Trabecular metal cup outcomes in complex acetabular reconstruction
Review of 42 cases with a 3-year follow-up

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Abstract
Introduction: The aim of this study is to assess our clinical-radiographic results with the use of trabecular tantalum cups for the reconstruction of complex acetabulums, both in primary surgeries and revisions, and compare them with other authors' similar series.
Materials and Methods: We carried out a retrospective revision of a series of 42 surgeries (29 revisions and 13 primary arthroplasties) in 40 patients between March 2010 and March 2016. The series included 20 females and 20 males who averaged 60 years of age (ranging from 27 to 93). The patients' average follow-up was of 37 months (ranging from 12 to 84). All the patients were treated with the same type of trabecular metal.
Results: At average 37-month follow-up survival rates in the acetabular component were of 97.6%. One patient was treated with resection arthroplasty due to persistent infection. Global complication rates were of 12% and the average postoperative Harris Hip Score was of 81.54 (63.25-92.75).
Conclusions: Although a longer follow-up is required, the use of trabecular metal cups gets promising results in the treatment of complex acetabulums.

Key words: Hip arthroplasty; complex acetabular reconstruction; trabecular metal.
Level of evidence: IV

Uso de copas de tantalio trabecular para la reconstrucción acetabular compleja. Resultados de una serie de 42 casos y un seguimiento promedio de tres años

Resumen
Introducción: El objetivo de este estudio es analizar nuestros resultados clínico-radiológicos con el uso de copas de tantalio trabecular para la reconstrucción de acetábulos complejos, tanto en cirugías primarias como en revisiones, y compararlos con series similares de otros autores.
Materiales y Métodos: Se llevó a cabo una revisión retrospectiva de una serie de 42 cirugías (29 revisiones y 13 artroplastias primarias) en 40 pacientes, entre marzo de 2010 y marzo de 2016. La serie incluyó a 20 mujeres y 20 hombres, con una edad promedio de 60 años (rango 27-93). El seguimiento promedio fue de 37 meses (rango 12-84). Todos los pacientes fueron tratados con el mismo tipo de metal trabecular.

Conflict of interests: The authors have reported none.

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Resultados: Al promedio de seguimiento mencionado la supervivencia del componente acetabular fue del 97,6%. Un paciente fue tratado con artroplastia de resección debido a una infección persistente. La tasa de complicaciones totales fue del 12% y el promedio del Harris Hip Score posoperatorio fue de 81,54 (rango 63,25-92,75).
Conclusiones: Aunque se necesita un seguimiento más prolongado, el uso de copas de metal trabecular logra resultados prometedores para el tratamiento de acetábulos complejos.

Palabras clave: Artroplastia de cadera; reconstrucción acetabular compleja; metal trabecular.
Nivel de Evidencia: IV

Introduction

The aims in primary or revision acetabular prosthetic surgery are to restore hip anatomy and function by stable and enduring fixation. In the case of a complex acetabulum, i.e. prosthetic revision with moderate or severe defects; Crowe 2 acetabular dysplasia and beyond,[1] acetabular fracture sequelae, acetabular protrusion, Paget disease, etc., many of the acknowledged reconstruction techniques can fail by not reaching the aforementioned aims.[2,3] In such scenarios, traditional cementless cups are the most frequently used methods and have resulted in very good results in numerous series.[4-6] Failure is associated with more complex cases where it is difficult to get initial stability and minimal 50% of contact with host tissues, both of them being indispensable requirements to ensure success in this technique.[7] The development and use of 75-80% porous trabecular tantalum metal with high friction quotient and Young's elasticity modulus similar to bone, what gives the implant a higher osteoconductive profile, gets better short- and mid-term results in the treatment of these complex acetabulums.[8-16]

The main aim of this study is to analyze our experience with the use of trabecular tantalum cups (MT, Zimmer, Warsaw, Indiana, US) for the treatment of these cases and compare our series with other author's similar ones.

Materials and Methods

We analyzed a series of 42 surgeries in 40 patients operated on between March 2010 and March 2016 with an average follow-up of 37 months (ranging from 12 to 84). All of them showed complex acetabulums: 22 cases (75.85%), acetabular revision with Paprosky's III type acetabular defects; seven (24.13%), Paprosky's II type acetabular defects where the contact with host bone was around 50%; six (14.28), dysplastic hip with implant-host bone contact lower than 50%; two cases (4.76%), severe acetabular protrusion; two cases (4.76%), osteoarthritis with Paget disease; one (2.38%), sequelae of acetabular fracture; one, (2.38%), sequelae of hip septic arthritis who received primary cement spacer and subsequent revision; and one case (2.38%), sequelae of hip avascular necrosis with great acetabular damage.

