European Journal of Orthopaedic Surgery & Traumatology (2019) 29:1411–1417
https://doi.org/10.1007/s00590-019-02458-8

ORIGINAL ARTICLE • HIP - ARTHROPLASTY

Post-operative hip centre restoration and migration after impaction bone grafting in revision and complex primary hip arthroplasty

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Received: 23 January 2019 / Accepted: 29 May 2019 / Published online: 3 June 2019

Abstract

Introduction/objectives Although impaction grafting proved efficacy in the reconstruction of acetabular defects in primary and revision hip arthroplasty, its role in large segmental defects is still debatable. Our objective is to determine hip centre restoration and last follow-up migration after acetabular reconstruction with impaction grafting in different types of acetabular defects.

Methods This is a single-centre retrospective radiographic study of (107) total hip arthroplasty (42 primary and 65 revision) in (104) patients using impaction grafting. The available radiographs were examined for normal, preoperative, immediate postoperative, and last follow-up vertical (*Y*) and horizontal (*X*) hip centre. Maximum acetabular defect distance (MADD), presence, and size of the mesh were recorded.

Results In type I and II AAOS defects, the post-operative hip centre was not significantly different from the normal hip centre on the contralateral healthy side. In type III defects, there was a significant variation between the normal hip centre and the post-operative hip centre (*P* value 0.034 and 0.001 for *Y* and *X*, respectively). At 44-month follow-up of 36 hips, 31 (86%) hips migrated. The mean migration ± SD was 5.72 ± 3.7, 2, 4.15 ± 1.2, and 11.26 ± 3.9 mm for types I, II, and III, respectively (*P* value 0.211). Hips with MADD > 15 mm, especially with large mesh sizes migrate significantly more (*P* value = 0.042, 0.037, and 0.039, respectively).

Conclusion Hip centre restoration was better, and migration was less for type I and II AAOS rather than for type III. Other options for reconstruction should be considered.

Keywords Hip centre migration · Impaction bone grafting · Complex hip arthroplasty · Revision hip arthroplasty

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Introduction

Restoration of anatomic hip centre of rotation (COR) is crucial in primary and revision total hip arthroplasty. Restoration of normal biomechanics decreases stresses and increases longevity of acetabular reconstruction [1]. Non-anatomic positioning of the acetabular component is associated with high rate of acetabular component failure [2].

Since introduction by Slooff et al. [3] in the 80s, impaction bone grafting (IBG) has been used to restore the hip centre and biologically reconstruct acetabular defects in primary and revision THR with good results at the short-term [3], at the midterm [4], and at the long-term follow-up [5]. Reproducibility of this technique was also proved by many centres other than the original one [6].

However, in large segmental acetabular defects, bone graft resorption and cup migration are serious limitations of this technique even in the presence of metallic mesh to contain the defect [7–10]. High rates of failure were reported with the use of IBG in large segmental acetabular defects and pelvic discontinuity [9].

The aim of the study is to determine the hip centre restoration (COR) in the immediate post-operative period and last follow-up migration after acetabular reconstruction with IBG in different grades of acetabular defects.

Patient and methods

This is a retrospective radiographic cohort study. We included all cases of primary or revision THA that were treated in the author's institution using impaction grafting between 2005 and 2016.

AAOS classification [11] was used to classify the acetabular defects, where type I is a segmental defect with loss of part of the acetabular rim or medial wall, type II (cavitary) is a volumetric loss in the bony substance of the acetabular cavity, type III (combined deficiency) is a combination of segmental bone loss and cavitary deficiency, when there is a pelvic discontinuity with complete separation between the superior and inferior acetabulum, and it is considered as type IV and type V when the hip is fused. All surgeries were done by the two senior authors. Modified lateral approach was used in all cases as was described by Pai [12] where instead of reflecting the anterior half of the gluteus medius and vastus lateralis as originally described by Hardinge, we only reflect the anterior third with preservation of the posterior two-thirds of the gluteus medius. After removal of the original implants, a thorough debridement was done to remove all debris, fibrous tissue, and cement remnants until a bleedy subchondral bone is reached. A cemented cup trial was then put at the level of the tear drop to determine the need for a mesh to contain the graft. Different sizes of meshes were used according to the defect size. Allograft from fresh frozen femoral head stored at our bone bank was used in all cases. Allografts were morselized using a rongeur into small pieces 7–10 mm. The morselized allograft was then washed with saline to decrease the fat content, and one gm vancomycin was added to each morselized femoral head. The grafts were impacted using serially smaller impactors until a stable graft bed is obtained. Cemented cup 4 mm smaller than the last impactor is cemented in the desired position.

