Medium-term outcomes of uncemented total hip arthroplasty in patients younger than 25 years old: A retrospective research

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Research Article

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Abstract

Objective: To evaluate the medium-term outcomes of uncemented total hip arthroplasty in patients ≤ 25 years.

Methods: A retrospective research was performed on patients ≤ 25 who received uncemented total hip arthroplasty at the Department of Orthopedics of the 940th Hospital of Joint Logistic Support Force of Chinese People's Liberation Army from January 2009 to December 2018. The clinical evaluation was measured with modified Harris Hip Score, Western Ontario & McMaster Universities Osteoarthritis Index, and Short-Form 36. Postoperative complications (such as infection, revision, dislocation, and incisional healing issues) were recorded. Using pelvic anteroposterior, hip anteroposterior and lateral X-rays, the radiographic outcome was evaluated, including the position of the implants, loosening, bearing-surface wear, osteolysis, and heterotopic ossification. Loosening of the acetabular or femoral component or revision for any reason was defined as failure.

Results: At a follow-up of 8.3±2.4 years (range, 3.8 to 12 years), the preoperative modified Harris hip score was 43.5±12.9 (range, 18 to 62) and increased to 88.3 ± 8.8 (range, 72 to 97), and the preoperative postoperative Western Ontario & McMaster Universities Osteoarthritis Index score improved from 43.6±8.4 (range, 33.1 to 62.3) to 11.5 ± 6.8 (range, 2.5 to 25.8). The Physical Component score-SF-36 improved from 48.5 ± 8.6 (range, 36.4 to 61.3) to 81.2 ± 10.3 (range, 60.3 to 97.5), while the Mental Component score-SF-36 increased from 56.6±12.5 (range, 39.4 to 78.6) to 82.6 ± 12.9 (range, 54.7 to 97). The latest X-ray revealed that the position of the implants did not change substantially since the postoperative image. The abduction angle of acetabular cup was 41.8° ± 6.7° (range, 31° to 57°), the anteversion angle of acetabular cup was 18.2° ± 3.6° (range, 9.5° to 25.7°), and the filling ratio was 90.1% ± 3% (range, 85.2%-95.3%). The preoperative leg length discrepancy was 1.8 cm ± 0.8 cm (range, 1 cm to 5 cm) and reduced to 1.4 cm ± 0.5 cm (range, 0.5 cm to 2.5 cm). No considerable loosening, bearing-surface wear, osteolysis, or heterotopic ossification was observed. At the latest follow-up, the overall survival rate of the 49 hips was 98%.

Conclusion: For patients with end-stage hip disease under 25 years old, uncemented THA exhibit excellent outcomes, with a high survival rate and fewer complications at medium-term follow-up.

Introduction

Total hip arthroplasty (THA) has been routinely utilized to treat advanced hip diseases in the elderly. It has been praised as "one of the most successful operations in the 20th century" because of its remarkable clinical performance[1]. Several diseases, such as avascular necrosis (AN), juvenile idiopathic arthritis (JIA), infection, and chronic dislocation, may cause disabling symptoms in young adults, but THA is rarely recommended to young patients due to multiple factors, including activity level, social attributes, the longevity of implants, subsequent revision, and surgery complications.[2–4]. However, THA can reduce patients’ financial burden and achieve a more accurate outcome when compared to the
potential additional expenses that may result from conservative treatment. Therefore, THA is an effective and cost-effective choice for the treatment of young patients with advanced hip disease.

Currently, cemented and uncemented fixation are the two main methods of THA, and the efficacy of these two methods has been controversial [4–7]. This study seeks to determine and report the clinical and radiographic outcomes of the mid-term follow-up of uncemented THA in patients under the age of 25 in order to provide doctors with a reference for future surgical decision-making.

**Materials and Methods**

**Inclusion Criteria**

(1) Patients who underwent THA due to end-stage hip disease at the Department of Orthopedics of the 940th Hospital of Joint Logistic Support Force of Chinese People's Liberation Army. (2) Patients who were under 25 at the time of surgery. (3) patients who received uncemented THA.

**Exclusion Criteria**

(1) Patients undergoing tumor-type THA for hip cancer; (2) Patients undergoing THA due to hip infection; (3) The duration of follow-up was less than three years; (4) Patients who were lost to follow-up or had incomplete data.

