MUSCULOSKELETAL SURGERY (2019) 103:173–179
https://doi.org/10.1007/s12306-018-0573-5

ORIGINAL ARTICLE

The biological acetabular reconstruction with bone allografts in hip revision arthroplasty

L. Busanelli[1] · F. Castagnini[1] · B. Bordini[2] · S. Stea[2] · P. P. Calderoni[1] · A. Toni[1]

Received: 24 March 2018 / Accepted: 10 October 2018 / Published online: 16 October 2018

Abstract

Background Reconstructions in case of acetabular bone loss in hip revision arthroplasty are challenging. A few techniques have been proposed, with inconstant outcomes. Biological reconstructions using bone allografts may address the acetabular bone loss and restore the hip anatomy. Aim of this work was the description of the surgical technique and the evaluation of the outcomes using a regional arthroplasty register.

Materials and methods Minor or massive bone allografting was performed in hip revision arthroplasties in a tertiary center. Bulk allografts were used in severe acetabular bone losses. Fresh-frozen femoral heads were impacted in the bone cavity and porous cups were implanted; multihole sockets were used when necessary. In DeLee A zone, no grafts were used in order to reduce overstress graft resorption. The results were evaluated using a regional arthroplasty register, and a comparison with revisions without bone grafts was performed investigating re-revision rates and reasons for further revisions.

Results At 10 years, acetabular revisions with bone allografts achieved a similar survival rate than revisions without bone grafts. The re-revisions occurred more frequently in revisions without bone allografts (10.8 vs. 9.7%). In the allograft cohort, septic loosening was lower (0.3 vs. 2.6%), whereas a higher rate of aseptic cup loosening was experienced (2.7 vs. 1.4%).

Conclusions Bone allografts may provide a good restoration of the acetabular bone stock and the hip biomechanics. Septic loosening does not seems a major concern, whereas a higher rate of aseptic cup loosening should be expected when bone grafts are used.

Keywords Acetabular · Bone loss · Massive · Loosening · Long term

Introduction

The hip revision arthroplasty is still a hot topic in orthopedic surgery. Despite the technical advancements of the implants, the rate of revision procedures is not decreasing, with instability and mechanical loosening being the most common reasons leading to reimplantation [1, 2].

In revision procedures, the main goals are the achievement of a good primary stability, the restoration of the hip biomechanics and the bone stock [3, 4]. In fact, the bone loss is a frequent cause of concern in revision procedures, in particular when the acetabular cup is involved [1–5]. The available techniques adopted to revise an acetabular cup with a reduced bone stock and a segmental defect without pelvic discontinuity are mainly three: morselized bone grafts, cages and cemented cups; acetabular revision shells (oblong, jumbo, pedestal, etc.); bone grafts and porous press-fit cups [1–5].

The technique involving morselized bone graft, cage (or mesh) and cemented cup allows an anatomical cup positioning in the true acetabulum [2–6]. The primary stability is achieved bypassing the bone loss, which is partially filled with morselized grafts: thus, it is independent from the bone grafts [2–6]. However, the main drawbacks are related to the large exposure, the challenging technique, and most of all, the lack of cage or mesh osseointegration [2–6]. Furthermore, the acetabular reconstructions using cemented cups demonstrated remarkable rates of long-term failures [2–6].

✉ F. Castagnini
francescocastagnini@hotmail.it

[1] Ortopedia-Traumatologia e Chirurgia protesica e dei reimpianti d'anca e di ginocchio, IRCCS Istituto Ortopedico Rizzoli, Via Pupilli 1, 40136 Bologna, Italy

[2] Laboratorio di Tecnologia Medica, IRCCS Istituto Ortopedico Rizzoli, Via di Barbiano 1/10, 40136 Bologna, Italy

The acetabular revision shells may provide a good primary stability with a theoretical large bone-implant contact, restoring the center of rotation [3–5, 7–9]. These surgical techniques are often demanding, and the cup positioning is challenging as well; excessive bone reaming may be required, furtherly sacrificing other supportive bones [3–5, 7–9]. The long-term results were not always satisfying; thus, these techniques should be performed in selected patients [3–5, 7–9].

