3M integral bipolar cup system for dysplastic osteoarthritis

CLINICAL AND RADIOGRAPHIC REVIEW WITH FIVE- TO SEVEN-YEAR FOLLOW-UP

T. Torisu, N. Kaku, H. Tumura, H. Taira, K. Tomari

From Oita Medical University and Shinbeppu Hospital, Japan

Between 1995 and 1997 we undertook 40 bipolar hip arthroplasties in 35 patients with dysplastic osteoarthritis. The steep and shallow acetabulum was excavated and the bipolar socket was placed high with an adjustment of leg-length. At follow-up of between five and seven years, there were 19 excellent, 16 good and five fair results according to the scoring system of Merle d'Aubigné and Postel. The mean radiographic superior migration of the bipolar socket was 2.1 mm (0 to 10). Osteolysis was noted in three hips within three years of the operation. Abduction on weight-bearing was recorded in 24 hips and the bipolar system was found to be functioning predominantly between the inner bearing and the metal femoral head in 20.

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Wear of polyethylene is an important issue in total hip arthroplasty (THA). The range of movement in a bipolar system between the neck of the stem and the rim of the polyethylene is less than that in a total hip system, which might be regarded as disadvantageous. There have been several reports of impingement in this area with the production of polyethylene wear.^{1,2}

The role of the high hip-centre after THA remains controversial. Biomechanical studies show that the position of the acetabulum influences the mechanical forces exerted upon it and it is recommended that the centre of the recon-

structed joint should be in an anatomical position.^{3,4} There have, however, been recent clinical reports and three-dimensional computer studies suggesting that a hip-centre which is high but not lateral, does not adversely affect the biomechanics of the hip.⁵⁻¹⁰

The purpose of this study was to present the five- to seven-year clinical and radiographic outcome of the 3M Integral Bipolar Cup (IBC) system in the treatment of dysplastic osteoarthritis. In this system, the range of ab/adduction is approximately 50°, which is the same as that of Bateman's original design. The removal of the slots from the UPF (Universal Proximal Femur) II and the polishing of the femoral neck were undertaken in order to reduce osteolysis.

Patients and Methods

Between 1995 and 1997, we carried out bipolar hip arthroplasty using the 3M IBC system (St Paul, Minnesota) on 35 patients (40 hips) with dysplastic osteoarthritis. There were 31 women and four men with a mean age of 62 years (35 to 72) at the time of the operation. Their mean height was 150 cm (135 to 159) and their mean weight was 54 kg (36 to 72).

The radiographic appearances of acetabular dysplasia were classified according to the criteria of Crowe, Mani and Ranawat.¹¹ There were 31 hips (77.5%) in group 1, seven (17.5%) in group 2 and two (5%) in group 3. No subsequent revision was required. One patient who had bilateral procedures died from carcinoma of the lung five years after operation; the patient's results were included in the study as the five-year follow-up had been completed. The mean diameter of the socket which was implanted was 41 mm (38 to 53). Bone cement was used in 18 hips. A modular Titanium Stem (3M, St Paul, Minnesota), with or without hydroxyapatite coating, was used in six and 16 hips, respectively.

Operative technique. We used a posterior approach without trochanteric osteotomy. After extraction of the head, osteophytes were removed from the inferomedial area of the acetabulum and the shallow and steep dysplastic acetabulum was excavated in the mediosuperior direction and prepared with reamers to obtain good support for the bipolar socket. The distance between the medial pelvic wall of the

T. Torisu, MD, PhD, Professor and Orthopaedic Surgeon
N. Kaku, MD, PhD, Assistant Professor and Orthopaedic Surgeon
H. Tumura, MD, PhD, Assistant Professor and Orthopaedic Surgeon
H. Taira, MD, Consultant Orthopaedic Surgeon
Department of Orthopaedic Surgery and Oncological Science, Faculty of Medicine, Oita Medical University, Hasama-cho, Oita 879-5593, Japan.

K. Tomari, MD, Consultant Orthopaedic Surgeon
Section of Orthopaedic Surgery, Shinbeppu Hospital, 3898 Tsurumi Beppu, Oita 874-0833, Japan.

Correspondence should be sent to Professor T. Torisu.

