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Cemented Calcar Replacement Femoral Component in Revision Hybrid Total Hip Arthroplasty

Ito, Hiroshi ; Tanino, Hiromasa ; Yamanaka, Yasuhiro ; Nakamura, Toshiki ; Minami, Akio ; Matsuno, Takeo

CEMENTED CALCAR REPLACEMENT FEMORAL COMPONENT IN REVISION HYBRID TOTAL HIP ARTHROPLASTY

Abstract

We evaluated intermediate to long-term survival of cemented calcar replacement femoral components in hybrid revision THA. We followed up 52 hips in 50 patients for a mean of 11.4 years. Six (12%) femoral components had been revised. Two for aseptic loosening, two for periprosthetic fracture, and two for deep infection. One additional femoral component was definitely loose. The number of previous revision operations ($p = 0.004$), preoperatively poorer femoral bone stock ($p = 0.005$) and postoperative poor cement mantle grading ($p = 0.003$) were significant factors for failure. Kaplan-Meier analysis revealed that the 15-year survival rate was 90% with mechanical failure as the end point. This technique remains a reasonable option for the first time revision, especially for older and less active patients.

Key words: revision total hip arthroplasty, calcar replacement femoral component, intermediate to long-term follow-up

Introduction

Bone defects in the proximal part of the femur in patients who need a revision THA present a technically difficult problem. Severe osteoporosis, osteolysis, and a loose prosthesis compromise the bone stock in the medial region of the femoral neck which is essential for the support of a conventional femoral component [1]. Cemented femoral components were traditionally used for femoral revision [1-9], however, cementless femoral components are more often used recently for their favorable clinical results [10-17].

Although good intermediate-term results of impaction bone grafting and bulk allograft with reinforcement device for acetabular revision were reported [18,19], porous-coated uncemented hemispheric acetabular components have provided good intermediate-term results, and they are the most common choice for acetabular revision in North America [20]. Sufficient contact against biologically active and mechanically supportive acetabular host bone is critical for this procedure. When osseous deficiency of the acetabulum is severe and does not allow a large hemispherical component to be used, the acetabular component is often positioned on viable bone at a high location to avoid bulk bone graft [20]. As a result, it is often necessary to use a femoral component with a longer neck to maintain leg length and soft tissue tension in this situation. Because the distance between the center of rotation and the most proximal portion of the initial fixation point of this type of femoral component is longer than that of the standard stem, possible increase in shear stress between the implant and the femur, resulting in early loosening, and high dislocation rate are concerns.

There have been conflicting results regarding the longevity of cemented femoral component fixation in revision THA [1-9]. Good intermediate-term results of hybrid revision have been reported [2,9] and use of cemented femoral components with a longer head-neck section without proximal femoral allograft has been reported as an option [1,21-23]. On the contrary, Davis et al [2] reported poor results of cemented femoral revision using modern cementing techniques when revising failed uncemented femoral components.

In the assessment of the intermediate to long-term results of cemented calcar replacement femoral components in hybrid revision THA, the purposes of the present study were to evaluate (1) survivorship, (2) surgical factors for failure, (3) the relationship between the location of the hip center and failure, (4) the relationship between clinical factors and clinical results, and (5) intraoperative and postoperative complications.

Materials and Methods

Between January 1989 and August 2001 we performed hybrid revision THAs for 266 hips in 238 patients We considered femoral reconstruction with cement for hips in less active and low-demand patients with poor femoral host bone stock and an intact cortical tube (consistent with a so-called stovepipe femur [24]). During the same period uncemented revision THAs were performed for 108 hips in 105 patients. For 63 revision hybrid THAs in 61 patients, cemented femoral components replaced the calcar femorale proximal to the lesser trochanter. A Precoat Modular Calcar component (Zimmer, Warsaw, IN), a Harris Precoat Plus long components (Zimmer), or Head and Neck Replacement components (Stryker Howmedica

Osteonics, Rutherford, NJ) was used. An uncemented acetabular component was used for all these 63 hips. The distance between the center of the femoral head and the most proximal portion of the initial fixation point by cement of all 63 stems was ≥ 50 mm. Eleven patients (11 hips) were excluded from the study: 7 patients (7 hips) died before a minimum follow-up of 7 years, 2 patients (2 hips) became bedridden and were too ill to return for follow-up evaluation, and 2 patients (2 hips) were lost to follow-up. At an average of 29 months (range, 3–61 months) postoperatively, all these 11 hips demonstrated well-fixed components radiographically and none of these hips had been rerevised.