The use of bone grafts provides a biological reconstruction of the acetabulum, allowing the implantation of a hemispherical press-fit cup [10–17]. The main advantages of this approach are the restoration of the hip anatomy and the bone stock [10–17]. The osteoconductive and osteoinductive properties of the allograft may provide a good mechanical construct, allowing the restoration of the offset and the center of rotation and enhancing the bony ingrowth [10–17]. Moreover, the renewed bone stock may provide an adequate support for a good cup osseointegration and a possible re-revision procedure [10–17]. Since the first results described by Paprosky et al. in severe defects, the literature reported a good cumulative survival rate at 5 years (77–100%) and at 10 years (74%) in Paprosky type III defects [12, 13]. Beyond some encouraging results, few drawbacks, as the partial resorption of the graft, the precocious cup loosening and a high rate of infection, were reported, questioning the results of the bone grafts [3–5, 10–17].

Aim of this report is describing the surgical technique with bone allografts in revision procedures. The registry outcomes of bone graft revisions were also reported and compared to revisions with no bone graft.

Materials and methods

Surgical technique

All the procedures start with a correct surgical preoperative planning, implying serial X rays, CT scan (from the fourth lumbar vertebra to the tibial plateau) and MARS protocol MRI when appropriate (pseudotumors, metal-on-metal implants). Infection must be ruled out.

We generally perform a lateral approach, with the patient in supine position. The components' stability is manually evaluated. Loosened components are removed: retention of the femoral component is suggested when the stem is well fixed and in adequate position, in order to avoid the high morbidity of an unnecessary removal. The acetabular component is easily removed in case of major osteolysis; however, removal blades (Explant, Zimmer, Warsaw, Indiana; CupX, Innomed, Savannah, Georgia) are adopted when the socket is at least partially integrated. Then, the acetabulum is widely debrided and all the fibrous and necrotic tissues are removed. The bony defects are visualized and classified according to Paprosky [10, 15]. Allograft bone filling is performed in case of a notable bone loss, with partial involvement of the columns, and no pelvic discontinuity (Paprosky type II and III defects) [3–5, 10, 12]. Minor acetabular defects are filled with the reamed bone or morselized bone allografts, and larger segmental ones require massive bone grafts [3–5, 10, 12]. In case of massive bone grafts, fresh-frozen femoral heads are prepared: the cartilage is fully abraded and the graft is modeled, in order to achieve a diameter which is larger than the bone defect. The graft can be also partially reamed before the impaction, outside the acetabulum, in order to achieve a more appropriate shape. Then, the graft is positioned inside the acetabulum and impacted. The graft may substitute the zones B and/or C according to DeLee and Charnley; the zone A is not filled [16, 17]. Grafting in zone A should be avoided as the risk of resorption is notable, in particular when the graft-cup contact exceeds 50% [16, 17]. Thus, a high hip center technique is adopted, without any bone graft in the superior part of the acetabular cavity: the cup is superiorly supported by the remaining native bone only [16, 17]. The acetabular cavity is then reamed with the same version and abduction of the future cup implant, preserving the bone stock of the posterior column. The orientation of the reaming is also dictated by the version of the stem, in order to provide a correct reciprocal positioning of both the components (combined anteversion) [5, 7]. The cup is then implanted, adding supplemental screw fixation in case of massive bone grafting and precarious primary stability. The femur is inspected as well: in case of osteolysis without a frank loosening, a bone filling of the metaphysis with morselized bone allograft is suggested. After liner positioning, a trail reduction is performed and the head is subsequently chosen. A modular head adapter system may be adopted to adjust the leg length, the offset and the version (Figs. 1, 2, 3). The capsule should be sutured whenever possible, in order provide a further restraint to dislocation. The abductor muscles are carefully reattached.

