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Surgical technique

Removing Well-Fixed, Collared and Noncollared Tapered Hip Stems Without an Extended Trochanteric Osteotomy Using a Novel Stem Removal System

Kevin M. Sagers, DO [a], Jonathan D. Creech, MD [a], John S. Shields, MD [a], David C. Pollock, MD [a], Maxwell K. Langfitt, MD [a], Johannes F. Plate, MD, PhD [a, b, *]

[a] Department of Orthopaedic Surgery, Division of Adult Reconstruction, Wake Forest School of Medicine, Winston-Salem, NC
[b] Department of Orthopaedic Surgery, University of Pittsburgh, Pittsburgh, PA

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ABSTRACT

Improvements in materials, components, and surgical techniques in cementless total hip arthroplasty are resulting in improved femoral stem fixation through bony ongrowth or ingrowth. While improved femoral stem fixation is one reason for the current excellent total hip survivorship, indications for stem removal such as infection, implant fracture, or osteolysis remain. A commonly used technique for fully ingrown femoral stems is an extended trochanteric osteotomy which can result in comminuted fractures of the proximal femur during stem removal requiring additional fixation. Therefore, a novel hip stem removal was developed to facilitate removal of these well-ingrown stems without the need for an extended trochanteric osteotomy. This study describes the removal system and surgical technique and presents a case series of successfully removed ingrown stems.

Introduction

Modern total hip arthroplasty (THA) is one of the most successful surgical procedures with excellent survivorship and functional outcomes. The demand for THA procedures is expected to grow by 174% by 2030. With this expected growth, the demand for revision procedures is projected to double by 2026 [1]. Revision and removal of well-ingrown cementless femoral components remains challenging, often complicated by poor bone stock and risk of fracture [2]. While advances in cementless stem design have led to significant improvements in stem fixation and bony ingrowth and ongrowth, it has increased the difficulty of stem removal when necessary.

Historically, an extended trochanteric osteotomy (ETO) has been used to provide exposure of the stem within the femoral canal to assist in implant removal [2]. However, there is a high risk of iatrogenic fracture during THA revision of 10% - 20% with the use of an ETO [3-6]. An ETO was found to reduce the femoral torque to failure by 73% despite appropriate fixation of the osteotomy [7]. This has led to more restrictions in weight-bearing and rehabilitation protocols, compromised abductor function, and increased need for abductor braces. In some cases, damage to the femur during removal can be catastrophic despite an ETO and potentially compromise subsequent reconstruction options and outcomes (Fig. 1).

There is a paucity of implant-specific removal devices for well-ingrown stems from the implant manufacturers leaving surgeons to seek innovation through third-party companies. A novel hip stem removal system (Watson Extraction System; Rivera Surgical, Naples, FL) was developed to facilitate removal of well-ingrown stems without the need for an ETO. This study describes the surgical technique and demonstrates successful stem removal in several cases without the need for an ETO.

Surgical technique

After dissection, capsulotomy and removal of the head ball, the soft tissue around the shoulder of the implant is excised to allow visualization of the proximal lateral aspect of the stem. A small portion of the abductor insertion may be recessed and the most

* Corresponding author. Department of Orthopaedic Surgery, University of Pittsburgh, 5200 Centre Avenue, Suite 415, Pittsburgh, PA, USA 15232. Tel.: +1 412 802 4100.
E-mail address: platefj2@upmc.edu

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proximal medial aspect of the trochanteric bone may be burred to facilitate direct in-line access to the stem. This essential step allows the instruments used to free the lateral aspect of the implant to translate slightly lateral while advancing. Without sufficient space for the instrument, the surgeon may inadvertently lever against the greater trochanter, increasing the risk for fracture and misdirection of the instrument distally.

