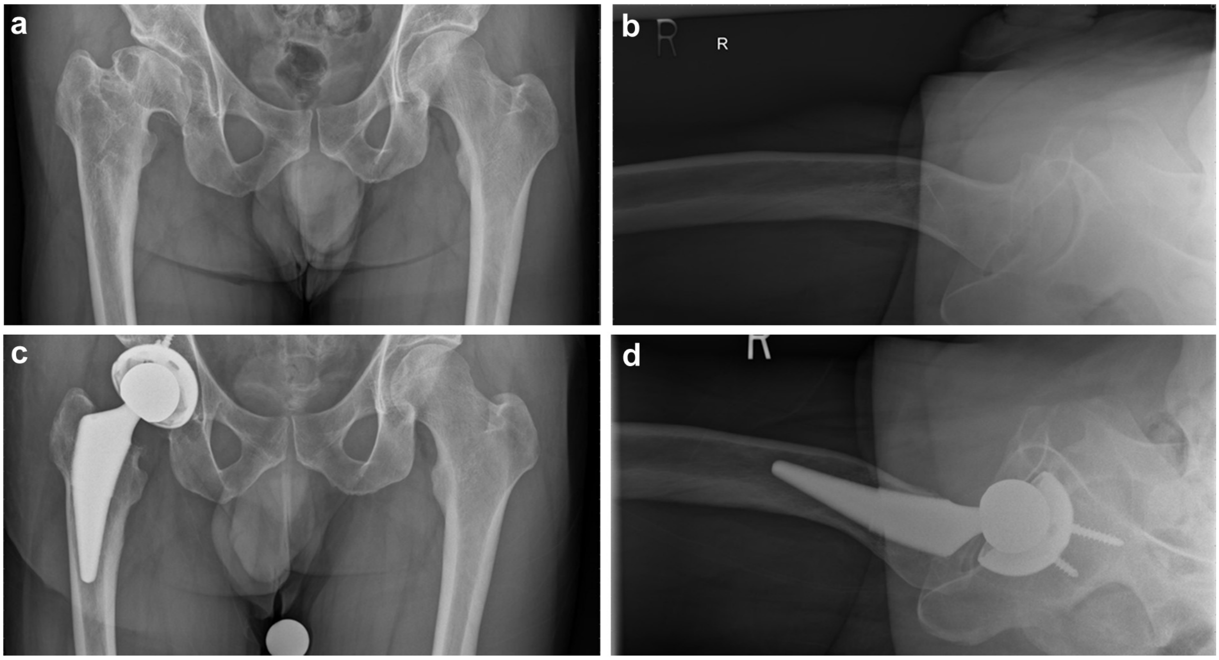

Figure 7. Preoperative AP (a), lateral (b), and 3-month postoperative AP (c) and lateral (d) views.

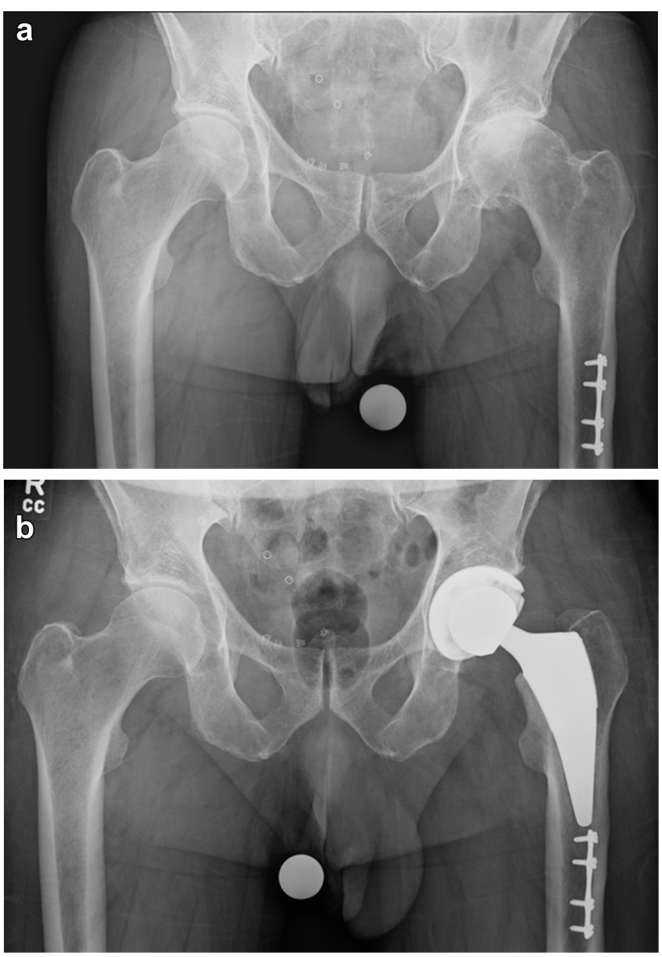

Figure 8. Preoperative (a) and 12-month postoperative (b) AP pelvis views.

(Western Ontario and McMaster Universities Arthritis Index) scores available in 5 of the studies also showed no difference between the groups (standard mean difference = 0.09, $P = .35$).

Preservation of bone stock is important, especially in younger patients who may need future revision. The use of a short-stemmed implant may minimize stress shielding by transferring loads to the metaphyseal region of the femur in a more physiologic manner. Studies have shown increased bone mineral density and less stress shielding in the metaphyseal region using dual energy x-ray absorptiometry [15,16]. The use of shorter stems has also been shown to result in less thigh pain [16–21] and easier insertion [3,22–24]. Several other authors have evaluated the survivorship and incidence of intraoperative complications with short-stemmed implants [3,25–29]. Table 1 outlines the stem-related survivorship and complication rates with some short-stem variations.

