



Original Research

Endofemoral Shooting Technique for Removing Well-fixed Cementless Stems

Kenichi Oe, MD, PhD^{*}, Hirokazu Iida, MD, PhD, Takashi Toyoda, MD,
Tomohisa Nakamura, MD, PhD, Naofumi Okamoto, MD, PhD, Takanori Saito, MD, PhD

Department of Orthopaedic Surgery, Kansai Medical University, Hirakata, Osaka, Japan

ARTICLE INFO

Article history:
Received 2 February 2022
Received in revised form
6 July 2022
Accepted 8 July 2022
Available online xxx

Keywords:

Extraction of femoral stem
Endofemoral removal
Cementless stem
Femoral revision
Total hip arthroplasty

ABSTRACT

Background: The removal of a well-fixed cementless stem poses technical challenges. The aim of this study was to evaluate the outcomes of our endofemoral extraction technique established in 2001.

Methods: Between January 2001 and December 2016, 118 consecutive revisions following bipolar or total hip arthroplasty, which required cementless femoral stem removal, were performed at our institution. This retrospective study evaluated 106 patients (108 hips) who were followed up for a mean of 9.2 years (range, 5–20 years). The patients included 15 men and 91 women with a mean age of 65 years (range, 33–87 years). Endofemoral extracted stem removal was performed as follows. Multiple Kirschner wires were sequentially inserted into the interface between the implant and cortical bone, after which the implant was detached using a thin chisel. After the cementless stem was removed, it was replaced with a cemented stem using an autograft, as needed. Radiological loosening of the femoral stem was defined as definite or probable loosening, based on the criteria of Harris et al. Prosthesis survival was analyzed using the Kaplan-Meier method, with the endpoint set as repeat revision surgery for stem loosening or femoral fracture.

Results: Re-revision surgery was performed in 7 hips. Stem loosening was observed in 4 hips, and the mean subsidence was 0.3 mm (0–3 mm). The 10-year survival rate was 97.7% (95% confidence interval, 93.2–100).

Conclusions: Our technique for removing well-fixed cementless stems yielded successful results.

© 2022 The Authors. Published by Elsevier Inc. on behalf of The American Association of Hip and Knee Surgeons. This is an open access article under the CC BY-NC-ND license (<http://creativecommons.org/licenses/by-nc-nd/4.0/>).

Introduction

Cementless fixation in total hip arthroplasty (THA) has been increasingly used worldwide although this trend is paradoxical given the registry data representing nationwide THA results [1]. Furthermore, the number of revision THAs has inevitably increased [2]. Some revision THAs require the removal of well-fixed femoral cementless stems because of periprosthetic joint infection, dislocation, periprosthetic fracture, and other reasons. However, removal of well-fixed femoral cementless stems remains challenging, often leading to complications such as femoral perforation, poor bone stock, and fracture [3].

In 1995, Younger et al. [4] introduced a new extended proximal femoral osteotomy for the removal of well-fixed cementless stems; the technique is based on an extended transfemoral osteotomy (ETO). ETO is the most widely used method to remove well-fixed cementless stems, and some analogous osteotomies have been reported [5–7]. However, such osteotomies are invasive and associated with numerous complications, including intraoperative fracture, weakness of the abductor mechanism, and postoperative fracture or stem loosening [6,8–10]. Some longitudinal split osteotomies have also been reported recently [7,11,12]. Although ETOs demonstrated good results [13,14], it is better to not use these osteotomies.

We have performed an endofemoral shooting technique for the removal of well-fixed cementless stems since 2001. Our technique can avoid an ETO or split procedure although it has technical requirements. This study aimed to retrospectively evaluate the clinical results of our technique. We hypothesized that our technique would be effective for removing well-fixed cementless stems.

^{*} Corresponding author. Department of Orthopaedic Surgery, Kansai Medical University, 2-5-1 Shinmachi, Hirakata, Osaka 573-1010, Japan. Tel.: +81 72 804 2436.

E-mail address: oecken@hirakata.kmu.ac.jp

Table 1
Preoperative patient characteristics.

