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Cementless Total Hip Arthroplasty in Hip Dysplasia with an Extensively Porous-Coated Cylindrical Stem Modified for Asians: A 12-Year Follow-Up Study

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ABSTRACT

Long-term outcomes of primary cementless total hip arthroplasty were examined for 198 hips of Asian patients with developmental dysplasia of the hip. AML stems were modified for patients' relatively small physique. Stable fixation was achieved despite various proximal femoral deformities. At follow up (mean 12.1 years), radiographs demonstrated fixation in all hips, with 100% stem survivorship. Radiographic changes revealed that the severity of stress-shielding was mild in 55% of hips, moderate in 26%, and severe in 19%. Longer follow up is needed to determine whether these changes will develop into clinical manifestations. A distal fixation stem can be a useful reconstruction option when application of a proximal fixation stem in primary total hip arthroplasty is difficult for various reasons.

Total hip arthroplasty (THA) in patients with developmental dysplasia of the hip (DDH) can be a challenging problem [1,2], with proximal femoral deformity being particularly problematic [3,4]. The outcomes of cementless THA are readily influenced by femur morphology. When proximal fixation stems are utilized in patients with severe proximal femoral deformities, it is difficult to achieve good proximal fit and fill and proper rotational alignment due to the underlying deformity [5,6]. One strategy to address these problems is the use of rotation-free modular stems [7–11] and another is the use of distal fixation stems.

The AML stem (Depuy, Johnson & Jonson, Warsaw, IN) is an extensively porous-coated, straight, cylindrical stem made of cobalt–chromium, and is classified as a distal fixation stem. Since it was first approved by the Food and Drug Administration in the United States in 1977, the AML stem has been used in more than 420,000 cases worldwide, over 97% of which are reportedly still in place 20 years after surgery [12–15]. Because the original AML stem was not suitable for the relatively small physique of Asian patients, the AML-A series with multiple stem diameter/length options was developed in 1988, which allowed stem length to be changed in relation to stem diameter. In 1997, the improved AML-plus series (Fig. 1), available in various stem sizes of 1-mm increments (as opposed to 1.5-mm increments previously) with an increased porous-coated area of 7/8 (5/8 previously) and a reduced neck taper-trunnion of 9/10 (10/12 previously), was introduced in Japan. Table 1 shows the size (distal diameter) and length of the AML and AML-plus stems. A few studies have reported follow-up results of THA using AML-A stems [16,17], but to the best of our knowledge clinical outcomes of THA using the AML-plus series have yet to be reported.

The aim of this study was therefore to investigate the outcomes of primary THA with AML-plus stems performed in Asian DDH patients more than 10 years earlier to reveal how the system was applied to femurs in patients with a small physique, the functional and radiographic outcomes of the reconstruction, and the advantages and limitations of distal fixation stems in DDH.

Materials and Methods

A total of 254 patients (272 hips) underwent primary THA at Kanagawa Rehabilitation Hospital between 1997 and 2001. We reviewed the patients' medical records and radiographs after approval of this study by the institutional review board. Based on a retrospective examination of the medical records and preoperative anteroposterior radiographs of both hips, 223 hips were diagnosed with osteoarthritis (OA) secondary to DDH in patients with obvious findings of superolateral subluxation of the femoral head. This study excluded patients with primary OA and patients with OA secondary to trauma,

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Fig. 1. The AML-plus stem. The series offers stem lengths in proportion to stem size in 1-mm increments and was introduced in Japan in 1997. The porous-coated area is 7/8 of the total stem surface with a 9/10 neck taper-trunnion.

femoroacetabular impingement, subchondral insufficiency fracture of the femoral head, or rapidly destructive coxarthrosis. Among the 223 hips, 3 treated by cement reconstruction and 2 treated with other types of cementless stems were excluded. Thus, the number of hips treated by primary THA using the AML-plus stem was 218 (205 patients). However, direct follow-up examination was not possible in 13 patients (13 hips) who died from causes unrelated to THA within 10 years of surgery (5 patients) or due to conditions such as advanced Alzheimer's disease and severe paralysis after stroke (8 patients). The survivorship of the stem in these 13 patients (13 hips) was confirmed by telephone interviews. Another 7 patients (7 hips) were lost to follow up. Direct medical examination and plain radiographs at least 10 years after surgery could be obtained in the remaining 185 patients (198 hips).

Among these 185 patients, 174 patients (187 hips) were women and 11 (11 hips) were men. Mean age at surgery was 56 years (range, 38–76 years), mean height was 152 cm (range, 136–173 cm), mean weight was 55 kg (range, 36–87 kg), and mean body mass index was 23.7 (range, 15.2–32.3). The mean follow-up period after surgery was 12.1 years (range, 10.0–15.5 years). The severity of superior subluxation of the femoral head according to Crowe's classification and based on preoperative anteroposterior plain radiographs was as follows: Group I, 81 hips (41%); Group II, 87 hips (44%); Group III, 20 hips (10%); and Group IV, 10 hips (5%).

Because operative exposure should be wide when operating on patients with DDH, which is often complicated with an acetabular or femoral deformity, the transtrochanteric approach with postoperative fixation of the greater trochanter with two wires was used in all hips. A straight reamer with a diameter 0.5 mm smaller than that of the stem was used to ream a medullary canal in the diaphysis. After reaming, the proximal femur was broached for stem insertion. In femurs with excessive neck anteversion, attention was paid to correct the stem anteversion as much as possible during broaching by utilizing the relatively small dimensions around the proximal portion of the stem. A 22-mm cobalt–chromium femoral head was used in all cases. Subtrochanteric femoral shortening osteotomy was performed in 5 Crowe Group IV hips. Cementless acetabular reconstruction was performed in all cases using a Duraloc 300 series cup with three spikes or a J-LOC 300 series cup (both from Depuy), and a conventional polyethylene liner (non-highly crosslinked grade) sterilized by irradiation in an argon environment. The patients were instructed to use a crutch for 6 weeks after surgery to limit weight bearing on their legs.

Table 1
Stem Size and Stem Length of the AML and AML-Plus Stems.

	AML (Small/Large)	AML-Plus
Distal Diameter (mm)	Nominal Length (mm)	Nominal Length (mm)
9.0	NA	123
10.0	NA	132
10.5	155/160	NA
11.0	NA	140
12.0	155/160	147
13.0	NA	154
13.5	155/160	NA
14.0	NA	162
15.0	155/160	169
16.5	150/160	180
18.0	150/155	NA
19.5	150/155	NA
21.0	150/155	NA
22.5	150/155	NA

NA: not applicable.

Implant Size

The association between the stem length used in THA and patient height was investigated.

Clinical Outcomes

Functional outcomes were assessed in accordance with the Japanese Orthopaedic Association (JOA) scoring system (total score 100), which consists of subcategories for pain (40 points), range of motion (ROM; 20 points), walking (20 points), and activity of daily living (ADL; 20 points) [18]. Complications such as intraoperative fractures, periprosthetic infections, dislocation, pulmonary embolism, and any failure leading to revision were investigated. In addition, revised components and reasons for revision surgery were assessed accordingly.

Radiographic Assessment

Anteroposterior plain radiographs taken at the last follow up were assessed for biological fixation of the stem according to the methods reported by Engh and colleagues [19,20]. Femoral component stress shielding was defined and assessed using a modification [21] of the criteria defined by Engh et al [22]. Mild stress shielding was limited to the upper third of the implant, moderate stress shielding extended to the middle third, and severe stress shielding extended to the lower third. We also investigated the state of bone union in the osteotomized greater trochanter and examined the acetabular and femoral osteolysis