Mid-Term Outcomes of Cemented or Uncemented Total Hip Arthroplasty for Failed Proximal Femoral Nail Antirotation Following Intertrochanteric Femur Fractures: A Retrospective Observational Study

Tao Huang¹,#, Shi Zhang²,#, Xinhang Liu³,#, Gang Lv², Heng Huang⁴, Shuxin Wang⁵, Mingdong Zhao⁶, Min Xiong⁶, Weiguang Yu⁵®, Qiuxia Cheng⁷, and Ting Huang⁸

Abstract

Introduction: The aim of this retrospective study was to assess the clinical outcomes of cemented or uncemented total hip arthroplasty (CTHA or UTHA) following prior failed proximal femoral nail antirotation (PFNA) fixation in patients with intertrochanteric femur fractures (IFFs). Materials and methods: Data from 244 patients with IFFs who experienced a conversion of PFNA to CTHA (n = 120) or to UTHA (n = 124) due to screw cut-out, mal/nonunion, or osteonecrosis during 2008-2018 were retrospectively analyzed. Follow-up occurred 1, 3, 6, and 12 months postoperatively and yearly thereafter. The primary outcome was the incidence of orthopedic complications; the secondary outcome was the Harris hip score (HHS). Results: The median follow-up was 60 months (range, 50-67 months). The incidences of orthopedic complications were 10% in the PFNA to CTHA group and 19.3% in the PFNA to UTHA group (P = .040). Significant differences were also observed regarding the incidence of prosthesis revision (1.7% for PFNA to CTHA vs 7.2% for PFNA to UTHA, P = .036). From the three years after conversion surgery to the final follow-up, significant differences were detected in HHS between groups (each P < .05). At the final follow-up, a statistically

¹Department of Orthopaedics, Wuhan Third Hospital, Tongren Hospital of Wuhan University, Wuhan, China
²Department of Anesthesiology, Renmin Hospital of Wuhan University, Wuhan, China
³Department of Anesthesiology, East Hospital, Renmin Hospital of Wuhan University, Wuhan, China
⁴Department of Anesthesiology, Wuhan Fourth Hospital, Puai Hospital, Tongji Medical College, Huazhong University of Science and Technology, Wuhan, China
⁵Department of Orthopaedics, The First Affiliated Hospital, Sun Yat-sen University, Guangzhou, China
⁶Department of Orthopaedics, Jinshan Hospital, Fudan University, Shanghai, China
⁷Department of Obstetrics, Renmin Hospital of Wuhan University, Wuhan, China
⁸Department of Anesthesiology, East Hospital, Renmin Hospital of Wuhan University, Wuhan, China

#These authors contributed equally to this work.

Corresponding Authors:
Qiuxia Cheng, Department of Obstetrics, Renmin Hospital of Wuhan University, No. 238, Jiefang Road, Wuchang District, Wuhan, Hubei, 430060, China.
Email: cocoolv@126.com

Ting Huang, Department of Anesthesiology, Renmin Hospital of Wuhan University, No. 238, Jiefang Road, Wuchang District, Wuhan, Hubei, 430060, China.
Email: 30469842@qq.com

Creative Commons Non Commercial CC BY-NC: This article is distributed under the terms of the Creative Commons Attribution-NonCommercial 4.0 License (https://creativecommons.org/licenses/by-nc/4.0/) which permits non-commercial use, reproduction and distribution of the work without further permission provided the original work is attributed as specified on the SAGE and Open Access pages (https://us.sagepub.com/en-us/nam/open-access-at-sage).
significant difference was detected in the HHS (79.54±18.85 for PFNA to CTHA vs. 75.26±18.27 for PFNA to UTHA, P = .014). **Conclusion:** The results of the study may demonstrate a significant statistical advantage with respect to the orthopedic complication rate and HHS in favor of CTHA compared to UTHA in patients with failed PFNA.