Characteristics	Value
Number of hips	108
Age at surgery (y), mean (range)	65 (33–87)
Sex, male:female	15:93
Follow-up period (y), mean (range)	9.2 (5–20)
Reason for revision	
Periprosthetic infection	40
Migration or subsidence of bipolar hip arthroplasty	18
Cup loosening	17
Stem loosening	12
Stem migration	10
Implant breakage	7
Recurrent dislocation	5
Osteolysis	4
Postoperative thigh pain	3
Periprosthetic fracture	2
Engh's classification	
Fixation	64
Fixation by bone ingrowth	39
Stable fibrous ingrowth	5
Unstable implant	0
Cementless stem design	
Category A	17
Category B	69
Category C	3
Category D	19

Material and methods

Study design and patients

Between January 2001 and December 2016, 118 consecutive revisions following bipolar hip arthroplasty (BHA) or THA, which required cementless femoral stem removal, were performed by 4 experienced surgeons at our institution. This retrospective cohort study included 106 patients (108 hips) who were followed up for at least 5 years; 4 patients died from unrelated causes, and 6 patients were lost to follow-up (follow-up rate, 92%). The patients included 15 men and 91 women, and the mean patient age at the time of surgery was 65 years (range, 33–87 years). The mean duration of clinical follow-up was 9.2 years (range, 5–20 years). The reasons for revision THA were periprosthetic infection in 40 hips, migration or subsidence of BHA in 18 hips, cup loosening in 17 hips, stem loosening in 12 hips, stem migration in 10 hips, implant breakage in 7 hips, recurrent dislocation in 5 hips, osteolysis in 4 hips, postoperative thigh pain in 3 hips, and periprosthetic fracture in 2 hips. Our institutional review board (2,021,152) approved this prospective cohort study. Each patient provided informed consent for inclusion in the published findings.

Variables

Fixation between the cementless stem and femoral bone at the time of revision was categorized according to Engh's classification [15]: fixation in 64 hips, fixation by bone ingrowth in 39 hips, stable

fibrous ingrowth in 5 hips, and unstable implant in 0 hips. The implanted stem was classified into the following types based on the removal of cementless stem: (1) category A, designed to stabilize in the proximal metaphysis with a cancellous bone bed (eg, Austin-Moore type); (2) category B, designed to obtain metaphyseal proximal cortical contact (eg, taper-wedge type, fit-and-fill type, anatomic type, modular type); (3) category C, designed to engage in the metaphyseal-diaphyseal junction and proximal diaphysis with edges (eg, Wagner type, Zweymuller type); and (4) category D, designed to engage proximal and distal cortical bone in the diaphysis (eg, full-porous type, long-stem type) (Tables 1 and 2).

Endofemoral shooting technique

The transgluteal approach in the lateral position was used in all the patients [16]. After incision through the skin and tensor fascia latae, a longitudinal incision was made using cutting diathermy. The hip was dislocated, and the femoral head was removed. First, the acetabular component was revised in accordance with preoperative planning, if necessary. For removal of the endofemoral extracted stem, disrupted bony overgrowth around the proximal stem was removed with a rongeur and osteotome to make it easier to insert wires. Second, multiple 2.0-mm Kirschner wires were sequentially shot to the interface between the cortical bone and the implant in a circumferential manner. Third, the implant was detached using a thin and flexible osteotome (Fig. 1). To prevent slipping down a forged path, a Kirschner wire was left in, whereas another wire was inserted accompanying the first wire. If this was unsuccessful, this process was carefully repeated, especially focusing on the porous surface of the stem. If still impossible, an anterior window (approximately 1 cm × 1 cm) was made with an osteotome, and wires were sequentially inserted. Regardless of the cementless stem type, the same method was used for the removal, and no fluoroscopy was used.

After removing the cementless stem, the cemented THAs were revised. In the acetabulum, we randomly used 2 implant types between January 2001 and December 2012: (1) the K-MAX CLHO flanged cup (KYOCERA Medical, Osaka, Japan) and (2) the Charnley Elite plus cup (DePuy International, Leeds, United Kingdom). Between January 2013 and December 2016, the K-MAX CLHO flanged cup was used. Structural allografts and KT plate (KYOCERA Medical) were used for massive bone defects if necessary [17,18]. In the femur, a variety of cemented stems with a 22.225-mm or 26-mm head were used.

For the selection of implanted stem types, the intraoperative condition and defect of the femur were classified as follows: type I, healthy femur; type II, thin cortical bone or presence of partial defect; type III, functionally intact gluteus medius in spite of proximal broad defect; and type IV, functional breakdown of gluteus medius and huge defect (Fig. 2). Type I was selected as the normal stem: SC stem (KYOCERA Medical) in 38 hips, HS-3 stem (KYOCERA Medical) in 23 hips, C stem (DePuy International) in 8 hips, and HS32 narrow stem (KYOCERA Medical) in 1 hip. Type II,

Table 2
Classification of cementless stem designs for the removal.

