CLINICAL ARTICLE

Bilaterally Primary Cementless Total Hip Arthroplasty for Severe Hip Ankylosis with Ankylosing Spondylitis

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Objectives: Total hip arthroplasty is a reliable therapeutic intervention in patients with ankylosing spondylitis, in whom the aims of surgery are to reduce pain, restore hip function and improve quality of life. The current study is a retrospective analysis of the clinical and radiographic findings in a consecutive series of patients with hip ankylosis associated with severe ankylosing spondylitis who underwent bilateral primary total hip arthroplasty using non-cemented components.

Methods: From June 2008 to May 2012, total hip arthroplasty was performed on 34 hips in 17 patients with bilateral ankylosis caused by ankylosing spondylitis. The study patients included 13 men and 4 women with a mean age of 24.2 years. The mean duration of disease was 8.3 years and the average duration of hip involvement was 7.6 years. All patients had severe hip pain and dysfunction with bilateral bony ankylosis and no range of motion preoperatively and all underwent bilateral cementless total hip arthroplasty performed by a single surgeon. Joint pain, range of motion (ROM), and Harris hip scores were assessed to evaluate the postoperative results.

Results: At a mean follow-up of 31.7 months, all patients had experienced significant clinical improvement in function, ROM, posture and ambulation. At the final follow-up, the mean postoperative flexion ROM was 134.4° compared with 0° preoperatively. Similar improvements were seen in hip abduction, adduction, internal rotation and external rotation. Postoperatively, 23 hips were completely pain-free, six had only occasional discomfort, three mild to moderate pain and two severe pain. The average Harris Hip Score improved from 23.7 preoperatively to 65.8 postoperatively. No stems had loosened at the final follow-up in any patient, nor had any revision surgery been required.

Conclusions: Bilateral severe hip ankylosis in patients with ankylosing spondylitis can be treated with cementless bilateral synchronous total hip arthroplasty, which can greatly improve hip joint function and relieve pain without significant complications. Provided the overall physical condition of a patient and their economic situation make surgery a feasible option and the surgeon is experienced, this treatment is a worthwhile surgical intervention for bilateral hip bony ankylosis. However, the technically demanding nature of the procedure and potential pre- and post-operative problems should not be underestimated.

Key words: Ankylosing spondylitis; Non-cemented; Total hip arthroplasty

Introduction

Ankylosing spondylitis (AS) is a chronic, autoimmune, progressive spondyloarthropathy with an age of onset

of 15–25 years^{1,2}. Although AS has a low prevalence, affecting 0.1%–1.0% of the population, 20% of HLA-B27-positive persons develop this disease. AS is considered a regional

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problem. Many patients experience a variety of symptoms for 7–10 years before the correct diagnosis is made^{3,4}. AS affects the axial spine, sacroiliac and peripheral joints, especially the hips, knees and shoulders, bony ankylosis reportedly occurring in 23.3%–73% of cases^{5–8}. The reported prevalence of hip disease in AS varies from 19% to 36%^{9,10}. This wide range can be explained by the different definitions used for the investigated persons and for hip involvement. Among persons with affected hips, 50%–90% present with bilateral hip ankylosis¹¹.

It has been reported that hip involvement increases the burden of AS and negatively impacts its prognosis^{9,10}. Additionally, hip arthritis appears to be associated with more severe spinal involvement^{12,13}. On the other hand, prolonged stiffness and lack of mobility in the spine can adversely affect the mobility of adjacent peripheral joints. Patients with juvenile onset AS (age at disease onset <16 years) are at the highest risk of developing hip disease and subsequently needing hip replacement surgery. Hip involvement occurs in 10%–50% of persons with AS¹; patients with juvenile onset having more hip involvement, but less severe axial disease¹⁴. Because hip disability hampers other activities related to spinal mobility, a patient's experience of functional impairment does not necessarily reflect only joint range of motion (ROM).