The alternative to short stems would be corrective osteotomy in the case of femoral deformity and hardware removal in the case of retained surgical implants. These additional procedures add complexity, operative time, and morbidity to THA but can give excellent outcomes. Holtgrewe and Hungerford described successful THA with corrective osteotomy for THA with proximal deformity as early as 1989 [30]. Onodera et al. published successful outcomes and survivorship for THA with corrective osteotomy and implant removal using an S-ROM stem (Depuy Synthes, Warsaw, IN) [31]. Corrective osteotomy at the time of THA can be technically challenging; however, various devices have been developed to assist with this procedure [32]. Surgeons must be prepared to perform this additional procedure with alternative implants if the short stem does not provide rigid initial fixation.

Summary

In conclusion, small, metaphyseal engaging stems are important tools that can be used in cases of challenging proximal femoral anatomy including metaphyseal-diaphyseal mismatch, excessive femoral bowing, diaphyseal deformities, and retained hardware. These implants have numerous advantages including preservation

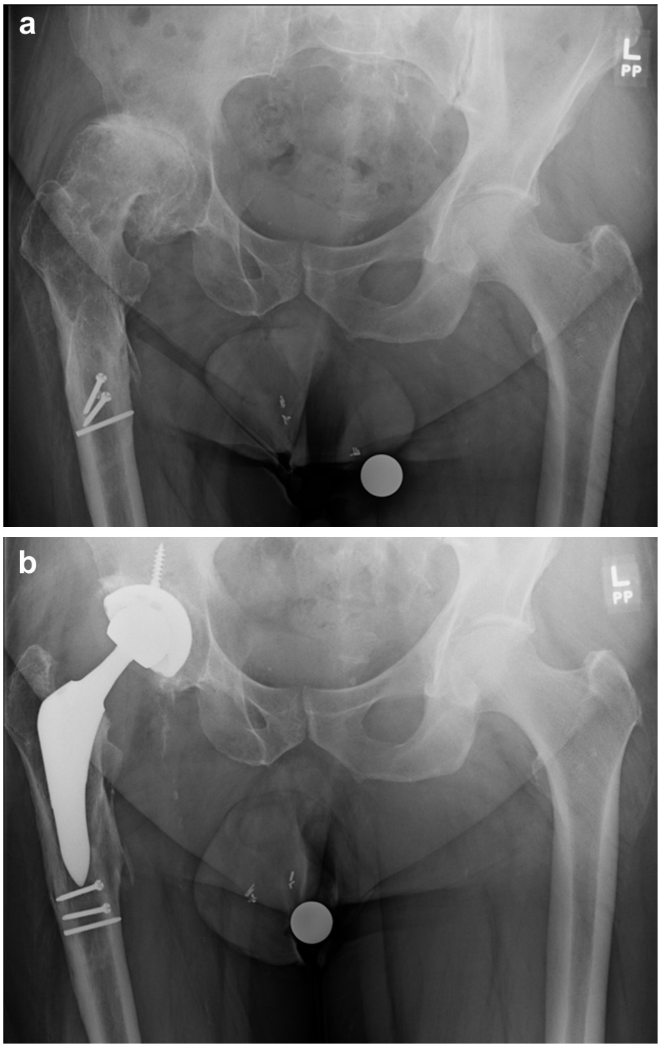

Figure 9. Preoperative (a) and 12-month postoperative (b) AP pelvis views.

Table 1
Summary table of stem-related survivorship and complications of short-stem variations.

Study	Short stem	Stem-related survivorship	Stem-related complications
Kim et al. [2]	Proxima (Depuy Synthes)	99.1% at 15.6 y	Aseptic loosening (0.9%) Periprosthetic fracture (0.6%)
Molli et al. [3]	TaperLoc Microplasty (Zimmer Biomet)	99.6% at 5.2 y	Periprosthetic fracture (0.4%)
Acklin et al. [7]	Fitmore (Zimmer Biomet)	97.1% at 2 y	Aseptic loosening (2.9%)
Budde et al. [8]	Nanos (OHST)	100% at 2 y	Periprosthetic fracture (5.6%)
McCalden et al. [9]	SMF (Smith & Nephew)	95.5% at 3.8 y	Aseptic loosening (4.5%)
Salemyr et al. [16]	Proxima (Depuy Synthes)	96.2% at 2 y	Periprosthetic fracture (3.8%)
Tamaki et al. [26]	TaperLoc Microplasty (Zimmer Biomet)	99.1% at 5 y	Periprosthetic fracture (2.7%)
Gkagkalis et al. [27]	Optimys (Mathys)	Age <60 y: 98.9% at 4.3 y Age >60 y: 97.8% at 3.6 y	Periprosthetic fracture (0.8%) Periprosthetic fracture (2.9%)

of femoral bone stock, decreased thigh pain, and durable survivorship. They can help avoid the potential morbidity of complex hardware removal and corrective osteotomy. These implants are an important tool in the treatment of challenging proximal femurs and a critical component in the armamentarium of any surgeon who performs challenging primary hip arthroplasties. Short stems would not be useful in cases with extremely proximal hardware or deformity or when torsional deformity prevents adequate stem version. These cases would require hardware removal, corrective osteotomy, and diaphyseal engaging or modular implants. Future long-term studies comparing short stems with corrective surgery and long stems are required to support their routine use in the complex femur.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests. Benjamin Frye, MD: Paid consultant for Zimmer Biomet.

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