Long-term clinical results of bipolar hemiarthroplasty for osteoarthritis and rheumatoid arthritis of the hip: A retrospective study

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ABSTRACT

We aimed to clarify the possibility of using bipolar hip arthroplasty (BHA) for degenerative diseases by examining long-term results postoperatively in 336 hips. Patients' average age was 61.0 years (range, 34–88 years), and the average follow-up period was 12.5 years (range, 5.0–27.3 years). The 5-year, 10-year, and 20-year Kaplan Meier survival rates (end point: revision) were 92.1%, 81.8%, and 20.1% in the osteoarthritis group and 96.4%, 90.1%, and 24.6% in the rheumatoid arthritis group, respectively. Since the survival rate for more than 10 years decreases rapidly, the use of BHA for treating degenerative diseases should be restricted.

1. Introduction

Total hip arthroplasty (THA) has been conducted worldwide for progressive degenerative diseases, such as hip osteoarthritis (OA) and rheumatoid arthritis (RA). The development of implants and surgical techniques has been remarkable, and recently stable long-term results have been obtained.¹ The indication for THA includes degenerative diseases as well as femoral neck fractures,^{2,3} and good long-term results have been reported for young people.^{4,5} For bipolar head arthroplasty (BHA), the Bateman UPFII prosthesis with a self-centering function (self-aligning) appeared in 1982.⁶ In self-aligning, the equatorial plane of the outer cup becomes perpendicular to the load direction by placing the center of the inner head inside the center of the outer cup. The characteristics of this procedure are that it is minimally invasive because the surgical technique is simple and treatment of the acetabulum is unnecessary.⁷ In addition, with the dual bearing function, a stable range of motion can be obtained. It is also possible to use the outer cup diameter since it is equivalent to the diameter of the acetabulum of the living body, and it has excellent dislocation resistance. This prosthesis is widely used for femoral neck fracture and femoral head necrosis, and good results have been obtained.^{8,9} Bone preservation on the side of the acetabulum is possible, and it is indicated for young people. We have also used BHA while improving surgical procedures for treating OA and RA. The purposes of this study were to clarify the possibility of using BHA to treat degenerative diseases, such as OA and RA, and to reveal long-term clinical results of BHA in a sufficient sample of patients.

2. Patients and methods

Four hundred sixty-five hips (OA 346, RA 119) of 368 patients who underwent BHA for OA or RA at our hospital from January 1981 to December 2006 were included in this retrospective study. Eight patients in the OA group and 6 patients in the RA group died during the postoperative follow-up period, and 83 patients in the OA group and 32 patients in the RA group discontinued within 5 years postoperatively (follow-up rates: OA group 73.7%, RA group 68.1%). Finally, 336 patients (OA 255, RA 81) participated in this study. This retrospective study design was approved by the institutional review board at our institution, and all study participants provided informed consent.

A posterolateral approach was used, and the capsule, piriformis, and short rotator muscles were repaired to prevent postoperative dislocation. In the OA group, we used a technique to excavate the acetabulum in a cup shape before performing BHA. In the RA group, we transplanted the autologous femoral head that was shaped like a chip while compressing the destroyed acetabulum, and then replaced it with bipolar head prosthesis. Cementless stems were used in all cases. Three types of hip systems were used: the Integral bipolar (Smith & Nephew Inc., Memphis, TN, USA) for 226 hips (OA 180, RA 46), Centrax bipolar (Stryker Orthopedics, Mahwah, NJ, USA) for 63 (OA 42, RA 21), and Tandem bipolar (Smith & Nephew Inc.) for 47 (OA 33, RA 14).

The following variables were assessed: the operative time, blood loss, Harris hip score, cup-center-edge (CE) angle, height of osteotomy from the upper edge of the lesser trochanter, postoperative complications, Kaplan-Meier survival rate, and radiographic findings. Cup

Abbreviations: THA, Total hip arthroplasty; OA, osteoarthritis; RA, rheumatoid arthritis; BHA, bipolar head arthroplasty; CE, cup-center-edge

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Fig. 1. This figure shows how to measure cup migration. To determine the center of the outer cup with the 2-dimensional template, we measured the vertical distance (triangular arrow) to the base line connecting the lower end of the teardrop (dotted line) and the horizontal distance (triangular arrow) to the center of the ipsilateral tear drop (dotted line).

migration, loosening, bony erosion, and osteolysis were evaluated by radiography. Cup migration was determined by measuring the vertical and horizontal distances between the center of the teardrop and the center of the outer cup (Fig. 1).¹⁰ Loosening was defined according to the appearance of the surrounding radiolucent line or as migration of 2 mm or more on the acetabular side accompanied by sinking of the femur by 5 mm or more.¹¹

2.1. Statistical analysis

Statistical analysis was conducted using the Mann-Whitney test and *t*-test with IBM SPSS statistics, version 22 (IBM Corp., Armonk, NY, USA). The level of statistical significance was set at $p < 0.05$, and the survival rate (with revision as the end point) was determined by the Kaplan-Meier method using analysis of variance.