Category	Design and concept of cementless stem	Type
A	Designed to stabilize in the proximal metaphysis with a cancellous bone bed	Austin-Moore type
B	Designed to obtain metaphyseal proximal cortical contact	Taper-wedge type Fit-and-fill type Anatomic type Modular type
C	Designed to engage in the metaphyseal-diaphyseal junction and proximal diaphysis with edges	Wagner type Zweymuller type
D	Designed to engage proximal and distal cortical bone in the diaphysis	Full-porous type Long-stem type

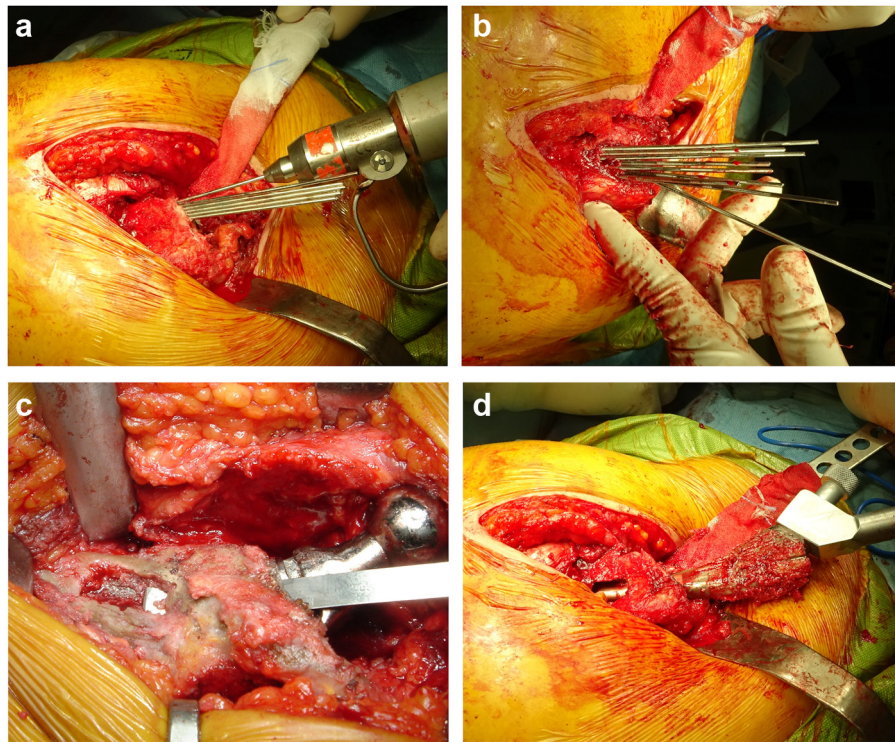


Figure 1. Intraoperative photograph of the left hip in the lateral position. (a) Multiple 2.0-mm Kirschner wires are sequentially shot to the interface between the implant and cortical bone. (b) Multiple 2.0-mm Kirschner wires are inserted in a circumferential manner. (c) The implant is detached using a thin and flexible osteotome. Through an anterior window, the direction of Kirschner wires or osteotome could be confirmed. (d) Cementless stem is removed.