A pencil-tip burr is then run around the proximal portion of the stem to create a starting point for the removal osteotomes. A specially designed, single-use lateral starting osteotome (Fig. 2) is then selected based on measuring the width of the lateral shoulder using the included measuring device. These osteotomes are designed to fit around the entire lateral aspect of the stem, including a portion of the anterior and posterior surfaces (Fig. 2). The radius of curvature of the osteotomes matches the taper angle of commonly used stems to preserve the maximum amount of native bone during removal. Osteotomes for a variety of stem geometries (eg, straight stems) are available. The starting lateral osteotome is advanced with a mallet to the distal end of the proximal porous coating on the stem (Fig. 2), taking caution to avoid hitting the osteotome with excessive force. The starting osteotome is then removed. For stems with hydroxyapatite coating distally, a longer lateral osteotome is then advanced as close to the tip of the implant as possible (Fig. 3).

In order to gain access to the medial calcar, it is recommended to remove a collar with a metal cutting burr or disc. To control the metal debris and facilitate removal upon suction and lavage, the authors recommend placing a surgical sponge over the exposed soft tissue within the wound and then applying sterile ultrasound gel. It should also be noted that some collars flare at the anterior/posterior edges which will need to be flattened to allow osteotome passage.

The appropriately sized medial osteotome is then introduced and advanced (Fig. 4). This osteotome has a cutout that will allow passage of the trunnion and neck of the implant to pass through the osteotome as it follows the medial taper of the stem (Fig. 4). The osteotome is advanced to the level of the distal porous coating and then removed.

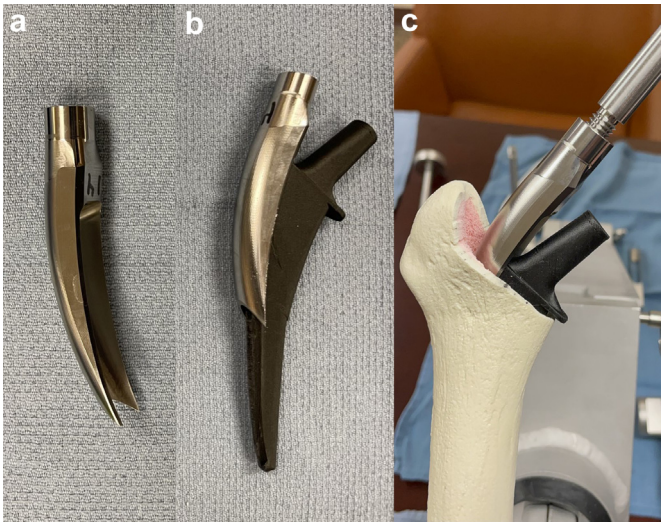

Figure 2. (a) The starting lateral osteotome in the Watson Extraction System. (b) The custom osteotome is designed to follow the geometry and taper of the stem. (c) A Sawbone model demonstrating the passage of the starting lateral osteotome.

The implant is then removed with an implant-specific extractor or a universal removal tool that attaches to the neck of the implant (Xtract-All; Shukla Medical Inc., Saint Petersburg, FL). The remainder of the procedure is then carried out according to the surgical indications and operative plan.

Case examples

Case 1

A 19-year-old male with a history of sickle cell anemia presented in 2017 with a complaint of bilateral hip pain due to avascular necrosis with collapse of bilateral femoral heads, resulting in

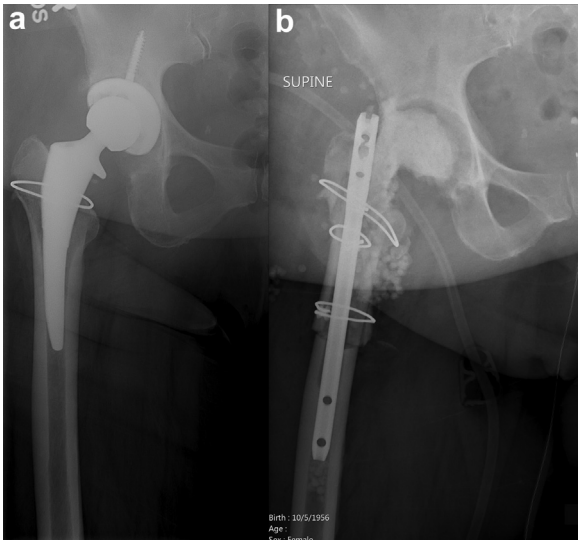

Figure 1. (a) Preoperative radiograph of a patient with a well-fixed collared stem who underwent explant for infection. (b) Postoperative radiograph after explantation with ETO. ETO resulted in a comminuted fracture of the proximal femur. An antibiotic-coated intramedullary nail was used as a spacer.

