Arthroplasty Today 30 (2024) 101477

Contents lists available at ScienceDirect

Arthroplasty Today

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

Surgical Technique

Retaining a Well-fixed Cone During Revision Total Knee Arthroplasty: Surgical Technique and Outcomes

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ARTICLE INFO

Article history:
Received 17 February 2024
Received in revised form
30 May 2024
Accepted 30 June 2024
Available online xxx

Keywords:
Metaphyseal cones
Aseptic revision
Revision total knee arthroplasty

ABSTRACT

Metaphyseal cones are frequently used in revision total knee arthroplasties (TKAs). However, during subsequent aseptic re-revisions, removing a well-fixed cone can be difficult. One innovative option is to retain the well-fixed cone and cement a new, stemmed revision component through the retained cone, yet minimal data exist on this technique. We describe a technique for retaining a well-fixed cone during re-revision TKA and report outcomes in 6 patients with 6 well-fixed metaphyseal cones. At a mean of 4 years follow-up, no retained cones with a new femoral or tibial component with stems were revised and there was no radiographic evidence of aseptic loosening. These early data suggest that retaining a well-fixed cone can be safe in re-revision TKA to minimize morbidity associated with cone removal.
Level of evidence: IV (retrospective study).

Introduction

The demand for total knee arthroplasty (TKA) in the United States has increased each year, with a projected annual incidence exceeding one million individuals for TKA by 2030 [1,2]. As expected, there has been a concomitant rise in the number of revision TKA (rTKA) procedures [1,3]. Regardless of the indication for rTKA, managing bone loss and achieving long-term implant fixation are common challenges that arise during rTKA surgery [4]. The use of highly porous metaphyseal cones has become an important tool for addressing bone loss and improving fixation during revision TKA [5–8]. As a result of the success of metaphyseal cones, there has been a notable increase in their utilization during rTKA within the United States in recent years [8].

Despite the success of metaphyseal cones, it is not uncommon for a rTKA to require re-revision for aseptic indications such as component loosening, stiffness, instability, implant fracture, or periprosthetic fracture [9,10]. As such, surgeons may be faced with the need to revise a rTKA implant that has an ingrown metaphyseal cone. Removal of an ingrown metaphyseal cone can result in substantial bone loss and potentially compromise future reconstruction efforts. When faced with the need to re-revise a rTKA with a well-fixed metaphyseal cone, an attractive option is to retain the well-fixed cone, revise the implant from within the cone, and recement a new rTKA implant back within the well-fixed cone. This strategy can avoid the bone loss and morbidity of metaphyseal cone removal. However, the results of this technique are not known, and given the increasing utilization of metaphyseal cone fixation, it is likely that surgeons will more commonly encounter the need to revise an implant secured to a well-fixed metaphyseal cone.

In this series, we present a technique for retaining a well-fixed metaphyseal cone during re-revision TKA, in which the implant within the retained cone is revised. The purpose of this study is to describe this surgical technique in detail and report the postoperative complications and radiographic results of re-revision TKAs in which this technique was used.

Material and methods

Patients and demographics

A review of our institutional total joint registry from 2005 to 2020 identified 6 rTKA patients with 6 well-fixed metaphyseal cones (4 femoral and 2 tibial) who underwent re-revision TKA with revision of the implant within the well-fixed cone without the cone itself being revised. During the study period, there were initially

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https://doi.org/10.1016/j.artd.2024.101477

6285 rTKAs identified, of which 1930 (30.7%) had a tibial or femoral cone. Of these 6285 rTKAs, there were 3883 re-revision TKAs, of which 966 (24.9%) had cones. Patients were excluded from the study if the femoral or tibial implant cemented into the well-fixed cone was not revised or if the revision was performed for infectious indications. This study was approved by our institutional review board prior to initiation.

Patient demographics and clinical details for the 6 cases in this series are listed in Table 1. Mean age at re-revision TKA was 64 years, and 50% of patients were female. Patients had a mean of three prior knee arthroplasty procedures. Indications for re-revision TKA were aseptic loosening (n = 3), instability (n = 2), and prosthesis fracture (n = 1). The 3 aseptic loosening cases included 2 tibial components and one femoral component. One patient revised for instability had a history of Ehlers-Danlos syndrome. Both of the 2 patients revised for instability were revised for global instability. The periprosthetic fracture case involved minimally displaced medial and lateral femoral condyle fractures with associated femoral component loosening; given minimal remaining bone stock, this was revised to a distal femoral replacement, and the tibial component (with a well-fixed cone that was retained) was revised to accommodate the new femoral component. The case of prosthesis fracture involved mechanical failure through the femoral stem housing mechanism with notable metallosis encountered intraoperatively. All retained metaphyseal cones in this series were highly porous tantalum cones (Trabecular Metal [TM]; Zimmer; Warsaw, Indiana, USA). Mean follow-up for the cohort was 4 years (range: 2 to 10 years).

