Original Article
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Total Hip Arthroplasty with Extra-small Femoral Stems in Extremely Hypoplastic Femurs: A Case-Series Study

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Background: Total hip arthroplasty (THA) in patients with hypoplastic femurs presents a significant challenge to orthopedic surgeons due to the limited space available for implant placement. Therefore, the extra-small femoral stems have been proposed as a solution to this problem, but there are limited data on the outcomes. We aimed to evaluate clinical and radiological outcomes of THA in patients with extremely hypoplastic femurs using the Bencox CM stem (Corentec), an extra-small femoral stem.

Methods: We included 6 hips from 4 patients. The mean age of the patients was 41.2 years (range, 19.6–60.4 years). The mean height was 135.1 cm (range, 113.6–150.0 cm) with a mean body mass index of 25.7 kg/m^2 (range, 21.3–31.1 kg/m^2). The diagnoses for THA were sequelae of septic arthritis in childhood, pseudoachondroplasia, spondyloepiphyseal dysplasia, and juvenile rheumatoid arthritis. Preoperative computed tomography scans were conducted to assess the extent of proximal femoral hypoplasia. The clinical outcomes were assessed using the modified Harris Hip Score, while the radiological outcomes were evaluated using radiographs. The mean follow-up was 2.3 years (range, 1.0–5.9 years).

Results: The average modified Harris Hip Score improved to 88.8 at the final follow-up. Intraoperative femoral fractures occurred in 2 cases (33.3%). During the follow-up, 1 stem underwent varus tilting from postoperative 6 weeks to 6 months without subsidence. Otherwise, all stems showed good osteointegration at the latest follow-up. No hip dislocations, periprosthetic joint infection, or loosening of the prosthesis occurred.

Conclusions: The use of extra-small femoral stems in THA for extremely hypoplastic femurs can provide reasonable clinical and radiological outcomes with minimal complications. We suggest that this femoral stem could be a viable option for patients with extremely hypoplastic femurs.

Keywords: *Hypoplastic femur, Total hip arthroplasty, Extra-small femoral stem*

Total hip arthroplasty (THA) in patients with hypoplastic femurs presents a significant challenge to orthopedic surgeons due to the limited space available for implant placement. The presence of soft-tissue contracture, fragile bone, and a narrow canal creates a hostile environment for the placement of a femoral stem.[1] Furthermore, patients with hypoplastic femurs have an increased risk of complications, including sciatic nerve palsy, intraoperative femoral fractures, and recurrent hip dislocation.[2]

Several techniques have been employed to address this challenge. Previous studies have reported favorable outcomes with the use of a cementless Wagner cone prosthesis (Zimmer)[1,3] or modular stem.[4] Alternatively,

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femoral osteotomy of the deformed femur has been proposed as a method to accommodate the femoral stem.[5,6] Extensive soft-tissue release was often required.[7] While these approaches are crucial for achieving optimal implant placement, they are not without inherent morbidity.

Furthermore, in extremely hypoplastic cases where these methods are unable to provide a solution, the lack of suitable alternatives can be concerning for surgeons. Therefore, the use of extra-small femoral stems has been proposed as a potential solution to this problem, but there are limited data on the outcomes. We aimed to evaluate the clinical and radiological outcomes of THA in patients with extremely hypoplastic femurs using the Bencox CM stem (Corentec), an extra-small femoral stem.

METHODS

The study design and protocol of this retrospective study were approved by the Institutional Review Board of Seoul National University Hospital (IRB No. H-2302-039-1402). Informed consent was not required because of the study's retrospective methodology. The use of the patient's images was later approved with further consent.

Patient Demographics

From November 2016 to March 2022, 4 patients (6 hips), who had extreme hypoplasia in the proximal femur, underwent THA at our institution. All hips were followed up for 2.3 years on average with a range from 1.0 to 5.9 years. The patients were all women, and their mean age at the time of arthroplasty was 41.2 years (range, 19–60 years). The average height was 135.1 cm (range, 113.6–150.0 cm) and their mean body mass index was 25.7 kg/m^2 (range, 21.3–31.1 kg/m^2) (Table 1).