The series was made up of 20 females and 20 males who averaged 60 years of age (ranging from 27 to 93). We carried out 29 revisions: 51.7% (15 cases) due to septic loosening; 44.8% (13 cases) due to mechanical loosening and 3.4% (1 case) due to instability (Table 1, Figure 1).

In 13 cases, we carried out primary arthroplasty: in 46.1% (6 cases), due to sequelae of dysplastic hip (Figure 2); in 15.3% (2 cases), due to osteoarthritis in patients with Paget disease; in 15.3% (2 cases), due to severe acetabular protrusion in patients with rheumatic osteoarthritis; in 7.6% (1 case), due to sequelae of acetabular fracture; in 7.6% (1 case), due to extensive acetabular injury in a patient with hip avascular necrosis; and in 7.6% (1 case), due to hip septic arthritis with joint destruction, with the patient being subject to two-time prosthetic replacement, receiving first a cement spacer with antibiotic and, later, hip reconstruction. The average number of surgeries per patient was 2.6 (ranging from 1 to 7). In all cases patients were subject to oblique X-rays and CT scan for our better evaluation of bone defects.[17]

The average preoperative Harris Hip Score[18] was 34.4 (ranging from 17.5 to 45.75). In every procedure we used tranexamic acid to decrease intraoperative bleeding.[19] Antibiotic prophylaxis consisted of i.v. second-generation cephalosporins. In every revision due to septic loosening we implemented the two-time replacement protocol, with a time span of 10 to 20 weeks between surgeries.[20,21]

We consistently used the PL approach and, in reoperation, we carried out synovial fluid aspiration previously to the incision of the capsule to carry out WBC count (white blood cells x mm^3 and polymorphonuclear cell ratios).[22]

In revision surgery of hip arthroplasty, the surgical procedure we carried out consisted of removal of the prosthetic components, removal of the cement if required, and removal of the membrane to then identify bone defects according to the Paprosky classification,[7] and correlate these data to our preoperative planning. In the cases of complex primary arthroplasties, we set out to identify the true acetabulum to restore the center of rotation of the femoral head and get adequate biomechanics (when such landmark was ascended), and to the conduct reaming and evaluation of the defects. Reaming was carried out as outlined by the line-to-line technique. In all cases we used the trial component to evaluate stability and the percentage of contact with host bone. Final contact between

Table 1. Data about the series

	Months	Surgery	Cause	Trabecular metal	Contact %	Increase in trabecular metal	Graft	Preoperative Harris Hip Score	Infection	Trabecular metal removal	Dislocation
1	84	R	ITHR	R	50%			86.6			
2	80	R	ITHR	R	<50%		Bank	85	Yes		
3	78	R	ITHR	R	<50%			70.4			
4	76	R	ITHR	R	<50%	Yes, 62x10			Yes	Yes	
5	74	P	PRO	M	>50%			92.75			
6	72	P	PRO	M	>50%			89.1			
7	62	P	DYS	M	<50%			89.1			
8	56	R	ML	M	<50%			92.75			
9	54	P	PA	M	>50%			88.25			
10	53	P	PA	M	>50%			90			
11	52	R	ITHR	M	<50%			66.9			
12	46	R	ML	M	<50%			85.35			
13	46	R	ML	R	<50%			79			
14	45	P	DYS	M	50%			91			
15	43	R	ITHR	R	<50%			84			
16	41	R	ITHR	R	<50%	Yes, 62x10		80			
17	41	P	SA	M	>50%			80			
18	40	R	ITHR	R	<50%			79.1			
19	39	R	ML	R	50%			77.25			
20	38	P	DYS	M	<50%		Bank	89.7			
21	35	P	HAN	R	50%			91.7			
22	31	R	ML	R	<50%			80			
23	30	R	ITHR	M	<50%			87.45			1
24	30	P	FX	M	50%			88			
25	28	R	ITHR	M	<50%			63.25			
26	26	R	ITHR	M	50%			87.1			
27	26	R	ITHR	R	<50%			79			
28	24	R	ML	M	50%			71.75			
29	23	P	DYS	M	50%			69.2			
30	22	R	ML	R	<50%			76.45			
31	20	R	ML	R	50%			83			
32	20	R	ML	R	<50%			74.25	Yes		
33	19	P	DYS	M	<50%			79			
34	19	P	DYS	M	50%			82			
35	19	R	ITHR	R	<50%			70.5			1
36	18	R	IN	R	<50%			82			
37	17	R	ITHR	M	<50%			90			
38	17	R	ML	R	<50%		Bank	73.75			
39	16	R	ITHR	M	<50%			81			
40	14	R	ML	M	<50%		Bank	82			
41	12	R	ML	M	<50%						
42	12	R	ML	R	<50%	Yes, 62x10					