**Keywords**
cemented, uncemented, total hip arthroplasty, intertrochanteric femur fracture, conversion

**Introduction**

Therapeutic advances in proximal femoral nail antirotation (PFNA) have extensively improved the outcomes for an increasing number of patients with a clinical diagnosis of intertrochanteric femur fractures (IFFs), a subtype of proximal femoral fractures, which was previously associated with poor prognoses.1-3 The number of IFFs treated with PFNA during the past decade has increased dramatically and will substantially increase, not only as a consequence of an aging population but also owing to its increasing use in young patients.4,5 Hence, the number of failed PFNAs that require revision procedures may also increase accordingly.2 Regrettably, the available options for revising a failed PFNA are limited.2 When a failed PFNA intervention is indicated, the treatment strategies remain challenging and controversial.1 Conversion from PFNA to cemented or uncemented total hip arthroplasty (CTHA or UTHA) tends to be an approved method.6,7 However, the choice of implant material (CTHA or UTHA) is frequently unclear.8,9 Most of those reports have been from academic centers, with a limited number of cases.10,11 The decision as to which type of implant (CTHA or UTHA) is optimal in treating patients with a failed PFNA may lead to a significant difference in the application of each intervention internationally.12,13 However, most of those reports have been from a highly specialized medical institution, with a limited number of cases.14

A comparative study15 assessing the clinical outcomes of the conversion to CTHA or UTHA in 198 elderly patients with failed PFNAs showed that CTHA had a lower rate of orthopedic complications than UTHA (19.0% vs. 40.8%, P = .001). In the comparative study patient comorbidities and severity of illness were not mentioned, although comorbidities have been proven to be associated with an increased risk of periprosthetic infection in patients experiencing arthroplasties.16,17 Recently, a retrospective study18 of 120 patients aged 30-60 years with prior failed primary fixations of proximal femoral fractures undergoing CTHA conversion showed that the rate of orthopedic complications was 18.3%. However, in the retrospective study, the leading etiologies of failure of a secondary CTHA conversion are unclear. Furthermore, the variety of implant versions and the lack of a control group may have some influence on their results. To date, mid-term outcomes regarding the superiority of PFNA to CTHA over PFNA to UTHA remain limited. In addition, with the increasing use of the PFNA device in clinical practice, it may be particularly important to conduct mid-term evaluations of these two conversions. We therefore performed this retrospective study to compare the clinical and radiographic outcomes of patients with failed PFNA who experienced a conversion to CTHA or UTHA in the Asian population.

**Methods**

**Study Population**

The data covering the period of July 1, 2008, to July 31, 2018, were obtained retrospectively from our medical center according to ICD-10 S72.101. The registry records of 292 consecutive patients who had undergone a conversion from PFNA to CTHA or to UTHA during the study period were retrospectively analyzed. These patient details were deidentified according to our protocol. The conversion procedure was executed as stated by the manufacturers’ instructions at three medical institutions by 6 surgeons who were all trained in arthroplasty. Co-morbidities related to patients were evaluated with the Charlson comorbidity index (CCI). The inclusion criteria were as follows: active elderly patients aged ≥60 years old; patients with a prior IFF (Type AO/OTA 31 A) treated with PFNA (a solid titanium nail, 200-240 mm in length, 11-16 mm in diameter, 125° or 130° in collodiaphyseal angle, Synthes, USA), followed by CTHA (an Exeter Universal stem and a cemented all-polyethylene cup [Stryker, Mahwah, NJ]) or UTHA (a Taperloc stem [Biomet, Warsaw, Ind] and an uncemented polyethylene cup [HCC, Houston, Tex]); and patients with failed fixation due to screw cut-out, mal/nonunion, or osteonecrosis. The key exclusion criteria included inadequate baseline data, hip dysplasia, active metabolic bone diseases, dyskinesia, lower extremity sensory disorders, metastatic diseases, severe medical diseases, dependence on alcohol or drug abuse, inability to follow instructions, vascular cognitive impairment, and an American Society of Anesthesiologists (ASA) score of IV or V. The ICD-10- Chinese Modification codes were applied to identify the relevant conditions mentioned in the exclusion criteria.
Surgical Procedures