Surgical technique

Following adequate surgical exposure of the knee, attention is turned to implant removal. Pencil tip burrs, saws, and/or osteotomes are utilized to disrupt the cement interface along the tibial tray and/or femoral component, depending upon which implant needs to be revised (Fig. 1). It is important to completely disrupt the visible bone-cement interface to minimize bone loss and maximize the ability to remove the femoral and/or tibial component from within the cement mantle in the well-fixed cone. Serial impaction is then utilized to remove the femoral and/or tibial components from within the remaining cement mantle (Fig. 2). Depending upon the quality of the remaining diaphyseal cement mantle and the desired diameter and length of the new stem, the surgeon can either utilize a cement-in-cement technique during the revision similar to the technique used in revision total hip arthroplasty (THA) [11,12] or remove unnecessary cement with standard techniques to accommodate a larger or longer stem. After implant removal, close inspection of the bone-metaphyseal cone interface is necessary to ensure the metaphyseal cone is well-fixed (Fig. 3). The femoral and/or tibial canals, as well as the bone ends, are then prepared to accommodate the new implants. It is important to remove any material (ie, loose cement, tissue, membrane, etc.) on the inner surface of the retained cone that may compromise subsequent cement fixation. We recommend using a metal cutting burr to create grooves within the cone to maximize cement fixation to the retained cone (Fig. 4a-c). One method commonly used at our institution to capture the resulting metal debris is direct application of sterile ultrasound jelly circumferentially around the area being burred, followed by adequate irrigation. This method minimizes the number of metal particles left on the surgical field. When trialing implants, it is important to assess for any mismatch between the retained cone and the implant that may force improper alignment or rotation. If this is occurring, the cone can be further modified with a metal-cutting burr to allow for appropriate implant positioning. Upon satisfactory bone and cone preparation, a cement gun is used to fill both the canal and cone in a retrograde fashion, and the new implants are cemented into place.

Clinical and radiographic assessment

Retrospective chart review was performed for all patients to identify any reoperations, revisions, or complications that occurred between surgery and the latest follow-up. Preoperative, immediate postoperative, and final follow-up anteroposterior (AP) and lateral radiographs were reviewed for evidence of radiolucent lines or implant loosening using the Knee Society radiographic evaluation system [13], updated to reflect modern long-stemmed components [14].

Results

Complications, revisions, and reoperations

No revisions for aseptic loosening of the retained cone-new rTKA implant constructs had been performed at the time of final follow-up. There were 2 knees that did require reoperation: one for periprosthetic joint infection and the other for tibial stem cortical perforation.

The first reoperation in the series was on a patient who was diagnosed with an acute hematogenous periprosthetic joint infection at 7 years postoperatively and was treated with irrigation and debridement with implant retention. Following 6 weeks of intravenous antibiotics, she was transitioned to lifelong oral antibiotic suppression and is now 10 years out from her re-revision TKA without any additional issues. The second reoperation in the series was performed for a tibial stem cortical perforation. On the immediate postoperative radiographs following re-revision TKA with tibial cone retention, it was noted that the new tibial stem had perforated through the anterolateral cortex of the tibia. Given the stable cemented fixation of the tibial component and the soft tissue envelope at the site of the stem perforation, this was initially managed nonoperatively. However, due to pain at the site of the

Table 1
Patient demographics and clinical characteristics.

Case	Age, years	Sex	BMI, kg/m^2	Prior arthroplasty procedures	Indication for revision following initial metaphyseal cone placement	Location of retained well-fixed cone
1	82	M	29.0	4	Aseptic loosening	Femur
2	77	F	19.5	3	Periprosthetic femur fracture and aseptic loosening	Tibia
3	55	F	28.0	3	Tibial component osteolysis and ligamentous laxity	Femur
4	45	M	35.9	2	Mechanical prosthesis failure	Femur
5	59	F	33.8	2	Aseptic loosening of tibial component and small lateral buccal fracture of tibia	Tibia
6	66	M	32.6	2	Recurrent progressive ligamentous laxity	Femur

BMI, body mass index.