The diagnoses for THA were pseudoachondroplasia in 1 patient (2 hips), juvenile rheumatoid arthritis in 1 patient (2 hips), spondyloepiphyseal dysplasia in 1 patient (1 hip), and sequelae of septic arthritis in childhood in 1 patient (1 hip).

Implants and Preoperative Planning of THA

All patients underwent preoperative computed tomography (CT) scans. The extremely hypoplastic femur was defined as follows: (1) femurs with a diameter measured less than 2 standard deviations from the mean diameter at the level of the lesser trochanter (LT) and 25 mm below the LT and (2) femurs where severe posterior bowing of the proximal femur rendered the use of conventional stems unfeasible.[8]

The femoral stem examined in this study is the Bencox CM stem (Corentec), classified as an extra-small type IIIC stem. It is composed of a titanium alloy (Ti6Al4V), containing 6% aluminum and 4% vanadium (Fig. 1). The stem design features a straight, tapered, double-wedged configuration with a rectangular shape. Its surface is grit blasted, resulting in a roughness of 5.5 µm, and it undergoes micro-arc oxidation treatment, providing enhanced biocompatibility. Notably, the proximal portion of the stem exhibits 3 vertical ribs: anterior, posterior, and lateral. These structural characteristics facilitate the precise anatomical fitting of the stem to the proximal femur while promoting improved biocompatibility.

Table 1. Demographic Data of the Cohort

Parameter	Value
Age (yr)	41.2 (19.6–60.4)
Female sex	4 (100)
Height (cm)	135.1 (113.6–150.0)
Body mass index (kg/m^2)	25.7 (21.3–31.1)
Diagnosis	
Pseudoachondroplasia	2 Hips
Juvenile rheumatoid arthritis	2 Hips
Spondyloepiphyseal dysplasia	1 Hip
Sequelae of septic arthritis	1 Hip
Follow-up period (yr)	2.3 (1.0–5.9)

Values are presented as mean (range) or number (%).

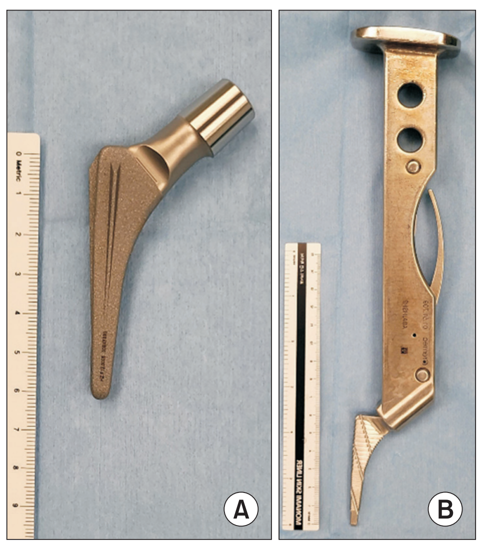

Fig. 1. Photographs of the Bencox CM stem (Corentec) (A) and its rasp with the handle (B).

The Bencox CM stem has the same design as the Bencox stem, which has been widely studied.[9-11] There are 15 different sizes of Bencox stem; the Bencox CM stem was smaller than the smallest Bencox stem. The length and horizontal offset of the smallest Bencox stem were 115.18 mm and 33.2 mm, respectively, while those of the Bencox CM stem were on average 72 mm and 31.6 mm. The Bencox CM stem used in this study was offered in 2 sizes: one with 80 mm from distal tip to stem shoulder, 33.2 mm in horizontal offset, 6–7 mm in width, and 135º neck-shaft angle, while the other with 64 mm in length, 30 mm with horizontal offsets, 7–8 mm in width, and the same neck-shaft angle. These stems were produced on order; therefore, it must be requested at least 1 month prior to surgery. We used both simple radiographs and preoperative CT scans to meticulously determine the size of the stem.