The previous PFNA device was removed using the original incision. CTHAs or UTHAs were implanted using the direct lateral approach. After reaming the femur, third-generation cementing techniques were used. After retrograde pressurization of the cement, the stem was inserted slowly at a uniform speed. The integrity of the greater or lesser trochanter was reconstructed using femoral neck bone masses and fixed with steel cables or steel cables plus metal mesh. The length of the cemented stem was approximately 2 cm greater than the length of the main nail, preventing possible adverse events (ie, malunion, non-union, periprosthetic femoral fracture) related to stress risers. Small bone fragments from the femoral neck and head were used to fill the proximal and lateral femoral screw holes after PFNA removal. Some of the excess cement was used to fill small defects in the greater or lesser trochanter. A cemented cup was inserted according to the manufacturer’s instructions. Acetabular defects were reconstructed with metal mesh and/or impaction autografts. Segmental posterosuperior defects greater than 20 mm were treated using metal mesh. The trimmed metal mesh was fixed to the iliac bone using 3-5 cm bicortical screws. Small medial wall defects or segmental defects less than 20 mm were treated using impaction autografts. After reconstructing the acetabular defects, we reserved a circumferential 2-mm cement mantle around the definitive cup. After testing the model cups, we used a 2-mm drill bit to drill through the sclerosed bone until blood oozed out to optimize vascularization and facilitate the incorporation of the graft into the cement. Adrenaline-soaked gauze was used to tamp the acetabulum to reduce acetabulum bleeding. Next, antibiotic-loaded cement (1 g cefazolin/50 g cement) was pressurized and the definitive cup was positioned with 40-45° of inclination and 20° of antversion. The technical details of UTHA and CTHA were the same, except for the third-generation cementing techniques.

Antibiotics (ie Cefazolin, cefalexin, and cefradine) were routinely administered intraoperatively until three days after surgery. Postoperatively, all patients were treated with low-molecular-weight heparin sodium or rivaroxaban for 4 weeks to prevent venous thrombosis. Patients were mobilized three days after surgery. In the case of extended reconstructions, touch weight bearing on the operated side with a walker was allowed for 6-10 weeks. After that, progressive weight bearing was encouraged.

Clinical and Radiographic Analysis

The clinical and radiographic outcomes were retrospectively reviewed by two authors (GL and TH). The primary outcome measure was the rate of orthopedic complications, including prosthesis revision, loosening, periprosthetic fracture, dislocation, periprosthetic infection, intolerable hip pain, lower limb shortening, and thrombotic events. Radiographic analysis consisted of anteroposterior views of the hip and pelvis and a true lateral view of the hip. The secondary outcome measure was the HHS (range, 0-100). Follow-up occurred at 1, 3, 6, and 12 months postoperatively and yearly thereafter. Patients included in the present study were followed up mainly through outpatient follow-up and telephone interviews.

Definition of Variables

The follow-up time was defined as the time interval between the date of PFNA to CTHA or PFNA to UTHA and the date of the final follow-up. The criteria used to define loosening of the acetabular component included >2 mm of radiolucent line, >3 mm of migration, and a change in the amount of lateral tilt of >5°.19,20 Radiographic loosening of the femoral component was diagnosed when there were signs of subsidence of >3 mm, continuous radiolucencies or fractures at the bone-cement or shaft-bone interface, or large defects around the stem.21 Periprosthetic infection was diagnosed according to the Musculoskeletal Infection Society Criteria.22 Osteolysis was evaluated by the criteria of McLaughlin et al13 Heterotopic ossification was assessed per the Brooker classification system.23 Prosthesis revision was defined as removal of the CTHA or UTHA device for any reason.24

Statistical Analysis

Categorical variables (ie, sex, side) were compared using the chi-square test or Fisher’s exact test. Continuous variables were compared using two-way ANOVA for normally distributed variables (ie, age, body mass index [BMI], bone mineral density [BMD], HHS, follow-up period) and the Mann-Whitney U test for nonnormally distributed variables (ie, mechanism of injury, IFFs, comorbidities, reasons for revision, time between two surgeries, ASA index, implant-related complications). The survival curve was drawn using the Kaplan–Meier method. A significant difference was defined as a one-sided P value <.05. All statistical analyses were executed using SPSS 26.0 (IBM Corp, Armonk, NY).