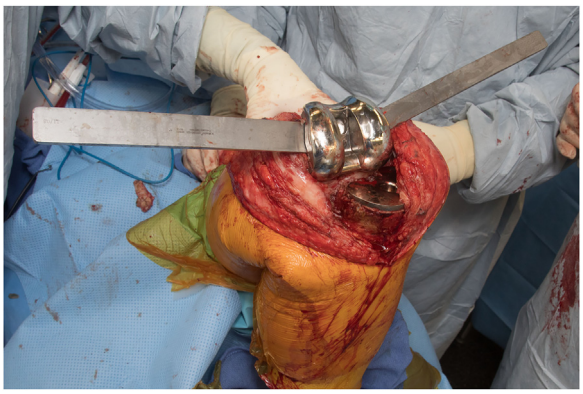

Figure 1. Intraoperative photo demonstrating the use of osteotomes to disrupt the cement mantle between the femoral implant and the well-fixed femoral cone.

perforation, the patient was taken back to the operating room at 4 weeks postoperatively. The distal extent of the prior incision was utilized and extended distally to expose the tip of the stem. The prominent stem tip was trimmed flush to the bone, and the cortical defect was supported with an allograft cortical tibial strut (Fig. 5a-c). The patient was made toe-touch weight bearing for 2 weeks in a knee immobilizer, after which she was allowed to weight bear as tolerated with initiation of range-of-motion exercises. She was weaned out of the knee immobilizer at 6 weeks postoperatively and has done well 4 years after the reoperation. None of the patients in the series experienced other medical or surgical complications postoperatively.

Radiographic outcomes

At final follow-up, no patients had radiographic evidence of aseptic loosening, and all retained metaphyseal cones remained well-fixed on radiographic analysis (Fig. 6a-c). Nonprogressive radiolucent lines were identified in at least one radiographic zone in all 6 rTKAs. Nonprogressive tibial radiolucent lines were present in zones 1 (n = 2), 2 (n = 1), and 3M (n = 1) on AP radiographs, and in zones 3A (n = 2) and 4P (n = 1) on lateral radiographs. Nonprogressive femoral radiolucent lines were present in zone 4L (n = 1) and 5 (n = 1) on AP radiographs and zones 4A (n = 1) and 5 (n = 1) on lateral radiographs.

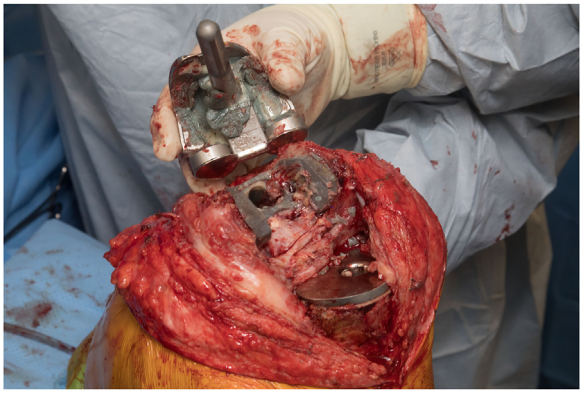

Figure 2. Intraoperative photo demonstrating removal of a femoral component from within the cement mantle of a well-fixed femoral cone.

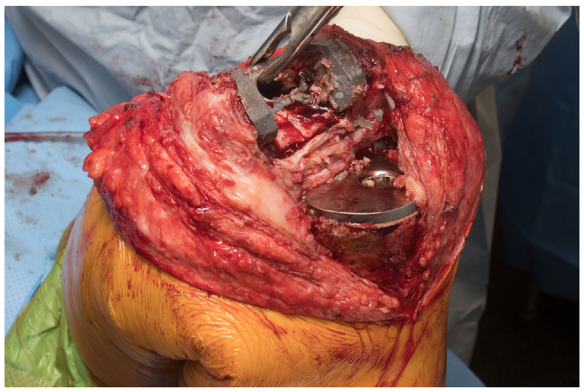

Figure 3. Intraoperative photo demonstrating inspection of the metaphyseal cone to ensure the cone is well-fixed to the femoral metaphysis.

Discussion

This study describes the outcomes and surgical technique for retaining a well-fixed metaphyseal cone when the rTKA within the cone is revised but the well-fixed metaphyseal cone is retained. At the final follow-up in this series, no retained cones with a new femoral or tibial component were revised, and all constructs with retained metaphyseal cones were radiographically well-fixed. These data suggest that a well-fixed metaphyseal cone can be safely retained, if needed, to minimize morbidity associated with metaphyseal cone removal during re-revision TKA.