The available radiographs (preoperative, immediate post-operative, and last follow-up) were examined for normal, pre-operative, immediate postoperative, and last follow-up vertical (*Y*) and horizontal (*X*) hip centre.

Centre of hip rotation (COR) was measured and calculated as described by Nunn et al. [13] using the teardrop as the reference point on both the operated side and the contralateral normal side to detect the normal hip centre. In case of abnormal contralateral hip, we used the method described by Ranawat et al. [14] to determine the normal COR. The immediate post-operative COR was then compared with the normal COR to detect restoration of the normal COR. Also, the last follow-up COP was compared with the immediate postop COR to detect the amount of migration.

The maximum acetabular defect distance (MADD) [15] was also measured to determine the maximum thickness of the graft layer in the immediate post-operative radiograph. All measurements were done by an independent researcher. Correction of radiographic magnification was done using the known diameter of the implanted femoral head. The presence and size of the mesh were also recorded.

Statistical analysis

Mann–Whitney *U* test was calculated to test the median differences of the data that do not follow normal distribution. For repeated measure analysis, related samples Wilcoxon signed-rank test was used to compare the median difference between the two groups. For variables with more than two categories, independent sample Kruskal–Wallis was used to compare the median difference between groups that do not follow normal distribution. Correlation analysis was used to test the association between variables. A *P* value equals or less than 0.05 was considered significant. The statistical software package (IBM-SPSS 21*) was used for analysis.

Table 1 Variation between post-operative vertical (*Y*) axis and the mean normal value

	Vertical axis (*Y*)		*P* value*
	Normal	Postoperative	
AAOS classification			
Type I	15.83 ± 2.1	19.35 ± 5.1	= 0.144
Type II	19.02 ± 6.0	19.13 ± 7.2	= 0.819
Type III	20.46 ± 7.6	23.83 ± 9.2	**= 0.034**

*Related samples Wilcoxon signed-rank test was used to compare the median difference between the two groups

Bold value represents $p < 0.005$

Table 2 Variation between post-operative horizontal (*X*) axis and the mean normal value

	Horizontal axis (*X*)		*P* value*
	Normal	Postoperative	
AAOS classification			
Type I	27.55 ± 4.8	32.72 ± 7.5	= 0.193
Type II	37.21 ± 6.9	34.63 ± 6.0	= 0.144
Type III	31.61 ± 6.2	34.81 ± 8.1	**= 0.001**

*Related samples Wilcoxon signed-rank test was used to compare the median difference between the two groups

Bold value represents p < 0.005

Results

One hundred and seven (107) total hip arthroplasty (42 primary, and 65 revision) patients in (104) patients were included in our cohort. There were six (5.6%) type I AAOS or segmental defects, 47 (43.9%) type II or cavitary defects, and 54 (50.5%) type III or combined cavitary and segmental defects. There were no cases of pelvic discontinuity (type IV defect).

For both type I and II AAOS acetabular defects, the immediate post-operative COR was not significantly different from the normal COR measured on the contralateral healthy side or by Ranawat method (Table 1).

Conversely, for type III defects, there was a significant variation between the normal hip centre and the immediate post-operative hip centre. Table 2 denotes a less effective restoration of the normal COR on the operated side in case of combined defects (Fig. 1).

Thirty-six hips were available for follow-up at a mean of 44 months (range 12–166). There were 6 (16.6%) type I AAOS or segmental defects, 15 (41.7%) type II or cavitary defects, and 15 (41.7%) type III or combined cavitary and segmental defects.

At an average of 44 month follow-up, 31 hips (86%) migrated, the mean amount (measured in millimetres) of migration for type I was 5.72 mm ± 3.7, for type II 4.15 mm ± 1.2, and for type III 11.26 mm ± 3.9 (*P* value 0.211) (Fig. 2).

Hips with MADD > 15 mm, with mesh, and with large mesh sizes migrate significantly more (*P* value = 0.042, 0.037, and 0.039, respectively).