**Operation Method**

The patient was positioned in a healthy lateral decubitus position following a satisfactory anesthetic. The epidermis, subcutaneous tissue, and fascia lata were sliced progressively using a 12-centimeter-long Kocher-Langebeck (K-L) approach. The gluteus maximus muscle was split and retracted anteriorly to reveal the gluteus medius muscle. The hip joint was exposed by severing the external rotation muscle group and joint capsule complex from the external posterior edge of the greater trochanter. The femoral head was removed 1 cm above the lesser trochanter after external rotation and oblique osteotomy. The labrum surrounding the acetabulum was excised, exposing the acetabulum in its entirety and cleaning the soft tissue of the acetabulum. In the hip joint, the proximal femur was exposed, followed by an open mouth opening with a medullary cavity number file and expanding pulp, a test after selecting an appropriate type side femoral prosthesis and neck long femoral head, and a hip reset immediately after the installation of the femoral prosthesis handle and femoral head prosthesis, all directions without dislocation of the hip and the impact of the event.

**Perioperative Management**

(1) Infection prevention: Use second-generation cephalosporin antibiotics for 48 hours after surgery, change dressing frequently to avoid exudation, and insert a drainage tube within 24h following the operation. (2) Thrombus prevention: Nadroparin Calcium Injection 3075 IU was injected subcutaneously once daily, and rivaroxaban tablet 10 mg was taken orally once a day after discharge until 5 weeks after surgery; Lower extremity pressure therapy instrument was used twice a day. Besides, patients were
encouraged to perform lower limb ankle pump exercise. (3) Functional exercise: non-weight-bearing standing exercises were conducted the day after surgery, and partial weight-bearing exercises were performed two weeks later. Walking with crutches and carrying weight began six weeks following surgery. Walking without a cane three months following surgery.

**Clinical Evaluation**

The clinical outcome was assessed by modified Harris hip Score (mHHS) and Western Ontario & McMaster Universities Osteoarthritis Index (WOMAC), while the Quality of life was evaluated by the Short-Form 36 (SF-36). Additionally, post-operative complications will be recorded (e.g., infection, revision, dislocation, wound healing problems, etc.). The goal of mHHS is to measure preoperative function impairment and postoperative improvement. The WOMAC index is used to evaluate changes in health following surgery, higher scores imply a poorer prognosis. The SF-36 is a generic questionnaire on quality of life which can be divided into a Physical Component Summary (PCS) and Mental Component summary (MCS), higher scores indicate a better outcome.

**Radiographic Evaluation**

Radiographic follow-up was performed in the anteroposterior pelvis, anteroposterior and lateral hip joint X-ray. Included in the evaluation were implants position, loosening, bearing-surface wear, osteolysis, heterotopic ossification and filling ratio. The appearance of a complete radiolucent line on radiography, the femur sinking by 2mm or more, or the acetabular prosthesis shifting by more than 4 mm horizontally or vertically, or turning by more than 5 degrees, was characterized as loosening. In addition, if loosening was discovered, it was recorded by the Charnley’s three acetabular zones and the Gruen's seven femoral zones [2; 8]. According to Tsukanaka’s previous report, osteolysis was defined as a clear area ≥ 3 mm in diameter surrounding the prosthesis[8; 9]. On the anteroposterior and lateral X-rays, the filling ratio was assessed at three levels: the upper border of the lesser trochanter, the mid-stem, and 1 cm proximal to the prosthesis tip[10].

THA failure was defined as loosening of the acetabular or femoral prosthesis or revision for any reason.

**Statistical Method**

The measurement data in accordance with normal distribution were expressed as (Mean ± SD), paired sample t-tests were used for clinical scores and independent sample t-tests were used for comparison between different liners. $P < 0.05$ was considered statistically significant. All the analysis were performed with SPSS software version 25.0 (SPSS, IBM, Armonk, NY, USA).