While we are not aware of any literature on the technique and outcomes of retaining a well-fixed metaphyseal cone during re-revision TKA, comparable techniques have been used for revision THA. Numerous studies have demonstrated excellent short-term results following cementation of metal dual-mobility liners into well-fixed acetabular components [15–18]. A retrospective review by Wilson et al. reported a 92% 2-year survival free of aseptic dual mobility revision and dislocation, along with 64 out of 65 hips demonstrating radiologically well-fixed dual mobility cups at the cement interface [15]. In a cohort of 28 revision THAs, Wegrzyn et al. reported no postoperative complications, reoperations, or re-revisions at a mean 3.5-year follow-up following cementation of a metal dual mobility liner into a well-fixed, retained acetabular component. Further small cohort studies describing the same technique by Moreta et al. and Chen et al. showed significant improvements in Harris Hip Scores, Hip Disability and Osteoarthritis Outcome Score for Joint Replacement, and Short-Form 12 Physical Component scores at 3.5-4-year follow-up. The technique reported in these studies is similar to the one described in this article, as both utilize cement to fix new metal implants into well-fixed components, thereby relying on cement for fixation rather than locking mechanisms or taper junctions. These data, as a general principle, support the concept of retaining osseointegrated components and using cement to fix new implants to the retained construct to avoid the morbidity of removing osseointegrated implants.

The current literature suggests that aseptic loosening of metaphyseal cones is relatively infrequent following rTKAs. A recent study by Heidenreich et al. demonstrated a revision-free survival of 91% in 83 cones (22 femoral, 62 tibial) in rTKAs at a mean follow-up of 41 months [19]. When excluding infections, cone survival was 100%. A contemporary meta-analysis by Fischer et al. involving 387 cones used for rTKA showed a 4% incidence of aseptic loosening at long-term (60+ month) follow-up [20]. Given the relatively low rates of metaphyseal cone removal following rTKA and the projected increase in rTKA volume in the coming years [21], it can be

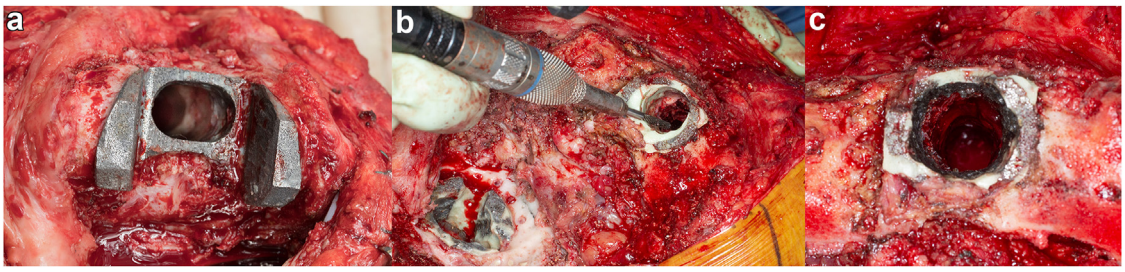

Figure 4. (a) Intraoperative photograph demonstrating removal of membrane and loose cement from within the cone to optimize subsequent cement fixation. (b) Intraoperative photograph of a different case demonstrating the use of a high-speed burr to clear cement from the inside portion of a retained metaphyseal cone. (c) Intraoperative photograph demonstrating the femoral cone from (b) after burring of the inner cone surface to optimize cement fixation.

reasonably inferred that surgeons will likely face the need to revise a rTKA implant that is well-fixed within an osseointegrated metaphyseal cone. At our institution, the rate of metaphyseal cone usage in rTKA increased to 52.6% over the final 2 years of the study period compared to 30.7% over the entire 20-year study period. Thus, a safe and efficient technique for cone retention is highly relevant. The overall goal of this study was to demonstrate that the original metaphyseal cone in an aseptic rTKA may safely be kept in place during re-rTKA. It can be difficult to explant a well-fixed cone without risking further bone loss and compromising the ability to subsequently achieve adequate fixation during rTKA. Several technique papers have described ways to extract well-fixed cones and mitigate the major risks of cone removal including catastrophic bone loss that comprises implant stability, periprosthetic fracture, and extensor mechanism disruption [22–24]. The technique described in this study for retaining a well-fixed cone may be used to altogether bypass the morbidity associated with removing a securely osseointegrated implant, especially in the setting of significant prior metaphyseal bone loss.

