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Intermediate-Term Results After Hybrid Total Hip Arthroplasty for the Treatment of Dysplastic Hips

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Background: In recent studies, good intermediate-term results have been reported after primary hybrid total hip arthroplasty (a cementless acetabular component with a cemented femoral stem) for the treatment of primary osteoarthritis. However, few studies have described the results of this technique in patients with developmental dysplasia of the hip.

Methods: One hundred primary hybrid total hip replacements were performed in ninety patients to treat degenerative arthritis of the hip secondary to developmental dysplasia. Seventy-one patients (eighty-one hips) were available for clinical and radiographic evaluation. The average duration of follow-up was 10.6 years. There were ten men and sixty-one women. Seventy hips were classified as type 1 (dysplasia); seven, as type 2 (low dislocation); and four, as type 3 (high dislocation), according to the classification system of Hartofilakidis et al.

Results: At the time of the final follow-up, the average Harris hip score was 86 points. Structural autograft was used in fifteen hips to supplement acetabular coverage. Within five years postoperatively, the acetabular component in six of the fifteen hips had an average of 4.5 mm of vertical migration and an average increase in vertical rotation of 3°, but the position appeared to stabilize thereafter. Revisions were performed in two hips because of recurrent dislocation. No acetabular or femoral component was revised because of aseptic loosening. Osteolysis was identified around two acetabular components and two femoral components. The average rate of polyethylene wear was 0.09 mm per year.

Conclusions: Hybrid total hip arthroplasty for the treatment of symptomatic degenerative arthritis secondary to developmental dysplasia provides favorable results at intermediate-term follow-up. With lower grades of dysplasia, the majority of patients can be treated effectively without a structural bone graft by placement of the cementless acetabular component at a medial or high position.

Level of Evidence: Therapeutic study, Level IV (case series [no, or historical, control group]). See Instructions to Authors for a complete description of levels of evidence.

Total hip arthroplasty for the treatment of osteoarthritis secondary to developmental dysplasia of the hip presents specific problems that include insufficient acetabular coverage, altered proximal femoral anatomy, an abnormal hip center, limb-length discrepancy, abductor insufficiency, abnormal anatomy of neurovascular structures, and muscular contractures[1-9]. The most common problem associated with dysplasia is insufficient acetabular bone coverage, which can compromise the durability of component fixation[2,3,5-8].

The hybrid total hip arthroplasty combines insertion of an acetabular component without cement and a femoral component with cement[10-12]. In recent studies, good intermediate-term results have been reported after primary hybrid total hip arthroplasty for the treatment of primary osteoarthritis[10,11]. However, few studies have described the results of this technique in patients with developmental dysplasia of the hip.

The present study evaluated the intermediate-term results after primary hybrid total hip arthroplasty for the treatment of osteoarthritis secondary to developmental dysplasia and compared them with those in previous studies[1-4,6-9], with particular attention to the assessment of the fate of and the need for structural bone-grafting of the dysplastic acetabulum.

Materials and Methods

Between March 1987 and July 1994, 129 total hip arthroplasties were performed in 113 patients to treat advanced

Fig. 1-A

Fig. 1-B

Figs. 1-A, 1-B, and 1-C Radiographs showing the classification of developmental dysplasia in adults according to the system described by Hartofilakidis et al.[4]. **Fig. 1-A** In type-1 hips (dysplasia), the femoral head is contained within the original acetabulum with some degree of subluxation. **Fig. 1-B** In type-2 hips (low dislocation), the femoral head articulates with a false acetabulum that overlaps the true acetabulum.

osteoarthritis secondary to developmental dysplasia of the hip. Twenty-nine total hip arthroplasties were performed without cement in twenty-three patients under the age of fifty-five years who had good-quality femoral cortical bone. These patients were excluded from the study, leaving 100 hybrid total hip arthroplasties in ninety patients. Of this group, nineteen patients (nineteen hips) were excluded from the study: twelve patients (twelve hips) died before a minimum follow-up of eight years, three patients (three hips) became bedridden and were too ill to return for follow-up evaluation, and four patients (four hips) were lost to follow-up. At an average of twenty-four months (range, five to seventy months) postoperatively, all nineteen of these hips demonstrated well-fixed components radiographically. The remaining eighty-one hips in seventy-one patients were available for clinical and radiographic review. The average duration of follow-up was 10.6 years (range, eight to fifteen years). The demographic characteristics of the patients are listed in Table I. According to the classification system of Hartofilakidis et al.[4], seventy hips were type 1 (dysplasia), seven were type 2 (low dislocation), and four were type 3 (high dislocation) (Figs. 1-A, 1-B, and 1-C)[4].