Bencox Hybrid cup was used in 5 cases and a polyethylene cup with reinforcement cage (Zimmer) was used in 1 case. The fourth-generation ceramic-on-ceramic bearing system (Biolox delta; CeramTec AG) was used in Bencox hybrid cup, while ceramic-on-highly cross-linked polyethylene was used in the case of reinforcement cage.

Surgical Techniques

Because of coexisting anatomical distortions around each hip, the surgical approaches were individualized. The surgery was performed in the lateral decubitus position through a combination of the modified direct lateral approach and additional posterolateral approach. To adequately expose the acetabulum and to release tight capsules and soft tissue, both approaches were utilized to mobilize the joint and to reduce prostheses.[5,12] The osteotomy of the greater trochanter was performed in 1 hip for better visualization, while the remaining 5 hips were managed using the combined approach described earlier. The medical records were retrospectively reviewed to assess the duration of the surgical procedure and the amount of intraoperative blood loss.

Patient Blood Management and Postoperative Care

Blood transfusion was based on a rigorous transfusion protocol that had been described previously.[13] The transfusion was initiated when hemoglobin concentrations went below 8 g/dL or there were symptoms of acute anemia (e.g., dizziness, chest discomfort, tachycardia, and prolonged hypotension). For the first 6 weeks after surgery, partial weight-bearing with a crutch gait was recommended, followed by tolerable to full weight-bearing. Patients were followed up for 6 weeks, 6 months, 12 months, and then annually after the surgery.

Follow-up Evaluations

Clinical evaluation included the modified Harris Hip Score along with additional inquiries regarding thigh pain, noise, and other potential complications.[14] Moreover, assessments were conducted to identify complications such as dislocation, infection, and nerve injury. Radiographic evaluations were performed by 2 independent observers who were not involved in the index THAs (YSK and SYK). The position of the femoral stem was evaluated based on anteroposterior (AP) radiographs taken at the 6-week mark. The positioning was determined by measuring the angle between the longitudinal axis of the stem and that of the femur. It was categorized as neutral, valgus (> 5° of lateral deviation), or varus (> 5° of medial deviation). The abduction of the acetabular component was measured using the method described by Engh et al.[15] Additionally, the anteversion of the acetabular component was calculated following the approach proposed by Woo and Morrey.[16]

Implant stability, including fixation, migration, loosening of components, and the degree of stress shielding, was assessed using the criteria established by Engh et al.[17] Radiolucent lines, focal osteolysis, heterotopic ossification, and notching of the femoral stem were also evaluated. The location and extent of radiolucent lines and osteolysis were assessed using the zones described by Gruen et al.[18] for the femoral side and DeLee and Charnley et al.[19] for the acetabular side. Osteolysis was defined as the presence of a periprosthetic cystic or scalloped lesion larger than 2 mm in diameter that was not observed on immediate postoperative radiographs. Heterotopic ossification was graded according to the criteria outlined by Brooker et al.[20] Serial radiographs were reviewed to identify any femoral stem neck or shoulder notching, indicative of impingement between the metal stem and ceramic liner.[21,22]

RESULTS

Intraoperative Parameters and Femoral Fractures

The mean operation time was 122.8 minutes (range, 50–397 minutes). The mean amount of estimated blood loss was 412.3 mL (range, 250–1,510 mL). No patient received a transfusion. The intraoperative periprosthetic femoral fractures occurred in 2 hips during the insertion of the stem, and these fractures were successfully treated with cerclage wires (Fig. 2). No patient had symptomatic deep vein thrombosis or pulmonary embolism.