Ideally, systemic therapies for AS should also prevent AS-related damage. Conservative treatments for patients with hip involvement by AS include etanercept, methotrexate and anti-tumor necrosis factor therapy; these therapies may have a protective effect in early stage AS-related hip involvement^{15,16}. Patients with end-stage hip disease experience unbearable pain and joint stiffness and do not respond to conservative treatment. Several factors are associated with end-stage hip disease, including early age at onset, disease duration, enthesopathy, arthritis and severity of axial disease¹⁷. Fused hips, loss of lumbar lordosis and progressive thoracic and cervical kyphosis all contribute to the functionally disabling stooped posture typical of AS patients. Because of the resulting loss of motion combined with severe pain, total hip arthroplasty (THA) is a reported reliable therapeutic intervention with good outcomes^{6,8,11,18,19}. The aims of surgical treatment in these patients are to reduce pain, restore hip function and improve quality of life²⁰. Because of the important and central function of the hip, impaired hip functioning is clearly related to functional impairment in patients with AS. Many surgeons are hesitant to perform total hip arthroplasty in young patients with early stage AS because of subsequent mechanical failures, such as wearing, loosening, prosthesis dislocation and heterotopic ossification. Currently, the survival of hip prostheses in patients with AS appears to be similar to that in patients with osteoarthritis, being estimated at 98.5%, 96.8%, and 66.3% at 5-, 10-, and 15-years postoperatively, respectively^{2,21}.

Spinal osteotomy is another common surgical intervention for AS; however, opinions differ regarding spinal osteotomy versus total hip arthroplasty for AS. In 1963, Lee suggested that THA should be performed before spinal

osteotomy because the resultant improved hip ROM and overall pain relief facilitates more accurate assessment of residual spinal deformity in patients with severe hip flexion deformity²². However, Zheng *et al.* believe that spinal osteotomy should be performed before THA because positioning of the acetabular component in THA can be performed more safely after spinal osteotomy²⁰.

Identifying the optimal disease stage for surgery is also controversial. Neumann *et al.* recommend not performing THA in young patients to avoid multiple revisions throughout the patient's lifetime²³. Others take the opposite view^{19,24}, believing that patients with AS should be encouraged to undergo THA at an early age as long as their physical condition allows it, to facilitate pain relief and functional recovery. Also, as AS progresses, more joints become involved, disability increases, the muscles surrounding the hip atrophy and loosen and the amount of sclerotin increases, increasing the surgical difficulty and risks in late-stage procedures, often resulting in poor postoperative outcomes^{25,26}.

Cementless hip arthroplasty is often performed to treat AS. The use of cementless implants with their potential for biologic in-growth may increase implant longevity and reduce failure rates, especially in younger patients. Cementless prostheses can also preserve a large bone mass, leading to less difficulty in future revisions^{8,19}. Bilateral synchronous THA can be performed under certain conditions on patients with severe bilateral hip joint lesions. This procedure can both reduce pain and eliminate the effects of a non-operated hip joint on an operated hip joint. Thus, bilateral synchronous THA restores function of the lower limbs; however, few studies of this procedure have been reported^{6,11,19}. Additionally, no reports have been published on the use of THA to treat severe flexion hip deformity in patients with AS.

The purpose of this study was to evaluate the clinical and radiographic results in a consecutive series of patients with AS and severe hip ankylosis who underwent bilateral primary THA using non-cemented components. We also evaluated whether bilateral hip THA is suitable for patients with AS-related severe flexion hip deformity and evaluated the technique of cementless hip arthroplasty in AS-related hip ankylosis. We believe that the severity of the hip deformity treated in this study is very rare. Also, we discuss only THA, leaving discussion of spinal osteotomy for another study.

Materials and Methods

Clinical Data

This study was a retrospective review of the medical records of patients with severe bony ankylosis who had undergone bilateral cementless THA for AS between June 2008 and May 2012. Seventeen patients with 34 hip arthroplasties whose diagnoses were in accordance with the New York clinical criteria for AS²⁷ were enrolled. All patients were followed for a minimum of 2 years with a mean duration of follow-up of 2.5 years (range, 2–6 years). They comprised 13 men and four women with a mean age of 24.2 years (range, 21–43 years). The mean

duration of disease was 8.3 years (range, 5–30 years) and the average duration of hip involvement 7.6 years (range, 4–20 years). All patients had severe hip pain and dysfunction, with a mean Harris Hip Score (HHS) of 23.7 ± 1.2 . No patients had evidence of any other seronegative spondyloarthropathy. The inclusion criteria were patients with bilateral bony hip ankylosis with no ROM, poor posture and intolerable pain who had not undergone prior surgery to the involved hip²⁸. Contraction of the abductor muscles was palpable in all hips in this study.

The exclusion criteria were patients with no functioning abductor muscles who still had hip motion on physical examination or who had undergone prior surgery such as primary pseudarthrosis, cup arthroplasty or THA.