Rehabilitation

The rehabilitation is started the day after. External rotation and adduction are prohibited, and a hip brace is positioned in case of compromised soft tissue envelopes. A touch-down weight bearing is allowed for 45–60 days using two crutches. Abductor strengthening exercises are encouraged. The full weight bearing is not allowed before the third month, and it should be delayed until the graft is radiographically integrated.

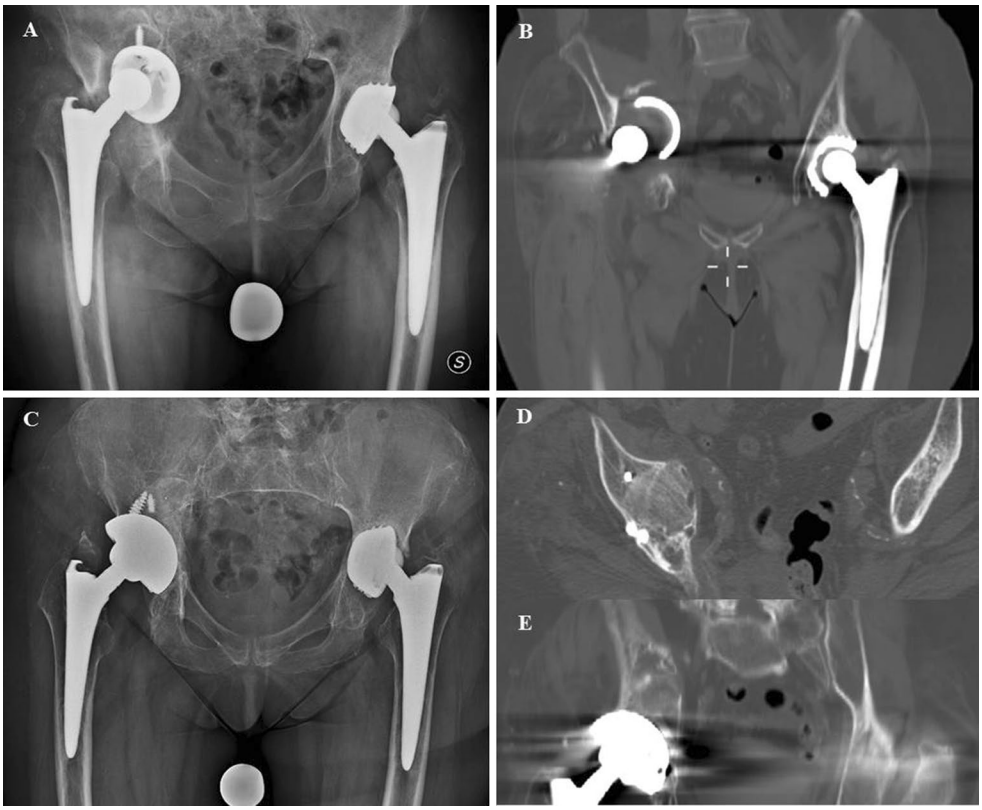


Fig. 1 Aseptic cup loosening with intrapelvic migration (Paprosky III B without pelvic discontinuity) was diagnosed in a 67-year-old female patient (**a** anteroposterior pelvis X-ray, **b** coronal CT scan). The revision procedure was performed using a femoral head allograft, positioned in zone B, and a multihole porous socket (Trilogy, Zimmer, Warsaw), stabilized with two screws. After 4 years, the anteroposterior X-ray (**c**) and the CT scan (**d** axial; **e** coronal) showed a stable implant with a good restoration of the bone stock

Methods

RIPO is the regional arthroplasty registry of Emilia Romagna region (over 4 million inhabitants), collecting data about primary and revision procedures about hip, knee and shoulder arthroplasties since 2000. For every primary or revision surgery, a specific form about the features of the patients, the diagnosis or reason for revision and the type of the implant (batch and code) are collected. The capture rate of RIPO is 98% [18]. We investigated the RIPO registry about the distribution and the survivorship of bone allografts in revision procedures. Data about all the revision surgeries were collected and used as a control cohort. The assessment was performed only considering the patients residing in Emilia Romagna region, in order to minimize the bias of loss to follow-up: in these cases, the procedure, even when performed outside the region, is reimbursed to Emilia Romagna region and it is captured by the registry [18]. Out of the resident patients evaluated by RIPO, only the hip revisions performed in our specialized tertiary care center were eventually included. In this way, the previous surgical technique with the above-mentioned indications could be assessed on a very large case series.