R = revision, P = primary, M = modular, ITHR= infection in total hip replacement, PRO = acetabular protrusion, DYS = dysplasia, ML = mechanical loosening, PA = Paget, SA = septic arthritis, HAN = hip avascular necrosis, FX= acetabular fracture, IN= instability.

Figure 1. Cases 3 and 19. **A.** X-ray. Septic loosening of left total hip prosthesis. **B.** Two-time revision, extensive trochanteric osteotomy and insertion of cement spacer. **C.** Prosthetic revision of left hip with trabecular metal cup and distal fixation conic stem. **D.** X-ray three years after the surgery. Good bone remodeling and fixed implants. Right hip mechanical loosening. **E.** One-time revision, extensive trochanteric osteotomy, trabecular metal cup and distal fixation conic stem.

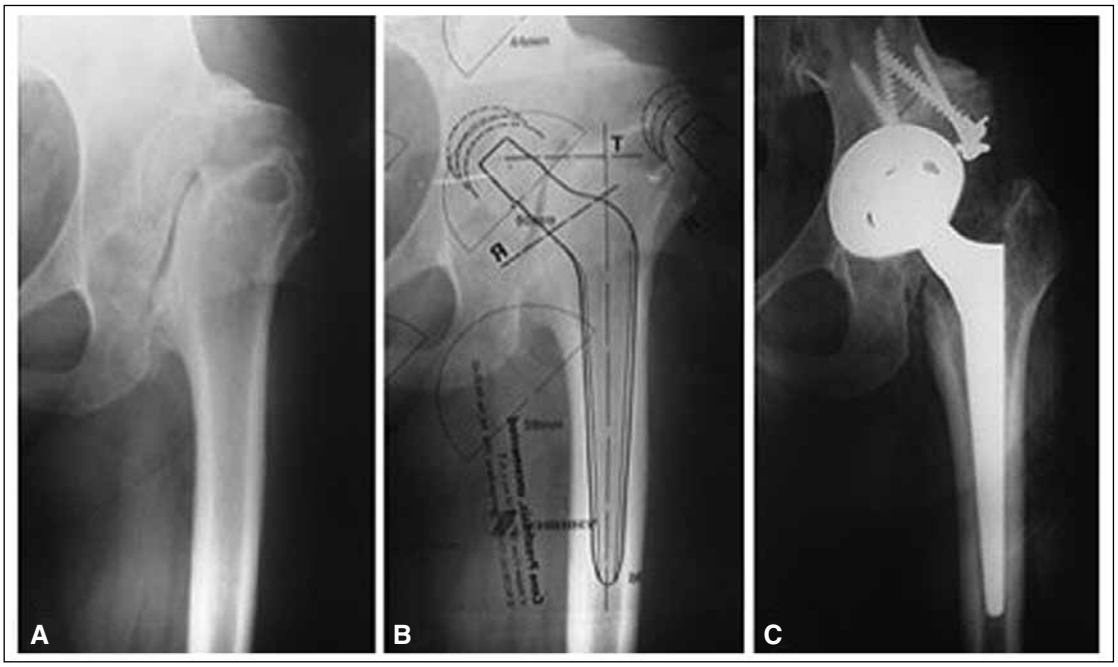

Figure 2. Case 20. Total hip replacement secondary to Crowe 2 dysplasia. **A.** Pre-operative X-ray. **B.** Preoperative planning with acetabular template in paleo-acetabulum and femoral planning. <50%-estimated contact between implant and native bone. **C.** Checkup two years after the surgery. Trabecular metal cup, incorporated structural allograft. Cementless conic femoral stem.

the host bone and the trabecular metal cup was <50% in 64.2% of the cases, about 50% in 21.4% of the cases, and >50% in 14.3% of the cases.

