Use of Structural Bone Graft for Reconstruction of Acetabular Defects in Primary Total Hip Arthroplasty: A 13-year Experience

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**A R T I C L E  I N F O**

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**A B S T R A C T**

Background/Purpose: The purpose of this study was to evaluate the clinical and radiographic outcomes of primary cementless total hip arthroplasty (THA) with acetabular defect reconstruction using structural bone grafts.

Methods: Between 2001 and 2012, 10 hips in eight patients with uncontained superolateral acetabular bone defects were reconstructed with femoral head grafts at the time of primary cementless THA. The mean age at surgery was 61.7 years. Patients were followed-up for a mean of 5.8 years for evaluation.

Results: With either revision or loosening as endpoints, the survival rate of the structural grafts was 100%. Significant improvements in clinical outcomes in terms of the Visual Analogue Scale for Pain (from 9.5 to 3.3, \( p = 0.005 \)) and Harris Hip Score (from 32.7 to 73.9, \( p = 0.005 \)) were noted.

Conclusion: Uncontained superolateral acetabular bone defects can be effectively reconstructed with structural bone grafts during primary THA, with excellent short- to midterm survival rate and significantly improved clinical outcomes.

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**Introduction**

In total hip arthroplasty (THA), reconstruction of large acetabular defects often poses a considerable technical challenge to the surgeon. Inadequate bone coverage leads to potentially unstable fixation of acetabular components. Various reconstruction techniques have been reported and are deployed according to the size and location of the defects. These include implantation of components at a high hip centre,\(^{1,2,3}\) medialisation/protrusio techniques,\(^{4,5}\) reinforcement ring, jumbo cup, trabecular metal augmentation, impaction bone graft, and structural bone grafting.\(^{6-13}\) We have performed structural bone grafting for reconstruction of acetabular defects since May 2001. Its advantages include anatomical placement of acetabular components, provision of support for acetabular components implantation, and reconstitution of bone stock that is beneficial for future revision surgery.

The current study serves to assess the clinical and radiographic outcomes of structural bone grafts for acetabular defect reconstruction.

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Methods

Patients

From May 2001 to May 2012, 10 primary THAs requiring reconstruction of the acetabulum with structural bone grafts were performed in eight patients at our department. All had acetabular defects Type 1A according to the classification by the American Association of Orthopedic Surgeons (AAOS),16 i.e., segmental deficiencies in the periphery of the acetabulum.

Patients comprised one man and seven women. The average age at the time of the operation was 61.7 years (range: 37–81 years). The original diagnoses were hip dysplasia (eight hips) and rheumatoid arthritis (two hips). Mean follow-up period of the patients was 5.8 years (range: 2–13 years) (Table 1).

Surgical techniques

All THAs were performed by a single senior surgeon (K.-Y. Wong) via posterior approach in lateral decubitus position. After adequate exposure of the acetabulum and identifying the lower border of the medial wall which is at the transverse ligament, it was reamed at the centre of the medial wall starting at 44 mm until 2 mm undersize at the best fit anteroposterior diameter. The size of the segmental acetabular defect was estimated after inserting a trial cup. In all cases, host acetabular coverage of acetabular components was between 50% and 70%.

Structural graft was fashioned from either femoral head autografts (7) or femoral head allografts (3). The graft was tailored to best fit the acetabular defect and fixed with two lag screws with or without washers. The acetabulum was reamed serially again to the best fit anteroposterior diameter. After fitting the trial cup to ensure adequate stability and no see-saw instability, a hydroxyapatite-coated cup was implanted and fixing it through its long portion into the ilium with cancellous screws. An acetabular reamer is then used to remove excess bone graft to create a hemispherical fossa for acetabular shell implantation. In our study, similar to several others,9–11 we used a smaller bone wedge cut from the femoral head to fill the acetabular defect.

Some early studies have shown good graft survival rates in the short-term,6 however, less favourable in the long term8,13; such failure was thought to be due to the larger size of the grafts used. Jasty and Harris30 and Shinar and Harris13 have demonstrated a positive correlation between the extent of structural graft cover and rate of acetabular component loosening.

Various recent studies where smaller grafts were used have shown high survival rates of grafts. Ito et al11 has reported, with revision and loosening as end-points, 11-year graft survival rates of 91.6% and 88.9%, respectively. Kim and Kadowako9 reported a 94% 10-year survival rate without revision for any reason. De Jong et al10 have shown in their long-term follow-up study the cumulative survival of grafts at 20 years was 78%. The results of the current study compare favourably with previous studies, with graft survival rates of 100% at an average of 5.8 years.