Local ethical committee approval was not necessary due to the features of RIPO, collecting data as a standard practice and concealing the identity of the patients.

Results

From January 2000 to December 2015, 2086 revisions were performed. According to the above-mentioned inclusion criteria (resident patients treated in our specialized center), 846 revision procedures were eventually considered. 339 patients (40%) were treated with a bone allograft (minor or massive grafts). 305 patients underwent an acetabular grafting, and in 34 patients, an acetabular and femoral grafting was performed in the same surgery.

The two revision cohorts (with a bone graft, 339 patients, and without a bone graft, 507 patients) were compared and a mean follow-up of 6.5 years was achieved. The survivorships (defined as no further surgical procedure performed) were roughly similar: at 10 years, the survival rate was 88.1% (83.1–91.8%) for bone graft revisions and 87.5 (83.6–90.6%) for revision without bone grafts (Fig. 4). In particular, the aseptic loosening occurred in 19 cases (2.7%) in the bone

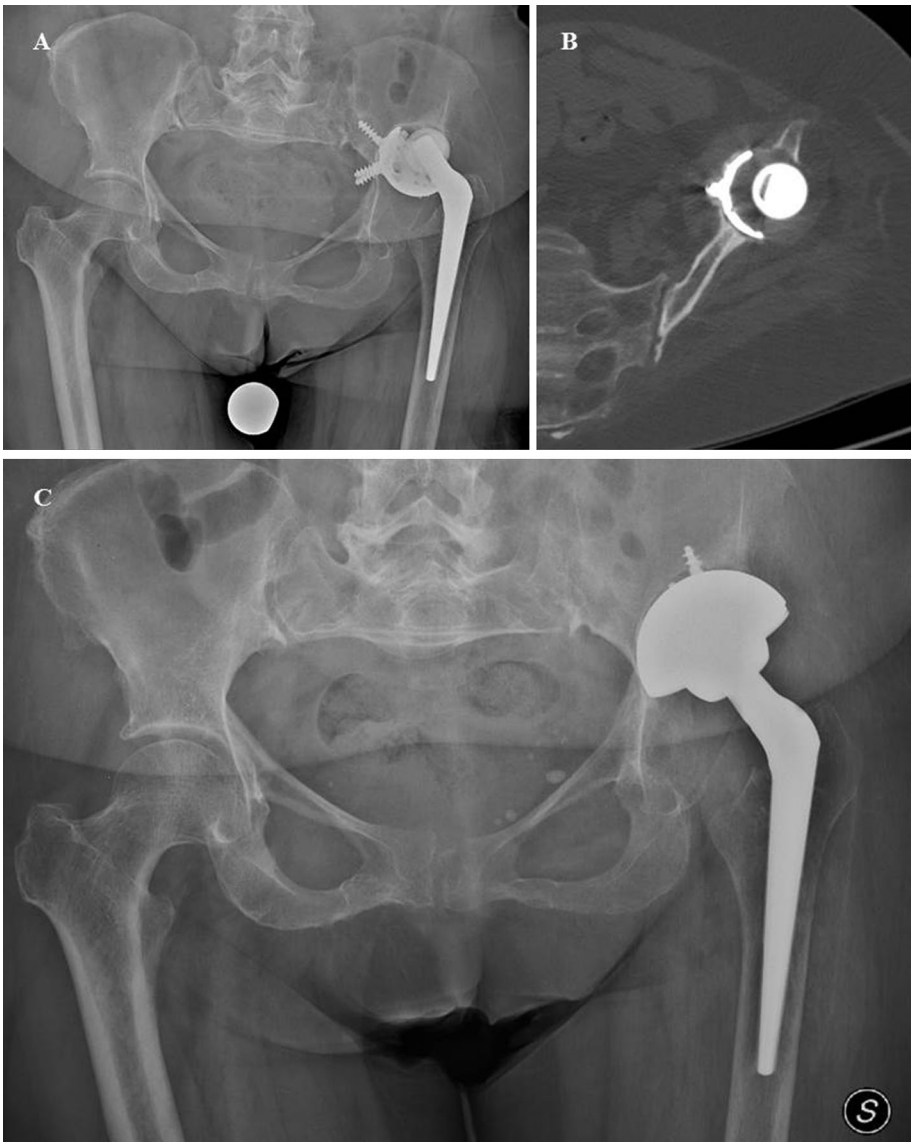


Fig. 2 The anteroposterior X-ray (**a**) and axial CT scan (**b**) showed an aseptic loosening of the cup in a 53-year-old female patient, with a severe bone loss and cranial migration classified as Paprosky III A. The cup was revised with multihole porous socket (Trilogy, Zimmer, Warsaw) and morselized bone apposition (**c** anteroposterior radiographic result after 3 years)

graft revision cohort and in 22 patients (1.4%) in the simple revision cohort. The revisions due to sepsis were inferior in procedures with bone grafts (0.3 vs. 2.6%) (Table 1).