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Fig. 1a

Fig. 1b

Fig. 1c

Radiographs of a 67-year-old man with bilateral dysplastic osteoarthritis. a) Preoperatively, there is a shallow, steep acetabulum, the complete disappearance of the acetabular space in the weight-bearing area and a marked osteophyte in the medioinferior region, b) One year after staged bilateral bipolar arthroplasty, there is 1 mm superior migration of the prosthesis in both hip joints. The patient had no pain and was able to undertake daily activities, c) Seven years after surgery, there has been 1 mm of superior migration on the right side and 2 mm on the left. The clinical score improved from a preoperative 5 points to a postoperative 16 points (pain 6, range of movement 4, walking ability 6) for the right hip and from 5 to 17 points (pain 6, range of movement 5, walking ability 6) for the left.

dysplastic acetabulum and the expected position and diameter of the bipolar socket were assessed on preoperative radiographs. The ideal centre-edge angle is about 20° . The thickness of the medial acetabular floor may be measured perioperatively using a depth gauge. The retained thickness of the medial acetabular wall should be at least 10 mm. The osteotomy of the femur was undertaken proximally on the femoral neck, raising the level of the articulation in order to maintain the greater trochanter in an anatomical position suitable for the adjustment of leg length discrepancy.

Mobilisation with partial weight-bearing started on the second postoperative day and full weight-bearing after four weeks.

Follow-up evaluation. In order to calculate the predicted cumulative survival of the prosthesis we used the survivor-

ship analysis method of Dobbs.¹² Clinical evaluation was undertaken using the Merle d'Aubigné and Postel hip-scoring system.¹³ For radiographic assessment we used radiographs taken preoperatively, immediately postoperatively, at one and two years and at final follow-up. The radiographs were taken with the patients supine. Superior and medial or lateral migration of the socket was assessed. A base line was drawn through the inferior margins of the teardrops or the top of the obturator foramina if the teardrops were difficult to identify. This enabled the degree of superior migration to be determined by measuring the distance between the centre of the bipolar socket and this line. In order to determine the medial or lateral shift of the centre of the socket we measured the distance between it and a vertical line, perpendicular to the base line. The shortest distance between the

perimeter of the socket and iliopectineal line was defined as the thickness of the acetabular wall.

In order to evaluate whether the prosthesis was functioning as a bipolar device, we observed abduction during weight-bearing in 24 hips which were randomly assessed by cineradiography at follow-up periods which ranged from 5.17 years to 7.17 years.

Results

There was 100% survival of the prosthesis at follow-up which ranged from five to seven years. The mean preoperative clinical score was 8.8 (6 to 12). The mean clinical score at final follow-up was 16.3 (11 to 18). The mean preoperative pain score was 2.4 (0 to 4). The mean pain score at final follow-up was 5.7 (4 to 6). There were 19 excellent, 16 good and five fair results according to the Merle d'Aubigné and Postel¹³ hip scoring system.

The mean distance between the centre of the bipolar socket and the base line on the anteroposterior (AP) radiographs of 40 hips taken immediately after operation was 29.0 mm (13 to 55). The mean distance from the centre of the normal femoral head to the base line of 17 patients with unilateral disease was 12 mm (6 to 17). The position of the bipolar socket immediately after the operation was statistically higher than that of the anatomical head ($p < 0.01$) and there was a mean leg-lengthening of 10.0 mm (0 to 30.0).

The mean superior migration of the surviving 40 hips was 2.0 mm (0 to 10) (Fig. 1). The mean medial migration was 2.4 mm (0 to 7). There was no statistical difference in the amount of migration between those prostheses which were cemented and those which were not.

Complications. There were no cases of infection, deep vein thrombosis, fracture of the medial acetabular wall or dislocation. Osteolysis was noted in three hips within three years of the operation.

Behaviour of the bipolar prosthesis after implantation. Weight-bearing, cineradiographic studies showed a mean abduction of 14.7° (6 to 26). The mean abduction at the acetabulum-outer head junction was 3.2° (0 to 11). Abduction in eight of 24 hip joints occurred only between the inner-bearing and the femoral head. Abduction occurred only at the acetabulum-outer head junction in one hip. As a whole, abduction under weight-bearing in 20 hips occurred predominantly between the inner bearing and femoral head.

