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Revision Arthroplasty

Structural Allograft Supporting a Trabecular Metal Cup Provides Durable Results in Complex Revision Arthroplasty

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ABSTRACT

Background: Revision total hip arthroplasty (THA) is challenging specially in the presence of severe acetabular bone deficiency. We report the use of a highly porous revision shell augmented by structural allograft to provide structural support and coverage to the acetabular component.
Methods: We identified 56 patients (58 hips) undergoing revision THA, where a trabecular metal revision cup was supported by structural allograft. Mean follow-up was 5.4 years (range 2-12 years). Preoperatively acetabular bone defects were classified as Paprosky 2A in 6 hips (10%), 2B in 12 hips (21%), 2C in 12 hips (21%), 3A in 11 hips (19%), and 3B in 17 hips (29%). Structural allograft configuration was classified as type 1 (flying buttress) in 13 hips, type 2 (dome support) in 23 hips, and type 3 (footings) in 17 hips, with 5 hips having combined configurations.
Results: All hips showed evidence of union between the allograft and host bone at latest follow-up, 14 hips had partial resorption of the allograft that did not affect cup stability. Three acetabular components demonstrated failure of ingrowth. Survivorship-free from radiographic acetabular loosening as end point was 94% at 5 years. The 5-year survivorship with revision for any reason as end point was 90%.
Conclusion: Trabecular metal shells combined with structural bone allograft in revision THA demonstrate excellent midterm survival, with 94% of acetabular components obtaining stable union onto host bone at 5 years. Allograft restored bone stock with minimal resorption, and when it occurred did not alter the survivorship of the acetabular component.

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Over the past decade, there has been an increase in the number of revision total hip arthroplasties (THAs) performed in the United States. The demand for hip revision procedures is projected to grow 137% by the year 2030 [1]. Revision THA in the presence of severe acetabular bone deficiency is a challenging problem for surgeons. Acetabular revision procedures can be performed using an uncemented hemispheric acetabular device with or without morselized bone allograft [2–5]. Uncemented porous-coated acetabular components provide effective long-term stability in the revision setting through biologic fixation to the host bone [6]. However, in certain conditions obtaining stable fixation and subsequent ingrowth of a conventional hemispherical cup without additional support may not be possible, particularly in the setting of pelvic discontinuity, poor bone quality, abnormally shaped defects, segmental bone defects, previous radiation, or conditions that preclude adequate contact of viable acetabular bone against the uncemented acetabular component [7]. In those particular situations, a spectrum of treatment options exist and include structural allograft [8–13], impaction grafting [14], the use of acetabular reconstruction cages [15–17], bilobed acetabular components [18,19], custom triflange cups [20,21], and more recently the use of modular trabecular metal (TM) augments [22–26].

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TM has emerged as an alternative to conventional porous-coated hemispherical cups, improving its initial press-fit fixation to bone as a result of its increased coefficient of friction, as well as enhancing rapid bone ingrowth because of its multiple interconnected pathways similar to trabecular bone [27,28]. A TM acetabular revision shell shows acceptable failure rates at midterm follow-up in the setting of contained bone defects when used without bone grafting [29]. However, when additional support augmentation is required to optimize the primary stability of the acetabular component, a structural bulk allograft has the advantage of providing mechanical support to the acetabular component, helping with restoration of hip center and providing potential for bone stock restoration.

Previous studies have reported satisfactory results using structural bone allograft in conjunction with acetabular reinforcement rings [16,30] and uncemented cups [9,12]. The disadvantages of this technique include the potential for graft resorption or nonunion to host bone resulting in failure of the construct [31,32]. These problems have lead arthroplasty surgeons to shy away from the use of allograft in this setting. The use of a TM shell, however, with its modulus of elasticity similar to bone and its increased early stability and osteointegration may improve the biomechanical environment of the construct, graft incorporation, decreasing graft resorption, and prolong implant survival. To the authors knowledge, the use of structural bone allograft with highly porous TM shell to reconstruct acetabular defects has not been reported previously. The purpose of the present study was to evaluate the midterm results of revision THA using structural bone allograft and a TM acetabular cup, emphasizing on complication rates, preoperative and postoperative functional hip scores, radiographic appearance of allograft and cup, as well as implant survivorship.