Patients' clinical and radiological details were recorded and analyzed. This study was approved by the Xi'an Honghui Hospital Committee for Clinical Research and informed consent was obtained from the patients participating in it. All patients also provided written informed consent for the publication of individual clinical details and accompanying images.

Preoperative Treatment

Preoperatively, C-reactive protein concentration and erythrocyte sedimentation rate were measured to quantify the severity of AS¹⁹. Clotting and vital organ functions were also assessed. X-ray templating was performed to carefully plan the anatomical reconstruction and determine the most appropriate approach depending on patient anatomy. CT scans and 3-D reconstruction were performed in some cases. First-generation cephalosporins and tranexamic acid were administered 30 min before the operation and these antibiotics were re-administered for operations exceeding 3 h.

Surgical Technique

All operative procedures were performed in an operating room equipped with a vertical laminar-flow clean-air system and body exhaust suits. All patients underwent bilateral THA

performed by a single surgeon. The most severely affected hip was operated on first¹¹, contralateral hip replacement being performed 7–10 days later. An anterior surgical approach²⁹ was used for five hips in five patients in a supine position (Fig. 1), and a posterolateral approach in a lateral position in the remaining 29 hips³⁰. After detaching the external rotators, the femoral neck resection line was identified by approaching the inferior neck and locating the pubofemoral arch and lesser trochanter. A trochanteric osteotomy was not performed. A superolateral bone spike was used to aid reaming and placing of the acetabular cup in a vertical position. Acetabular preparation began with piecemeal removal of the remaining femoral head. Reaming with sequentially larger reamers was then performed in a medial direction. Intraoperative radiographs were used to help in identifying the location of the original joint plane and foveal soft tissue (Fig. 2)⁸. Even in hips with bony fusion, incomplete gray ossifying cartilage remained at the location of the original joint plane. The prosthesis insertion angle was determined based on the specific hip deformity. In all hips, the short external rotator muscles were closed after the surgical procedure and the wound closed with a drain. All patients received cementless THAs (eight metal/poly, six ceramic/ceramic and 20 ceramic/poly; Link, Hamburg, Germany or Zimmer, Warsaw, IN, USA). Fixation was routinely supplemented with one to three screws, except for two hips in one patient who received press-fit cup technology without screws^{31,32}.

Postoperative Care

Prophylactic parenteral antibiotics were routinely given, as stated above, with one dose preoperatively and continuation for 3 days postoperatively. Cephalosporin antibiotics were chosen to better prevent infection with gram-negative organisms. Prophylaxis for deep vein thrombosis comprised rivaroxaban, 10 mg, once daily, for 35 days. Prophylactic anti-inflammatory medication (indomethacin, 25 mg, every 8 h, for 14 days) was routinely administered to all patients to prevent heterotopic ossification⁸. Physiotherapy began on the

Fig. 1 A 43-year-old man with AS had pain and disability of both hips for more than 30 years before coming to our hospital. Poor economic status had prevented him from receiving effective treatment in the early stages. (A) Photograph showing bilateral bony ankylosis with 0° range of motion; this patient could only walk indoors. (B) Preoperative X-ray film showing bilateral hip ankylosis. (C) Three-dimensional reconstruction showing pelvic malrotation. (D) X-ray film 2 weeks post-operatively.

Fig. 2 Intraoperative radiograph taken to help in inserting the acetabular cup in an ideal position.

second postoperative day, patients usually being allowed to walk with support after 3 days. Full weight-bearing was permitted after a minimum of 2 weeks.

Evaluation of Efficacy

Patients were evaluated clinically using both subjective and objective information based on HHS³³. Postoperative evaluation was performed at 6 weeks, 3 months, 6 months, 12 months, and then annually. Radiographic evaluation was also performed at each clinical interval, including a standing anteroposterior radiograph of the pelvis with the X-ray beam centered on the pubic symphysis and a lateral radiograph of the operated hip joint².

Acetabular inclination was measured using the inter-teardrop line as a reference point^{34,35}. The method proposed by Pradhan was used to calculate acetabular cup anteversion in anteroposterior radiographs³⁶. Loosening of acetabular prostheses was assessed on radiographs using the criteria of Hodgkinson *et al.*³⁷. Based on demarcation of the acetabular components in the zones described by DeLee and Charnley³⁸, an acetabular component was considered to have loosened if a continuous radiolucent line of any thickness was evident in all three zones (Type 3 demarcation) or if the cup had changed position or migrated (Type 4 demarcation). Femoral stems were evaluated radiographically using the system of Engh *et al.*³⁹, and the bone-prosthesis interface was evaluated for radiolucency and recorded according to the zonal system described by Gruen *et al.*⁴⁰. A femoral component was considered “definitely unstable” if there was subsidence greater than 2 mm over time^{34,41}. Ectopic ossification was graded according to the system described by Brooker *et al.*⁴², classes III and IV being considered clinically important as described by Kilgus *et al.*²⁸.