All of the procedures were performed by the senior author (T.M.) through a posterolateral approach without trochanteric osteotomy. A total capsulectomy was performed. A titanium hemispherical Harris-Galante porous-coated acetabular component (HGP; Zimmer, Warsaw, Indiana) was used for all hips. An HGP-1 component was inserted in fourteen hips and an HGP-2, in sixty-seven hips. In fifteen (19%) of eighty-one hips, structural bone-grafting was performed to augment bone stock when the component surface was in contact with <60% of host bone as determined by intraoperative visual inspection. Structural bone-grafting was performed in eleven of the seventy hips with a Hartofilakidis type-1 abnormality, two of the seven hips with type 2, and two of the four hips with type 3. This structural autogenous bone graft was processed from the retrieved femoral head and was fixed by two screws to the lateral border of the acetabulum. In lower grades of dysplasia, the acetabular component was placed as medial and inferior as possible to restore more normal hip mechanics and to maximize the contact area with host bone.

When there were severe soft-tissue contractures, however, we elected not to try to achieve intraoperative limb-lengthening, as preoperatively planned, and instead we inserted a small acetabular component at a high position. The acetabular bed was prepared with hemispherical reamers, and the components were inserted with a line-to-line fit. The abduction angle of the acetabular component was aimed to be 30° for the HGP-1 component, as described by Harris[13], and 45° for the HGP-2 component, as recommended by the manufacturer. We accepted a vertical position of up to 50° of abduction for the HGP-2 component. Morselized autogenous bone was retrieved from the acetabular reamings and was used as nonstructural graft to supplement the uncovered superolateral part of the ilium above the acetabular component (Figs. 2-A and 2-B). Morselized autogenous bone graft also was used to fill cystic acetabular lesions.

An average of 3.7 screws (range, two to six screws) was used to supplement acetabular component fixation. The average outer diameter of the acetabular component was 50.5 mm (range, 40 to 64 mm). The diameter of the prosthetic femoral head was 22 mm in all hips. The average thickness of the polyethylene liner was 8.5 mm (range, 3.3 to 15.3 mm).

A Harris Precoat, Precoat Plus, or CDH Precoat femoral component (all manufactured by Zimmer) was used. A so-called second-generation cementing technique was used in all but eight hips. In the first four hips a methylmethacrylate plug was not used, and in four subsequent hips, which had the CDH Precoat stem inserted, the canal was too narrow to accept a plug.

Fig. 1-C

In type-3 hips (high dislocation), the femoral head completely articulates with the iliac wing and is separated from the true acetabulum.

TABLE I Demographic Characteristics of the Seventy-one Patients (Eighty-one Hips)

Mean age (range) *(yr)*	62 (26 to 80)
Mean height (range) *(cm)*	153 (136 to 170)
Mean weight (range) *(kg)*	58 (41 to 95)
Gender *(no. of patients)*	
Male	10
Female	61
Previous treatments *(no. of hips)*	
Closed reduction	6
Closed reduction and later femoral osteotomy	1
Open reduction and later femoral osteotomy	1
Open reduction and later arthrodesis	1
Femoral osteotomy	2
Acetabular shelf operation	1
Arthrodesis	1

Clinical evaluations were made according to the Harris hip-scoring system[14]. An anteroposterior radiograph and a true lateral radiograph were made preoperatively and at each follow-up examination. Preoperative, immediate postoperative, and all intermediate radiographs as well as those made at the latest follow-up visit were analyzed by four orthopaedic surgeons who specialized in hip surgery but were not the surgeon of record for these patients. Observer variability studies were not done.

Anteversion of the acetabular component was measured according to the method described by Pradhan[15]. The magnification ratio for each radiograph was determined by measuring the diameter of the prosthetic femoral head and dividing it by the known diameter of the femoral head[8]. The vertical and horizontal position of the acetabular component was determined according to the method described by Russotti and Harris[9]. The acetabular component was classified as migrated if there was a change of at least 4 mm in the horizontal or vertical position of the center of the component compared with that seen on the immediate postoperative anteroposterior radiograph[9]. The rotation of the acetabular component was defined as a change of the abduction angle in relation to the interteardrop line on the anteroposterior radiograph. The prosthesis-bone interface on the anteroposterior radiograph was divided into three zones as described by DeLee and Charnley[16]. Regions in which the surface of the acetabular component was not in contact with bone on the immediate postoperative radiographs were classified as gaps, to distinguish them from