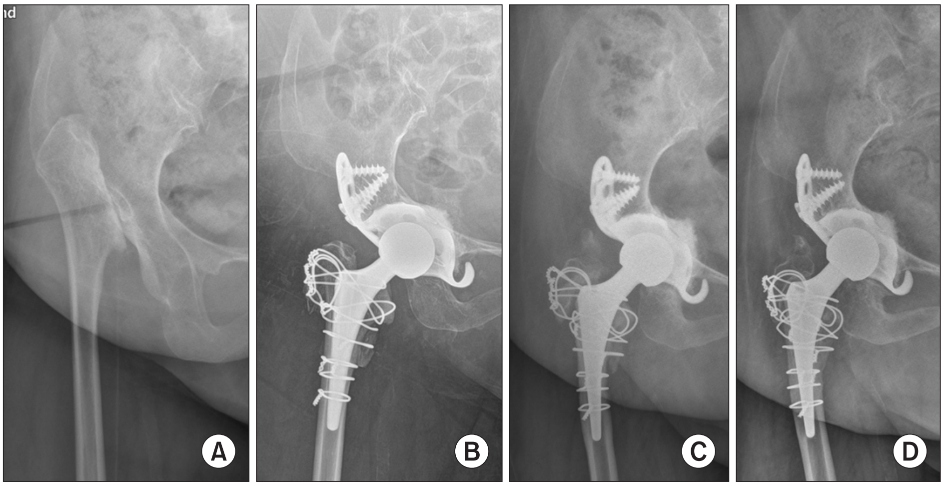

Fig. 2. (A) A 60-year-old woman had arthritic pain due to sequelae of septic arthritis of the hip. (B) She underwent total hip arthroplasty using the Bencox CM stem. An intraoperative periprosthetic femoral fracture was managed using a multiple-wiring technique. Anteroposterior radiographs taken at 1 year (C) and 6 years (D) after the surgery showed no signs of prosthetic loosening, wear, or osteolysis.

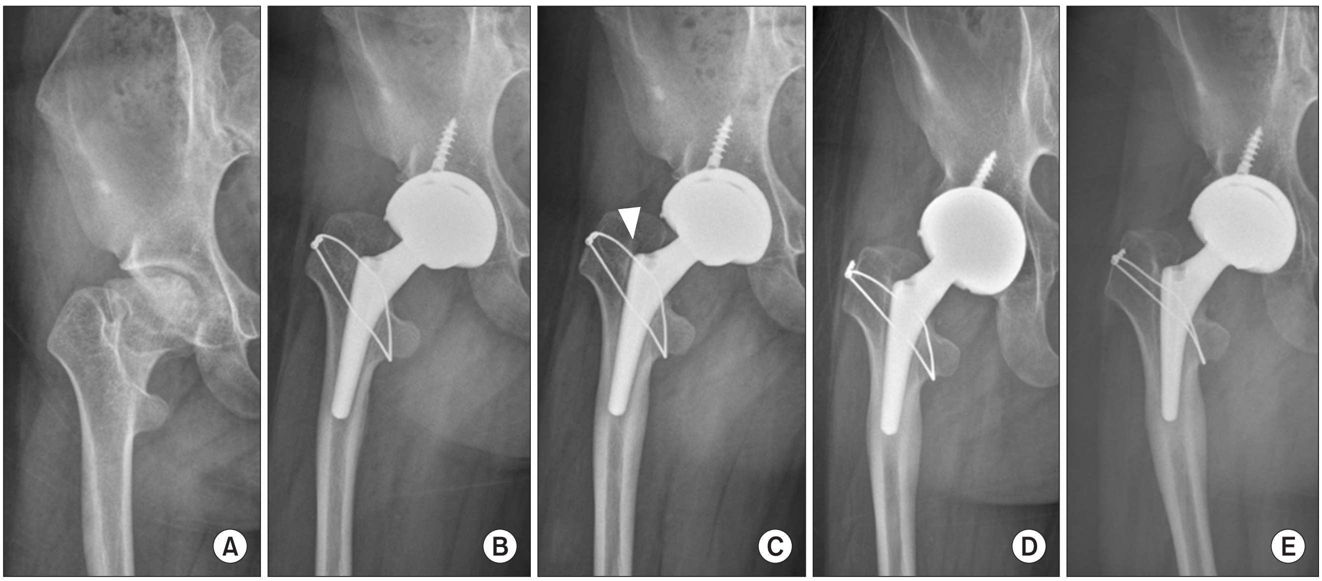

Fig. 3. (A) A 20-year-old woman had juvenile rheumatoid arthritis in her hip. (B) Total hip arthroplasty was performed. An intraoperative femoral crack was detected and treated with a wiring technique. Radiographs at postoperative 6 weeks (C) and 6 months (D) showed progressive varus tilting (arrowhead) of the femoral stem without definite evidence of stem subsidence. (E) The anteroposterior radiograph taken at 1.5 years after the surgery showed no further migration, and the patient remained asymptomatic.