Figure 3. (a) The second lateral osteotome. (b) The additional length allows freeing of the stem from any ongrowth at the hydroxyapatite-coated portion. (c) A Sawbone model demonstrating the passage of the second osteotome.

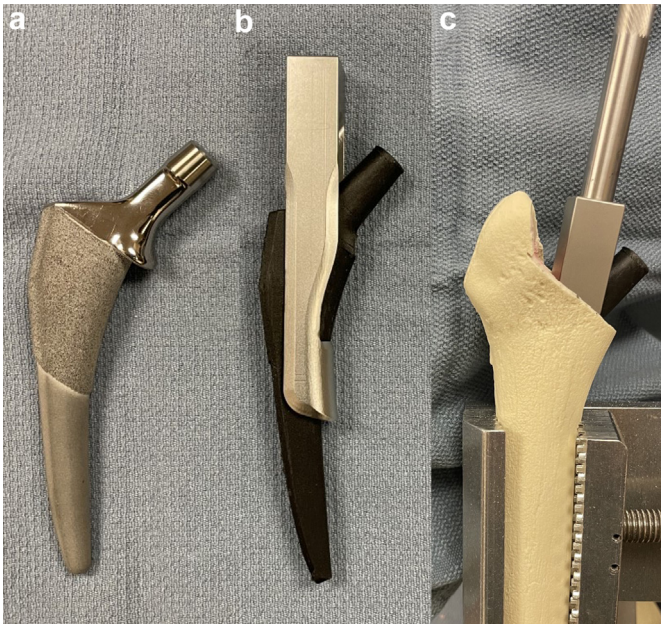

Figure 4. (a) A commonly used cementless triple tapered collared stem (Actis; DePuy Synthes). (b) The medial osteotome is passed along the medial ingrowth portion of the stem once the collar is removed. (c) A Sawbone model demonstrating the passage of the medial osteotome.

debilitating pain and immobility. He eventually underwent staged bilateral THA in 2018 with collared, triple tapered stems (Fig. 5) (Actis; DePuy Synthes, Warsaw, IN).

The patient's postoperative course was complicated by an acute deep infection in the right hip at 3 weeks with methicillin-sensitive *Staphylococcus aureus* and treated with irrigation and debridement. The infection recurred at 9 months. The patient was indicated for two-stage revision requiring implant removal. Despite recurrent infection, radiographs demonstrated a well-ingrown stem.

Stem extraction was performed successfully using the aforementioned technique without the need for ETO, and the cup removed with a commonly used extraction device (Fig. 5). A spacer coated with antibiotic impregnated cement (Prostalac; DePuy Synthes, Warsaw, IN) was placed (Fig. 5). No fracture was noted in the femur after removal. Second-stage reconstruction is pending clearance of infection.

Case 2

A 51-year-old female presented to the clinic 2 years after right THA with a collarless, triple-tapered stem (TaperFill; DJO, Lewisville, TX) (Fig. 6). She had continued pain after her index procedure, localized to the groin, anterior thigh, and buttock area despite extensive workup and nonsurgical management. Workup for infection was negative. Her pain was determined to be multifactorial: She had a progressive lucent line along the proximal lateral aspect of the stem on the radiograph, allowing for possible cantilever movement, as well as a 1-cm increase in her leg length after index surgery.

The patient elected to proceed with revision of the femoral component. The stem was successfully removed in less than 30 minutes using the described technique, and a revision component was placed (Fig. 6). No fracture was noted in the femur after removal. A prophylactic cable was placed around the calcar before preparation of the femur for the revision stem.

Case 3

A 68-year-old male presented to the emergency department after feeling a "pop" and experiencing immediate pain and inability to bear weight while golfing. His index bilateral metal-on-metal THAs were in 2005 at an outside institution. He had previously undergone bilateral head-liner conversions to ceramic-on-polyethylene components in 2019. X-ray on presentation revealed a fractured neck of the right femoral component (TRI-LOCK; Depuy Synthes, Warsaw, IN) (Fig. 7).