Fifty-two cemented calcar replacement femoral stems in hybrid revision THA in 50 patients who were alive at a minimum of 7 years postoperatively were analyzed. The most recent results for patients who had died after at least 7 years of follow-up were included in the analysis. The mean duration of follow-up was 11.4 years (range, 7–20 years). The mean age of the patients at the time of the operation was 66 years (range, 35–83 years). The average height was 152 ± 10 cm (range, 130–178 cm), and the average weight was 53 ± 11 kg (range, 32–79 kg years). There were 35 women (36 hips) and 15 men (16 hips). Thirty-six revisions were performed on the right side, and 16 were performed on the left. Thirty-two of the index revisions were first revisions, 16 were second revisions, and four were third revisions. The original diagnosis was osteoarthrosis for developmental dysplasia (28 hips), osteonecrosis (9 hips), fracture (8 hips), rheumatoid arthritis (5 hips), slipped capital femoral epiphysis (1 hip) and ankylosing spondylitis (1 hip).

The diagnoses that led to the 52 index procedures included aseptic loosening of femoral and acetabular components (28 hips), aseptic loosening of the femoral component (14 hips), aseptic loosening of the acetabular component (4 hips), periprosthetic femoral fracture (4 hips), femoral component fracture (1 hip), and infection (1 hip). In 4 hips with aseptic loosening of only the acetabular component, the femoral component without radiographic evidence of loosening was revised to lengthen the limb to adjust for limb-length discrepancy.

The femoral bone deficiency before the index surgery was evaluated radiographically and classified according to the system described by Della Valle and Paprosky [25].

Surgical Procedure

All 52 index revision THAs were performed with insertion of a femoral component with cement and an acetabular component without cement. All of the procedures were done through a posterolateral approach without trochanteric osteotomy. THAs had been previously implanted in 37 hips, bipolar arthroplasties in 14 hips, and a unipolar arthroplasty in 1 hip. The femoral prostheses that were removed at the time of revision were listed in Table 1. These were fixed with cement in 42 hips and without cement 9 in hips. One hip had index revision as a second stage procedure 3 months after removal of a Charnley component because of infection.

The femoral components inserted at the index revision were 22 Precoat Modular Calcar components, 22 Harris Precoat Plus long components, and 8 Head and Neck Replacement components, depending on the respective inserted acetabular component and condition of femoral bone deficiency. None of the revision stems had a polished surface.

We selected a longer femoral component for the index revision using preoperative radiographic templating. Selection criteria for the length of the stem were as follows; (1) the stem tip should be seated at least 3 cm distal to the tip of the revised stem and (2) the stem tip should be seated at least 2 cm distal to the tip of the existing cement mantle. The average length of the femoral component was 193 mm (range, 140–250 mm). The average distance between the center of the femoral head and the most proximal portion of the initial fixation point by cement was 58 mm (range, 50–80 mm).

Femoral components were inserted with use of second generation cementing techniques, including use of a medullary canal plug, retrograde filling of the canal with Simplex-P bone cement (Stryker Howmedica Osteonics) impregnated with antibiotic powder (amikacin sulfate 400 mg), and pulsatile lavage. Vacuum mixing, centrifugation, proximal cement pressurizers, or stem centralizers were not used.

Immediate postoperative full weight bearing was allowed for patients without intraoperative periprosthetic fracture. Follow-up evaluations were performed at 1, 2, 3, 6, 12 months, and yearly thereafter. Clinical evaluations were made according to the Harris hip scoring system. 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 obtained at the latest follow-up visit were analyzed by four orthopaedic surgeons who specialized in hip surgery.