Materials and Methods

This study was approved by the institutional review board. Between 2000 and 2010, 60 patients (62 hips) underwent an acetabular revision using structural bulk allograft in conjunction with a TM revision metal shell. The bone allograft specimens were compliant with the American Association of Tissue Banks standards. The decision to use the structural bulk allograft rather than alternative reconstruction technique was based on surgeon's preference in moderate to severe bone loss acetabular defects when the geometry was considered less favorable for using metal augments. None of the alternative techniques such as modular porous metal augments, custom triflange cups, acetabular reconstructions cages, or bilobed acetabular components were used by the authors during these procedures, but were in use at the authors institution during the same time frame. Four patients did not have a minimum of 24 months of follow-up were excluded. The remaining 56 patients (58 hips), had a mean follow-up of 5.4 years (range 2-12 years). There were 10 men and 46 women with an average age of 64 years (range 35-86 years). The primary indication for acetabular revision was aseptic loosening in 42 hips (73%), loosening in association with pelvic discontinuity in 12 hips (20%), and second-stage reimplantation after infection in 4 hips (7%). Demographic information, preoperative, intraoperative, and postoperative surgical data were obtained from medical records.

In brief, the surgical technique involved exposure and removal of the previous failed acetabular component. After appropriate debridement and exposure of the remaining bone, the acetabular defect was classified using the Paprosky system. Preliminary reaming or “freshing up the bone” was carried out in a sequential fashion until the acetabular reamer filled that anteroposterior (AP) dimension in the native hip center when possible. The type of allograft bone to be used was then decided. Depending on the defect, a femoral head, a distal femoral allograft configured in a reverse figure of 7, or a distal femoral hemicondylar graft were used. The graft was fixed to host bone with 6.5 mm cancellous screws with washers, placed away from the introitus of the acetabulum so that additional reaming could be carried out if necessary to obtain good apposition of the acetabular component to the graft (Fig. 1). A revision TM acetabular component of the same size as the last reamer was impacted and fixed with multiple screws, some through new holes made into the TM shell. We always tried to place screws in the ilium and ischium to ameliorate the chances of osseointegration and prevent early cup failure. A liner was then cemented into the shell.

Standardized hip radiographs were performed before the revision procedure, postoperatively, and at follow-up examinations at 3 months, 6 months, and annually thereafter. All radiographs were reviewed collectively by three of us (HP, RJS, and MEC). The hip center was measured on the AP radiographs of the pelvis following the method of Pagnano et al [33], which allows measurement of the horizontal and vertical distances between the approximate femoral head center (AFHC) and the center of the prosthetic femoral head. Acetabular bone deficiency was categorized according to the method of Paprosky et al [34], which is based on the presence or absence of an intact acetabular rim and its ability to support an acetabular component. Hips were classified as Paprosky 2A in 6 hips (10%), 2B in 12 hips (21%), 2C in 12 hips (21%), 3A in 11 hips (19%), and 3B in 17 hips (29%).

Postoperatively, the AP radiographs were assessed for radiolucent lines in the 3 zones of the acetabulum described by DeLee and Charnley [35], cementless cup fixation was determined by Massin et al [36] criteria as definitive or probably loose, or a stable component. Postoperative cup position was determined by obtaining abduction and anteversion angles, on the AP and cross-table lateral view, respectively.

To describe the configuration of the structural bone allograft in the acetabulum, we used an analogue description for modular augments presented by Nehme et al and Lewallen et al [23,37], in one of three patterns (Fig. 2): A “flying buttress” configuration (type 1) for peripheral segmental defects particularly in the posterior superior quadrant, the “dome support” configuration (type 2) is an oblong construct often used for correction of elliptical contained cavitary defects where defect size or available AP dimensions precluded simply reaming up to a jumbo socket, and finally a “footing” (type 3) when the augmentation is placed medially in the depths of the acetabulum to provide mechanical stability to the construct for the treatment of massive medial cavitary or segmental defects so as to allow support for the cup on the still intact acetabular rim. The configuration of the structural allografts was classified as type 1 in 13 hips, type 2 in 23 hips, and type 3 in 17 hips, with 5 hips having combined configurations.

The percentage of coverage of the acetabular component by the structural allograft was determined using the immediate AP postoperative radiograph. The arc of graft coverage was measured in degrees using computer software (Cedara I-Reach), and expressed as the percent of the hemispherical cup supported by the graft.

Allografts were assessed radiographically for union to host bone as evidenced by trabecular bridging through the graft-host interface, graft remodeling, and reorientation of trabecular pattern using the Knight Criteria [11]. Graft fracture, large graft resorption, and collapse were indicators of graft failure.

Harris Hip Scores were assessed preoperatively and postoperatively from most recent follow-up visit available, using standardized patient questionnaires.

Kaplan-Meier survivorship analysis was performed using radiographic evidence of acetabular component loosening, acetabular revision, and any revision as end points. All analyses were

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