This study has several limitations. First, there is limited sample size in this study, which limits our ability to make more definitive conclusions regarding our technique of retaining a well-fixed metaphyseal cone. While our initial data are promising, a larger study population is needed for high-power statistical analysis demonstrating the efficacy of our described technique. Second, as there is no long-term follow-up for this study cohort, no conclusions can be reached regarding longitudinal clinical and radiographic outcomes. However, all constructs within the retained

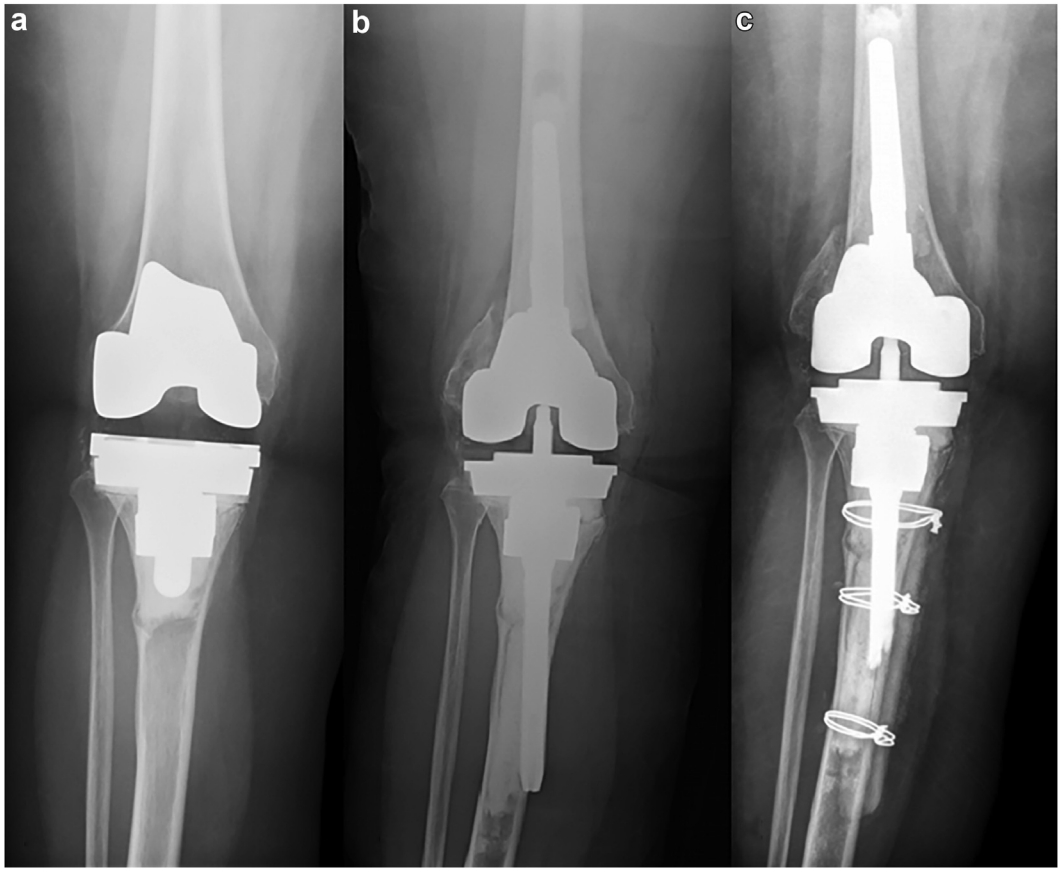

Figure 5. (a) Preoperative AP radiograph; (b) immediate postoperative AP radiograph after revision with tibial cone retention; and (c) a postoperative radiograph after re-revision for the symptomatic protruding tibial stem. The tibial cone was well-fixed and retained during the procedure.