The femoral cement mantle was classified according to the criteria of Mulroy and Harris [26], as grade A (complete filling of the intramedullary cavity of the femoral diaphysis with cement), grade B (a slight radiolucent line at the cement-bone interface), grade C1 (a more extensive radiolucent line [encompassing 50 to 99% of the cement-bone interface] or voids in the cement), grade C2 (a thin mantle of cement measuring <1 mm at any site or a defect in the mantle with direct prosthesis-bone contact), or grade D (a radiolucent line encompassing 100% of the cement-bone interface on any radiograph, or no cement distal to tip of the stem, or multiple defects or large voids in the cement mantle). Loosening of the femoral component was defined with use of the criteria described by Harris and McGann [27]. Definite loosening was defined as migration of the component, cement fracture, or appearance of a radiolucent line at the cement stem interface 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. Possible loosening was defined as a radiolucent zone involving 50 to 99% of cement-bone interface on any view and radiolucency not present immediately postoperatively. A hip center was defined as high for hips with a center of rotation of the femoral head located ≥35 mm proximal to the interteardrop line [28], and as anatomic in those <35 mm proximal to that. Definite acetabular loosening was defined as acetabular migration of ≥2 mm in either the horizontal or vertical direction, rotation of the implant, screw breakage, or a radiolucent line of >1 mm in all zones [29].

Statistical analyses were performed using SPSS software (SPSS Inc., Chicago, IL). Clinical, radiographic, and surgical factors that had a significant association with failure were identified with use of chi-square tests, the Student t test or Mann-Whitney U test where appropriate. Preoperative and postoperative Harris hip scores were compared with use of the

Wilcoxon signed-rank test. A probability value less than 0.05 was considered significant. Kaplan-Meier survival curves with end points defined as rerevision for any reason, mechanical failure of the femoral component (rerevision because of aseptic loosening, or probable or definite radiographic loosening), and overall failure of the femoral component (rerevision for any reason, or probable or definite radiographic loosening) were calculated. All survivorship data were reported with 95% confidence intervals (CI).

Results

At the time of final follow-up, 6 (12%) of the 52 femoral components had been revised. Reasons for rerevision were aseptic loosening (2 hips), postoperative periprosthetic fracture (2 hips), and deep infection (2 hips). The average time to rerevision was 7.1 years (range, 0.6–15.5 years). One (2%) additional femoral component was definitely loose according to radiographic criteria. The mechanical failure of the femoral component, which includes rerevision because of aseptic loosening or radiographic probable or definite loosening, was 6% (3 of 52 hips). The mechanical failure occurred in 2 of the 22 Harris Precoat Plus long components and 1 of the 8 Head and Neck Replacement components ($p = 0.253$). The overall failure of the femoral component, which includes rerevision for any reason or probable and definite radiographic loosening, was 13% (7 of 52 hips). Two (4%) additional femoral components were possibly loose. Forty-three (83%) femoral components were rigidly fixed at the time of the final follow-up (Figs. 1 and 2). Kaplan-Meier analysis revealed that the 15-year survival rate was 90% (95% CI, 82.6%–97.6%) with mechanical failure of the femoral component (rerevision because of aseptic loosening, or probable or definite radiographic loosening) as the end point, 89% (95% CI, 84.1%–93.7%) with rerevision of the femoral component for any reason as the end point, and 82% (95% CI, 74.1%–90.0%)with overall failure of the femoral component (rerevision for any reason, or probable or definite radiographic loosening) as the end point.

Of the 6 femoral components that required rerevision, 5 had been implanted during a second revision procedure and 1 had been implanted during a third revision procedure, indicating that the number of previous revision operations was a significant factor of rerevision ($p = 0.004$).