In four patients (9.5%), we used bank allograft bone. In three cases (7%), we used trabecular metal enhancement devices (Figure 3E), which were fixed to the pelvic bone by screws and to the acetabular cup by a thin cement layer.[23,24] These segment-like enhancement devices provide the implant with extra fixation thus compensating segmental or cavitary defects in structural-graft-fashion but without its disadvantages. We used trabecular metal cups (Zimmer, Warsaw, Indiana, US)—23 were modular cups and 19, revision cups. Non-modular revision cups entirely manufactured with trabecular tantalum can be inserted in such a way that greater contact with host bone can be expected, because the polyethylene component will be then cemented within optimizing its orientation. Moreover, they allow surgeons to carry out additional drilling through the trabecular metal to get better anchorage with screws in areas of good bone stock. In all cases we inserted at least three screws (ranging from 3 to 7). The average cup diameter was 58 mm (ranging from 48 to 70). All polyethylene inserts or cups that we used were of the high cross-linking type (Zimmer, Warsaw, Indiana, US); when we used revision cups, independently of the reason for revision we cemented the polyethylene component using cement with antibiotics. Only in one case of revision due to previous prosthetic instability we used a constrained insert. One patient with severe Paprosky's type IIIB acetabular defect and pelvic dissociation was treated by the Cup-Cage reconstruction technique.[17,25] In 26 (89.6%) revision cases we also carried out femoral revision using 25 revision implants of the distal fixation modular conic type (23 ZMR stems, Zimmer, Warsaw, Indiana, US, and 2 MP stems, Waldemar Link, Hamburg, Germany). In 19 (65.5%) of them we used extensive trochanteric osteotomy to facilitate the removal of the implants and the cement (if required), to then carry out concentric reaming in the femoral canal during the subsequent revision.[26]

In seven (54%) of the primary cases, we used cementless stems (6 ML Taper stems and 1 Wagner stem, Zimmer, Warsaw, Indiana, US) and, in the remaining six (46%) cases, we used cemented stems (Versys Herita-ge Zimmer, Warsaw, Indiana, US).

For thromboembolic prophylaxis we administered low molecular weight heparin-0.4 mg/day as from 12 hours after the surgery and up to one month afterwards. The postoperative rehabilitation protocol consisted of quadriceps isometric contraction exercises, ankle and knee flexion-extension, and sitting position on the first postoperative day, followed by normal walking aided by a four-wheeled walker on the second postoperative day. When initial fixation was optimal, we allowed patients partial weight-bearing; in the remaining patients weight bearing on the limb operated on was delayed about 6-8 weeks, when they started with partial weight-bearing up to post-

operative month 3, and then we allowed these patients complete weight-bearing.

Clinical and radiographic checkups were carried out 45 days, 3 and 6 month and one year after the surgery, and then on a yearly basis. The evaluation of the post-operative clinical results was carried out using the Harris Hip Score.[18] In radiographic evaluations we compared patients' immediately postoperative X-rays with their last follow-up X-rays. As reference to determine failure in construction and migration of the acetabular component we set out >3mm-migration and >5°-changes in the abduction angle.[27]

Results

Survival of acetabular components was of 97.6% at average follow-up of 37 months (ranging from 12 to 84). The only failure was that in a patient subject to two-time revision due to septic prosthetic loosening. Infection recurrence and lack of response to surgical toilet led to the complete removal of the arthroplastic devices three months after the revision. After eight surgeries, this case ended up with resection arthroplasty (Figure 3).

Complication rates were 12% (5 cases): three infections (7%), two of them resolving with surgical toilet without recurrence and preservation of stability in the implant up to the patient's last follow-up consultation, whereas the other case is that of the aforementioned patient with resection arthroplasty. Two patients suffered dislocation episodes (5%), which were closely reduced under anesthesia in the operating room, and there were no reports on recurrences. The postoperative average Harris Hip Score was 81.7 (ranging from 63.25 to 92.75). At last follow-up, there was no evidence of failure in acetabular reconstruction in any of the patients as estimated by the criteria of >3mm-migration and of >5°-changes in the abduction angle. At the time of comparing this series with other authors', results were similar in survival parameters (Table 2).