Fig. 2-A

Fig. 2-B

Figs. 2-A and 2-B Anteroposterior radiographs of a sixty-five-year-old woman with a Hartofilakidis type-2 abnormality (low dislocation) of the left hip. (The preoperative radiograph is shown in Fig. 1-B.) **Fig. 2-A** Radiograph made one week after surgery, showing morselized autogenous bone graft placed against the superolateral part of the ilium above the acetabular component. **Fig. 2-B** Radiograph made nine years after surgery, showing incorporation of the morselized graft within the acetabular host bone. The clinical result was excellent.

radiolucent lines that appeared on subsequent radiographs in areas where no gaps had existed initially. Linear head penetration into the polyethylene liner was measured with use of the techniques described by Livermore et al.[17].

The femoral cementing technique was graded according to the method described by Barrack et al.[18]. Femoral osteolysis was defined as areas of endosteal, intracortical, or cancellous loss of bone that were scalloped or had the appearance of destruction of bone rather than disuse osteopenia. A radiolucent zone that was linear but >2 mm wide was deemed to be osteolysis. The dimensions and location of radiolucent lines at the bone-cement interface of the femoral component and osteolytic lesions were recorded according to the zones described by Gruen et al.[19]. Loosening of the femoral component was defined with use of the criteria described by Harris and McGann[20]. Definite loosening was defined as migration of the component, cement fracture, or the appearance of a radiolucent line at the cement-stem interface that was not present on the immediate postoperative radiograph. Probable loosening was defined as a continuous radiolucent line at the cement-bone interface without migration of the component.

Statistical analysis was performed with use of chi-square tests with Yates correction, Mann-Whitney U tests, and analysis of variance. The Kaplan-Meier survivorship analysis was used to calculate the probability of retention of the original prosthesis with 95% confidence intervals (StatView; SAS Institute, Cary, North Carolina).

Results

At the time of the most recent follow-up, two acetabular components in two patients had been revised because of recurrent dislocation. None of the acetabular or femoral components was revised because of loosening or was found to be definitely loose on radiographs. The Kaplan-Meier survivorship analysis, with failure defined as revision surgery, demonstrated that the probability of retention of the acetabular component fifteen years after surgery was 98% (95% confidence interval, 0.94 to 1.0) and that of the femoral component was 100%.

The average Harris hip score increased from 44 points (range, 24 to 76 points) preoperatively to 86 points (range, 42 to 100 points) at the most recent follow-up examination.

The relationship between Hartofilakidis type and various factors is summarized in Table II. Although the average

TABLE II Relationship Between Hartofilakidis Type and Various Factors

Factors	Type of Abnormality According to Classification System of Hartofilakidis et al.[4] Type 1 (Dysplasia)	Type 2 (Low Dislocation)	Type 3 (High Dislocation)
No. of hips	70	7	4
Structural graft used *(no. of hips)*	11	2	2
Nonstructural graft used *(no. of hips)*	43	4	0
Mean Harris hip score at time of latest follow-up (range) *(points)*	87 (42-100)	81 (70-96)	82 (76-90)
Radiographic evidence of definite or probable loosening of the acetabular or femoral component *(no. of hips)*	0	0	0
Complications *(no. of hips)*			
Postoperative dislocation	6	2	1
Sciatic nerve palsy	1	0	0
No. of revisions	2	0	0

Harris hip score at the time of follow-up in type-1 hips was higher than that in type-2 and type-3 hips, the difference was not significant ($p = 0.18$).

The average angle of abduction of the eighty-one acetabular components at the latest follow-up examination was 46° (range, 25° to 63°). The average anteversion of the acetabular components was 16° (range, 0° to 28°), and the average combined anteversion of the acetabular and femoral components was 42° (range, 20° to 68°). All fifteen structural autogenous bone grafts united. The acetabular component in six of the fifteen hips treated with the structural graft had an average of 4.5 mm (range, 4 to 6 mm) of vertical migration and an average increase in vertical rotation of 3° (range, 2° to 8°) within five years postoperatively. However, serial radiographs did not show any progression of the migration or rotation thereafter, and there were no continuous radiolucent lines at the time of the most recent follow-up. Because vertical migration of the acetabular component had been observed in hips with the structural graft, structural bone-grafting was not performed after September 1992. None of the twenty-nine hips treated after that time had <60% of the acetabular cup covered with host bone at the time of surgery, as the acetabular component was consistently placed at a deepened medial or high position. None of the acetabular components without structural bone graft showed radiographic signs of migration, rotation, or a continuous radiolucent line.