Discussion

Biomechanical studies have suggested that the position of the acetabulum influences the mechanical forces exerted upon the socket and that the centre of the reconstructed joint should be placed in an anatomical position. For patients with dysplastic osteoarthritis, bone graft and reinforcement are required.

Recently, Delp et al⁸ analysed a three-dimensional computer model and suggested that a centre of the hip, which is

high but not lateral, does not adversely affect the biomechanics of the hip. They calculated the moment arms of muscles around the hip joint and concluded that a superior displacement of the centre of the hip by 2 cm changes the force-generating capacity of the abductor muscles of the hip by less than 10%, if the length of the neck of the prosthesis is increased to compensate for the decrease in muscle length. Doehring et al⁹ reported that relocation of the centre of the hip superiorly by between 25 and 37 mm produces no increase in the reaction force of the joint.

Since 1981, we have prepared the steep and shallow acetabulum superomedially without attempting to place the bipolar socket in the anatomical position in order to expand the indications for bipolar hip arthroplasty.¹⁴ Since 1995, the osteotomy has been undertaken high on the femoral neck in order to adjust the discrepancy in leg length and to maintain the length of the abductor muscles.¹⁵ The results using the IBC system were satisfactory. Complete pain relief (score 6) was obtained in 30 of 40 hips and mild pain (score 5) in ten. Altogether, 35 hips were rated as excellent or good on the Merle d'Aubigné and Postel¹³ hip scoring system.

Bipolar hip arthroplasties are usually used in the treatment of fractures of the femoral neck and osteonecrosis of the femoral head. We have previously reported good results using the bipolar arthroplasty in the treatment of patients with osteonecrosis who have normal acetabular articular cartilage at follow-up of between five and 15 years.¹⁶ Chan and Shih¹⁷ described 28 patients with bilateral osteonecrosis of the femoral head who were treated with a cementless bipolar prosthesis on one side and a cementless THA on the other. There was a lower incidence of osteolysis after bipolar arthroplasty (3.6% v 18%) after follow-up of more than six years. Matsumoto et al¹⁸ reported excellent results using a bipolar arthroplasty for the treatment of idiopathic osteonecrosis with a follow-up of more than ten years.

The results of bipolar hip arthroplasty, however, depend upon the condition of the acetabular articular cartilage. Polyethylene wear, with subsequent osteolysis, has been reported due to impingement between the acetabular component and the femoral neck.^{1,2} Cabanela¹⁹ reported that the long-term results of bipolar arthroplasty in the treatment of osteonecrosis were less good than those of THA for osteoarthritis. A retrieved implant showed polyethylene wear at the rim of the cup, although the articulation was undamaged with minimal linear wear.²⁰

The purpose of our study was to report the technical difficulties, and clinical and radiographic outcome of using a bipolar arthroplasty (the IBC system) for the treatment of dysplastic osteoarthritis. Using this system, the range of abduction is approximately 50° which is the same as Bateman's original design. The removal of the slots from the UPF II and the polishing of the femoral neck were undertaken in order to reduce osteolysis. The polyethylene, however, was not cross-linked. Our study has shown radiological evidence of osteolysis within three years in

three of 40 hips. This study suggests that the more recently developed and stronger polyethylene should be combined with a greater range of ab/adduction in a bipolar system in order to reduce polyethylene wear and osteolysis.

Whether a bipolar arthroplasty functions as a bipolar or unipolar device remains controversial. Using fluoroscopy, Phillips²¹ examined movement between the components in 100 bipolar prostheses with a follow-up of one year. He found that the prosthesis functioned as a bipolar device in 80% of 24 hips with normal acetabular cartilage, and as a unipolar device with movement between the inner bearing and femoral head in 75% of 76 hips with degenerative acetabular cartilage. Our study showed that movement of bipolar arthroplasties was predominantly between the inner bearing and the femoral head in 20 of 24 hips (83.3%) with a degenerative prepared acetabulum.

In conclusion, the functional life of a prosthetic total joint is influenced by its materials and design, the technical aspects and the quality of the host bone. We obtained 87.5% satisfactory results without loosening in a series of 40 hips with dysplastic arthritis in whom a bipolar arthroplasty was placed high.

Three patients, however, developed osteolysis within three years. Movement occurs mainly between the inner bearing and the femoral head and improvements in the design of the prosthesis are suggested in order to reduce polyethylene wear and osteolysis.

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