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ORIGINAL STUDY

Clinical results and complications of a two-stage procedure in hip infection using preformed antibiotic-loaded cement spacers

Ester Garcia-Oltra, Sebastian Garcia, Jordi Bosch, Andreu Combalia, Alex Soriano, Guillem Bori

From the Department of Orthopaedic and Trauma Surgery, Hospital de Berga, Spain

Antibiotic-loaded cement spacers are used in two-stage hip replacement. The aim of our study was to compare our results using a Spacer-G with previous results reported in the literature. From June 2002 to April 2010, all patients treated with a two-stage revision were retrospectively reviewed. On the basis of the results of the first-stage procedure, 52 patients underwent the second stage, six developed a dislocation, in eight the spacer was maintained, and five patients developed an acute infection of the spacer or the infection was not resolved. With regard to the second-stage procedure the revision was successful in 44 patients, a re-infection developed in four patients and the definitive prosthesis presented a mechanical complication in four more. The literature results reported that 97.5% of the spacers were reimplanted, although 12.09% of them developed a dislocation. Surgeons must assess several aspects so as to avoid mechanical complications like dislocation and re-infections during the two stages of the procedure.

Keywords : infection ; hip arthroplasty ; spacer ; two-stage

INTRODUCTION

Two-stage replacement is now the most frequently used technique for the treatment of chronic hip arthroplasty infection *(12,17,28)*, chronic infection after osteosynthesis of proximal hip fractures *(25)*, and sequelae of septic native arthritis *(20,25)*. The first-stage procedure consists of the removal of the infected prosthesis, osteosynthesis or an infected femoral head, surgical debridement and implantation of a cement spacer. Several types of spacers have been reported in the literature, including static or articulating spacers which can be handmade/custom-molded/prefabricated *(3,17)*. The hemiarthroplasty Spacer-G is a mobile, industrially preformed antibiotic-loaded spacer (InterSpace® Hip, Tecres SpA, Verona, Italy - Hexactech Inc.

■ Ester Garcia-Oltra[1,2] MD
■ Sebastian Garcia[2,3,6] PhD
■ Jordi Bosch[2,4] PhD
■ Andreu Combalia[3,6] PhD
■ Alex Soriano[2,5,6] PhD
■ Guillem Bori[2,3,6] PhD

[1]*Department of Orthopaedic and Trauma Surgery, Hospital de Berga, Spain.*
[2]*Bone and Joint Infectious Diseases Unit. Hospital Clinic of Barcelona, University of Barcelona, Barcelona, Spain.*
[3]*Department of Orthopaedic and Trauma Surgery, Hospital Clinic of Barcelona, University of Barcelona, Barcelona, Spain.*
[4]*Department of Microbiology, Hospital Clinic, University of Barcelona, Barcelona, Spain.*
[5]*Department of Infectious Diseases, Hospital Clinic of Barcelona, University of Barcelona, Barcelona, Spain.*
[6]*Institut d'Investigacions Biomèdiques August Pi i Sunyer (IDIBAPS).*

Correspondence : G.Bori, Department of Orthopaedic and Trauma Surgery, Hospital Clinic, University of Barcelona, Villarroel 170, Barcelona 08036, Spain. Tel: +0034 932275533, 649531789.

E-mail : ester_garcia_oltra@hotmail.com

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Gainesville, Florida, USA). Mobile hip spacers improve patients' clinical outcomes, encourage early mobilization and joint function and maintain the tissue planes intact, thus preparing the area for the second-stage procedure *(3,4,17)*.

The aim of our study was to compare our results using a Spacer-G and previous results reported in the literature *(10,11,13,15,18,21-23,25,26)*. We assessed (A) the infection eradication rate and (B) complications during the interim period and after reimplantation of the definitive prosthesis.

MATERIALS AND METHODS

From June 2002 to April 2010, all patients treated with a two-stage revision at our third level teaching hospital were retrospectively reviewed (level-IV study). The Spacer-G, an off-the-shelf polymethylmethacrylate antibiotic-loaded pre-formed hip spacer, is used at our hospital to treat implant-related hip infections or septic hip arthritis.

Patients

The three indications for a two-stage revision at our hospital are chronic hip arthroplasty infections, chronic infection after osteosynthesis of proximal hip fractures, or sequelae of septic native arthritis. The patients were classified according to McPherson staging system.

During the first-stage procedure, a surgical debridement is performed and the Spacer-G implanted. There was no objective method to determine the spacer positioning was sufficiently stable. To cement or not cement the proximal part of the spacer was surgeon decision. If the surgeon thought that the spacer was stable, the surgeon didn't cement the spacer. If the surgeon thought that the spacer was not stable, the surgeon cemented the spacer. The inner part of the Spacer-G features a stainless steel rod, which increases mechanical resistance. The cement is pre-loaded by the manufacturer with gentamycin at a concentration of 1.9%. It is available with three different head sizes and two stem sizes, short (260 mm) and long (360 mm), which can be chosen intra-operatively. At least six samples of periprosthetic tissue were taken during surgery for microbiology (two liquid, two solid, two swabs). Systemic antibiotics were started during first-stage just after obtaining samples for culture and histological study. The protocol included vancomycin plus ceftazidime and it was adjusted once the culture results were available. The duration of antibiotic regimen was six weeks. Chronic hip infection was considered in two different situations : A) the isolation of the same microorganism in two different samples and B) the presence of pus. The definitive diagnosis of infection proposed by the Musculoskeletal Infection Society in 2011 was not used because the study was performed before this definition had been published.