Sixty hips (74%) had no gaps at the interface between bone and the acetabular component on the immediate postoperative radiograph. Forty-eight (80%) of the sixty sockets had no radiolucent lines at the bone-implant interface at the time of the most recent follow-up. New radiolucent lines were observed around twelve cups (20%). These lines were all ≤1 mm wide and occurred in zone 1 in five hips, zone 2 in eight hips, and zone 3 in seven hips. No socket had a continuous radiolucent line. Twenty-one (26%) of the eighty-one hips had at least one initial gap. None of these gaps increased in size. In nineteen hips (90%), the gap persisted at the time of the latest follow-up, whereas in two hips (10%) the gap had resolved.

Pelvic osteolytic lesions were observed adjacent to the acetabular component in two hips. One lesion was associated with an acetabular screw in zone 2, and the other involved a small area (9 by 12 mm) in zones 1 and 2. The average rate of head penetration into the polyethylene liner was 0.09 mm per year (range, 0 to 0.29 mm per year). A significant relationship was detected between wear and male gender ($p = 0.020$) and patient weight ($p = 0.039$). With the numbers available, no significant relationship was found between wear rate and patient age ($p = 0.60$), acetabular component abduction ($p = 0.38$), anteversion angle of the acetabular component ($p = 0.93$), or polyethylene thickness ($p = 0.39$). None of the acetabular screws broke. One HGP-1 acetabular component showed radiographic evidence of a broken tine without dissociation of the liner.

None of the femoral components showed definite or probable loosening at the time of the most recent follow-up. Fifty femoral components were inserted in a neutral position; twenty-eight, in a valgus position; and three, in a varus position. The cementing of the femoral component was grade A in two, grade B in twenty-one, grade C1 in twenty-seven, grade C2 in twenty-nine, and grade D in two. Grade C1 was given mainly because of the presence of small voids; grade C2, because of the presence of a thin mantle of cement; and grade D, because of an insufficient cement mantle distal to the tip of the stem. Radiolucent lines were observed around fourteen (17%) of eighty-one femoral components. All radiolucent lines were seen at the bone-cement interface and were located in the most proximal zones (zones 1 and 7). No radiolucent line was observed at the implant-cement interface. Eleven hips showed radiolucent lines only in zone 1. Three hips showed radiolucent lines in zones 1 and 7. None of the femora had radiolucent lines other than in these most proximal zones. Two hips showed focal osteolysis in zone 7.

The preoperative limb-length discrepancy ranged from 0.5 to 6 cm. Four total hip arthroplasties were performed on the side of the longer limb. All four longer limbs were contralateral to a Hartofilakidis type-2 or type-3 dislocated hip, and all four showed a residual postoperative limb-length discrepancy. Fifty-six total hip arthroplasties were performed on the side of the shorter limb. All fifty-six shorter limbs were lengthened, and forty-nine were found to be equal in length to the contralateral limb postoperatively. Twenty-one total hip arthroplasties were performed in patients without a limb-length discrepancy. Two were noted to be lengthened by 1 cm postoperatively.

The center of the hip was placed an average of 24 mm (range, 15 to 50 mm) proximal to the interteardrop line. In eighty hips, the center was within 30 mm of the interteardrop line. In one hip, the center was placed 50 mm proximal to the interteardrop line, and the patient had good clinical and radiographic results at the time of the latest follow-up examination.

Nine hips (11%) dislocated posteriorly. A significant relationship was detected between dislocation and heavier patients ($p = 0.029$) and between dislocation and combined anteversion angle of the acetabular and femoral components ($p = 0.036$). With the numbers available, no significant relationship was found between dislocation and patient age ($p = 0.32$), gender ($p = 0.07$), and abduction angle ($p = 0.47$). Two of the nine hips had undergone revision of the acetabular component because of recurrent dislocation. One patient had a mild sciatic nerve palsy, which resolved nearly completely within eighteen months. There were no deep infections or clinically evident pulmonary emboli.