Seven reconstructions failed at a mean of 38 month follow-up (range 12–95) (Fig. 3). Five were type III, one type I, and one type II. The mean MADD in the immediate post-operative radiograph was 23.95 (range 14.9–42.6), and the mean vertical migration at the last follow-up was 23.9 (range

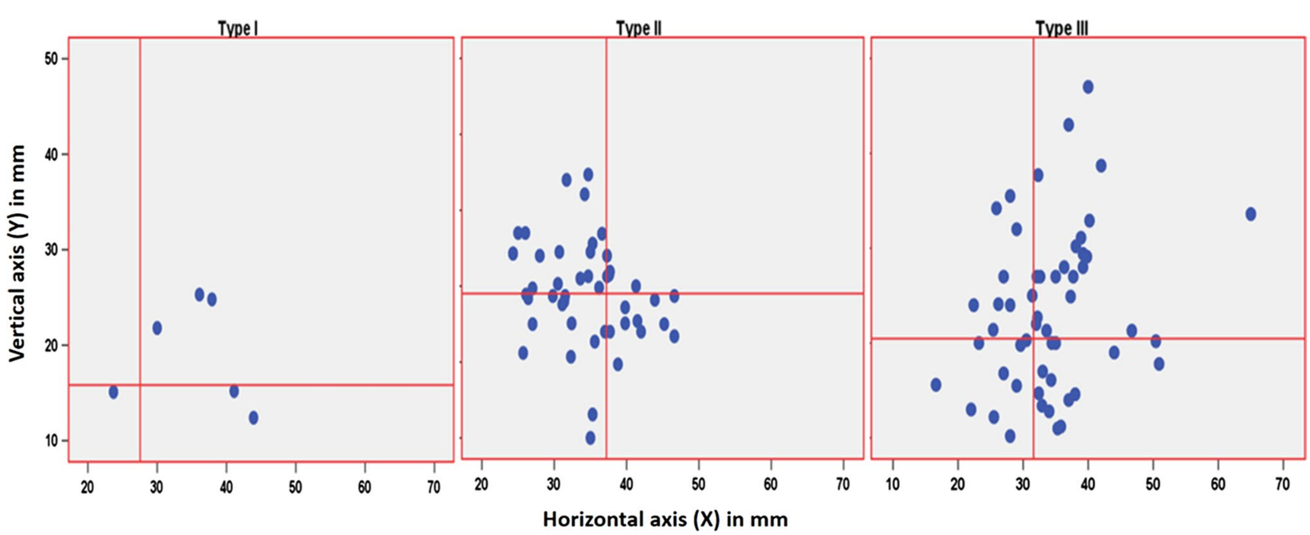

Fig. 1 Scatter plot comparing post-operative COR (blue points) restoration with the average normal COR (the intersection of the horizontal and vertical red lines) between different types of AAOS defects (colour figure online)