Results

Based on our inclusion and exclusion criteria, 244 consecutive patients (244 hips) were identified from the registry (PFNA to CTHA: n = 120, mean age, 68 years [range, 64-77 years]; PFNA to UTHA: n = 124, mean
From July 1, 2008, to July 31, 2018, 292 consecutive patients obtained from the China Southern Medical Centre database who had undergone a conversion from PFNA to CTHA or to UTHA following a failed PFNA were identified.

**Primary Outcome**

Seventeen orthopedic complications in 12 CTHA patients were observed compared with 30 in 24 UTHA patients (10% vs. 19.3%, P = .040). Of the 17 orthopedic complications in the PFNA to CTHA group, 3 (2.5%) patients had prosthesis loosening, and 4 (3.3%) were diagnosed with periprosthetic fracture. Of the 30 orthopedic complications in the PFNA to UTHA group, 8 (6.4%) had prosthesis loosening, and 6 (4.8%) experienced periprosthetic fracture, as shown in Table 2. Within the first two years of follow-up, there were no significant differences between groups on the subject of prosthesis revision, loosening, or periprosthetic fracture. A difference in the rate of prosthesis revision was observed at the final follow-up (1.7% for PFNA to CTHA vs 7.2% for PFNA to UTHA, P = .036), as shown in Figure 2. Furthermore, 1 (50.0%) of prosthesis revisions for CTHA were caused by prosthesis loosening compared with 6 (66.7%) of prosthesis revisions.
The survival curve for prosthesis loosening is shown in Figure 3.

**Secondary Outcome**

At the final follow-up, the scores were 79 (range, 61-97) for PFNA to CTHA and 75 (57-93) for PFNA to UTHA (P = .014). Figure 4 illustrates the variation trend of postoperative functional scores. From the three years after conversion surgery to the final follow-up, significant differences were detected in HHS between groups (each P < .05), and CTHA had a noteworthy functional advantage compared to UTHA in these cases. Within three years after conversion surgery, noteworthy differences regarding the HHS failed to be detected at each follow-up (each P > .05).

**Discussion**

Mid-term outcomes regarding the superiority of PFNA to CTHA over PFNA to UTHA remain lacking. This retrospective study aimed to evaluate the clinical outcomes of single brands of CTHA or UTHA following failed PFNA fixation in IFF patients and may show a significant advantage for UTHA. The survival curve for prosthesis loosening is shown in Figure 3.

**Table 1. Patient demographics and outcomes.**

| Variable                        | PFNA to CTHA<sup>a</sup> (n = 120) | PFNA to UTHA<sup>b</sup> (n = 124) | P value |
|---------------------------------|-----------------------------------|----------------------------------|---------|
| Sex, M/F                        | 63/57                             | 64/60                            | .890    |
| Age, years                      | 68 (64-77)                        | 68 (63-76)                       | .305    |
| BMI, kg/m<sup>2</sup>           | 25 (19-32)                        | 26 (20-34)                       | .176    |
| BMD                             | −3.75 (−4.2 to −3.2)              | −3.74 (−4.4 to −3.5)             | .201    |
| Side, left/right                 | 56/64                             | 59/65                            | .886    |
| Mechanism of injury, no.%       |                                   |                                  | .338    |
| Traffic-related injury           | 29 (24.1)                         | 34 (27.4)                        |         |
| Injury by falling               | 72 (60.0)                         | 76 (61.3)                        |         |
| Tamp injury                     | 19 (15.9)                         | 14 (11.3)                        |         |
| IFFs, AO/OTA, no.%              |                                   |                                  | .381    |
| 31A1                            | 13 (10.8)                         | 17 (13.7)                        |         |
| 31A2                            | 67 (55.8)                         | 71 (57.2)                        |         |
| 31A3                            | 40 (33.4)                         | 36 (29.1)                        |         |
| CCI at revision, no.%           |                                   |                                  | .300    |
| Low                             | 21 (17.5)                         | 29 (23.4)                        |         |
| Medium                          | 77 (64.2)                         | 75 (60.5)                        |         |
| High                            | 22 (18.3)                         | 20 (16.1)                        |         |
| Reasons for revision, no.%      |                                   |                                  | .754    |
| Instability<sup>e</sup>         | 35 (29.1)                         | 37 (29.8)                        |         |
| Instability and mechanical failure | 65 (54.2)                       | 69 (55.6)                        |         |
| Mechanical failure              | 20 (16.7)                         | 18 (14.6)                        |         |
| Time between two surgeries (years), no.% | 23 (19.2) | 30 (24.2) | .161    |
| <1                              | 23 (19.2)                         | 30 (24.2)                        |         |
| 1-2                             | 60 (50.0)                         | 65 (52.4)                        |         |
| >2                              | 37 (30.8)                         | 29 (23.4)                        |         |
| ASA index, no.%                 |                                   |                                  | .380    |
| I                               | 21 (17.5)                         | 26 (20.9)                        |         |
| II                              | 58 (48.3)                         | 62 (50.0)                        |         |
| III                             | 40 (33.2)                         | 36 (29.1)                        |         |
| HHS before conversion           | 60 (50-68)                        | 60 (49-67)                       | .281    |
| Follow-up period (months)       | 60 (50-67)                        | 60 (51-66)                       | .175    |