Discussion

A few acetabular cup revision techniques are currently available in case of a segmental bone loss without pelvic discontinuity: among them are cage and cemented cups, revision shells, bone graft and porous cups [1–17]. Cemented cups achieved disappointing results (survival rates lower than 70% at 10 years) [3, 4, 9]. Revision implants, oblong and pedestal shells were burdened with limited experiences and applicability along with inconstant outcomes and technical challenges [3, 4, 8, 9]. Porous metal augments and acetabular bone grafts appear to be the most valid techniques, with encouraging outcomes [3, 4, 8, 9]. However, the promises of trabecular metal cups and porous augments have not been yet confirmed by long-term studies (survival rates higher than 90% at 3 years) [3, 4, 8, 9]. On the other hand, acetabular bone grafts achieved encouraging survival rates (> 80%) at 10 years in severe acetabular bone loss [12–14, 16]. Nevertheless, a few concerns about graft resorption, cup loosening and infection still exist [3–5, 10–16].

In the present case series, the survival rate of bone graft revisions (encompassing morselized bone and bulk allografts) was 88% at 10 years, comparable to the survival rate of revisions without bone allografts. The survivorship of bone allograft revisions was higher than the pertinent literature about similar bone defects (Paprosky type II and III) [12–16]. Two main findings should be highlighted: the rate of septic loosening was lower for graft revisions and the rate of aseptic loosening was higher in the bone graft