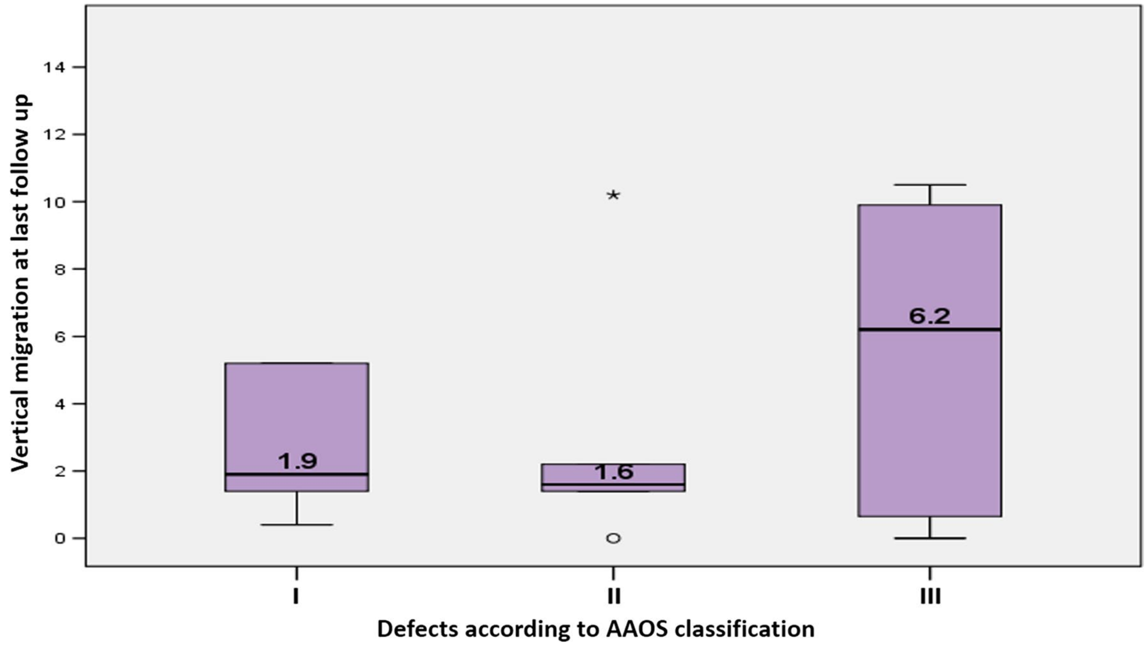

Fig. 2 Boxplot of the amount of last follow-up migration for each group

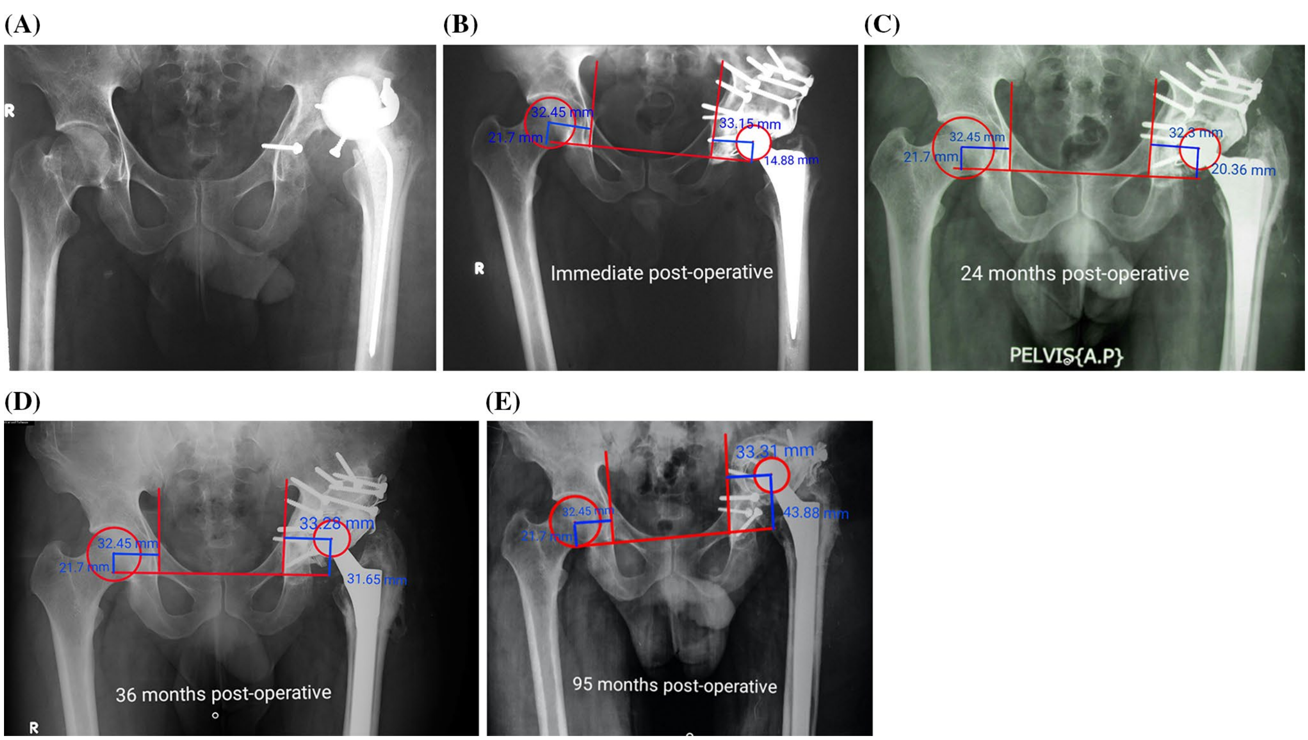

Fig. 3 Male patient 36 years with type III AAOS defect. **a** Pre-operative AP pelvis radiographs, **b** immediate post-operative radiographs with restoration of the COR, **c** after 24-month follow-up, COR migrated about 6 mm, **d** after 36-month follow-up, COR migrated about 16 mm, **e** after 95-month follow-up, cup loosening with COR migration about 28 mm

6.2–42 mm). Mesh was used in six cases. Four were large, one medium, and one small.

Discussion

Reconstruction of large acetabular defects in revision total hip arthroplasty continues to constitute a great challenge. Small contained defects can be successfully managed with morselized allografts and a cemented or cementless cups [16]. However, the optimal option for large uncontained defects remains challenging and controversial.

The surgical options include extra-large hemispheric cups [17] and reconstruction cages [18]. More recent techniques to manage sever acetabular defects include the custom triflange acetabular component CTAC [19] and trabecular metal implants and augments [20, 21].