After all participants were identified, we gathered their contact information and verbal consent for the study. This study was a retrospective study, and the Committee waived the requirement for written informed consent because the patient data remained anonymous and the study had no adverse effects on patient health.
Results

A total of 89 patients (112 hips) who underwent THA in our department from January 2009 to December 2018 were screened according to the inclusion criteria. Following exclusion criteria, 37 patients (49 hips) were enrolled in this study, including 26 males (33 hips) and 11 females (16 hips). The general data of the patients are shown in Table 1. The mean age was (21.8 ± 2.6) years (19–25 years), with 29 left-sided hips (48.1%) and 20 right-sided hips (51.9%). 12 patients received bilateral THA and 25 patients underwent unilateral THA. The average body mass index (BMI) was (22.3 ± 3.2) kg/m\(^2\) (16.8–29.1 kg/m\(^2\)). The mean duration of follow-up time was (8.3 ± 2.4) years (3.8–12 years).

The average length of hospitalization was (13 ± 4.7) days (5–18 days). 4 hips received general anesthesia, while 45 hips received intrathecal anesthesia. The average operation time was (128.2 ± 40.8) minutes (60–240 minutes), and the average intraoperative blood loss was (360.6 ± 171.4) ml (150–800 ml). On the choice of bearing surfaces, 23 hips (46.9%) were lined with the ceramic-on-highly cross-linked polyethylene (CoP), and 26 hips (53.1%) were lined with the ceramic-on-ceramic (CoC). There was no significant difference between the two bearing surfaces at the latest follow-up, as shown in Table 2. The causes of 49 hips included Avascular necrosis of the femoral head (AVN) (30 hips), Developmental Dysplasia of the Hip (DDH) (8 hips), Rheumatoid arthritis (RA) (5 hips), Ankylosing spondylitis (AS) (5 hips), and hip osteoarthritis (OA) (1 hip). In the patients with Avascular necrosis of femoral head, the causes were mainly trauma (11 hips), idiopathic (9 hips), hormone (8 hips), and alcohol (2 hips), as shown in Table 3. The preoperative modified Harris hip score was 43.5 ± 12.9 (range, 18 to 62) and increased to 88.3 ± 8.8 (range, 72 to 97), and the preoperative postoperative Western Ontario & McMaster Universities Osteoarthritis Index score improved from 43.6 ± 8.4 (range, 33.1 to 62.3) to 11.5 ± 6.8 (range, 2.5 to 25.8). The Physical Component score-SF-36 improved from 48.5 ± 8.6 (range, 36.4 to 61.3) to 81.2 ± 10.3 (range, 60.3 to 97.5), and the Mental Component score-SF-36 increased from 56.6 ± 12.5 (range, 39.4 to 78.6) to 82.6 ± 12.9 (range, 54.7 to 97). The comparison of clinical scores is shown in Table 4. The latest X-ray revealed that the position of the implants did not change substantially since the postoperative image. The abduction angle of acetabular cup was 41.8° ± 6.7° (range, 31° to 57°), the anteversion angle of acetabular cup was 18.2° ± 3.6° (range, 9.5° to 25.7°), and the filling ratio was 90.1% ± 3% (range, 85.2–95.3%) (Fig. 1 and Fig. 2). The preoperative leg length discrepancy was 1.8 cm ± 0.8 cm (range, 1 cm to 5 cm) and reduced to 1.4 cm ± 0.5 cm (range, 0.5 cm to 2.5 cm). No obvious loosening, wear, osteolysis, or heterotopic ossification. All components were stable and integrated. There were no differences between CoC and CoP bearing surfaces(\( P \) 0.05).
Table 1
General data of 37 patients (49 hips)

<table>
<thead>
<tr>
<th>No. of patients</th>
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<tbody>
<tr>
<td>No. of hips</td>
<td>49</td>
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<tr>
<td>Age at time of surgery(yr)</td>
<td>21.8</td>
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<tr>
<td>Mean body mass index(kg/m²)</td>
<td>22.3</td>
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<tr>
<td>Follow-up time(yr)</td>
<td>8.3</td>
</tr>
<tr>
<td>Hospitalization time(d)</td>
<td>13</td>
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<tr>
<td>Mean operation time(min)</td>
<td>128.2</td>
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<tr>
<td>Mean blood loss(ml)</td>
<td>360.6</td>
</tr>
<tr>
<td>Gender</td>
<td></td>
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<tr>
<td>Male</td>
<td>26</td>
</tr>
<tr>
<td>Female</td>
<td>11</td>
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<tr>
<td>Laterality</td>
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<tr>
<td>Left</td>
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<tr>
<td>Right</td>
<td>20</td>
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<tr>
<td>Bearing surface</td>
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<tr>
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<td>23</td>
</tr>
<tr>
<td>CoC</td>
<td>26</td>
</tr>
<tr>
<td>Anesthesia method</td>
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<td>intrathecal anesthesia</td>
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Table 2
Comparison of CoC and CoP