<sup>a</sup>An Exeter Universal stem and an All-poly cup (Stryker, Mahwah, NJ).

<sup>b</sup>An Taperloc stem (Biomet, Warsaw, Ind) and a polyethylene cup (HCC, Houston, Tex).

<sup>c</sup>Analyzed using the Chi-square test.

<sup>d</sup>Analyzed using two-way ANOVA.

<sup>e</sup>Analyzed using the Mann-Whitney test.

<sup>f</sup>screw loosening, unacceptable displacement of the fracture site, nonunion, tendency of dislocation. PFNA: proximal femoral nail anti-rotations; CTHA: cemented total hip arthroplasty; UTHA: uncemented total hip arthroplasty; BMI: body mass index; BMD: bone mineral density; IFFs: intertrochanteric femur fractures; CCI: Charlson comorbidity index; HHS: Harris hip score; ASA: American Society of Anesthesiologists.
advantage in the clinical outcomes of CTHA over those of UTHA. There was a significant statistical advantage with respect to the orthopedic complication rate in favor of CTHA compared to UTHA. The HHS improved in the PFNA to CTHA group after the 36-month follow-up, in contrast to the PFNA to UTHA group, in which there was a significantly lower HHS after 36 months. The diverse developments in the HHS over time may suggest a better HHS in the PFNA to CTHA group at the 5-year follow-up than in the PFNA to UTHA group. Future studies should focus on long-term conversion results. While our analysis may statistically validate the difference in the HHS, it failed to validate the differences in the rate of orthopedic complications during the first 2 years, most likely owing

**Table 2. Long-term follow-up: implant-related complication rate.**

| Variable                                | PFNA to CTHA (n = 120) | PFNA to UTHA (n = 124) | p valuea |
|-----------------------------------------|------------------------|------------------------|----------|
| Prosthesis revision                     | 2 (1.7)                | 9 (7.2)                | .036*    |
| Prosthesis loosening                    | 3 (2.5)                | 8 (6.4)                | .138     |
| Periprosthetic fracture                 | 4 (3.3)                | 6 (4.8)                | .355     |
| Dislocation                             | 2 (1.7)                | 2 (1.6)                | .974     |
| Periprosthetic infection                | 3 (2.5)                | 4 (3.2)                | .735     |
| Insufferable hip pain                   | 2 (1.7)                | 5 (4.0)                | .269     |
| Lower limb shortening (>1.5 cm)        | 2 (1.7)                | 4 (3.2)                | .433     |
| Thrombotic events                       | 1 (0.8)                | 1 (0.8)                | .981     |

*aStatistically significant values.
*bAn Exeter Universal stem and an All-poly cup (Stryker, Mahwah, NJ).
*cAn Taperloc stem (Biomet, Warsaw, Ind) and a polyethylene cup (HCC, Houston, Tex). PFNA: proximal femoral nail anti-rotations; CTHA: cemented total hip arthroplasty; UTHA: uncemented total hip arthroplasty.
*cAnalyzed using the Chi-square test.