Impaction grafting of the acetabulum has been advocated as an excellent method for reconstructing acetabular defects with an excellent long-term survival [5].

Impaction grafting allows for restoration of acetabular bone stock and normal hip centre of rotation [7]. However, most of these series included a heterogenous groups of small and lager defects and did not focus on the size of defect. With more extensive and segmental defects, there is controversy whether impaction bone grafting is similarly efficient.

Van Haaren et al. [9] reported high failure rate using impaction grafting for large acetabular defects. At a mean follow-up of 7.2 years, 20 (28%) out of 71 acetabular components required re-revision for aseptic loosening, giving an overall survival of 72%. Of these failures, 14 (70%) had an AAOS type III or IV bone defect. Of the AAOS IV group (six patients), five hips failed and only one succeeded. On the other hand, Van Egmond et al. [22] reported good results with the use of impaction grafting in large acetabular defects. At a mean follow-up of 8.8 years of 27 reconstructions (25 type III, two type IV), only three hips were revised (11.1%) and two were radiographically loose (7.4%).

In our series, there was a significantly less efficient restoration of the normal COR in cases with type III defects than with types I or II defects. At a mean of 44 months of 36 hips, 81% of hips migrated. Using radiostereometric (RSA) analysis, in the setting of IBG, almost all socket migrates in the post-operative time. At 5-year follow-up, Ornstein et al. [23] detected a significant migration of 16 out of 17 cemented cups from 0.4 to 8.2 (median, 2.5 mm) with impaction grafting. Although migration rate decreased gradually during the observation period, four sockets continued to migrate between the 4- and 5-year follow-up. Mohaddes et al. [24] detected higher early proximal migration of the hip centre with the use cemented of cup rather than uncemented cups with impaction grafting in acetabular revision followed for 17 years. Klerken et al. [25], in a stereometric analysis of 312 acetabular revision, concluded that early (2 year) migration of hip centre after revision total hip arthroplasty is a strong predictor of aseptic loosening.

We could detect a correlation between size of the defect and migration of the hip centre. However, due to small number of cases in the follow-up group, it did not reach the statistical significance. However, there was a significant impact of graft thickness (MADD > 15 mm), the presence and size of the mesh (large mesh) on the amount of vertical migration.

Iwasi et al. [15] defined the term MADD maximum acetabular defect distance (MADD) as a quantitative post-operative radiographic assessment of bone stock deficiency. Cup survival was compromised with MADD of more than 20 mm or with severe uncontained defect that had to be contained by double meshes.

Out of 173 acetabular reconstruction with the use of impaction bone grafting, Boldt et al. [26] detected migration of the acetabular component > 4 mm in four cases only. All of them were type III Paprosky acetabular defect. Severity of the defect was a significant indicator of migration. In type III defects, they recommend using a cage rather than a mesh.

Similarly, Buttaro et al. [27] showed that metal mesh did not prevent cup migration with an average of 5.1 mm (range 2–25 mm) migration occurred all cases (23). They recommended using mesh and IBG in medium contained acetabular defects, not for large uncontained defects. Mesh size was also a risk factor with higher failure rate with larger meshes [28]. They also advised against the use of IBG in segmental defects.

Rigby et al. [8] reported disappointing results when a large rim mesh is used to reconstruct a large segmental defect. Nine out of 60 (15%) segmental defects were revised for aseptic loosening.

Garcia et al. [10] reported on 204 acetabular reconstruction Paprosky type IIIA (100) and Paprosky type IIIB (104) with use of IBG with or without mesh.

At a mean of 10 years, the results were better for hips with contained or large medial defects than for hips with large segmental rim defect with large rim mesh. They suggest seeking for another method of reconstruction for such challenging defects.

Due to poor results, many authors advice to combine the use of trabecular metal augments with impaction grafting instead of using large metallic meshes [20].

Our study has many limitations. A small number of patients were included in the follow-up. More number of patients with more follow-up is required for more significant results. We used only conventional radiographs which are inadequate for detecting migration less than 4–6 mm [29] and for detecting early loosening. Radiostereometric analysis can detect less than 1 mm migration and less than 18° of rotation [23].

Conclusion

Hip centre restoration (COR) was better, and migration was less for type I and II AAOS rather than for type III. Other options for reconstruction of these challenging defects should be considered.

Compliance with ethical standards

Conflict of interest All authors declare that they do not have conflict of interest, and no funding had been received for this research.

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