<table>
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<tr>
<th>modified Harris hip score</th>
<th>WOMAC score</th>
<th>The Physical Component score-SF-36</th>
<th>The Mental Component score-SF-36</th>
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<tr>
<td>CoC</td>
<td>87.2 ± 8.5</td>
<td>6.8 ± 4.9</td>
<td>79.9 ± 10.9</td>
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<tr>
<td>CoP</td>
<td>88.9 ± 9.1</td>
<td>7.9 ± 4.2</td>
<td>81.9 ± 10.1</td>
</tr>
<tr>
<td>t value</td>
<td>-0.49</td>
<td>-0.66</td>
<td>0.49</td>
</tr>
<tr>
<td>P value</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
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Table 3  
Causes of 49 hips

<table>
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<tr>
<th>diagnosis</th>
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<th>DDH</th>
<th>RA</th>
<th>AS</th>
<th>OA</th>
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<tr>
<td>the causes of AVN</td>
<td>30</td>
<td>8</td>
<td>5</td>
<td>5</td>
<td>1</td>
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<tr>
<td>Trauma</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Idiopathic</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Hormone</td>
<td></td>
<td></td>
<td></td>
<td></td>
<td></td>
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<tr>
<td>Alcohol</td>
<td>11</td>
<td>9</td>
<td>8</td>
<td>2</td>
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</table>

Table 4  
Comparison of clinical scores

<table>
<thead>
<tr>
<th></th>
<th>modified Harris hip score</th>
<th>WOMAC score</th>
<th>The Physical Component score-SF-36</th>
<th>The Mental Component score-SF-36</th>
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<tbody>
<tr>
<td>Preoperative</td>
<td>43.5 ± 12.9</td>
<td>43.6 ± 8.4</td>
<td>48.5 ± 8.6</td>
<td>56.6 ± 12.5</td>
</tr>
<tr>
<td>Latest follow up</td>
<td>88.3 ± 8.8</td>
<td>11.5 ± 6.8</td>
<td>81.2 ± 10.3</td>
<td>82.6 ± 12.9</td>
</tr>
<tr>
<td>t value</td>
<td>-25.3</td>
<td>19.6</td>
<td>-10.2</td>
<td>-7.3</td>
</tr>
<tr>
<td>P value</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
<td>0.05</td>
</tr>
</tbody>
</table>

Complications and preoperative interventions

A patient suffered a sinus tract at the surgical site more than 4 months after right THA, and was readmitted for surgical treatment. During the surgery, it was discovered that the sinus tract connected to the deep gluteus maximus muscle and hip capsule. The granulation tissue was entirely removed, and the liner and femoral head was replaced. One patient with bilateral femoral head necrosis received bilateral core decompression (CD) nine months prior to THA, whereas the other patient with more severe right femoral head necrosis than left underwent left core decompression during right THA. Before THA, all patients with trauma-induced femoral head necrosis had had various hip procedures, including closed reduction and cannulated screw internal fixation and open reduction and internal fixation.

At the latest follow-up, the overall survival rate of the 49 hips was 98%.

Discussion

Although THA has been widely utilized in elderly patients with advanced hip disease, its application in younger patients remains controversial. Torchia[11] discovered that the failure rates in young patients increased significantly over time, reaching as high as 45%. Halvorsen[12] reported 747 patients (881 hips) under the age of 21 who received THA and discovered an 86% 10-year survival rate. These high reported failure rates may be attributed to the design of early prosthesis and the cemented technique[13]. In light of these high failure rates, few young patients receive THA, and relevant data and study findings are still
lacking. However, compared with the "hip preservation" treatment with uncertain efficacy and eventual surgery, THA can help young patients in regaining hip function, rebuilding normal social attributes, and reducing the impact of the disease on their studies, work and life. In this study, we focused on patients ≤ 25 years who received uncemented THA. During an average of 8.3 years follow-up, the mHHS and WOMAC index significantly improved at the last follow-up, indicating that the uncemented THA is suitable for young patients and can achieve optimal performance. The quality of life, both physical and mental components, as measured by the SF-36, showed significant improvement in 49 hips. Furthermore, the latest X-ray revealed that the position of the implants did not change substantially since the postoperative image, and that there was no obvious loosening, wear, osteolysis, or heterotopic ossification. All components were stable and integrated. The total survival rate was 98%, which was comparable to the survival rate recorded in literature[4; 9; 14–16].