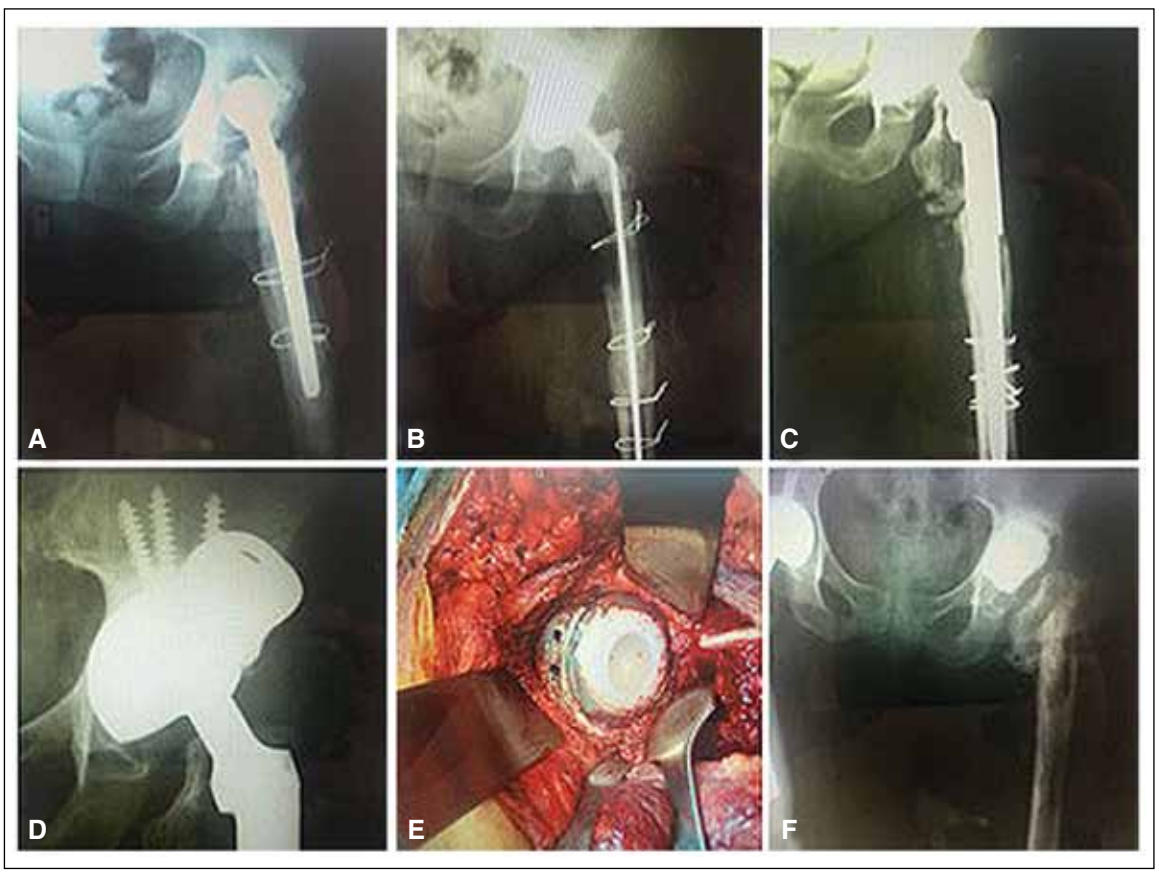

Figure 3. Two-time revision in infected total hip replacement. Multiple previous surgeries. **A.** Pre-operative X-ray. **B.** Cement spacer. **C-E.** Revision with trabecular metal cup and increase in trabecular metal to get greater stability. Femoral revision, distal fixation conic stem. **F.** Resection arthroplasty three months after such surgery due to persistent infection.

Discussion

The management of complex acetabulums implies a true challenge for hip surgeons. Surgical techniques such as the use of conventional cementless cups, impacted bone graft associated with cemented cups, structural or impacted bone graft with reconstruction rings, and tailor-made or triflange acetabular implants *were* and *are* used in such scenarios, but their results seem to be poorer, their techniques, more complex, and their complication rates, higher than those in high porosity cementless cups, especially in the more severe cases.[3,28-32]

In our series, we describe the use of trabecular tantalum implants for the resolution of complex acetabulums, both in primary surgeries and revisions; in 36 out of 42 cases (85%), contact between the acetabular component and host bone was ≤50% (Table 1). Survival rates were of 97.6% at average 38-month follow-up; the only failure was subsequent to deep infection in a patient with history of infection. In no other case there was loosening of the acetabular component at average follow-up. Our shot-term results coincide with those in published reports (Table 2).