He elected to proceed with revision of the femoral component. The stem was successfully removed in less than 30 minutes using the described technique, and a revision component was placed (Fig. 7). No fracture was noted in the femur after removal.

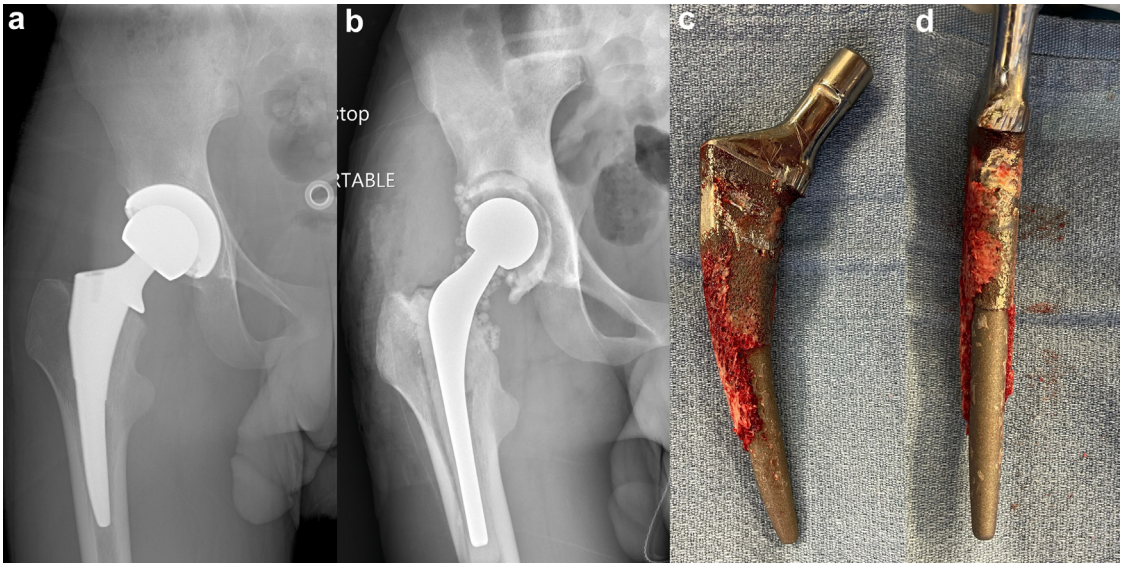

Figure 5. (a) Preoperative radiograph of a patient that was indicated for explant of a well-fixed collared stem due to infection. (b) Postoperative radiographs after successful removal of the stem without ETO or fracture using the Watson Extraction System. (c and d) Clinical photographs of the removed stem demonstrate minimal bone loss associated with stem removal.