**Figure 2.** Kaplan–Meier survival curve for both groups with prosthesis revision for any reason as the endpoint.

**Figure 3.** Kaplan–Meier survival curve for both groups with periprosthetic loosening as the endpoint.
to the short follow-up. The mid-term outcomes of CTHA or UTHA for patients with a failed PFNA are a matter of great debate. However, a growing but still very limited body of literature has investigated the therapeutic role of these two endoprostheses and has suggested that the differences between CTHA and UTHA may be attributed to errors in surgical techniques or indications. No literature has provided guiding principles to reduce or avert mechanical complications. Consistent with previous studies, we failed to observe conspicuous differences in the HHS at the end of the 3-year follow-up. This lack of differences could be attributed to the relatively short follow-up.

The outcomes regarding the rate of orthopedic complications were within acceptable limits. Our findings are comparable to those of prior reports with at least a 2-year follow-up. Nevertheless, the quantitative comparison is problematic for interpretation since a majority of prior reports included a mixed population of proximal femoral fractures and multiethnic, younger patients, and stress shielding of the proximal femur is especially age-dependent. Previous literature has demonstrated that UTHA has a higher rate of orthopedic complications than CTHA. Additionally, recent evidence favors UTHA for proximal femur fractures with a high rate of orthopedic complications.

Our findings are supported by previously available literature in this area that showed an increased revision rate in UTHA cases. Nevertheless, the majority of population reports that focus on this subject are based on 10-year follow-up data. Few prior studies have quantified the risk for revision in this setting. Additionally, our study sheds light on the risk for revision surgery for patients with a failed PFNA treated with UTHA. Although it has been previously recognized that this cohort has a higher 5-year revision rate than those undergoing CTHA, the true risk to a patient treated with UTHA tends to be higher than previously reported. The higher rate of revision could be associated with dissimilarities in implant materials. The decision about whether to proceed with surgery is mostly based on the balance between revision risks and benefits. Previous reports were commonly restricted to specific implants or small populations, without a definite focus on the results of patients. Hence, the decision-making process for such patients failed to be fully considered and could result in an inapposite intervention.

The inherent limitations of the current study are similar to those of other retrospective analyses. First, observational reports such as our study are susceptible to absent variables and the subsequent inability to adjust for certain biases inherent to the methodology. Assessing the superiority of one device over another tends to be restrictive in nature and could be compromised by a relatively small population, improper control of confounding factors, and moderately short follow-up. The exclusion of patients who lost contact during follow-up (ie, death) may have overstated our results. Second, although antibiotics were routinely used in each patient, there were some differences in the type, dosage, and duration of antibiotics in some patients, which could introduce potentially confounding factors when considering periprosthetic infection as an endpoint.

Conclusions
The goal of the current study was to provide a possible explanation that CTHA may have a significant statistical advantage with respect to functional results and fewer orthopedic complications than UTHA in the conversion setting. Our findings could help settle ongoing debates about the decision-making process for revisions in such patients. Future multicenter trials are needed to further validate these findings.
Weiguang Yu  
ORCID iD  
https://orcid.org/0000-0001-9596-8572

Declaration of Conflicting Interests
The author(s) declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article.

Funding
The author(s) received no financial support for the research, authorship, and/or publication of this article.

Ethics Approval
This study was approved by the Investigational Ethics Review Board (Wuhan Third Hospital, Wuhan, China), and an exemption from informed consent was obtained from the board.