In 2006, Sporer et al. reported a series of 28 revisions with trabecular cups in Paprosky's IIIA type acetabular defects, with survival rates of 96% for loosening three years after the surgery.[24] One years later, Weeden and Schmidt published results in 43 revisions with these cups in Paprosky's III type acetabular defects, with 98%-survival rates four years later.[13] In 2008, Lakstein et al. reported their results in a series of 53 revisions using trabecular metal devices with <50%-contact between implants and host bone, with survival rates of 96% four years after the surgery.[14] In 2012, the same group reported 100%-success at six-year follow up with this technique when contact between prosthetic devices and host bone was between 50% and 80%, and 93%-success when such contact was <50%.[11]

Malkani et al.[8] reported survival rates of 95% at average 39-month follow-up in a series of 22 revisions. Buttaro et al.[9] published 95%-survival rates at an average follow-up of 2.5 years with the use of trabecular metal cups in association with impacted allograft bone for severe defect-hip revisions.

In 2011, Skyttä et al.[10] reported 92%-survival rates at three-year follow-up in a series of 827 hip revisions using trabecluar metal of Finnish registry.

In 2016, Clement et al.[15] reported survival rates of 92% in 55 revisions in Paprosky's II and III types acetabular defects,[7] with minimal follow-up of five years. In a systematic bibliographic revision which included 1541 revisions with rings and 1959 revisions with trabecular metal, Beckmann et al. verified significantly lower loosening rates and fewer revisions in the latter group, especially in the cases of severe defect with pelvic discontinuity.[30]

Our work shows weaknesses which impose limitations to conclusions, such as its retrospective character, the short follow-up, the diverse etiology in hip conditions, and the lack of control group. However, we believe that it has strengths too—the report on the use of trabecular metal for the management of complex acetabulums in primary arthroplasties, about which although there are recommendations in specialized bibliography, there are not many reports near us.[33] Moreover, the low percentages (9.5%) of use of bank allograft bone to satisfactorily solve severe acetabular defects, what on top of decreasing related complications,[34] simplifies revision surgeries from a technical point of view due to the great osteoconductive profile and initial fixation potential of trabecular tantalum.[6]

Table 2. Comparison with other authors' series

Authors	Number of cases	Average follow-up (months)	Range (months)	Survival rates
Sporer et al.[24]	28	37	12-48	96%
Malkani et al.[8]	22	39	28-55	95%
Skyttä et al.[10]	827	36		92%
Weden et al.[13]	43	33	24-48	98%
Lakstein et al.[14]	53	45	24-71	96%
Clement et al.[15]	55	60		92%
Sternheim et al.[11]	102	72,4	60-102	>50% = 100% <50% = 93%
Buttaro et al.[9]	20	30	24-48	95%
Our series	42	37	12-86	97.6%

Conclusions

The use of acetabular cups of trabecular metal in the treatment of complex acetabulums offers short- and mid-term promising and predictable results, with high survival rates and low complication rates as compared to other reconstructive methods. It is necessary to carry out a longer follow-up so as to add up to conclusions and determine if in fact these devices can become the reference pattern to treat these types of cases.

