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Massive Bone Defect Compromises Postoperative Cup Survivorship of Acetabular Revision Hip Arthroplasty with Impaction Bone Grafting

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ABSTRACT

We evaluated 66 acetabular revision arthroplasties using cemented cup with impaction bone grafting (IBG) to detect the extent that bone defect affects the outcome. We defined the maximum acetabular defect distance (MADD), which indicates the greatest depth of the grafted layer. Cup survival analysis with aseptic loosening as the endpoint revealed that the "MADD ≤ 20 mm" group showed higher survivorship than the "MADD > 20 mm" group (95% vs. 74%, $P = 0.034$), and that the simple-wall-defect group (none or one mesh used) showed higher survivorship than the complex-wall-defect group (two meshes used) (96% vs. 73%, $P = 0.044$). A favorable indication for acetabular IBG reconstruction is cases in which those cups can be placed at ≤ 20 mm MADD with a simple wall defect.

Acetabular impaction bone grafting is a well-recognized option for revision total hip arthroplasty for cases combined with acetabular bone stock deficiency [1–4]. Restoration of bone stock and reconstruction of hip biomechanics can be achieved by placing the new cup at the true acetabulum [5], combined with containment of bony wall defect and filling of the defect using impacted morselized graft.

Although good long-term or mid-term clinical results of acetabular revision with impaction bone grafting technique were reported from the original center [2] and other institutions [6,7], some catastrophic failures were shown in severe bone loss cases [8,9]. Furthermore, as the remaining acetabular bone stock is always thin, weak, and eburnated, the procedure is often challenging for hip surgeons [10].

We have carried out acetabular impaction bone grafting for revision total hip arthroplasty in acetabular bone defect cases since 2001, and have reported our preliminary clinical experience [7]. However, as it has been unclear how the severity of bone loss and segmental defect might influence the stability of a revised cup, we analyzed mid-term clinical and radiographic results at least two years of follow-up after acetabular revisions with impaction bone grafting, with regard to the quantity of bone defect and the severity of segmental defect of the acetabulum.

Patients and Methods

The senior author (T.I.) performed 69 consecutive acetabular revisions with impaction bone grafting in 68 patients from February 2001 to April 2011. One patient died from unrelated causes two years after the operation, two patients were lost to follow-up within two years after the surgery because they lived far away, and one patient had entered a nursery home far from our hospital one year and nine months after the surgery. These four cases (four hips) were excluded from clinical and radiographic assessment. Therefore, this study is based on the records of the remaining 66 hips of 64 patients.

The average age of the patients at revision total hip arthroplasty was 68.5 years (range: 36–85 years). Fifty-two patients were female and 12 were male. The average follow-up period was 6.6 years (range: 2.8–12 years). The average bone mass index (BMI) of the patients was 23.8 kg/m^2 (range: 16.2–36.6 kg/m^2). The reason for the operation was aseptic cup loosening in 45 hips, migration of bipolar heads in 17, secondary reconstruction for deep infection in 3, and revision for recurrent dislocation in one.

All operations were performed through a posterolateral approach. After removal of the loose acetabular component or bipolar head, cement, and granulation tissue, acetabular bone defects, if the new cup was placed at the true acetabulum, were assessed. After containing segmental wall defects using an X-change metal mesh (Stryker Benoist Girard, Herouville-Saint-Clair, France) with small cortical screws for peripheral wall defects and/or for medial wall defects, morselized cancellous allograft bone chips made using a hand rongeur were tightly impacted into the contained acetabular cavity with hemispherical impactors and a metal hammer. An ultra-high-molecular-weight polyethylene cup was cemented into this newly formed acetabular cavity. We used Simplex P bone cement (Stryker

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Limerick, Limerick, Ireland) in all cases. The cups used were the Exeter Contemporary Cup (Stryker Orthopaedics, Mahwah, New Jersey, USA) in 34 hips, the Crossfire All Polyethylene Acetabular Cup (Stryker Orthopaedics, Mahwah, New Jersey, USA) in 27 hips, the Charnley Ogee cup (Depuy International, Leeds, UK) in 3 hips, the ZCA all-polyethylene cup (Zimmer, Warsaw, Indiana, USA) in one hip, and the Kyocera F-PW cup (Kyocera, Kyoto, Japan) in one hip. The internal diameter of the acetabular component was 22 mm in 7 hips, 26 mm in 57, and 28 mm in 2.

Stems were revised by the impaction bone grafting technique [11,12] in 32 hips, by the cement-within-cement technique [13] in 18 hips, using a cemented stem in 2 hips, and using an allograft-stem composite [14] in one hip. The stems were not revised in the remaining 13 hips.

The postoperative rehabilitation protocol involved early mobilization using a walking frame and toe-touch weight-bearing on the operated side for 3 to 6 weeks, depending on the degree of bone defect. Subsequently, progressive weight-bearing was allowed as tolerated. Patients used a crutch or a cane for at most 6 months after the operation.

Acetabular bone defects were assessed using preoperative radiographs and intraoperative findings in all cases and were categorized according to the American Academy of Orthopaedic Surgeons (AAOS) classification [15] of acetabular defects. The place and number of metal meshes used for containment were recorded.

For clinical assessment, the Merle d'Aubigné and Postel hip score [16] was assessed preoperatively and at the final follow-up, and perioperative complications, such as intraoperative fracture, dislocation, deep venous thrombosis (DVT), and infection, were recorded.