References
1. Yu WG, Zhang XC, Zhu XF, et al. Proximal femoral nails anti-rotation versus dynamic hip screws for treatment of stable intertrochanteric femur fractures: an outcome analyses with a minimum 4 years of follow-up. *BMC Musculoskel Disord*. 2016;17:222.
2. Zeng X, Zhan K, Zhang L, et al. Conversion to total hip arthroplasty after failed proximal femoral nail antirotations or dynamic hip screw fixations for stable intertrochanteric femur fractures: a retrospective study with a minimum follow-up of 3 years. *BMC Musculoskel Disord*. 2017;18:38.
3. Sanli I, Arts JJC, Geurts J. Clinical and Radiologic Outcomes of a Fully Hydroxyapatite-Coated Femoral Revision Stem: Excessive Stress Shielding Incidence and its Consequences. *J Arthroplasty*. 2016;31:209-214.
4. Yu W, Zhang X, Zhu X, et al. A retrospective analysis of the InterTan nail and proximal femoral nail anti-rotation-Asia in the treatment of unstable intertrochanteric femur fractures in the elderly. *J Orthop Surg Res*. 2016;11:10.
5. Zhang H, Zhu X, Pei G, et al. A retrospective analysis of the InterTan nail and proximal femoral nail anti-rotation in the treatment of intertrochanteric fractures in elderly patients with osteoporosis: a minimum follow-up of 3 years. *J Orthop Surg Res*. 2017;12:147.
6. Akiyama H, Kawanabe K, Goto K, et al. Computer-assisted fluoroscopic navigation system for removal of distal femoral bone cement in revision total hip arthroplasty. *J Arthroplasty*. 2007;22:445-448.
7. Berend ME, Smith A, Meding JB, et al. Long-term outcome and risk factors of proximal femoral fracture in un cemented and cemented total hip arthroplasty in 2551 hips. *J Arthroplasty*. 2006;21:53-59.
8. Clement ND, van der Linden M, Keating JF. Higher rate of complications with un cemented compared to cemented total hip arthroplasty for displaced intracapsular hip fractures: A randomised controlled trial of 50 patients. *Eur J Orthop Surg Traumatol*. 2021;31:587-594.
9. Liu WL, Lin HY, Zeng XS, et al. Uncemented versus cemented arthroplasty after metal-on-metal total hip replacement in patients with femoral neck fractures: a retrospective study. *J Int Med Res*. 2021;49:3000650211012210.
10. Borton ZM, Mumith AS, Nicholls AJ, et al. The Outcome of Revision Surgery forFailed Metal-on-Metal Total Hip Arthroplasty. *J Arthroplasty*. 2019;34:1749-1754.
11. Brubaker SM, Brown TE, Manasswi A, et al. Treatment options and allograft use in revision total hip arthroplasty. *J Arthroplasty*. 2007;22:52-56.
12. Bhakdiya HP, Singh SP. Results With the Cementless Spotorno Stem in Total Hip Arthroplasty. *J Arthroplasty*. 2009;24:1188-1192.
13. Bryan AJ, Calkins TE, Karas V, et al. Primary Total Hip Arthroplasty in Patients Less Than 50 Years of Age at a Mean of 16 Years: Highly Crosslinked Polyethylene Significantly Reduces the Risk of Revision. *J Arthroplasty*. 2019;34:S238-S241.
14. Chang JD, Kim TY, Rao MB, et al. Revision Total Hip Arthroplasty Using a Tapered, Press-Fit Cementless Revision Stem in Elderly Patients. *J Arthroplasty*. 2011;26:1045-1049.
15. Yu WG, Han XL, Chen WL, et al. Conversion from a failed proximal femoral nail anti-rotation to a cemented or uncemented total hip arthroplasty device: a retrospective review of 198 hips with previous intertrochanteric femur fractures. *BMC Musculoskel Disord*. 2020;21:791.
16. Bozic KJ, Lau E, Kurtz S, et al. Patient-Related Risk Factors forPeriprosthetic Joint Infection and Postoperative Mortality Following Total Hip Arthroplasty in Medicare Patients. *J Bone Joint Surg*. 2012;94:794-800.
17. Kunutsor SK, Whitehouse MR, Blom AW, et al. Patient-Related Risk Factors for Periprosthetic Joint Infection after Total Joint Arthroplasty: A Systematic Review and Meta-Analysis. *PLoS One*. 2016;11:e0150866.
18. Yu ML, Yu MJ, Zhang YD, et al. Implant survival of cemented arthroplasty following failed fixation of proximal femoral fractures in patients aged 30-60 years: a retrospective study with a median follow-up of 10 years. *BMC Musculoskel Disord*. 2022;23:637.
19. Temmerman OPP, Rajmakers P, David EFL, et al. A Comparison of Radiographic and Scintigraphic Techniques to Assess Aseptic Loosening of the Acetabular Component in a Total Hip Replacement. *J Bone Jt Surg Am Vol*. 2004;86:2456-2463.
20. Cheung A, Lachiewicz PF, Renner JB. The role of aspiration and contrast-enhanced arthrography in evaluating the un cemented hip arthroplasty. *Am J Roentgenol*. 1997;168:1305-1309.
21. M¨unger P, R¨oder C, Ackermann-Liebrich U, et al. Patient-related risk factors leading to aseptic stem loosening in total
22. Tischler EH, Cavanaugh PK, Parvizi J. Leukocyte Esterase Strip Test: Matched for Musculoskeletal Infection Society Criteria. *J Bone Joint Surg*. 2014;96:1917-1920.