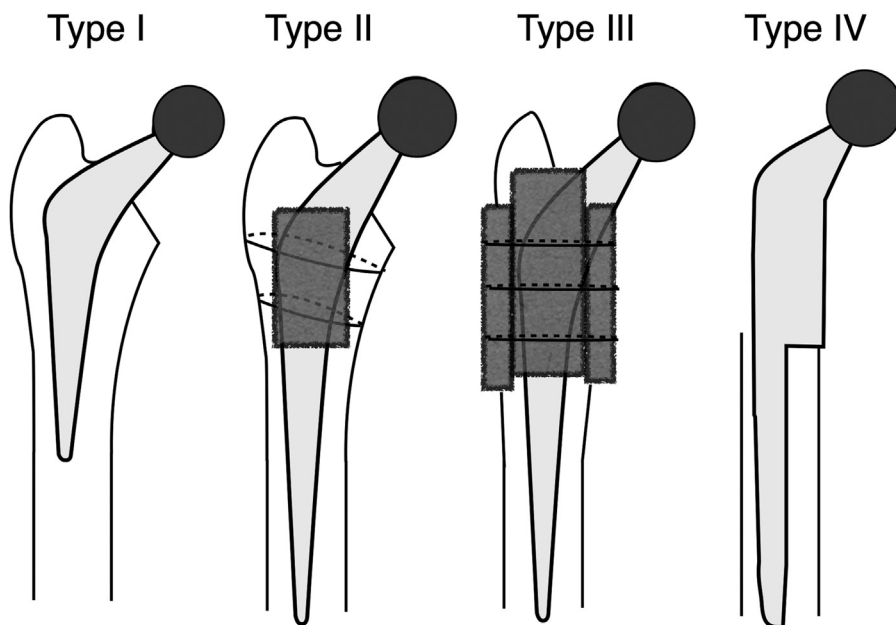


Figure 2. Classification of the intraoperative condition and bone defect: Type I, Healthy femur; type II, thin cortical bone or presence of partial defect; type III, functionally intact gluteus medius in spite of proximal broad defect; and type IV, functional breakdown of gluteus medius and huge defect.

Table 3
Intraoperative conditions and reconstruction implants.

Type	Implant classification (additional autograft)	Reconstruction stem (n)
I	Normal stem (partial augmentation if necessary)	SC stem (38) HS-3 stem (23) C stem (8) HS32 narrow stem (1)
II	Long stem (partial augmentation)	HS-3 long stem (24) SC long stem (4) PHS type 1 long stem (2) PHS type 7 long stem (1)
III	Long stem (proximal cerclage reconstruction)	HS-3 long stem (3) SC long stem (1) Charnley Elite long stem (1)
IV	Mega-prosthesis (proximal cerclage reconstruction if necessary)	PHS type 1 long stem (1) KLS mega-prosthesis stem (1)

which was considered instability of the stem, was selected as the long stem: HS-3 long stem (KYOCERA Medical) in 24 hips, SC long stem (KYOCERA Medical) in 4 hips, PHS type 1 long stem (KYOCERA Medical) in 2 hips, and PHS type 7 long stem (KYOCERA Medical) in 1 hip. In the absence of cortical bone, the strut only allograft was augmented using Ethibond (Johnson & Johnson K.K., Tokyo, Japan). Type III was selected as the long stem, and the proximal broad defect was cylindrically reconstructed with the strut only allografts: HS-3 long stem in 3 hips, SC long stem in 1 hip, and Charnley Elite long stem (DePuy International) in 1 hip. We augmented the strut only allografts using Ethibond or ultra-high-molecular-weight polyethylene fiber cable (NESPLON Cable System; Alfresa Pharma Co., Osaka, Japan) [19]. Type IV was selected as the mega-prosthesis: PHS type 1 long stem (KYOCERA Medical) in 1 hip, and KLS mega-prosthesis stem (KYOCERA Medical) in 1 hip (Table 3). The HS-3 stem is a smooth-collared tapered stem, whereas the SC stem and C stem are polished collarless tapered stems. The HS-3 stem was used initially but was replaced with SC stem or C stem since 2005. For the long stem, the HS-3 long stem was used initially but was replaced with the SC long stem since 2016. In the cases of intramedullary lost bone stock, modified impaction bone grafting, which does not impact cancellous allografts but compresses them using a reversed reamer, was combined with revision THA [20,21]. All components were fixed with an ENDURANCE Bone Cement (DePuy CMW, Blackpool, United Kingdom) using the third-generation cement technique. After implantation, a dislocation test was performed. Full weight-bearing was allowed as soon as possible although the patients were encouraged to use a cane for up to 3 months.

Follow-up protocol

Postoperative follow-ups were performed at 2 weeks, 3 months, 6 months, 1 year, and annually thereafter. A retrospective analysis was performed by 2 blinded orthopedic surgeons. For clinical assessment, the Merle d'Aubigné and Postel grading system was used preoperatively and at the last follow-up [22]. Perioperative and postoperative complications were also recorded. For radiological

assessment, anteroposterior radiographs of the pelvis were evaluated using a ruler (Carestream Health Japan Co., Ltd., Tokyo, Japan). Subsidence of the femoral stem was evaluated according to the method by Fowler et al. [23]. Cement interdigitation was assessed using the classification by Barrack et al. [24]. Radiological loosening of the femoral stem was defined as definite or probable loosening based on the criteria of Harris et al. [25].

Statistical analyses

Comparisons between measurements were performed using Student's *t*-test. Prosthesis survival was determined using the Kaplan-Meier method with 95% confidence intervals (CIs). The study endpoint was repeat revision surgery for stem loosening or femoral fracture. All statistical analyses were performed using SAS 9.2 (SAS Institute Inc., Cary, NC). $P < .05$ was considered statistically significant.