For radiological assessment, anteroposterior (AP) radiographs of the bilateral hip joints were analyzed preoperatively and at one month, 6 months, one year, and annually thereafter. The position of the postoperative femoral head center and the inclination angle of the cup were measured using a postoperative AP radiograph. The height of the femoral head center was measured perpendicular to the inter-teardrop line. The horizontal location of the femoral head center was measured as the distance from the ipsilateral teardrop on the inter-teardrop line. The cup inclination angle was determined with reference to the inter-teardrop line.

Clear lines of more than 2 mm around the cups were assessed using the DeLee and Charnley zone classification [17], as was migration of the cups. Loosening was assessed according to the classification system of Hodgkinson et al [18], and type 3 (complete demarcation line) and type 4 (migration of more than 5 mm or change of the angle by more than 5°) were classified as "loosening".

To assess the amount of bone defect, we defined the maximum acetabular defect distance (MADD) as the radiographic measure (Fig. 1), which indicates the depth of the thickest grafted bone layer around the cup on a planar postoperative radiograph of the hip. The MADD was evaluated as the distance between the furthest point of the bone defect margin and the outer margin of the cup from the femoral head center.

Survival Analysis

Kaplan–Meier survival analysis [19] was performed with radiographic aseptic loosening or re-operation for aseptic loosening as the endpoint. Non-parametric survivorship analysis using the log-rank test was applied to the following variables: the amount of bone defect (moderate-defect group: MADD $\leq$ 20 mm vs. large-defect group: MADD > 20 mm), the degree of wall defect, which was classified by the number of metal wire meshes used (simple wall defect group: none or one metal mesh used vs. complex wall defect group: two meshes used), the degree of cup inclination angle (CIA) (CIA $\leq$ 45° group vs. CIA > 45° group), and the body mass index (BMI) (standard-BMI group: BMI < 25 kg/m^2 vs. high-BMI group [20]: BMI $\geq$ 25 kg/m^2). All statistical analyses were carried out with the software StatView for Windows ver. 5.0 (SAS Institute Inc., Cary, NC, USA). A probability value (P value) of < 0.05 was considered significant.

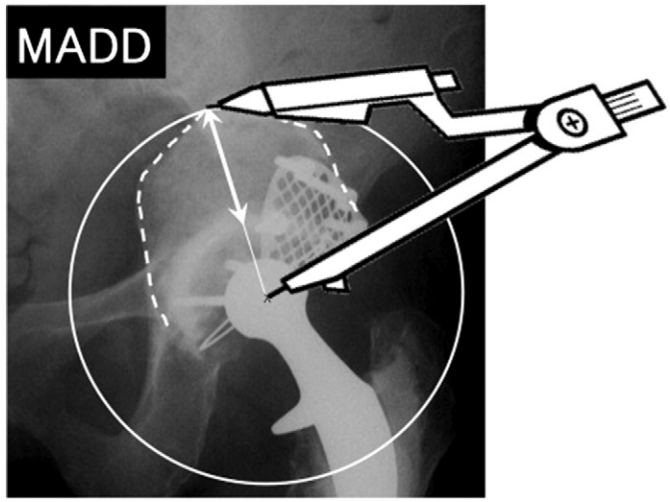

Fig. 1. Maximum acetabular defect distance (MADD). The MADD was evaluated using the postoperative radiograph as the distance between the furthest point of the bone defect margin and the outer margin of the cup from the femoral head center.

Results

According to the AAOS acetabular bone defect classification, one hip was classified as type I (superior segmental defect), 14 hips as type II (medial cavitary defect), and 51 hips as type III (combined segmental and cavitary defect).

With reference to location of segmental wall defects of the 51 AAOS type III hips, combination of segmental defects was as follows: 25 hips with superior segmental defect only; 11 hips with superior and medial segmental defects; 9 hips with superior and posterior segmental defects; 3 hips with superior, posterior and medial segmental defects; 2 hips with superior and anterior segmental defects; and one hip with anterior, superior and posterior segmental defects. All of these segmental defects of type III hips were combined with medial cavitary defect. Aseptic loosening occurred in 1 of 25 hips with superior segmental defect and medial cavitary defect, 2 of 11 hips with superior and medial segmental defects with medial cavitary defect, 1 of 9 hips with superior and posterior segmental defects with medial cavitary defect, 1 of 2 hips with superior and anterior segmental defect with medial cavitary defect, and 1 hip with anterior, superior and posterior segmental defects with medial cavitary defect. Although no apparent relationship between the location of the segmental defects and aseptic loosening was observed, 5 of 6 aseptic loosening hips showed multiple segmental defects.

For the 14 type II hips, no mesh was used. A metal mesh for containing peripheral segmental wall defect was used in 52 hips. Of these, an additional metal mesh for containing medial or anterior wall defect was used in 18 hips. Thus, double metal meshes were used in 18 hips of AAOS type III defect cases and none or a single mesh was used in 48 hips (1 hip of AAOS type I, 14 hips of AAOS type II, and 33 hips of AAOS type III).

During the follow-up period, re-revision operations were performed in 3 hips because of aseptic loosening and clinical assessments for these three hips were recorded before their surgery.

Clinical Assessment

The mean Merle d'Aubigné and Postel hip score of the 66 hips improved from 11.4 points (standard deviation (SD): 2.6, range 2–17