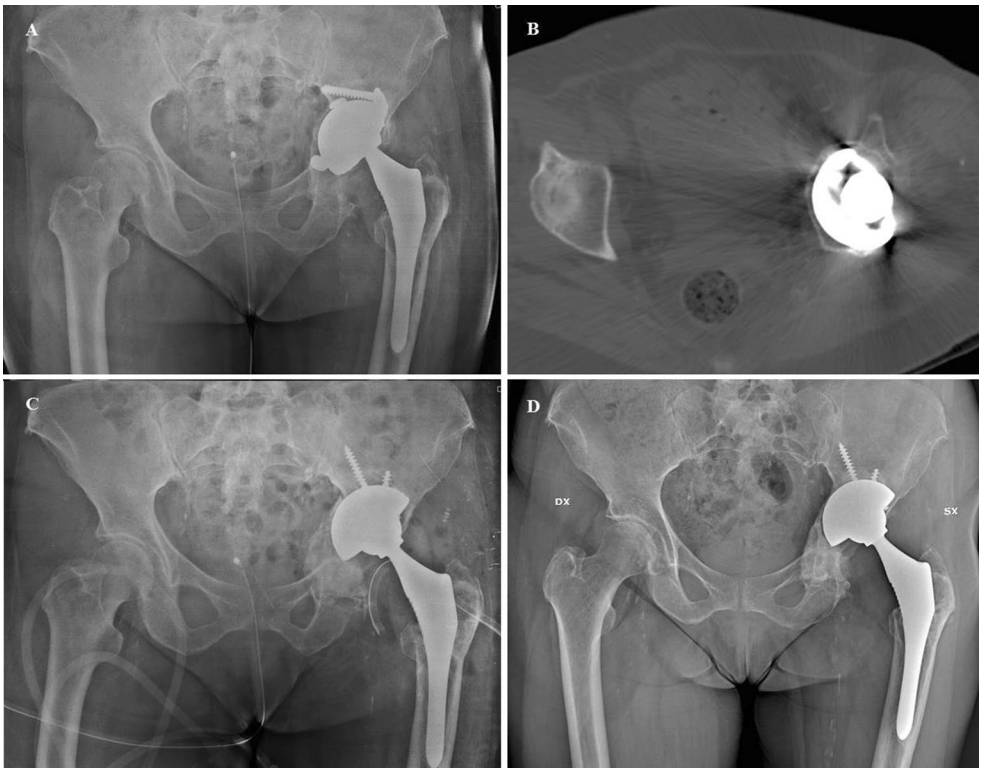
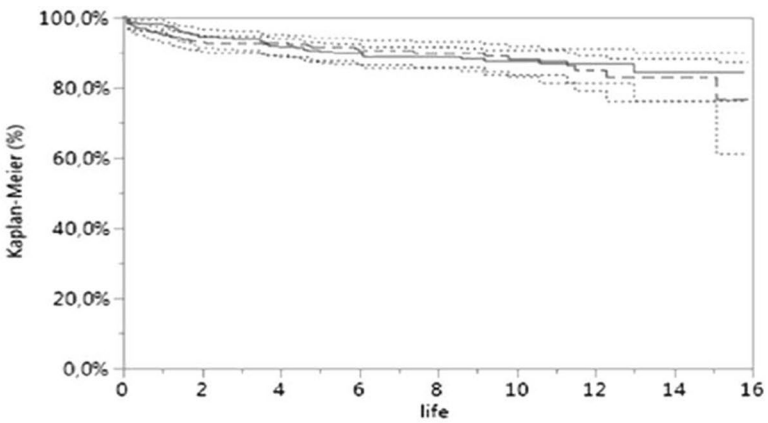


Fig. 3 Aseptic cup loosening with severe bone loss Paprosky III B without pelvic discontinuity was diagnosed in a 71-year-old female patient (**a** anteroposterior pelvis X-ray; **b** axial CT scan). The revision procedure was performed using a femoral head allograft, positioned in zones B and C, and a multihole porous socket (Trilogy, Zimmer, Warsaw), stabilized with two screws (**c**). After 2 years, the anteroposterior X-ray showed a stable implant with a good restoration of the bone stock (**d**)



	Survivorship 5 years	Survivorship 10 years
Without bone allografts	90.2 (87.0-92.6) Exposed: 309	87.5 (83.6-90.6) Exposed: 102
With bone allografts	91.4 (87.7-94.1) Exposed: 215	88.1 (83.1-91.8) Exposed: 85

Fig. 4 The Kaplan–Meier curves of hip revisions with bone allografts (black line) and without bone allografts (dotted line) showed similar outcomes, bone allografts performing better at long follow-ups

cohort. Thus, aseptic loosening is still a possible drawback of allograft revision procedures [12, 14, 16]. However, after a valid bone grafting, if a cup loosening occurs, the restoration of the bone stock may provide the surgeon a valid support for a simpler cup re-revision, converting the previous high graded defect in a minor bone loss [14, 16]. Thus, the use of allografts in case of segmental bone defects, massive or minor ones, seems reliable even at