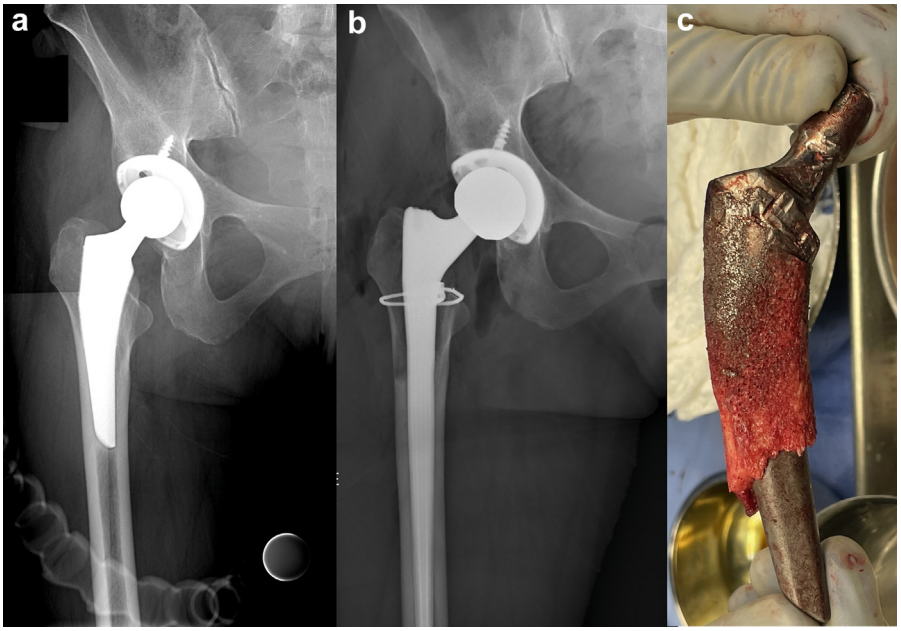

Figure 6. (a) Preoperative radiograph of a patient indicated for revision of the femoral stem due to progressive lucent lines and pain. (b) Postoperative radiographs after successful removal of the stem without ETO or fracture using the Watson Extraction System and stem revision. (c) Clinical photograph of stem after removal.

Case 4

A 57-year-old female presented to the clinic with a 6-month history of left hip pain, 10 years after left THA with a proximally coated straight stem (Summit; DePuy Synthes, Warsaw, IN). Radiographs revealed catastrophic polyethylene wear with notching of the femoral neck secondary to impingement on the acetabular component (Fig. 8). She elected to proceed with revision of both components. A stem-specific osteotome for straight stems was used, and the femoral component was extracted in 4 minutes without fracture or a need for ETO. A trochanteric plate was placed with cables to protect the osteolytic bone at the greater trochanter from fracture during placement of revision components.

Discussion

The extraction of well-fixed cementless stems during THA revision remains challenging. Much like the progression from spoon osteotomes to modern cup-cutters which significantly improved removing well-fixed acetabular components, the authors have found similar improvements in the removal of well-fixed femoral stems with the use of a novel, stem-specific extraction system. Previously, stems were removed with various tools, including flexible osteotomes, burrs, and Gigli saws. However, the use of these tools resulted in common complications associated with stem removal. Flexible osteotomes often skive off ingrown bone surrounding the stem perforating the femoral cortex which can result in iatrogenic fracture when converting to an ETO (Fig. 1). The stem-specific osteotomes presented here are sharp and robust to avoid these perforations while following the geometry of the stem precisely to preserve the bone. In the cases performed at the authors' institution, there have been no femoral fractures observed, and an ETO was not needed while using the described technique.

Another potential advantage of implant-specific extraction tools is improved efficiency. Prolonged operative times are associated with poor perioperative outcomes in primary arthroplasty procedures [8-10]. Increased operative time (>120 minutes) in revision THA has been shown to increase risk of pulmonary embolism and thromboembolic complications, infection, and prolonged hospital stay [11]. It is imperative that surgeons use measures to reduce operative time without compromising surgical technique and outcomes. Optimizing femoral component removal without the need for ETO with implant-specific extraction devices can potentially reduce operative time, decrease complications, and improve cost savings.

Many factors contribute to successful implant removal including exposure, bone quality, stem type, and geometry as well as available extraction tools. Preoperative planning is essential to avoid complications. Tools such as flexible osteotomes, high-speed burrs, curettes, and ultrasonic tools should be readily available during extraction. The early experience with the instruments used in this case series is encouraging regarding the possibility of removing well-fixed stems without the need for an ETO or iatrogenic fracture. However, surgeons must acknowledge the continued risk of fracture and the potential need for ETO regardless of what tools are available. Patients need to be counseled about these risks, and surgeons should plan appropriately should these situations arise.