Implant Position

Four stems were placed in the neutral position, while 2 stems were in the varus position. The mean anteversion and abduction of the cup were 27.4° (range, 13°–37°) and 41.3° (range, 31°–47°), respectively.

Clinical and Radiological Outcome

No hip dislocations or revisions were observed throughout the follow-up period. In 1 case of periprosthetic femoral fracture, the position of a stem shifted 1.4° in varus position from 6 weeks to 6 months postoperatively, but without subsidence (Fig. 3). No further migration was observed thereafter, and the patient remained asymptomatic. Apart from this case, all prostheses demonstrated stable osseointegration at the latest follow-up (Fig. 4). There were no periprosthetic joint infections or periprosthetic osteolysis. Furthermore, no cases of heterotopic ossification were identified in any of the hips. The mean modified Harris Hip Score was 88.8 points (range, 79–98 points) at the final follow-up.

DISCUSSION

THA with cementless stems presents technical challenges

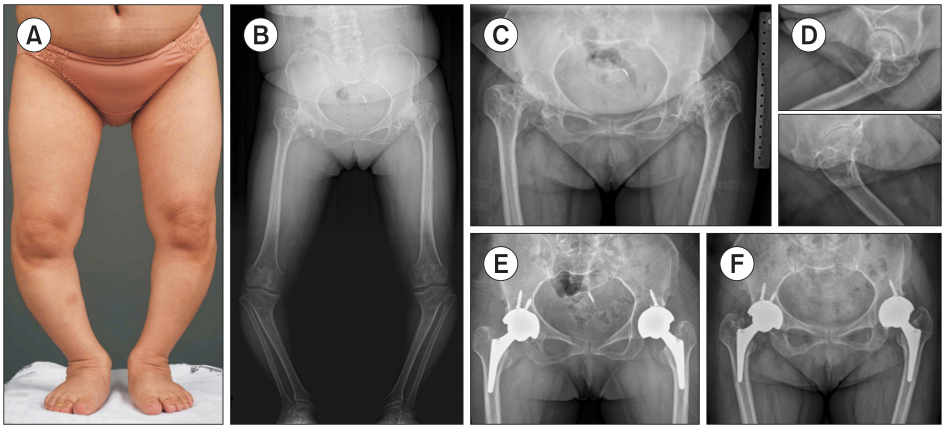

Fig. 4. A 46-year-old woman had total hip arthroplasty because of secondary arthritis of pseudoachondroplasia. (A, B) The clinical and radiographic presentation of her lower limbs demonstrated short stature (126.5 cm). (C, D) Both hip joints displayed end-stage osteoarthritis, along with severe posterior bowing in both proximal femurs. The length of the ruler placed on the right side was 13 cm in the preoperative image. (D) Immediate postoperative radiographs. (E, F) On the radiographs taken 2 years postoperatively, no indications of prosthetic loosening, wear, osteolysis, or ceramic fracture were observed.

in patients with smaller anatomical structures, as achieving secure initial stability through 3-point fixation can be difficult. These challenges are particularly pronounced in patients with preexisting anatomical deformities of the hip, such as sequelae of previous infection, genetic musculoskeletal disorders, or juvenile inflammatory arthritis.[23,24) To achieve adequate insertion and fixation of the femoral stem in hypoplastic femurs, surgeons have to select the smallest available premade stem. Moreover, additional osteotomy or trochanteric osteotomy is required, which is surgically demanding and leads to the risk of other complications. Furthermore, patients with hypoplastic femurs have been shown to exhibit inferior clinical outcomes and higher complication rates following THA.[2,23)

The strength of the femoral stem evaluated in this study lies in its ability to provide adequate fixation without the need for additional procedures. Despite its short length and slim diameter, the CM stem belongs to the type IIIC stem with grit-blasted surfaces and is primarily fixed in the metaphyseal-diaphyseal junction. Its rectangular design enhances resistance to rotational deforming forces.[25) THA utilizing extra-small femoral stems in patients with extremely hypoplastic femurs demonstrated favorable clinical and radiological outcomes with minimal complications.