3. Results

Patients' average age was 61.0 years (range, 34–88 years), and the average follow-up period was 12.5 years (5.0–27.3 years). There were 91 male patients and 245 female patients with an average height of 148.3 cm (range, 135–169 cm), weight of 52.9 kg (37.0–84.0 kg), and body mass index of 24.1 kg/m² (16.6–35.9 kg/m²). The Crowe classifications in the OA group were type I in 177 hips (67.6%), type II in 70 hips (26.8%), type III in 8 hips (2.8%), and type IV in 0 hips. The Kellgren-Lawrence classifications were grade 0 to II in 0 joints, grade III in 138 joints (53.9%), and grade IV in 117 joints (56.1%). The Larsen classifications in the RA group were grade 0 to I in 0 hips, grade II in 6 hips (8.0%), grade III in 26 hips (32.2%), grade IV in 30 hips (36.4%), and grade V in 19 hips (24.0%). The Steinbrocker classifications in the RA group were stage I to II in 0 hips, stage III in 19 hips (23.5%), and stage IV in 62 hips (76.5%) (Table 1).

Average values for the operative time and blood loss were 120 min (range, 90–235 min) and 120 min (75–405 min), and 340 mL (40–820 mL) and 310 mL (50–900 mL) in the OA group and RA group, respectively. Cup CE angles were 25.4° (range, 10–59°) and 31.4° (19–38°), and distances from the upper limb of the lesser trochanter to the osteotomy site were 10.8 mm (0–22 mm) and 12.8 mm (6.4–29.7 mm) in the OA group and RA group, respectively. In the OA group and RA group, venous thrombosis requiring additional treatment

Table 1
Patients' background data.

Sex (male/female)	91/245
Height (mm)	148.3 (135–169)
Body weight (kg)	52.9 (37–84)
BMI (kg/m ²)	24.1 (16.6–35.9)
Age (years)	61.0 (34–88)
Follow-up period (years)	12.8 (1.2–27.3)
Outer head (mm)	47.0 (38–58)
Inner head (mm)	23.6 (20–28)
Crowe classifications (OA)	I: 172 (67.6%), II: 68 (26.8%), III: 7 (2.8%), IV: 0
Kellgren-Lawrence classifications (OA)	0-II: 0, III: 137 (53.9%), IV: 117 (56.0%)
Larsen classifications (RA)	0-I: 0, II: 6 (8.0%), III: 25 (32.2%), IV: 29 (36.4%), V: 19 (24%)
Steinbrocker classifications (RA)	I-II: 0, III: 19 (23.5%), IV: 62 (76.5%)

BMI, body mass index; OA, osteoarthritis; RA, rheumatoid arthritis.

was observed in 6 (2.3%) and 3 (3.7%) hips, dislocation was seen in 4 (1.5%) and 2 hips (2.4%), and infection was observed in 0 (0%) hips and 1 hip (1.2%), respectively. The total Harris hip score significantly improved from 50 points preoperatively to 92 points at the final survey in patients of the OA group after revision surgery, and from 39 points preoperatively to 78 points in the RA group; and pain improved from 17 points preoperatively to 39 points at the final survey in patients of the OA group after revision surgery, and from 16 points preoperatively to 38 points in the RA group. Cup migration distances were 3.7 mm horizontally and 4.1 mm vertically at the time of the final survey in the OA group, and 5.7 mm horizontally and 8.1 mm vertically in the RA group. Other than requiring revision surgery, 35 hips (60.3%, including cases of revision) of the OA group and 10 hips (47.6%, including cases of revision) of the RA group showed obvious loosening on the radiographic image. Osteolysis occurred in 18 hips (31.0%, including cases of revision) of the OA group and 6 hips of the RA group (28.5%, including cases of revision). According to the Kaplan-Meier analysis with revision surgery as the end point, the 5-year survival rates were 92.1% in the OA group and 96.4% in the RA group. The 10-year survival rates were 81.8% in the OA group and 90.1% in the RA group; and 20-year survival rates were 20.1% in the OA group and 24.6% in the RA group (Fig. 2; Supplementary Figs. 1–3).