Traditionally, the most common THA fixation methods are cemented and uncemented fixation. Cemented THA can achieve good initial stability, but the bone cement is particularly prone to fatigue fracture under long-term stress, and the bone cement particles generated can cause osteolysis around the prosthesis and lead to prosthesis loosening, which is more common in patients with high activity or young age; within contrast to cemented THA, the early stability of uncemented THA depends on the tight compression of bone tissue and prosthesis, while the later stability depends on the bone tissue growing into the prosthesis[17; 18]. It is generally accepted that uncemented THA has a better prognosis and is more conducive to at least one revision surgery in the future for patients with younger age, longer life expectancy, greater mobility, and good bone growth function[18–20]. Although modern cement technology has increased the efficacy of prosthesis fixation, the risk of failure remains higher than with uncemented fixation. Buddhdev[21] reported 51 patients accepting uncemented THA at the age of 16.7 years, with an average survival rate of 97% after 9.3 years of follow-up. Smith[22] conducted a long-term follow-up of 50 hips undergoing cemented THA and found the revision rate to be 38%. Boyle[23] observed that the revision rates of cemented THA was significantly higher than uncemented THA. In this study, all 49 hips were treated with uncemented THA, thereby avoiding complications such as osteolysis and prosthesis loosening caused by bone cement.

Although uncemented prostheses reduce several issues associated with cemented prostheses, intraoperative and postoperative complications still exist. For instance, intraoperative cleavage fractures frequently occur in the proximal femur in order to ensure a close fit between implants and bone bed; in addition, a large amount of evidence proves that uncemented prostheses within two years of THA frequently exhibit varying degrees of micro thigh pain related to the distal femoral prosthesis [24]. In this study, no postoperative thigh pain was identified in 49 hips until the follow-up, which may be attributable to the close fit of the prosthesis to the bone bed during surgery and the patients' healthy bone mass.

As uncemented implants have generally replaced the traditional cemented implants, the prosthesis bearing surfaces have undergone several iterations to reduce excessive wear and osteolysis[5; 25]. The CoP bearing has superior wetness, hardness and inertness, whereas the CoC bearing improves wear, wetness, biological inertia and osteolysis, and has become the most prevalent bearing surface in young
patients over the past decade[21; 26–31]. In this study, 49 THA were treated with CoP (23 cases, 46.9%) and CoC bearings (26 cases, 53.1%) respectively. The survival rate and clinical results of these two bearings at the latest follow-up were similar to those of Pallante[26], who retrospectively analyzed the clinical outcomes of CoP, CoC and metal-on-highly cross-linked polyethylene (MoP), finding CoC and CoP with excellent outcomes. Kim[32] found that highly cross-linked polyethylene had superior wear resistance compared to traditional polyethylene, and that neither osteolysis nor aseptic loosening of the prosthesis occurred. Buddhdev[21] evaluated 51 patients (60 hips) receiving THA at a mean age of 16.7 years, 60 hips adopted CoC bearing, and the overall survival rate was 97% after an average follow-up of 9.3 years. Therefore, it is wise to utilize CoP and CoC as the bearing of choice for youth[26; 28].

In this study, AVN (30 hips) was the most common diagnosis among 49 hips, and the pathogenic factors were trauma (8 hips), idiopathic (9 hips), hormone (8 hips) and alcohol (2 hips). This is comparable to the findings of Konopitski[5], who revealed that THA indications had evolved over time. From 1971 to 1992, the most prevalent surgical indication was JIA, followed by DDH and post-traumatic arthritis. From 2000 to 2015, the most common indication for THA was AVN. This may be related to the early diagnosis and treatment of JIA and DDH, resulting in a lower frequency of late complications associated with these diseases[33].