Several previous studies reported the outcome of THA for patients with femoral hypoplasia who were treated with either off-the-shelf stems or custom-made stems.[2,26,27) De Man et al.[2) reported 90% implant survivorship for all hips at 15 years with aseptic revision of the stem as the endpoint in 84 THAs in 77 patients (mean height, 160 cm) with a hypoplastic femur using an off-the-shelf, cemented, small, curved, cobalt-chromium stem. DiFazio et al.[26) reported favorable clinical and radiological outcomes of 16 THAs performed on 11 patients (mean height, 152 cm) with either congenital dislocation or severe hip dysplasia with the custom-made cemented swan-neck stem. The survival rate of this implant was 94%, with an average follow-up period of 13.3 years. Interestingly, the cohort of our study with extremely hypoplastic femurs and a mean height of 135.1 cm also showed comparable results with those of the previous literature. Even in the dysplastic femur, THA could be safely performed with an adequately prepared femoral stem.

Previously, several short stems have been introduced to the market, such as Proxima (DePuy) and Metha (Aesculap). Drawing direct comparisons between the CM stem and ultra-short stem designs in this specific population might seem inappropriate, given that these ultra-short stems were developed for extreme metaphyseal fixation in the relatively normal proximal femur, aimed at reducing stress-shielding of the proximal femur. Despite their intended use in a different context, the rarity of this type of stem provided an opportunity to gain additional insights into the overall longevity of extra-small femoral stems. Numerous studies have reported favorable short- and mid-term outcomes with these stem designs, albeit in a limited number of patients and with relatively short follow-up periods.[28-30) However, the initial concerns regarding early aseptic loosening due to the absence of diaphyseal fixation have not been fully addressed. Loss of stability of the stem and failure of osseous ingrowths are potential concerns with the use of an ultra-short, proximal-loading, cementless femoral stem[30) and an extra-small femoral stem as well.

Several surgical techniques have been introduced to achieve secure initial fixation and favorable surgical outcomes in patients with hypoplastic femurs. Femoral osteotomy is one such techniques that can be performed to correct anteversion and prevent excessive leg lengthening, as well as to minimize tension on the sciatic nerve.[31] However, the femoral osteotomy is technically demanding, particularly in cases of extremely hypoplastic femurs, and may be associated with complications such as nonunion and morbidity at the osteotomy site. While some studies have reported excellent outcomes with the use of cone prostheses or modular systems,[2-4,32] these options may not be suitable for patients with extremely hypoplastic femurs, as in our current study. Therefore, the utilization of extra-small femoral stems has been proposed as a potential solution to address this challenge, although limited data are available regarding their outcomes.

Although the CM stem showed comparable results in the early to midterm follow-up, 2 significant concerns require further investigation. The first concern is the incidence of intraoperative periprosthetic femoral fractures. In this study, the rate of intraoperative periprosthetic femoral fractures in the cohort was remarkably high compared to conventional THA (33.3% vs. 5%).[33] This finding can be attributed to the inherent vulnerability of the femur in this specific patient population, characterized by a weak femur, extremely narrow canal, and structural deformities such as excessive posterior bowing. Therefore, meticulous care is required during the preparation of the femoral canal, including careful dissection to avoid excessive soft-tissue tension.

The second concern is the potential risk of early aseptic loosening due to insufficient metaphyseal and diaphyseal support. The CM stem, being an extra-small stem without enough diaphyseal support, relies on firm initial fixation for its long-term survival. Hence, precise preoperative templating using not only simple radiographs but also CT scans is necessary to avoid early aseptic loosening. In other words, proper preoperative templating, wise selection of implants, and meticulous surgical techniques are crucial factors contributing to improved outcomes.[1]

There are certain limitations of this study. First, this is a retrospective study with its intrinsic limitations. Second, the small number of patients due to the rarity of diseases might have biased the results. Future large-scale randomized prospective trials with a comparison with other stems are required. In addition, since the minimum follow-up period of 1 year was relatively short, concise follow-up was required to analyze the effect of confounding variables.