Clinical evaluation to calculate HHSs was performed by a clinical researcher doctor who did not take part in the treatment³³. Clinical results were evaluated by calculating HHS and ROM pre- and post-operatively. Student's *t*-test was used to analyze the HHS and range of motion data. Statistical analysis was performed using SPSS software (SPSS, Chicago, IL, USA). $P < 0.05$ was considered statistically significant.

Results

General Results

All patients had no ROM preoperatively. No patients had bony ankylosis of both the knees and ankles and none had ipsilateral flexion contracture of the knee. Adductor tenotomy was performed in 15 hips, iliopsoas muscles were released in 27 hips and anterior capsulectomy was performed in 29 hips to correct severe contractures. For single-side THA, blood loss during the surgery ranged from 450 to 1100 mL, with a mean of 580 mL. Operating time ranged from 90 to 170 min, with an average of 125 min.

Clinical Outcomes

Preoperatively, all hips had hip flexion contracture, the average flexion deformity being 83° (range, 60°–110°). At a mean follow-up of 31.7 months (range, 29–77 months), all patients had experienced significant clinical improvement in function, ROM, posture and ambulation. Flexion contracture was found in nine patients (mean, 17°; range, 15°–25°) at the most recent examination. Compared with 0° preoperatively, the mean postoperative flexion ROM at the final follow-up had improved greatly ($134.4^\circ \pm 6.3^\circ$, $P < 0.05$). Similar significant improvement was seen in hip abduction, adduction, internal rotation, and external rotation (respectively: $30.3^\circ \pm 0.9^\circ$, $12.1^\circ \pm 1.3^\circ$, $27.5^\circ \pm 2.4^\circ$ and $16.7^\circ \pm 0.6^\circ$; $P < 0.05$). Postoperatively, 23 hips were completely pain-free (asymptomatic), six hips had only occasional discomfort, three mild to moderate pain and two severe pain. The average preoperative HHS was 23.7 ± 1.2 (range, 21–43), the average score having improved to 65.8 ± 4.1 (range, 61–73; $P < 0.05$) at the most recent follow-up.

Pre-operatively, five patients required support for ambulation and could walk indoors only (Fig. 3). The remaining 12 patients could not walk even with support and could not sleep lying down (Fig. 1). Postoperatively, nine patients were walking independently without support; six were using one cane occasionally, two required two canes for ambulation and only two were unable to ambulate without support at the final follow-up. The longest preoperative limb length discrepancy was 2 cm. At the final follow-up, no patient had limb length discrepancy >1.5 cm.

Complications

Complications were minimal. Osteolysis resulting from polyethylene wear was found in three hips, all of which had osteolysis of the acetabulum. No stems had loosened at the final

Fig. 3 A 21-year-old man with AS. (A) Preoperative X-ray film showing bony ankylosis of both hips. (B) X-ray film 1.5 years after cementless THA. An intraoperative proximal femoral fracture is visible in the right hip, as is the cerclage wiring used to repair it.

follow-up in any patient and none had undergone revision; oral alendronate sodium tablets were given to inhibit osteolysis. Over-reaming of the acetabulum was identified in only one hip; this was treated with a bulk femoral allograft and morcelized auto- and allo-grafts to achieve stability of the acetabular cups. Intraoperative fractures occurred in two hips, requiring additional cerclage wiring (Fig. 3). There were no thromboembolic complications or cases of implant breakage. Postoperative complications occurred in four hips and included superficial wound infection in two hips, anterior dislocation in one hip (only in extreme extension, $>30^\circ$) and sciatic nerve palsy in one hip. The dislocation was treated successfully with closed reduction and the sciatic nerve injury recovered spontaneously after 3 months. Three acetabular components in two patients showed non-progressive radiolucencies of <1 mm in two zones (Type 1 in two hips, and Type 2 in one hip)³; none were revised for loosening. The remaining 31 cups showed bony integration. None of the 34 hips showed any evidence of socket migration. Heterotopic ossification developed in four hips (11.7%), with Brooker Class I ossification in two hips and Class II ossification in two hips. Heterotopic ossification leading to re-ankylosis occurred in none of the hips and no patients were given any advanced treatments. Acetabular inclination was within the accepted range in 29 (85.3%) hips. Seven of the 34 hips (20.6%) were outside the Lewinnek acetabular cup anteversion safe range^{6,19}.