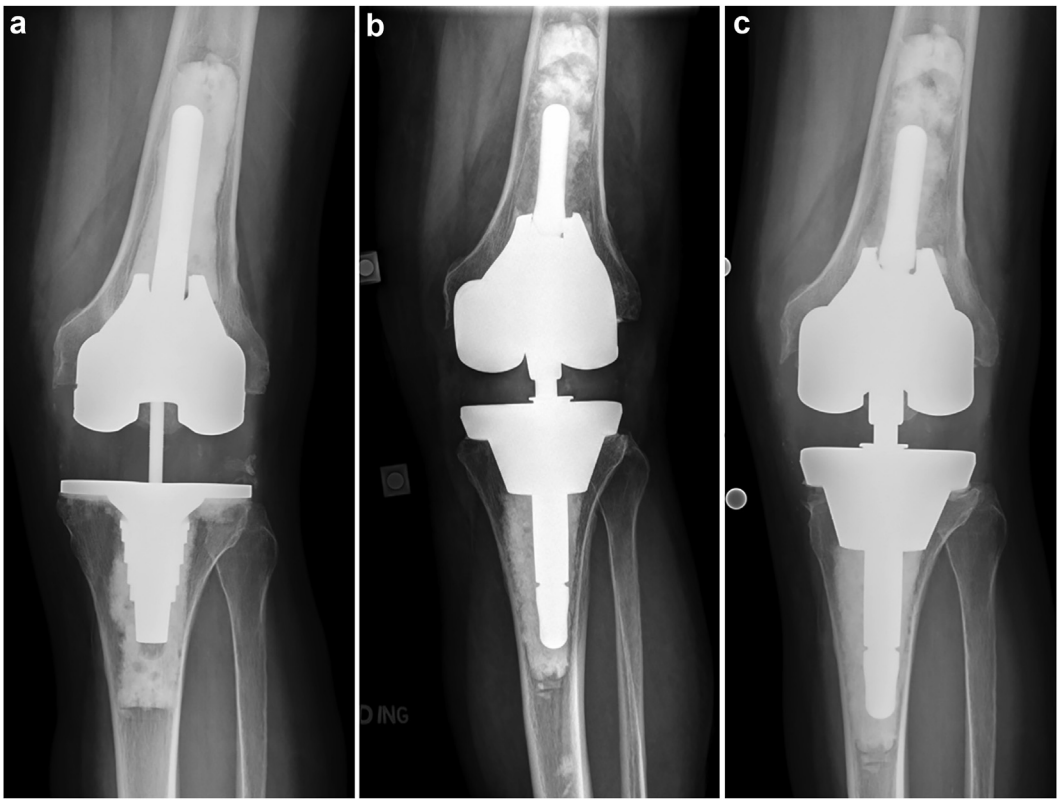

Figure 6. (a) Preoperative AP radiograph; (b) 6-week postoperative AP radiograph; and (c) a 5-year postoperative radiograph of a patient who underwent re-revision TKA for instability. The femoral cone was well-fixed and retained during the procedure. Diaphyseal impaction grafting was performed to cement femoral fixation within the diaphysis in the setting of a previously instrumented canal.

cones were radiographically well-fixed at final follow-up. Lastly, only one type of metaphyseal cone was used in this study cohort, so results are not necessarily generalizable to other metaphyseal cone designs.

Summary

This study describes a novel technique for retaining a well-fixed metaphyseal cone during re-revision TKAs. The early data from this series suggest that a well-fixed metaphyseal cone can be safely retained to minimize morbidity associated with cone removal without compromising implant fixation. In the short term, there did not appear to be any complications or aseptic loosening associated with retention of well-fixed cones, and overall rTKA construct survival was excellent. While long-term follow-up is needed, retaining a well-fixed metaphyseal cone provides an appealing option in difficult re-revision TKAs.

Conflicts of interest

M. P. Abdel receives royalties from Stryker/OsteoRemedies and Springer and is on the board of directors of AAHKS, IOEN, and Mid-America. N. A. Bedard is a paid consultant for Stryker; is an editorial board member of the Journal of the American Academy of Orthopaedic Surgerons and the Journal of Arthroplasty; and is a board/committee member of the AAHKS Program Committee. D. G. Lewallen receives royalties from Zimmer Biomet; is a paid consultant for Acuitive Technologies, BIOS, and Zimmer Biomet; has stock options in Acuitive, BIOS, and Ketai Medical Devices; receives research support from Corin U.S.A.; and is a board/committee member of the Mid-America Orthopaedic Association and the Orthopaedic Research and Education Foundation. The other authors declare no potential conflicts of interest.

For full disclosure statements refer to https://doi.org/10.1016/j.artd.2024.101477.

CRediT authorship contribution statement

Xiao T. Chen: Writing – review & editing, Writing – original draft, Visualization, Validation, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Michael W. Seward:** Writing – review & editing, Writing – original draft, Visualization, Investigation, Formal analysis, Data curation, Conceptualization. **Robert T. Trousdale:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **David G. Lewallen:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Matthew P. Abdel:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization. **Nicholas A. Bedard:** Writing – review & editing, Writing – original draft, Supervision, Methodology, Conceptualization.

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