The use of the Bencox CM stem, an extra-small type IIIC femoral stem made of titanium alloy, in THA for extremely hypoplastic femurs can provide favorable clinical and radiological outcomes with minimal complications. We suggest that this femoral stem could be a viable alternative for patients with extremely hypoplastic femurs, addressing the challenges associated with limited space and providing improved clinical outcomes. Further studies with larger sample sizes and longer follow-up periods are warranted.

CONFLICT OF INTEREST

No potential conflict of interest relevant to this article was reported.

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REFERENCES

1. Mahajan NP, Gadod LL, Chandanwale AS, G S PK, Narvekar M, Gajbe I. Primary total hip replacement in a case of unilateral hypo plastic proximal femur: a case report. J Orthop Case Rep. 2021;11(4):48-51.

2. De Man FH, Haverkamp D, Van der Vis HM, Besselaar PP, Marti RK. Small stem total hip arthroplasty in hypoplasia of the femur. Clin Orthop Relat Res. 2008;466(6):1429-37.

3. Zhen P, Liu J, Lu H, Chen H, Li X, Zhou S. Developmental hip dysplasia treated by total hip arthroplasty using a cementless Wagner cone stem in young adult patients with a small physique. BMC Musculoskelet Disord. 2017;18(1):192.

4. Drexler M, Dwyer T, Marmor M, et al. Nineteen year results of THA using modular 9 mm S-ROM femoral component in patients with small femoral canals. J Arthroplasty. 2013;28(9):1667-70.

5. Kim JT, Kim HS, Lee YK, Ha YC, Koo KH. Total hip arthroplasty

with trochanteric ostectomy for patients with angular deformity of the proximal femur. J Arthroplasty. 2020;35(10):2911-8.