Bibliography

1. Hartofilakidis G, Stamos K, Karachalios T, Ioannidis TT, Zacharakis N. Congenital hip disease in adults. Classification of acetabular deficiencies and operative treatment with acetabuloplasty combined with total hip arthroplasty. *J Bone Joint Surg Am* 1996;78:683-92. doi: https://doi.org/10.2106/00004623-199605000-00007
2. Deirmengian GK, Zmistowski B, O'Neil JT, Hozack WJ. Management of acetabular bone loss in revision total hip arthroplasty. *J Bone Joint Surg Am* 2011;93:1842-52. doi: https://doi.org/10.2106/JBJS.J.01197
3. Boscainos PJ, Kellett CF, Maury AC, Backstein D, Gross AE. Management of periacetabular bone loss in revision hip arthroplasty. *Clin Orthop Relat Res* 2007;465:159-65. doi: https://doi.org/10.1097/BLO.0b013e3181560c6c
4. Lugones A, Díaz Gallardo P, Bidolegui F, Vindver G, Allende B. Artroplastia total de cadera con copa no cementada en secuela de fractura de acetábulo. *Rev Asoc Argent Ortop Traumatol* 2012;77(3):185-91. doi: https://doi.org/10.15417/128
5. Della Valle CJ, Berger RA, Rosenberg AG, Galante JO. Cementless acetabular reconstruction in revision total hip arthroplasty. *Clin Orthop Relat Res* 2004;420:96-100. doi: https://doi.org/10.1097/00003086-200403000-00013
6. Bobyn JD, Stackpool GJ, Hacking SA, Tanzer M, Krygier JJ. Characteristics of bone ingrowth and interface mechanics of a new porous tantalum biomaterial. *J Bone Joint Surg Br* 1999;81(5):907-14. PMID: https://www.ncbi.nlm.nih.gov/pubmed/10530861
7. Paprosky WG, Perona PG, Lawrence JM. Acetabular defect classification and surgical reconstruction in revision arthroplasty. A 6-year follow-up evaluation. *J Arthroplasty* 1994;9(1):33-44. doi: https://doi.org/10.1016/0883-5403(94)90135-X
8. Malkani AL, Price MR, Crawford CH 3rd, Baker DL. Acetabular component revision using a porous tantalum biomaterial: a case series. *J Arthroplasty* 2009;24(7):1068-73. doi: https://doi.org/10.1016/j.arth.2008.07.008
9. Buttaro M, Ali J, Comba F, Sirio A, Zanotti G, Piccaluga F. Copas de metal trabecular y aloinjertos óseos impactados en defectos acetabulares graves. Resultados a los 2-4 años. *Rev Asoc Argent Ortop Traumatol* 2014;79(2):82-91. doi: https://doi.org/10.15417/298
10. Skyttä ET, Eskelinen A, Paavolainen PO, Remes VM. Early results of 827 trabecular metal revision shells in acetabular revision. *J Arthroplasty* 2011;26(3):342-5. doi: https://doi.org/10.1016/j.arth.2010.01.106
11. Sternheim A, Backstein D, Kuzyk PR, Goshua G, Berkovich Y, Safir O, et al. Porous metal revision shells for management of contained acetabular bone defects at a mean follow-up of six years: a comparison between up to 50% bleeding host bone contact and more than 50% contact. *J Bone Joint Surg Br* 2012;94(2):158-62. doi: https://doi.org/10.1302/0301-620X.94B2.27871
12. Fernandez Fairen M, Murcia A, Blanco A, Meroño A, Murcia A Jr, Ballester J. Revision of failed total hip arthroplasty acetabular cups to porous tantalum components: a 5-year follow-up study. *J Arthroplasty* 2010;25(6):865-72. doi: https://doi.org/10.1016/j.arth.2009.07.027
13. Weeden SH, Schmidt RH. The use of tantalum porous metal implants for Paprosky 3A and 3B defects. *J Arthroplasty* 2007;22 (Suppl 2):151-5. doi: https://doi.org/10.1016/j.arth.2007.04.024
14. Lakstein D, Backstein D, Safir O, Kosashvili Y, Gross AE. Trabecular Metal cups for acetabular defects with 50% or less host bone contact. *Clin Orthop Relat Res* 2009;467(9):2318-24. doi: https://doi.org/10.1007/s11999-009-0772-3
15. Clement RG, Ray AG, MacDonald DJ, Wade FA, Burnett R, Moran M. Trabecular metal use in Paprosky type 2 and 3 acetabular defects: 5-year follow-up. *J Arthroplasty* 2016;31(4):863-7. doi: https://doi.org/10.1016/j.arth.2015.10.033
16. Issack PS. Use of porous tantalum for acetabular reconstruction in revision hip arthroplasty. *J Bone Joint Surg Am* 2013;95: 1981-7. doi: https://doi.org/10.2106/JBJS.L.01313
17. Garcia-Cimbrelo E, Tapia M, Martin-Hervas C. Multislice computed tomography for evaluating acetabular defects in revision THA. *Clin Orthop Relat Res* 2007;463:138-43. doi: https://doi.org/10.1097/BLO.0b013e3181566320
18. Harris WH. Traumatic arthritis of the hip after dislocation and acetabular fractures: treatment by mold arthroplasty. An end-result study using a new method of result evaluation. *J Bone Joint Surg Am* 1969;51:737-55. PMID: https://www.ncbi.nlm.nih.gov/pubmed/5783851
19. Yamasaki S, Masuhara K, Fuji Takeshi. Tranexamic acid reduces postoperative blood loss in cementless total hip arthroplasty. *J Bone Joint Surg Am* 2005;87:766-70. doi: https://doi.org/10.2106/JBJS.D.02046