Results

The mean Merle d'Aubigné Clinical Score significantly improved from 10.4 points (range, 2–15 points) preoperatively to 15.4 points (range, 9–18 points) at the last follow-up ($P < .05$). A repeat revision surgery was performed in 7 patients for the following indications: periprosthetic infection in 3 (2.8%) patients; recurrent dislocation, 2 (1.9%) patients; and stem loosening, 2 (1.9%) patients. The mean subsidence was 0.3 mm (0–3 mm) at the final follow-up or immediately before revision surgery. With respect to Barrack's classification, 35, 71, and 0 hips were categorized as grade A, B, and C or D, respectively. Stem loosening was observed in 4 hips, probable loosening in 3 hips, and definite loosening in 1 hip (Table 4). One hip with definite stem loosening was noted in a 75-year-old woman who underwent revision THA using a long stem for a periprosthetic fracture 7 years prior. Re-revision THA was performed for periprosthetic fractures due to stem loosening. Another hip with probable stem loosening was noted in a 67-year-old man who underwent revision THA using a normal stem for periprosthetic

Table 4
Patients with stem loosening.

Case no.	Age/sex	Cementless stem design	Indication for revision	Intraoperative condition	Reconstruction stem	Harris's classification	Duration from revision to re-revision
1	56/F	Category B	Periprosthetic infection	Type I	HS-3	Probable loosening	(-)
2	75/F	Category B	Implant breakage	Type I	HS-3	Probable loosening	(-)
3	52/M	Category B	Periprosthetic infection	Type I	HS-3	Probable loosening	15 y
4	68/F	Category B	Periprosthetic fracture	Type II	HS-3 long	Definite loosening	7 y

Table 5
Relationship between the cementless stem design and intraoperative condition.

Stem design (n)	Intraoperative condition (n)	Repeat revision (n)
Category A (17)	Type I (12)	None
	Type II (4)	None
	Type III (1)	None
	Type IV (0)	(-)
Category B (69)	Type I (47)	Infection (3), loosening (1)
	Type II (21)	Dislocation (1), loosening (1)
	Type III (1)	None
	Type IV (0)	(-)
Category C (3)	Type I (1)	None
	Type II (2)	None
	Type III (0)	(-)
	Type IV (0)	(-)
Category D (19)	Type I (10)	Dislocation (1)
	Type II (4)	None
	Type III (3)	None
	Type IV (2)	None

infection 15 years ago. Re-revision THA was performed for thigh pain.

The relationship between cementless stem design and intraoperative condition is shown in Table 5. In category D, there were some type III and IV catastrophic intraoperative conditions. The 10-year survival rate with repeat revision surgery for stem loosening or femoral fracture was 97.7% (95% CI, 93.2-100). The 15-year survival rate was 73.3% (95% CI, 31.7-100).

Discussion

Removal of well-fixed femoral cementless stems is challenging because it is associated with complications such as femoral perforation, bone loss, and fracture [3]. ETOs are commonly utilized to remove well-fixed femoral cementless stems, and excellent outcomes have been reported. Abdel et al. [14] analyzed 612 ETOs, including Younger and Paprosky's osteotomy (lateral approach-

based osteotomy; n = 367) and Wagner's osteotomy (anterior approach-based osteotomy; n = 245) at a single institution. They found nonunion of the ETO occurred in 2%, ETO fragment migration of >1 cm in 7%, intraoperative fracture of the ETO diaphyseal fragment in 4%, postoperative fracture of the ETO diaphyseal fragment in 0.5%, and postoperative fracture of the greater trochanter in 7%. The 10-year rates of survival without revision for aseptic loosening and without femoral or acetabular component removal or revision for any reason were 97% and 91%, respectively. Malahias et al. [13] systematically reviewed 1478 ETOs and reported a 93.1% union rate of the ETO and a 7.1% rate of radiographic femoral stem subsidence >5 mm. However, these studies were limited because they included results without the removal of well-fixed femoral cementless stems. In addition, they did not describe postoperative management and the duration of hospitalization. ETO has inherent risks, including not only nonunion and fracture of the ETO but also altered rehabilitation and the need for repeat operations [3,9]. Furthermore, there are other disadvantages to ETO. For example, ETO always requires a longer stem to bypass the osteotomy, which may have severe consequences in the additional revision. In addition, it was initially not approved for patients with fragile or thin cortical bone.