One important technical precaution is that we need to identify the transverse ligament and medial wall of the acetabulum during surgical exposure. The advantage of this measure is twofold. Firstly, the level of the anatomical hip centre can be obtained. Secondly, by being able to remove any osteophytes or overgrowths on the

Evaluation methods

All patients were assessed clinically and radiographically by an observer not involved in the index operation. For clinical assessment, modified Harris Hip Score (HHS)17 and Visual Analogue Scale for Pain (VAS) were used. The structural grafts were evaluated radiographically for incorporation (bridging trabeculae of the host–graft interface), fracture, and resorption. Complications such as loosening, dislocation, infection, and revision arthroplasty were also recorded.

Statistical analysis was performed using IBM SPSS Statistics version 22 (IBM Corporation, Armonk, NY, USA). Wilcoxon signed-rank test was used to analyse differences between pre- and postoperative HHS and VAS. A p-value < 0.05 was considered statistically significant.

Results

The survival rate of structural grafts was 100%, with either revision or loosening as the endpoint. All grafts were incorporated into host acetabula, with bridging trabeculae and disappearance of the host–graft interface. No resorption, fracture, dislocation, or infection occurred.

Significant improvements were noted in postoperative VAS and HHS compared with preoperative assessments. Mean VAS improved from 9.5 to 3.3 (p = 0.005), whereas mean HHS improved from 32.7 to 73.9 (p = 0.005) (Table 2).

Discussion

In primary THA, causes of acetabular defect include hip dysplasia, rheumatoid arthritis, infection, and acetabular fracture. The most common classification systems for acetabular defects include the AAOS classification18 (Table 3) and the Paprosky classification19 (Table 4).

Reconstruction of acetabulum defect is a surgical challenge. The goals of reconstruction are to reconstitute acetabular bone stock, ensure secure fixation of the acetabular component, restore hip centre, and restore leg length.

The objective of the current study is to evaluate the results of augmentation of deficient acetabulum using structural bone grafts. This technique has the advantages of restoring anatomical hip centre as well as acetabulum bone stock. A classically described technique19 is to make a “number 7” cut over the medial portion of a femoral head graft, buttressing the axilla part of the graft against the ilium and fixing it through its long portion into the ilium with cancellous screws. An acetabular reamer is then used to remove excess bone graft to create a hemispherical fossa for acetabular shell implantation. In our study, similar to several others,9–11 we used a smaller bone wedge cut from the femoral head to fill the acetabular defect.

Table 1

Patient demographics.

| No. of patients | 8 |
| No. of THAs | 10 |
| Sex | Male 1 Female 7 |
| Age at time of THA (y) | Mean 61.7 Range 37–81 |
| Diagnoses | Hip dysplasia 8 Rheumatoid arthritis 2 |
| Duration of follow up (y) | Mean 5.8 Range 2–13 |

THA — total hip arthroplasty.
medial wall, the metal shell can be medialised with increased host-bone coverage, therefore avoiding the use of larger bone grafts for superolateral support.

Choice between allograft and autograft does not appear to have a significant effect on component loosening or revision rate, as shown by Shinar and Harris. In this study, autografts were used in seven out of 10 cases (70%) while the remainder were allografts (30%); allografts were used when there was insufficient bone in the autologous femoral head (e.g., avascular necrosis with advanced collapse) or the bone was too sclerotic.

The longest follow-up case is a lady who was 69 years old at the time of the index operation. She had Crowe Type I dysplastic left hip causing secondary osteoarthritis. During THA, the true acetabulum was identified above the transverse acetabular ligament and lower border of the medial wall and was reamed at the centre of medial wall. The host bone coverage was estimated to be about 70% after

Figure 1. Female patient: (A) pelvic anteroposterior radiograph of a 58-year-old female patient showing bilateral dysplastic hip with secondary degenerative changes and superolateral acetabular defect; (B) intra-operative photo during total hip arthroplasty. There was a 30% segmental acetabular defect over superolateral aspect (dashed line); (C) femoral head autograft was cut into a wedge shape (dashed line) and fixed onto the acetabular defect using Kirschner wires and then screws; (D) the acetabulum was reamed to the desired size. The acetabular shell was implanted and fixed with acetabular screws; (E) postoperative radiograph; and (F) radiograph on final follow up.
placement of a trial shell. Autologous structural bone graft was fashioned from the excised femoral head, fitted to the defect, and fixed with two screws. The acetabulum was serially reamed to 52 mm diameter. A cementless shell was implanted with line-to-line fit and fixed with bone screws. The latest radiographs showed incorporation of the bone graft with no loosening of the implants.