Discussion

In this study, we assessed the fate of and the need for structural bone graft in patients with osteoarthritis secondary to acetabular dysplasia. The results at an average of 10.6 years of follow-up continued to be encouraging, with revision of only two acetabular components in the entire group. No acetabular or femoral component was revised because of aseptic loosening, and none was found to be loose radiographically. Radiolucent lines that were seen in zone 3 around the acetabular component in seven hips were not progressive; however, careful observation is indispensable for these hips because this sign can be early evidence of loosening.

Acetabular reconstruction of dysplastic hips in total hip arthroplasty has been reported to be difficult because of deficient acetabular bone coverage[1-9]. In previous reports, structural bone-grafting with femoral head autograft to increase acetabular capacity and then insertion of the acetabular component with cement into the restored acetabulum provided satisfactory short-term results[21], but longer-term follow-up data have shown high rates of failure[3,22]. Shinar and Harris[22] reported that thirty-three (60%) of fifty-five acetabular components in patients who had been managed with a bulk autogenous graft were loose at an average follow-up of 16.5 years.

In this report, six of fifteen hips with the structural acetabular bone graft showed early vertical migration and change in rotational alignment of the acetabular component, but we did not observe progressive collapse or loosening of the acetabular component. It is possible that the component migration was related to some resorption of the osteopenic femoral head that was used as a bone graft. Maloney et al.[23] reported that an acetabular component with a bulk bone graft may migrate early but stabilize at twenty-four months and then remain stable at ten years. That observation coincides with the findings in the six hips in this series. Whether the acetabular components in our study will subsequently migrate further or become loose is not clear. We have not, however, performed structural bone-grafting since September 1992. We recommend that a structural bone graft be avoided if possible, especially for hips with mild developmental dysplasia.

Fig. 3

Anteroposterior radiograph made eight years after surgery to treat a Hartofilakidis type-3 abnormality (high dislocation) of the left hip in a fifty-one-year-old woman. (The preoperative radiograph is shown in Fig. 1-C.) The acetabular component is just proximal to the true acetabulum. The patient reported no hip pain, and the clinical result was good.

Jasty et al.[6] proposed that porous-coated acetabular components inserted without cement make it possible to reconstruct many dysplastic hips without the need for extensive structural bone-grafting. To obtain maximum coverage, we deepened the acetabular cavity to the medial wall or sometimes to the protruded position as described by Dorr et al.[2]. We always used screw fixation to maximize contact with the host bone.

Placement of the acetabular component in Hartofilakidis type-2 and type-3 hips is technically demanding and depends on the amount of available bone stock as well as the magnitude of limb-length discrepancy. The true acetabular cavity is shallow, vertical, and deficient anteroposteriorly. We recommend placement of an acetabular component that is as large as possible at the correct or nearly correct anatomical level without compromising the posterior wall of the acetabulum (Fig. 3). This technique brings the hip center inferiorly, which is a more desirable location biomechanically. It also allows the use of a larger cup, which may minimize the need for a thin polyethylene liner, and avoids the need for structural bone-grafting. In one patient with severe soft-tissue contractures, however, we did place a small acetabular component at a higher position in order to avoid excessive limb-lengthening and structural bone-grafting[6,10].

Of the eighty-one hips, two had pelvic osteolysis and two had femoral osteolysis. This rate was equivalent to or lower than the rates reported in previous studies of hybrid total hip arthroplasty[11,23,24].

Mallory et al.[25] reported that dislocations after total hip arthroplasty occurred frequently in patients with developmental dysplasia. The dislocation rate of 11% in our study was equal to or higher than those reported in previous series of patients with developmental dysplasia[3,5,8]. Our use of the posterior approach without repair of the external rotators and the posterior aspect of the capsule might have been a factor leading to the high dislocation rate.

One limitation of this study is that the present group of patients was a selected one. Total hip arthroplasty was performed without cement for most of our younger, high-demand patients during the same time-period, and these patients were excluded from the study. Consequently, the average age of the patients in the present series is higher than that in previous series of patients with developmental dysplasia[1-5,7-9].

We concluded that hybrid total hip arthroplasty provides satisfactory intermediate-term results in patients with osteoarthritis secondary to developmental dysplasia. In the majority of the patients, the cementless acetabular component can be implanted without the need for structural bone-grafting. For hips that have insufficient acetabular coverage, we recommend placement of the acetabular component at a deepened medial or high position to maximize the contact with host bone. Currently, we perform hybrid total hip arthroplasty for patients with developmental dysplasia who are fifty-five years of age or older; however, we consider total hip arthroplasty without cement for active patients who are less than fifty-five years old and have good-quality femoral cortical bone. ■

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