Regarding endofemoral extraction for the removal of well-fixed femoral cementless stems, Shah et al. [26] reported 3 cases using the Steinman pin technique. They described that Steinman pins may have a lower profile than the larger osteotomes often used for extraction. In addition, they used a rotational mechanism to break the interface rather than an axial wedging force. Similar to their concept, our technique involves multiple Kirschner wires that are sequentially shot in a circumferential manner, avoiding going in the same way. Although this technique might make it challenging to remove well-fixed cementless stems depending on the type of implant, it allows for the removal of well-fixed cementless stems in all patients. The 10-year survival rate was 97.7% under repeat revision surgery

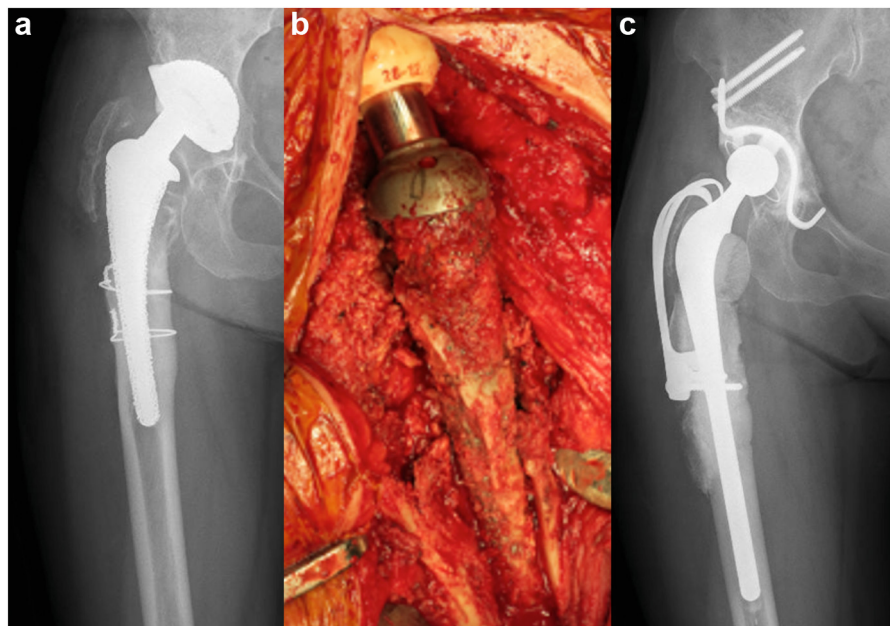


Figure 3. Difficult case 1. (a) Anteroposterior radiograph from a 51-year-old woman who underwent primary THA (stem design category D: full-porous stem) for secondary osteoarthritis due to dysplasia 20 years ago and underwent revision THA because of periprosthetic infection. (b) Intraoperative photograph: right hip in lateral position. Intraoperative condition is type III, and an HS-3 long stem (KYOCERA Medical, Osaka, Japan) is selected with a proximal cerclage reconstruction. (c) Anteroposterior radiograph at 8 years postoperatively showing no evidence of loosening.