Two hips were classified as type I femoral bone deficiency (minimal loss of metaphyseal cancellous bone; intact diaphysis), 11 hips as type II (extensive loss of metaphyseal bone; intact diaphysis), 25 hips as type IIIA (severely damaged metaphysis and nonsupportive; minimum of 4 cm of intact cortical bone present in the femoral isthmus), 11 hips as type IIIB (severely damaged metaphysis; some intact cortical bone present distal to isthmus [< 4 cm]); and 3 hips as type IV (extensive metaphyseal damage; isthmus nonsupportive; distal fixation unachievable; widened femoral canal). The relationship between the preoperative bone stock of the femur and aseptic loosening was evaluated excluding 4 hips with rerevision because of postoperative periprosthetic fracture or infection. Although none of the 2 type I hips and none of the 10 type II hips had possible or definite aseptic loosening, 2 of the 23 type IIIA hips, 2 of the 10 type IIIB hips, and 1 of the 3 type IV hips had rerevision or loose femoral component. Preoperative poorer femoral bone stock of type IIIB or type IV was a risk factor of loosening ($p = 0.005$).

Postoperatively, the cement mantle was classified as grade A in 6 hips (12%), grade B in 15 (29%), grade C1 in 19 (37%), grade C2 in 9 (17%), and grade D in 3 (6%). In the group of 5 hips that had revision for aseptic loosening or definitely or possibly loose femoral component, the postoperative cement mantle was classified as grade C1 in 1 hip, grade C2 in 3, and grade D in 1. Excluding 4 hips with rerevision because of periprosthetic fracture or infection, the aseptic loosening occurred in 1 of 15 hips in which the cement mantle was grade C1, 3 of 9 hips in which the cement mantle was grade C2, and 1 of 3 hips in which the cement mantle was grade D. Postoperative poorer cement mantle grade of C2 or grade D was a risk factor for loosening ($p = 0.003$).

The average location of the hip center proximal to the interteardrop line was 35 mm (range, 15–65 mm) and 24 (46%) hips were classified to have a high hip center. With the numbers available, no relationship was found between the aseptic loosening and hips with or without high hip center. Four acetabular components had been revised. Reasons were polyethylene wear and osteolysis (1 hip), recurrent dislocation (1 hip), and deep infection (2 hips as described above). At the time of rerevision, 2 of the 4 femoral components were not revised and only modular femoral heads were exchanged.

The average Harris hip scores improved from 51 points (range, 22–74 points) preoperatively to 76 points (range, 38–100 points) at the time of the latest follow-up ($p < 0.001$). In the evaluation of 44 patients (46 hips) without rerevision, 37 (85%) patients (39 hips) had mild or no pain, and 7 patients (15%) (7 hips) had moderate to severe pain. Of the

7 patients with moderate or severe pain, 3 had a possible or definite loose femoral component, 3 had severe osteoporosis, and 1 had rerevision of the acetabular component because of recurrent dislocation. Twenty-four patients used no walking aids, 12 used a cane intermittently, and 6 required full-time ambulatory aids, and 2 were unable to walk because of severe Alzheimer disease and renal failure. With the numbers available, no relationship was found between the most recent Harris hip score and patient gender, age, original diagnosis, or weight. Also no relationship was found between the aseptic loosening and patient gender, age, original diagnosis, weight, neck or stem length of the femoral component.

Intraoperative complications included 4 shaft fractures that required fixation with cerclage wiring or plate and cable grip system. These fractures occurred during removal of previous femoral components or cement and were not related to insertion of the stem. None of these 4 hips had rerevision of the femoral component. Other complications included 2 femoral canal perforations, 1 of which showed radiographic possible loosening at the time of latest follow-up. Seven (13%) of the 52 hips had dislocated by the time of the latest follow-up; 4 had a single dislocation, 1 had 2 dislocations, 1 had 3 dislocations, and 1 had multiple dislocations which required rerevision of the acetabular component. Six patients had a periprosthetic femoral fracture at an average 5.0 years (range, 0.6–10 years) postoperatively. Preoperative bone stock of these patients was type II in 3 hips, type IIIA in 2 hips, and type IIIB in 1 hip ($p = 0.449$). Two of these 6 hips required rerevision of the femoral component. Two deep infections in 2 patients necessitated removal of both femoral and acetabular components 7 and 12 months postoperatively.