6. Kim YH, Park JW, Jang YS, Kim EJ. Long-term follow-up of management of the hypoplastic femur with femoral episiotomy and onlay allograft during total hip arthroplasty. J Arthroplasty. 2022;37(7):1308-13.
7. Wu X, Li SH, Lou LM, Cai ZD. The techniques of soft tissue release and true socket reconstruction in total hip arthroplasty for patients with severe developmental dysplasia of the hip. Int Orthop. 2012;36(9):1795-801.
8. Kim SL, Kim YM, Choi IH, Seong SC, Chung CY, Kim DH. Anthropological studies on the proximal femur of the Korean. J Korean Orthop Assoc. 1986;21(5):767-80.
9. Park CW, Eun HJ, Oh SH, Kim HJ, Lim SJ, Park YS. Femoral stem survivorship in Dorr type A femurs after total hip arthroplasty using a cementless tapered wedge stem: a matched comparative study with type B femurs. J Arthroplasty. 2019;34(3):527-33.
10. Kim HJ, Yoo JJ, Seo W, Kim MN, Kang T. Cementless total hip arthroplasty using the COREN hip system: a minimum five-year follow-up study. Hip Pelvis. 2018;30(3):162-7.
11. Lee JM, Jeon JB. Result of a minimum five-year follow-up of hip arthroplasty using the Bencox(R) hip stem. J Korean Orthop Assoc. 2014;49(2):126-32.
12. Mulliken BD, Rorabeck CH, Bourne RB, Nayak N. A modified direct lateral approach in total hip arthroplasty: a comprehensive review. J Arthroplasty. 1998;13(7):737-47.
13. Kim SK, Seo WY, Kim HJ, Yoo JJ. Postoperative intravenous ferric carboxymaltose reduces transfusion amounts after orthopedic hip surgery. Clin Orthop Surg. 2018;10(1):20-5.
14. Byrd JW, Jones KS. Prospective analysis of hip arthroscopy with 2-year follow-up. Arthroscopy. 2000;16(6):578-87.
15. Engh CA, Griffin WL, Marx CL. Cementless acetabular components. J Bone Joint Surg Br. 1990;72(1):53-9.
16. Woo RY, Morrey BF. Dislocations after total hip arthroplasty. J Bone Joint Surg Am. 1982;64(9):1295-306.
17. Engh CA, Hooten JP Jr, Zettl-Schaffer KF, et al. Porous-coated total hip replacement. Clin Orthop Relat Res. 1994;(298):89-96.
18. Gruen TA, McNeice GM, Amstutz HC. "Modes of failure" of cemented stem-type femoral components: a radiographic analysis of loosening. Clin Orthop Relat Res. 1979;(141):17-27.
19. DeLee JG, Charnley J. Radiological demarcation of cemented sockets in total hip replacement. Clin Orthop Relat Res. 1976;(121):20-32.
20. Brooker AF, Bowerman JW, Robinson RA, Riley LH. Ectopic ossification following total hip replacement. Incidence and a method of classification. J Bone Joint Surg Am. 1973;55(8):1629-32.
21. Lee S, Yoo JJ, Kim HJ. Impingement between the metal stem and the ceramic liner in total hip arthroplasty: the neck is not the only place where impingement occurs. J Bone Joint Surg Am. 2021;103(2):139-45.
22. Kim HS, Park JW, Lee SJ, Lee YK, Ha YC, Koo KH. High risk of neck-liner impingement and notching observed with thick femoral neck implants in ceramic-on-ceramic THA. Clin Orthop Relat Res. 2022;480(4):690-9.
23. Chiavetta JB, Parvizi J, Shaughnessy WJ, Cabanela ME. Total hip arthroplasty in patients with dwarfism. J Bone Joint Surg Am. 2004;86(2):298-304.
24. Moore HG, Schneble CA, Kahan JB, Polkowski GG, Rubin LE, Grauer JN. Total joint arthroplasty in patients with achondroplasia: comparison of 90-day adverse events and 5-year implant survival. Arthroplast Today. 2021;11:151-6.
25. Kim JT, Yoo JJ. Implant design in cementless hip arthroplasty. Hip Pelvis. 2016;28(2):65-75.
26. DiFazio F, Shon WY, Salvati EA, Wilson PD. Long-term results of total hip arthroplasty with a cemented custom-designed swan-neck femoral component for congenital dislocation or severe dysplasia: a follow-up note. J Bone Joint Surg Am. 2002;84(2):204-7.
27. Klapach AS, Callaghan JJ, Miller KA, et al. Total hip arthroplasty with cement and without acetabular bone graft for severe hip dysplasia: a concise follow-up, at a minimum of twenty years, of a previous report. J Bone Joint Surg Am. 2005;87(2):280-5.
28. Melisik M, Hrubina M, Hert J, Cibula Z, Cabala J, Necas L. Mid-term results of Proxima ultra-short anatomical stem: analysis of 130 cases. Acta Chir Orthop Traumatol Cech. 2021;88(1):50-7.
29. Gombar C, Janositz G, Friebert G, Sisak K. The DePuy Proxima short stem for total hip arthroplasty: excellent outcome at a minimum of 7 years. J Orthop Surg (Hong Kong). 2019;27(2):2309499019838668.
30. Kim YH. Ultra-short bone conserving cementless femoral stem. Hip Pelvis. 2021;33(4):181-9.
31. Perry KI, Berry DJ. Femoral considerations for total hip replacement in hip dysplasia. Orthop Clin North Am. 2012;43(3):377-86.
32. Kim HS, Park JW, Lee YK, Yoo JJ. The early- to mid-term outcome of novel cementless modular femoral stem in East Asian patients. Clin Orthop Surg. 2023;15(2):211-8.
33. Siddiqi A, Springer BD, Chen AF, Piuzzi NS. Diagnosis and management of intraoperative fractures in primary total hip arthroplasty. J Am Acad Orthop Surg. 2021;29(10):e497-512.