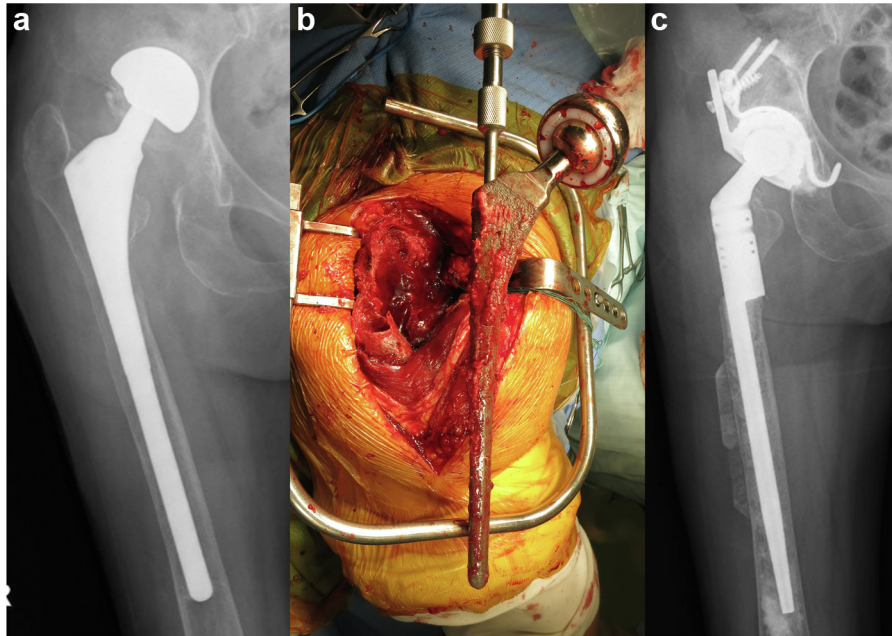


Figure 4. Difficult case 2. (a) Anteroposterior radiograph from a 70-year-old woman who underwent bipolar hip arthroplasty (stem design category D: long stem) for femoral neck fracture 3 years ago and underwent revision THA because of periprosthetic infection. (b) Intraoperative photograph: right hip in lateral position. Intraoperative condition is type IV, and a PHS type 1 long stem (KYOCERA Medical, Osaka, Japan) is selected with a constrained cup. (c) Anteroposterior radiograph at 7 years postoperatively showing no evidence of loosening.

for stem loosening or femoral fracture as the endpoint. However, care should be taken when handling category D because there were some type III and IV catastrophic intraoperative conditions. It is necessary to prepare not only allografts but also mega-prosthesis in the case of category D (Figs. 3 and 4). Using fluoroscopy may be recommended until beginners get used to this technique. Well-fixed cementless stems should always be removable because as periprosthetic infection, periprosthetic fracture, adverse reactions to metal debris, and even dislocation can occur. Patients who undergo primary THA have a probability of needing a revision THA.

There were some limitations to this study. First, we retrospectively evaluated the patients without a control group. All the patients received the current technique. Furthermore, our follow-up period was limited to a minimum of 5 years. Continued follow-up will be required to establish the long-term outcomes of this procedure. Second, we do not randomly use reconstruction stems, and there is a difference in the period of use and number. In addition, the HS-3 stem is a straight cylindrical stem that is potentially subject to early failure because of the high stress around the tip of the stem [27]. Although we did not use the HS-3 stem for the above reason, it might have affected the current study (Table 4). Third, all revisions were performed by high-volume surgeons. The technique might be difficult if the revisions are performed by other surgeons. This could lead to poor outcomes. The surgeon needs to be proficient with the technique using allografts.

Conclusions

Our technique is safe and reliable for removing well-fixed cementless stems in patients who underwent BHA or THA. It can avoid an ETO or split procedure although it has technical requirements. Thus, this technique can be used as an alternative to ETO for removing well-fixed cementless stems although care should be taken when handling a category D cementless stem design.

Acknowledgments

The authors would like to thank Nami Okada for providing the manufacturer's knowledge and Tomomi Oe for their contributions as the supervisor and all stuffs involving this study.

Conflict of interest

The authors declare there are no conflicts of interest.

For full disclosure statements refer to <https://doi.org/10.1016/j.artd.2022.07.007>.

References

- [1] Troelsen A, Malchau E, Sillesen N, Malchau H. A review of current fixation use and registry outcomes in total hip arthroplasty: the uncemented paradox. *Clin Orthop Relat Res* 2013;471:2052–9.
- [2] Patel A, Pavlou G, Mújica-Mota RE, Toms AD. The epidemiology of revision total knee and hip arthroplasty in England and Wales: a comparative analysis with projections for the United States. A study using the National Joint Registry dataset. *Bone Joint J* 2015;97:1076–81.
- [3] Brown JM, Mistry JB, Cherian JJ, et al. Femoral component revision of total hip arthroplasty. *Orthopedics* 2016;39:e1129–39.
- [4] Younger TI, Bradford MS, Magnus RE, Paprosky WG. Extended proximal femoral osteotomy. A new technique for femoral revision arthroplasty. *J Arthroplasty* 1995;10:329–38.
- [5] Taylor JW, Rorabeck CH. Hip revision arthroplasty. Approach to the femoral side. *Clin Orthop Relat Res* 1999;369:208–22.
- [6] MacDonald SJ, Cole C, Guerin J, Rorabeck CH, Bourne RB, McCalden RW. Extended trochanteric osteotomy via the direct lateral approach in revision hip arthroplasty. *Clin Orthop Relat Res* 2003;417:210–6.
- [7] Bauze AJ, Charity J, Tsiridis E, Timperley AJ, Gie GA. Posterior longitudinal split osteotomy for femoral component extraction in revision total hip arthroplasty. *J Arthroplasty* 2008;23:86–9.
- [8] Huffman GR, Ries MD. Combined vertical and horizontal cable fixation of an extended trochanteric osteotomy site. *J Bone Joint Surg Am* 2003;85:273–7.
- [9] Mardones R, Gonzalez C, Cabanela ME, Trousdale RT, Berry DJ. Extended femoral osteotomy for revision of hip arthroplasty: results and complications. *J Arthroplasty* 2005;20:79–83.
- [10] Charity J, Tsiridis E, Gusmão D, Bauze A, Timperley J, Gie G. Extended trochanteric osteotomy followed by cemented impaction allografting in revision hip arthroplasty. *J Arthroplasty* 2013;28:154–60.
- [11] Jack CM, Molloy DO, Esposito C, Walter WL, Zicat B, Walter WK. Limited slot femorotomy for removal of proximally coated cementless stems. A 10-year