20. Gomez MM, Tan TL, Manrique J, Deirmengian GK, Parvizi J. The fate of spacers in the treatment of periprosthetic joint infection. *J Bone Joint Surg Am* 2015;97(18):1495-502. doi: https://doi.org/10.2106/JBJS.N.00958

21. Hofmann AA. Two-stage exchange is better than direct exchange in the infected THA. *Orthopedics* 1999;22(10):918. PMID: https://www.ncbi.nlm.nih.gov/pubmed/10535552

22. Della Valle C, Parvizi J, Bauer TW, et al. American Academy of Orthopaedic Surgeons. Diagnosis of periprosthetic joint infections of the hip and knee. *J Am Acad Orthop Surg* 2010;18:760-70. PMID: https://www.ncbi.nlm.nih.gov/pubmed/?term=PMID%3A+21119142

23. Levine B, Della Valle CJ, Jacobs JJ. Applications of porous tantalum in total hip arthroplasty. *J Am Acad Orthop Surg* 2006; 14(12):646-55. PMID: https://www.ncbi.nlm.nih.gov/pubmed/?term=PMID%3A+17077337

24. Sporer S, Paprosky W. The use of a trabecular metal acetabular component and trabecular metal augment for severe acetabular defects. *J Arthroplasty* 2006;21(6 Suppl 2):83-6. doi: https://doi.org/10.1016/j.arth.2006.05.008

25. Kosashvili Y, Backstein D, Safir O, Lakstein D, Gross AE. Acetabular revision using an anti-protrusion (ilio-ischial) cage and trabecular metal acetabular component for severe acetabular bone loss associated with pelvic discontinuity. *J Bone Joint Surg Br* 2009;91(7):870-6. doi: https://doi.org/10.1302/0301-620X.91B7.22181

26. Vindver G, Bidolegui F, Di Stefano C. Osteotomía trocantérea extendida para revisiones femorales: indicaciones, técnica y resultados. Evaluación de 100 pacientes con 116 osteotomías. *Rev Asoc Argent Ortop Traumatol* 2010;75(2):115-24. http://www.aaot.org.ar/revista/2010/n2/Rev_AsocArgentOrtopTraumatol_2010_75_115-124_Vindver.pdf

27. Massin P, Schmidt L, Engh CA. Evaluation of cementless acetabular component migration: an experimental study. *J Arthroplasty* 1989;4:245-51. PMID: https://www.ncbi.nlm.nih.gov/pubmed/2795031

28. Buttaro MA, de la Rosa DM, Comba F, Piccaluga F. High failure rate with the GAP II ring and impacted allograft bone in severe acetabular defects. *Clin Orthop Relat Res* 2012;470(11):3148-55. doi: https://doi.org/10.1007/s11999-012-2402-8

29. Van Haaren EH, Heyligers IC, Alexander FG, Wuisman PI. High rate of failure of impaction grafting in large acetabular defects. *J Bone Joint Surg Br* 2007;89:296-300. doi: https://doi.org/10.1302/0301-620X.89B3.18080

30. Beckmann NA, Weiss S, Klotz MC, Gondan M, Jaeger S, Bitsch RG. Loosening after acetabular revision: comparison of trabecular metal and reinforcement rings. A systematic review. *J Arthroplasty* 2014;29(1):229-35. doi: https://doi.org/10.1016/j.arth.2013.04.035

31. Van Egmond N, De Kam DC, Gardeniers JW, Schreurs BW. Revisions of extensive acetabular defects with impaction grafting and a cement cup. *Clin Orthop Relat Res* 2011;469(2):562-73. doi: https://doi.org/10.1007/s11999-010-1618-8

32. DeBoer DK, Christie MJ, Brinson MF, Morrison JC. Revision total hip arthroplasty for pelvic discontinuity. *J Bone Joint Surg Am* 2007;89(4):835-40. doi: https://doi.org/10.2106/JBJS.F.00313

33. Keurentjes JC, Pijls BG, Van Tol FR, Mentink JF, Mes SD, Schoones JW, et al. Which implant should we use for primary total hip replacement? A systematic review and meta-analysis. *J Bone Joint Surg Am* 2014;96(Suppl 1(E):79-97. doi: https://doi.org/10.2106/JBJS.N.00397

34. Rees HW, Fung DA, Cerynik DL, Amin NH, Johanson NA. Revision total hip arthroplasty without bone graft of high-grade acetabular defects. *J Arthroplasty* 2012;27(1):41-7. doi: https://doi.org/10.1016/j.arth.2011.04.004