Discussion

Bone defects in the proximal part of the femur in patients after failed THAs present a technically difficult problem for hip surgeons. The recent results of cementless femoral components seem better than those of cemented components [10-15,17]. Our study demonstrated that the 15-year survival rate was 89% with rerevision of the femoral component for any reason as the end point, and 90% with mechanical failure of the femoral component (rerevision because of aseptic loosening, or probable or definite radiographic loosening) as the end points. We found that number of previous revision operations, proximal medial femoral bone loss, and a poor cement mantle were significant risk factors for failure. Compared to previous literatures in which average follow-up was more than 10 yours, our mechanical failure rate of 6% did not seem disappointing (Table 2). With the numbers available, no relationship was found between the aseptic loosening and high hip center in this study. The use of cemented femoral components with a long-neck in hybrid revision THA can be a reasonable option for low-demand and less active patients. This technique is simple and straightforward for hips with proximal femoral bone deficiency and a high location of the hip center.

The results of cemented stems in revision THA using first-generation cementing techniques have been less satisfactory [32-34]. There have been conflicting results of the cemented stems using modern cementing techniques [1-9]. A long cemented component allows one to achieve cement fixation in fresh bone that was previously not used to achieve fixation. Dohamae et al [35] showed that after a first revision, the bone-cement interface shear strength is only 20.6% of the shear strength achieved after primary arthroplasty. After a second revision, bone-cement interface shear strength further declines to 6.8% of the strength following primary arthroplasty. The number of previous revision operations was a significant factor and first time revision seems to have a chance to achieve the good bone-cement interface at the distal part of the stem. Hultmark et al [6] demonstrated that the ten-year rate of survival free of mechanical failure was 93% for long-stem implants but only 79% for standard-length stems. The majority of the stems that were revised in that series were cemented. The length of femoral component was not a significant factor with the numbers available, however, the average stem length of 193 mm used in this study was relatively long, which may be a reason for the present favorable results. The achievement of cement fixation in fresh bone that was not previously used for fixation seems the most important technical point for this procedure. We inserted longer femoral components than revised components for the present index revision. Ideal situations may be first revisions for hips with type I, II and IIIA bone deficiency after failed femoral components with short to standard length.

The importance of the quality of the cement mantle has been controversial [1,3,4,6-9]. Postoperative poor cement mantle grading was a significant risk factor for mechanical failure in this study ($p = 0.003$). Our finding suggests that, over the intermediate to long-term, the integrity of the initial postoperative cement mantle appears to be predictive of future radiographic evidence of fixation. It is difficult to obtain good cement interdigitation with the cancellous microstructure of bone for the proximal inner surface of the femur in which original femoral component had been implanted. Bone loss during loosening and further cancellous bone loss during removal of component, cement, or canal preparation at the time of revision often leaves little cancellous bone for cement interdigitation at the time of revision. The failure to obtain a good cement-bone interface in many patients was reflected by the high percentage of hips with a grade-C cement mantle. The subgroup of patients with a grade-C2 or D defect had a 33% failure rate. If distal cement fixation in fresh bone can not be expected, use of cementless femoral components would be preferable.

One limitation of this study is that the present group of patients was a selected one. During the same time-period, revision THAs without cement had been performed for active and high-demand patients. The population of this study consists of relatively low-demand, less active, small and light-weight patients, which may have contributed to the present favorable results.

Recently cementless femoral components are often preferred for femoral revision. Immediate fixation by hybrid revision THA allows postoperative full weight bearing, enhancing rehabilitation. Postoperative dislocation was the most common complication as previously reported [1-3,6,8,9,21-23,28,32,34], however, revision hybrid THAs can be a reasonable option for older and less active patients, especially for first time revision after failed femoral components with short to standard length.

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