Table 1 Reasons for revision were listed for hip revisions without bone allografts and with bone allografts: the rates were reported as absolute values and as percentages

Reasons for revision	Without bone allografts (507 patients)	With bone allografts (339 patients)
Pain without loosening		1 (0.3%)
Periprosthetic fracture	2 (0.4%)	4 (1.2%)
Dislocation	11 (2.2%)	6 (1.8%)
Septic cup loosening	1 (0.2%)	
Septic stem loosening	1 (0.2%)	
Aseptic cup loosening	7 (1.4%)	9 (2.7%)
Aseptic loosening (cup + stem)	4 (0.8%)	4 (1.2%)
Aseptic stem loosening	11 (2.2%)	6 (1.8%)
Septic loosening (cup + stem)	11 (2.2%)	1 (0.3%)
Neck breakage	1 (0.2%)	1 (0.3%)
Cup breakage		1 (0.3%)
Cup breakage in pedestal implant	2 (0.4%)	
Liner breakage	2 (0.4%)	
Wear	2 (0.4%)	
Total	55 (10.8%)	33 (9.7%)

long-term follow-ups. The rate of re-revisions is not higher than in revisions in general, although more cases of aseptic loosening should be expected.

Successful outcomes are related to a careful surgical technique. The most remarkable tricks of this technique are related to the use of allografts and the choice of the implant. In our present case series and in the previous study by Traina et al., the femoral head allograft was shaped and impacted in the bone defect in order to restore the bone stock of the DeLee and Charnley zones B and/or C [16]. Allografts were not used to restore the bone loss in DeLee and Charnley zone A [16, 17]. In fact, the bone graft resorption is higher if the allograft is overstressed [16, 17]. In case of bone loss in zone A, the use of a high hip center is a feasible technique to bypass the bone loss, providing durable results without impairing the abductor functions [16, 17].

In the revision approach, the use of a porous cup plays a remarkable role. A porous socket in biocompatible materials, with a modulus of elasticity close to the bone and a high surface roughness, allows an effective primary stability [9]. When a porous cup is not sufficient, supplemental screws may provide a rigid initial fixation [3, 4, 9]. In particular, when a large defect is present and the initial fixation is precarious, a multihole socket may provide a valuable solution [3, 4]. The reinforcements rings or antiprotrusio cages should not be adopted to protect the bone grafts: these devices require large exposures and, if not correctly positioned, show an unacceptable rate of early failures (up to 50% of the cases) [15].

Registry studies show limits by their nature [18]. Some elder and severely ill patients may have been unwilling to undergo a re-revision. Thus, the survivorship may have been overestimated, even if the comparison between the two revision cohorts should not have been affected. Bone allografts are usually performed in more difficult cases, whereas revisions without bone grafts can be appropriate in case of non-notable bone loss: thus, the outcomes of the graft cohort may have been not properly compared. A channeling bias should be expected as well, as registry does not allow to select the patients basing on the defect size. However, in our Unit, the use of bone grafts in revision procedures have been performing with the same indications since 2000 (see "Methods" section). On the contrary, the strengths of this study are related to the difficult cases involved, the large case series and the follow-up.

Bone allografts to fill acetabular bone defects in revision hip arthroplasty may provide good long-term results, comparable to simpler revisions with no need of bone allografts. Sepsis is not a major concern when a bone graft is adopted. However, a higher rate of aseptic cup loosening should be expected in such a cohort. To achieve satisfying results, a meticulous surgical technique should be adopted: it is important to protect the allograft from any stress and use a porous cup to improve the osseointegration of the implant. Case–control studies should be performed in order to confirm these preliminary results.

Compliance with ethical standards

Conflict of interest The last senior Author has received benefits for personal and professional use from a commercial party related directly and indirectly to the subject of this article (Zimmer, Warsaw, US; CeramTec, Plochingen, Germany; Adler Ortho, Milan, Italy, Cremascoli Ortho). The other authors declare that there is no potential conflict of interest relevant to this article.