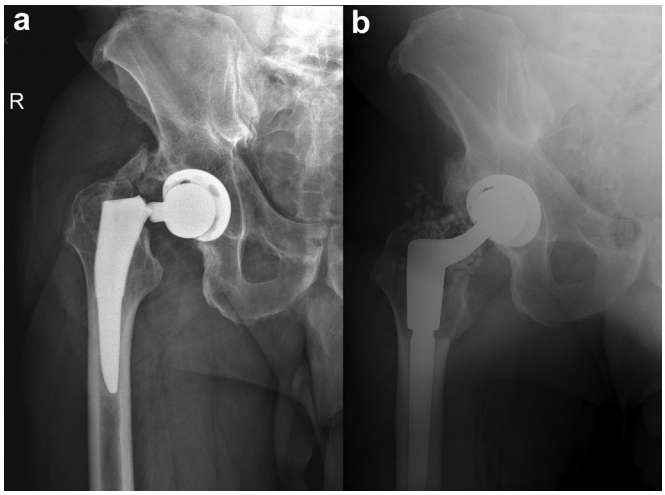

Figure 7. (a) Preoperative radiograph of a patient with fractured neck of the previously implanted cementless stem. (b) Postoperative radiograph after successful removal of stem without ETO or fracture and stem revision.

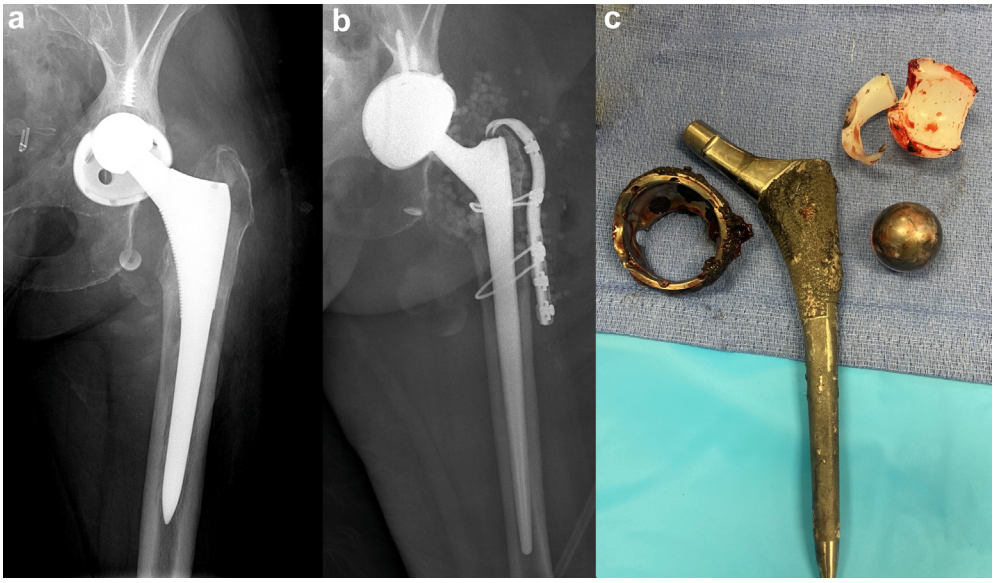

Figure 8. (a) Preoperative radiograph of a catastrophic polyethylene liner wear or polyethylene liner dislocation with destruction of acetabular component and screw with superior migration of the femoral component. The neck of the femoral component appeared to have worn on the acetabular rim creating a notch concerning for risk of fracture and necessitating stem removal in addition to acetabular revision. (b) Postoperative radiograph after successful removal of the stem without an ETO and insertion of a monolithic revision stem and addition of a trochanteric hook plate with cable fixation due to osteolysis of the greater trochanter. (c) Clinical photograph of the stem after removal with minimal bone loss.

Summary

Removal of a well-fixed cementless femoral stem remains challenging, and ETOs performed by experienced surgeons still carry significant risks. A novel extraction system designed based on individual stem geometry may allow for enhanced bone preservation, thereby decreasing patient morbidity during the resection of well-fixed femoral stems that have traditionally been difficult to remove. However, long-term studies will be necessary to evaluate this extraction system.

Conflicts of interest

The authors declare the following financial interests/personal relationships which may be considered as potential competing interests: J. S. Shields is a paid consultant for Smith & Nephew. D. C. Pollock received royalties from and is a paid consultant for DePuy Synthes. J. F. Plate is a paid consultant for Total Joint Orthopaedics and Smith & Nephew; has stock or stock options in Eventum Orthopedics; received research support from Biocomposites Inc.; and is in the editorial/governing board of VisualDX and *Journal of Arthroplasty*. The remaining authors have nothing to disclose.

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