The latest case is a 70-year-old lady with a history of rheumatoid arthritis treated with corticosteroids and diabetes mellitus. She had Ficat Stage IV avascular necrosis of the left hip with superolateral acetabular bone defect. The acetabulum was reconstructed using a similar method to that described in the first case. The host bone coverage was estimated to be about 70%. A 52-mm cementless shell was implanted with line-to-line fit. The latest radiographs again showed incorporation of the bone graft with no loosening of the implants.

There are various alternative methods of reconstruction reported in the literature. Use of high hip centre has the advantage of reduced surgical complexity at the expense of normal hip biomechanics and bone stock for future revision. Studies have produced contradictory results regarding the outcomes of high hip centre, with some reporting high loosening rates while others have produced better results.

The use of jumbo-sized cementless cups has been reported to have low failure rates in various studies. A jumbo cup enables a large area of host bone contact for biological attachment, while bringing the hip centre to a more anatomical position. Negating the need for bone grafting reduces surgical complexity; however, the loss of bone stock cannot be addressed. Furthermore, it is less suitable for oblong defects. In a recent study, Gustke et al. have shown that in 196 jumbo cups used in revision hip arthroplasty, survivorship was 98% at 4 years and 96% at 16 years.

Larger acetabular defects require the use of reinforcement rings. The ring provides coverage for cementation of the polyethylene cup in the anatomical position. This technique can be combined with structural or impaction bone grafting behind the ring for restoration of bone stock. The ring protects the bone graft from mechanical stress during osteointegration. In a systematic review of 1541 reinforcement rings by Beckmann et al., the loosening rate and revision rate were 9% and 3.9%, respectively, at mean 5.7 years.

Recently, the development of trabecular metal implants offers a similar method to that described in the first case. The host bone. An elastic modulus compatible with bone reduces bone loss by stress shielding. The combination of different augments, cups, and rings allows reconstruction of acetabular defects of various sizes and shapes. Beckmann et al. have found that the use of trabecular metal components was especially beneficial for reconstruction of severe acetabular defects when compared with reinforcement rings (yearly failure odds ratio 0.259 in favour of trabecular metal).

In summary, there are various techniques for reconstruction of a deficient acetabulum. These should be chosen judiciously according to the defect size, shape and location, as well as the surgeon’s expertise.

Limitations of the current study include small sample size and retrospective nature. There was no control group or blinding of the outcome measures. Moreover, only medium-term results were reported in this study. A longer follow-up period is required for better indication of the longevity of the structural bone grafts.

Conclusion

The current study showed that structural bone grafting for reconstruction of superolateral acetabular defect in primary THA yielded favourable clinical and radiographic outcomes during a mean follow up of 5.8 years.

Conflicts of interest

The authors declare that they have no financial or nonfinancial conflicts of interest related to the subject matter or materials discussed in the manuscript.

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Table 2
Comparison between preoperative and postoperative clinical assessments.

|                      | Preoperative | Postoperative | p    |
|----------------------|--------------|---------------|------|
| VAS (SD)             | 9.5 (±1.08)  | 3.3 (±2.54)   | 0.005|
| HHS (SD)             | 32.7 (±9.14) | 73.9 (±16.94) | 0.005|

HHS = Harris Hip Score; SD = standard deviation; VAS = Visual Analog Scale for Pain.

Table 3
AAOS classification of acetabular bone loss.

| Type       | Classification                        |
|------------|--------------------------------------|
| Type I     | A. Peripheral: superior/anterior/posterior |
| Segmentation | B. Central: medial wall absent       |
| Type II    | A. Peripheral: superior/anterior/posterior |
| Cavity deficit | B. Central: medial wall present |
| Type III   | Combined segmental and cavitary deficiencies |
| Combined deficit | Pelvic discontinuity               |
| Type IV    | Pelvic discontinuity                 |
| Type V     | Arthrodesis                          |

AAOS – American Association of Orthopedic Surgeons.

Table 4
Paprosky classification of acetabular bone loss.

| Type         | Classification                                      |
|--------------|----------------------------------------------------|
| Type 1       | Minimal bone loss, rims and columns intact         |
| Type 2       | A. Superior bone loss, rim intact                  |
| Type 3       | A. Superolateral bone loss                         |
| Type 4       | B. Superolateral bone loss, rim distorted           |
| Type 5       | C. Medial wall destruction                         |
| Type 6       | A. Superolateral bone loss                         |
| Type 7       | B. Superomedial bone loss                          |
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