- follow-up of an unreported surgical technique. *J Arthroplasty* 2013;28:1000–4.
- [12] Nagoya S, Sasaki M, Kaya M, Okazaki S, Tateda K, Yamashita T. Extraction of well-fixed extended porous-coated cementless stems using a femoral longitudinal split procedure. *Eur Orthop Traumatol* 2015;6:417–21.
- [13] Malahias MA, Gkiatas I, Selemon NA, et al. Outcomes and risk factors of extended trochanteric osteotomy in aseptic revision total hip arthroplasty: a systematic review. *J Arthroplasty* 2020;35:3410–6.
- [14] Abdel MP, Wyles CC, Viste A, Perry KI, Trousdale RT, Berry DJ. Extended trochanteric osteotomy in revision total hip arthroplasty: contemporary outcomes of 612 Hips. *J Bone Joint Surg Am* 2021;103:162–73.
- [15] Engh CA, Bobyn JD, Glassman AH. Porous-coated hip replacement. The factors governing bone ingrowth, stress shielding, and clinical results. *J Bone Joint Surg Br* 1987;69:45–55.
- [16] Oe K, Iida H, Kobayashi F, et al. Reattachment of an osteotomized greater trochanter in total hip arthroplasty using an ultra-high molecular weight polyethylene fiber cable. *J Orthop Sci* 2018;23:992–9.
- [17] Oe K, Iida H, Kawamura H, et al. Long-term results of acetabular reconstruction using three bulk bone graft techniques in cemented total hip arthroplasty for developmental dysplasia. *Int Orthop* 2016;40:1949–54.
- [18] Oe K, Iida H, Tsuda K, Nakamura T, Okamoto N, Ueda Y. Bone remodeling in acetabular reconstruction using a Kerboull-type reinforcement device and structural bone-grafting in total hip arthroplasty. *J Arthroplasty* 2017;32:908–14.
- [19] Oe K, Jingushi S, Iida H, Tomita N. Evaluation of the clinical performance of ultrahigh molecular weight polyethylene fiber cable using a dog osteosynthesis model. *Bio Med Mater Eng* 2013;23:329–38.
- [20] Gie GA, Linder L, Ling RS, Simon JP, Slooff TJ, Timperley AJ. Impacted cancellous allografts and cement for revision total hip arthroplasty. *J Bone Joint Surg Br* 1993;75:14–21.
- [21] Okamoto N, Iida H, Nakamura T, Kato M, Asada T, Wada T. Femoral morcelised bone grafting using reverse reaming in revision total hip arthroplasty with cement. *Orthop Surg Traumatol* 2012;55:1131–6 [in Japanese].
- [22] Merle d'Aubigné R, Postel M. Functional result of hip arthroplasty with acrylic prosthesis. *J Bone Joint Surg Am* 1954;36:451–75.
- [23] Fowler JL, Gie GA, Lee AJ, Ling RS. Experience with the Exeter total hip replacement since 1970. *Orthop Clin North Am* 1988;19:477–89.
- [24] Barrack RL, Mulroy Jr RD, Harris WH. Improved cementing techniques and femoral component loosening in young patients with hip arthroplasty. A 12-year radiographic review. *J Bone Joint Surg Br* 1992;74:385–9.
- [25] Harris WH, McCarthy Jr JC, O'Neill DA. Femoral component loosening using contemporary techniques of femoral cement fixation. *J Bone Joint Surg Am* 1982;64:1063–7.
- [26] Shah RP, Kamath AF, Saxena V, Garino JP. Steinman pin technique for the removal of well-fixed femoral stems. *J Arthroplasty* 2013;28:292–5.
- [27] Kimura G, Onishi E, Kawanabe K, Kazutaka S, Tsukanaka M, Akiyama H. Characteristic loosening of the distally straight cylindrical femoral stem. *J Orthop Sci* 2014;19:437–42.