Discussion

Indications for THA for AS-related Hip Ankylosis

In early-stage AS in young patients, many surgeons hesitate to perform THA because of mechanical failure, potentially increased rates of wearing and loosening, and increased rates of heterotopic ossification leading to reduced postoperative ROM and complete ankylosis^{1,43,44}. The traditional general

consensus is that THAs do not last long and revision surgery is required quickly, particularly when THAs are performed in young individuals. However, several authors have reported that THA is a reliable therapeutic intervention in relatively young patients with AS because it results in excellent pain relief and improved ROM^{1,2,6,11,35}. However, to the best of our knowledge, few reports have focused specifically on bilateral conversion of ankylosed hips using cementless techniques. We found no published cases with the severity of severe hip deformity that was present in our study subjects.

Key Points of Surgical Procedure

In AS-related bilateral hip ankylosis, there is always deformity, including flexion, adduction or abduction deformity and internal or external rotation deformity, which make it difficult to expose the femoral head and neck. Many researchers recommend a standard transtrochanteric approach to avoid damage to the greater trochanter or posterior acetabular wall during femoral neck resection^{6,28}. Brinker *et al.* performed 20 primary non-cemented THAs in 12 patients with AS³⁴; they used a posterior surgical approach in three hips and a Hardinge approach in 17 hips. In our study, we used an anterior surgical approach in 5 hips in five patients and a posterolateral approach in the remaining 29 hips. We did not perform trochanteric osteotomy in any of the 34 procedures. We agreed with Bangjian *et al.*'s opinion that use of a posterolateral approach during femoral neck osteotomy makes it easy to expose anatomical structures such as the femoral head and neck, posterior border of the acetabulum, and ischial tuberosity, even in hips with external rotation deformity, to expose the lesser trochanter of the femur¹¹. However, we did not use the two-step system advocated by Bangjian *et al.* because our cases had more severe hip deformities. In our study, the main problem we encountered after detaching the femoral neck and dislocating the joint was

inability to remove the remaining portion of the femoral head. Therefore, after we had thoroughly excised the articular capsule and osteophytes and sufficiently exposed the acetabulum, we reamed the acetabulum beginning with the smallest reamer (42 mm reamer) until we found the original joint plane. As stated earlier, even in hips with bony fusion, incomplete gray ossifying cartilage remains at the original joint plane. Our reaming technique ensured that components were optimally implanted.

Patients with AS have grotesque hip deformities, especially those with bilateral hip ankylosis. This makes it difficult to select the conversion procedure, especially that for insertion of the prosthesis. In routine THA, the acetabular cup is inserted with an anteversion of 20° and fixed 45° inclination, whereas the femoral prosthesis is inserted with an anteversion between 10° and 20°. Tang and Chiu believed that the pelvic malrotation in the sagittal plane often seen in patients with AS can cause errors in cup positioning². To address this, we used preoperative 3-D CT reconstruction (Fig. 1C) and intraoperative radiography (Fig. 2) to facilitate insertion of the acetabular cup into the ideal position. We agree with the methods proposed by Bangjian *et al.*¹¹, and therefore inserted the prosthesis using a conversion procedure as much as possible. If we could not, we adjusted the prosthesis insertion according to the specific deformity. If hip flexion deformity was present with limb internal rotation, we reduced the anteversion angle of the acetabular cup and increased the anteversion angle of the femoral prosthesis. In contrast, we increased the anteversion angle of the acetabular cup and reduced the anteversion angle of the femoral prosthesis or maintained it at 0° when hip flexion deformity was present with external rotation deformity of the limb. When hip flexion deformity was present with hip adduction deformity, we removed some of the contracted adductors and reduced the acetabular cup inclination angle, which may have reduced hip function but enhanced stability.

Malposition of an acetabular cup increases the risk of postoperative dislocation⁶. In our study, we encountered no postoperative dislocation, not even in cases in which the acetabular cup had been inserted out of the safe range. However, we did identify one anterior dislocation in one hip (only during extreme extension, >30°). The dislocation was treated successfully by closed reduction and the patient had no trouble walking. We believe that preexisting external rotation deformity with soft tissue contracture may explain the propensity of prostheses to dislocate anteriorly. Trial reduction after trial positioning of the components to check for stability in all directions helps minimize the dislocation rate.