References

1. Bozic KJ, Kurtz SM, Lau E, Ong K, Vail TP, Berry DJ (2009) The epidemiology of revision total hip arthroplasty in the United States. J Bone Joint Surg Am 91(1):128–133
2. Lamo-Espinosa J, Duart Clemente J, Díaz-Rada P, Pons-Villanueva J, Valentí-Nín JR (2013) The Burch–Schneider antiprotrusio cage: medium follow-up results. Musculoskelet Surg 97(1):31–37
3. Sheth NP, Nelson CL, Springer BD, Fehring TK, Paprosky WG (2013) Acetabular bone loss in revision total hip arthroplasty: evaluation and management. J Am Acad Orthop Surg 21(3):128–139
4. Chen AF, Hozack WJ (2014) Component selection in revision total hip arthroplasty. Orthop Clin North Am 45(3):275–286
5. Kim YH (2017) Acetabular cup revision. Hip Pelvis 29(3):155–158

6. Hourscht C, Abdelnasser MK, Ahmad SS, Kraler L, Keel MJ, Siebenrock KA, Klenke FM (2017) Reconstruction of AAOS type III and IV acetabular defects with the Ganz reinforcement ring: high failure in pelvic discontinuity. Arch Orthop Trauma Surg 137(8):1139–1148
7. Pulido L, Rachala SR, Cabanela ME (2011) Cementless acetabular revision: past, present, and future. Revision total hip arthroplasty: the acetabular side using cementless implants. Int Orthop 35(2):289–298
8. Stihsen C, Hipfl C, Kubista B, Funovics PT, Dominkus M, Giurea A, Windhager R (2016) Review of the outcomes of complex acetabular reconstructions using a stemmed acetabular pedestal component. Bone Joint J 98(6):772–779
9. Trumm BN, Callaghan JJ, Liu SS, Goetz DD, Johnston RC (2012) Revision with cementless acetabular components: a concise follow-up, at a minimum of twenty years, of previous reports. J Bone Joint Surg Am 94(21):2001–2004
10. Paprosky WG, Perona PG, Lawrence JM (1994) Acetabular defect classification and surgical reconstruction in revision arthroplasty. A 6-year follow-up evaluation. J Arthroplast 9(1):33–44
11. Bilgen OF, Bilgen MS, Oncan T, Danış M (2012) Acetabular reconstruction by impacted cancellous allografts in cementless total hip arthroplasty revision. Acta Orthop Traumatol Turc 46(2):120–125
12. Brubaker SM, Brown TE, Manaswi A, Mihalko WM, Cui Q, Saleh KJ (2007) Treatment options and allograft use in revision total hip arthroplasty the acetabulum. J Arthroplast 22(7 Suppl 3):52–56
13. Sporer SM, O'Rourke M, Chong P, Paprosky WG (2006) The use of structural distal femoral allografts for acetabular reconstruction. J Bone Joint Surg Am 88(Suppl 1 Pt 1):92–99
14. Piriou P, Norton M, Marmorat JL, Judet T (2005) Acetabular reconstruction in revision hip surgery using femoral head block allograft. Orthopedics 28(12):1437–1444
15. Paprosky WG, Sporer SS, Murphy BP (2007) Addressing severe bone deficiency: what a cage will not do. J Arthroplast 22(4 Suppl 1):111–115
16. Traina F, Giardina F, De Clerico M, Toni A (2005) Structural allograft and primary press-fit cup for severe acetabular deficiency. A minimum 6-year follow-up study. Int Orthop 29(3):135–139
17. Dearborn JT, Harris WH (1999) High placement of an acetabular component inserted without cement in a revision total hip arthroplasty. Results after a mean of ten years. J Bone Joint Surg Am 81(4):469–480
18. Castagnini F, Sudanese A, Bordini B, Tassinari E, Stea S, Toni A (2017) Total knee replacement in young patients: survival and causes of revision in a registry population. J Arthroplast 32(11):3368–3372