4. Discussion

Since the bipolar head prosthesis has two sliding faces, there is a possibility that abrasion on the sliding face can be reduced if the condition is good around the outer head. However, because the bipolar head prosthesis has a self-centering function, the center of the inner head exists inside the center of the outer head, and the oscillation angle

Fig. 2. This figure shows Kaplan-Meier survival rates (end point: revision). Twenty-year survival rates: osteoarthritis (OA) group 20.1%, rheumatoid arthritis (RA) group 24.6%. There is no statistical significance ($p = 0.12$).

between the outer head and the inner head decreases. Consequently, cup-neck impingement is likely to occur, and wear on the polyethylene rim increases.^{10,12} The polyethylene rim of the old outer head is removed when the progression of osteolysis causes discoloration and the surface becomes partially deformed and peels off, which occurs in many cases, but the sliding surface has a glossy smooth surface. It has been reported that the degree of oxidation of the polyethylene rim is higher than that of sliding surfaces, and many short chains are present at the molecular level.

If the acetabular cartilage remains, bipolar head prostheses with a dual bearing function can rotate the inner head and the outer cup even in vivo. As a result, the dual bearing with self-centering function works well. Even in femoral neck fracture, BHA is comparable to THA in postoperative hip joint function and activities of daily living. In addition, surgical invasion, postoperative dislocation, and revision surgery rates are considered low, suggesting that BHA is an effective treatment modality. Clinical results equivalent to that of THA have been reported in femoral head necrosis with cases downgrading to stage 3B even though the old version of the bipolar head prosthesis was used. Abe and colleagues reported that 79 hips with femoral head necrosis up to stage 3B underwent BHA with new generation prostheses, and the survival rate was 97% over an average of 8 years.⁸

Bateman reported that the bipolar type of artificial femoral head in 1974 was able to preserve acetabular bone compared with the total hip prosthesis; therefore, it was used in young people with OA and RA who needed replacement in the future. Results of BHA comparable to that of THA have been reported until the mid-term follow-up.^{13,14} However, when we evaluated the course after the mid-term follow-up exceeding 10 years, progressive migration of the artificial femoral head occurred together with osteolysis due to wear of the polyethylene, which necessitated revision surgery, and the survival rate decreased rapidly. Pellegrini and colleagues reported that in 173 hips with degenerative disease, 21.2% had some mechanical failure over an average of 12.2 years; additionally, 5.8% of revision surgeries were performed on the femoral side, and 19.2% were performed on the acetabular side.¹⁵ In addition, Sochart et al. performed BHA for degenerative diseases in 226 hips, and replacement was conducted in 11% (OA) and 15% (RA) on the femoral side, and in 42% (OA) and 21% (RA) on the acetabular side over an average of 19.7 years.¹⁶ Similar reports may be found elsewhere.^{17–19} In the case of degenerative diseases in which the cartilage has already disappeared, friction between the outer cup and acetabular bone becomes stronger, and the outer cup barely moves.²⁰ The range of motion is limited only to the sliding surface between the polyethylene insert and the ball head, resulting in a lower oscillation angle compared to that in THA. Therefore, impingement from the polyethylene rim is likely to occur, and the risk of polyethylene abrasion is considered to be increased. Tsumura and colleagues compared the distances of migration between two groups: stage 3 with cartilage remaining and stage 4 with femoral head necrosis. Migration values of 0.2 mm on the inside and 0.8 mm on the upper side were observed in up to stage 3, and migration values of 2.6 mm on the inside and 3.7 mm on the upper side were observed in stage 4. There was less progression of migration up to stage 3, and migration progressed further when osteolysis was present.⁸

The limitations of this research study were that it had a retrospective design, the models used were not unified, and it is not possible to compare the BHA group with a THA group of patients from our hospital.

The dual bearing structure of the total hip prosthesis makes it possible to use the large femoral head, and currently, it has excellent dislocation resistance and good mid-term clinical results.^{21,22} This survey surpasses a past study of BHA for degenerative diseases in terms of the sample size and follow-up period.^{14,22–25} Our study had a long-term observation period and evaluated more cases than previous clinical reports; therefore, we can provide a conclusive position on the use of BHA for degenerative diseases. Approximately 20% of the patients had good success, but the survival rate sharply decreased after 10 years

and was not much different from the long-term results of THA. Regarding the use of BHA, it was reaffirmed that it is important that the cartilage remains on the acetabular side. There may be little consideration for performing BHA in super elderly people who do not have a long life expectancy, and the use of BHA for degenerative diseases is extremely limited.

In conclusion, we investigated the results of BHA in 336 hips with degenerative diseases, such as OA and RA, that were followed up with for more than 5 years. Over an average observation period of 12.5 years, approximately only 20% of the patients had good success. Since the survival rate for more than 10 years decreases rapidly, the use of BHA for degenerative diseases should be restricted.

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Conflicts of interest

The authors declare that they have no conflict of interest.

Ethical approval

This retrospective study design was approved by the institutional review board of Oita University.

Informed consent

Informed consent was obtained from all individual participants included in the study.

Appendix A. Supplementary data

Supplementary data to this article can be found online at <https://doi.org/10.1016/j.jor.2019.08.010>.

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