In our study, three acetabular components in two patients (9%) showed non-progressive radiolucencies with no aseptic stem loosening at the latest follow-up. This outcome compares favorably with rates reported in other series^{1,8,45}. One important reason is that the average duration of follow-up was shorter than in other studies^{6,8,19,46} and our patients had a low average weight (<61 kg). The rate of loosening may increase with longer follow-up.

Choice of THA Arthroplasty

Because the onset of AS is characteristically earlier than that of inflammatory arthritides, surgery is performed at a younger age. AS tends to spare the upper limbs; however, kyphotic deformity may cause a downward and forward shift of the patient's center of gravity, which forces the lower extremities to compensate for the sagittal imbalance by extending the hips, flexing the knees and plantar flexing the ankles⁴³. Young patients are expected to have increased rates of wear and loosening of components and to inevitably require revision operations. Yang *et al.* found that AS patients have severe osteoporosis with associated massive bone loss in the cortical bone of the stem canal of the upper femur, which results in notable morphological changes in the proximal femur⁴⁷. Therefore, the choice of implant is particularly important for long-term fixation and hip function in these patients. The use of cementless implants with their potential for biologic in-growth may increase the longevity of the THA components and reduce failure rates, especially in younger patients⁸. Cementless prostheses can also preserve a large bone mass, leading to less difficulty in future revisions¹⁹. To achieve solid fixation, some authors recommend using modular femoral stems or extensively-coated stems with distal fixation^{8,11,47,48}. In our study, all patients received cementless THAs; however, five patients chose polyethylene acetabular components for economic reasons.

Surgical Efficacy

The rates of ectopic bone formation following THA in patients with AS vary widely, ranging between 4% and 74.7%². Controversy continues regarding whether specific prophylactic measures should be used to prevent the formation of heterotopic bone after THA in AS. Before 1990, perioperative prophylaxis for heterotopic bone formation was not routinely administered; however, some authors have recently suggested using perioperative prophylaxis routinely after THA^{49,50}. Kilgus *et al.* advocated that patients with complete hip ankylosis preoperatively may be at increased risk of formation of large amounts of heterotopic bone²⁸. Considering the deleterious effects of prophylactic therapy such as non-steroidal anti-inflammatory medications or radiation therapy, we selected 2 weeks of indomethacin prophylaxis, which has minimal adverse effects. Heterotopic ossification (Brooker Classes I or II) was present in four of 34 hips (11.7%) in our study. None of the hips of patients who received perioperative prophylaxis for heterotopic bone formation developed heterotopic ossification leading to re-ankylosis. We encountered no Brooker Class III or IV heterotopic bone ossification.

Our results suggest that THA using non-cemented techniques provides acceptable outcomes in AS patients with hip ankylosis. The average HHS improved from 23.7 points before surgery to 65.8 points at a mean follow-up of 31.7 months. The mean postoperative sum ROM at the final

follow-up was 134.4° (range, 0°–180°) compared with 0° preoperatively. This is less satisfactory than the outcomes of other AS series^{6,11} because the hip deformities were more severe in our study and full extension of the hip may damage blood vessels and nerves. Also, because most of our patients initially had severe spinal deformities; we accepted final <15° hip flexion deformity. Even so, all patients were satisfied with their functional outcomes.

Our study has certain limitations. Although patients were identified from a prospectively gathered database, the study was retrospective and there was no control group. Also, bias may have been present because we did not compare the performance of the different cementless THA designs. Another concern is that, in cases with severe spinal deformity, spinal osteotomy before or after THA may provide more satisfactory outcomes. Our mean follow-up duration was approximately 31.7 months, which is much shorter

than that of other reports^{6,11,18,19}. It is conceivable that with longer follow-up, degenerative changes may become more obvious. Finally, results may be more convincing with larger samples in future studies.

Conclusions

In conclusion, in this study, overall outcomes after bilateral cementless THA in the treatment of severe hip deformities in AS patients were favorable, and patients were highly satisfied with the procedure and clinical outcomes. Therefore, if a patient's overall physical condition and economic circumstances allow for surgery and the surgeon is very experienced, this surgical treatment is a worthwhile intervention in patients with bilateral hip bony ankylosis. Future studies should be larger and the long-term effects should be evaluated further.

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