In young patients, acetabular and femoral prosthesis loosening and polyethylene wear are the major causes of revision, with aseptic loosening accounting for up to 60% of THA failure[8; 34; 35]. The history of one or more previous procedures, hip trauma, disorders affecting lower limb function, and a high preoperative BMI will all raise the failure rate[4]. Besides, Ravi[36] believed that the risk of revision is also closely related to the annual operation volume of the surgeon. When the surgeon does fewer than 35 THA per year, the probability of early revision of THA increases. Therefore, competent surgeons and a thorough preoperative examination can effectively lower the chance of THA failure in young patients. In our study, all patients got a thorough preoperative evaluation, and the operations were performed by experienced chief physicians, resulting in good clinical and imaging outcomes.

**Conclusion**

We ascribe the majority of patients' improvement in this study to uncemented implants, the use of CoC and CoP bearings, enhanced surgical procedures, and higher bone quality in younger patients. Along with the continuous renewal of prostheses and the development of new technologies such as computer navigation, the number of young patients will increase, and they will be able to obtain a better surgical outcome. These data can help surgeons in decision-making and improve confidence in young patients. This research is a retrospective study of a small sample with selection bias, and the length of the follow-up period may impact the accuracy of the results. Future multicenter, large-sample, randomized, controlled trials are required to evaluate the efficacy of uncemented THA in young patients.

**Abbreviations**
THA: Total hip arthroplasty
AN: avascular necrosis
JIA: juvenile idiopathic arthritis
K-L: Kocher-Langebeck approach
mHHS: modified Harris hip Score
WOMAC: Western Ontario & McMaster Universities Osteoarthritis Index
SF-36: Short-Form 36
PCS: Physical Component Summary
MCS: Mental Component summary
CoP: ceramic-on-highly cross-linked polyethylene
CoC: ceramic-on-ceramic
MoP: metal-on-highly cross-linked polyethylene
AVN: Avascular necrosis of the femoral head
DDH: Developmental Dysplasia of the Hip
RA: Rheumatoid arthritis
AS: Ankylosing spondylitis
OA: osteoarthritis

Declarations

Ethics approval and consent to participate

The study was approved by Ethics Committee of The 940th Hospital of Joint Logistic Support Force of Chinese People's Liberation Army. This study was a retrospective study, the Committee waived the requirement for written informed consent because the patient data remained anonymous and the study had no adverse effects on patient health. All methods were carried out in accordance with relevant guidelines and regulations, and follows the ethical principles of the Declaration of Helsinki 1964.

Consent for publication

Verbal consent was obtained from all patients.
Availability of data and materials

All data generated or analyzed during this study are included in this published article.

Competing interests

The authors have no relevant financial or non-financial interests to disclose. The authors have no conflicts of interest to declare that are relevant to the content of this article. All authors certify that they have no affiliations with or involvement in any organization or entity with any financial interest or nonfinancial interest in the subject matter or materials discussed in this manuscript. The authors have no financial or proprietary interests in any material discussed in this article.

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Authors' contributions

Yu XY and Zhan LR contributed equally to this work and should be considered as equal first authors. Yu XY and Zhan LR wrote the manuscript and revised it. Qiao YJ, Li XS, Li ZY, Song XY, Zhang WH completed follow-up visits and collected data. Zhang HQ made the final review and revision of the manuscript.

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References


Figures

**Figure 1**

**A 24-year-old male patient who underwent the left THA.** A. Preoperative anteroposterior pelvic X-ray showed left femoral head necrosis. B. Anteroposterior pelvic X-ray immediately after surgery; C. Lateral hip joint X-ray immediately after surgery; D. Anteroposterior hip joint X-ray 3 years after surgery; E. Lateral hip joint X-ray 3 years after surgery. F. Anteroposterior pelvic X-ray at the latest follow-up.
Figure 2

A 22-years-old female patient who undergone the left THA. A. Preoperative anteroposterior pelvic X-ray showed left DDH; B. Anteroposterior pelvic X-ray immediately after surgery; C. Lateral hip joint X-ray immediately after surgery; D. Anteroposterior pelvic X-ray at the latest follow-up.