23. Gordon A, Southam L, Loughlin J, et al. Variation in the secreted frizzled-related protein-3 gene and risk of osteolysis and heterotopic ossification after total hip arthroplasty. *J Orthop Res*. 2007;25:1665-1670.

24. Mäkelä KT, Matilainen M, Pulkkinen P, et al. Failure rate of cemented and uncemented total hip replacements: register study of combined Nordic database of four nations. *Br Med J*. 2014;348:g7592.

25. Tetsunaga T, Fujiwara K, Endo H, et al. Total hip arthroplasty after failed treatment of proximal femur fracture. *Arch Orthop Trauma Surg*. 2017;137:417-424.

26. Fowler AK, Gray AR, Gwynne-Jones DP. Hybrid Fixation for Total Hip Arthroplasty Showed Improved Survival Over Cemented and Uncemented Fixation: A Single-Center Survival Analysis of 2156 Hips at 12-18 Years. *J Arthroplasty*. 2019;34:2711-2717.

27. Fernández-Fairen M, Murcia A, Blanco A, et al. Revision of Failed Total Hip Arthroplasty Acetabular Cups to Porous Tantalum Components. *J Arthroplasty*. 2010;25:865-872.

28. de Vries LM, Sturkenboom M, Verhaar JAN, et al. Complications after hip arthroplasty and the association with hospital procedure volume. *Acta Orthop*. 2011;82:545-552.

29. Liu T, Hua X, Yu W, et al. Long-term follow-up outcomes for patients undergoing primary total hip arthroplasty with uncemented versus cemented femoral components: a retrospective observational study with a 5-year minimum follow-up. *J Orthop Surg Res*. 2019;14:371-371.

30. Mao S, Chen B, Zhu Y, et al. Cemented versus uncemented total hip replacement for femoral neck fractures in elderly patients: a retrospective, multicentre study with a mean 5-year follow-up. *J Orthop Surg Res*. 2020;15:447-2020.

31. Hailer NP, Garellick G, Kährholm J. Uncemented and cemented primary total hip arthroplasty in the Swedish Hip Arthroplasty Register. *Acta Orthop*. 2010;81:34-41.

32. Liu T, Hua X, Yu W, et al. Long-term follow-up outcomes for patients undergoing primary total hip arthroplasty with uncemented versus cemented femoral components: a retrospective observational study with a 5-year minimum follow-up. *J Orthop Surg Res*. 2019;14:371-2019.

33. Pitto RP, Schramm M, Hohmann D, et al. Clinical outcome and quantitative evaluation of periprosthetic bone-remodeling of an uncemented femoral component with taper design. A prospective study. *La Chirurgia degli organi di movimento*. 2001;86:87-97.

34. Hawi N, Kendoff DO, Hessling U, et al. Effectiveness of an autologous transfusion system following cemented and non-cemented revisions of total hip arthroplasty. *Int Orthop*. 2014;38:1603-1608.

35. Hanly RJ, Whitehouse SL, Lorimer MF, et al. The Outcome of Cemented Acetabular Components in Total Hip Arthroplasty for Osteoarthritis Defines a Proficiency Threshold: Results of 22,956 Cases From the Australian Orthopaedic Association National Joint Replacement Registry. *J Arthroplasty*. 2019;34:1711-1717.