During the interim period, clinical symptoms of infection progressively improved in some patients and the second stage was performed ; other patients presented with an acute infection of the spacer, or their infection was not resolved, and in others the spacer was maintained for a variety of reasons or it presented a mechanical complication such as dislocation. If the spacer presented with an acute infection or if the infection was not resolved, the spacer was removed or a resection arthroplasty was performed.

The second-stage procedure (removal of the cement spacer and implantation of the definitive arthroplasty) was performed when C-reactive protein (CRP) levels were normalized and after at least two weeks without clinical symptoms of infection after discontinuation of antimicrobial therapy. Hip aspiration was not performed before the second-stage. The second-stage procedure was not performed unless the two criteria mentioned above were met. Patients who presented clinical symptoms of infection underwent debridement or resection arthroplasty.

During the second-stage procedure a minimum of six samples of periprosthetic tissue were again taken for microbiology. Systemic antibiotics (vancomycin and ceftazidime) were prescribed initially and were then maintained or discontinued depending on the microbiology results.

Furthermore, during the second-stage procedure infection was considered in the same two situations as in the first-stage. The infection was interpreted as persistent when the same microorganism was isolated in both procedures, and as a re-infection

when the microorganism was different in the first and second stages. The infection was considered resolved when the inflammatory test parameters were persistently normalized and when there were no clinical symptoms of infection during follow-up after the second-stage procedure.

Microbiology

The protocol for sampling in the first and second-stage procedures comprised six samples for microbiology study (two synovial fluid, two swabs and two solid tissue), as follows : liquid samples were aspirated from the operative site after arthrotomy using a sterile syringe, and were immediately inoculated into Bactec 9000 Blood Culture Systems (Becton Dickinson Diagnostic Instruments, Sparks, Maryland) and were incubated for five days. Positive flasks were subcultured in aerobic and anaerobic agar media. Swab samples were obtained by passing a sterile swab (Deltalab invasive sterile eurotube collection swab with Stuart transport medium ; Rubi, Catalonia, Spain) over the area of tissue, bone, or fluid that was suspected of being infected. Solid tissue samples from the pseudocapsule, the membrane around the tissue or space, or tissue suspected to be infected were immediately placed into a separate sterile universal bottle. Solid tissue samples and swab samples were cultured in aerobic and anaerobic agar media and in thioglycolate broth enriched with vitamin K and hemin, and were incubated for ten days. Positive cultures were sent for organism identification and sensitivity testing.

Literature reviewed

We systematically reviewed the literature for articles addressing two-stage revision of a chronical hip infection using a preformed hip spacer such as Spacer-G.

Statistical analysis

Qualitative variables were expressed as percentage and continuous variables were expressed as the mean and range. The analysis was done with the StatCrunch program (StatCrunch™. Data analysis on the Web-Copyright 2007-2015 Integrated Analytics LLC. Distributed exclusively by Pearson Education).

RESULTS

Seventy-one spacers were implanted in 67 patients from June 2002 to April 2010 : 35 males and 32 females with a mean age of 70.35 years (range, 35-89 years). Clinical aspects of the patients included in the study are shown in the Table I. According to McPherson staging system : 19 patients type I, 4 patients type II and 44 patients type III ; 32 patients type A and 35 patients type B ; and 54 patients type 1 and 13 patients type 2.

The mean follow up was 57.20 months (range 13-97 months). The reasons for implantation were chronic total hip arthroplasty infection in 57 cases (80.28%), chronic infection of hemiarthroplasty in eleven (15.49%), chronic infection after osteosynthesis of proximal hip fractures in two cases

Table I. — Clinical aspects of patients included in the study

Age in years (range)	70.35 (35-89)						
Previous implant (N)	Hemiarthroplasty (11)		Total hip arthroplasty (57)		Others* (3)		
Longevity implant in months (range)	40.38 (1-154)						
CRP in mg/dL (range)	5,68 (1,2-36)						
ESR in mm/h (range)	58,77 (35-130)						
Positive intraoperative histology (%)	91,78						
Microbiology (N)	CNS 23	Enterococcus spp 5	Staphylococcus aureus 6	Pseudomonas aeruginosa 6	Escherichia coli 8	Negative 10	Others** 15

* Ostheosynthesis of proximal hip fractures or chronic septic arthritis. ** Peptococcus spp, Propionibacterium acnes, Corynebacterium spp, Serratia spp, Salmonella spp, Candida albicans. PCR, C-Reactive protein, ESR, erythrocyte sedimentation rate. CNS, Coagulase-negative staphylococci.

Table II. — Patients who developed spacer dislocation

Number of patient	Previous arthroplasty dislocation	Cause of spacer dislocation (*)	Surgery in the interim period (**)	Head spacer	Stem spacer	Cultures in the first stage (***)	Cultures during surgery in the interim period (***)	Cultures in the second stage	Final situation (****)	Follow-up (months)
1	Yes	IIIA defect	D + RA	54	Long	CNS	Negatives	-	RA	84
2	No	MI	No	54	Long	CNS	-	Negatives	THA	72
3	No	MI	D + RA	60	Long	Enterococcus sp.	A. baumanii	-	RA	6 (Death)
4	No	IIIB defect	D + RA / D / D	60	Long	Negatives	CNS, C. tropicalis, CNS	-	RA	30
5	Yes	MI	D + RA	46	Long	E. coli, P.aeruginosa	CNS, Enterococcus	-	RA	2 (Death)
6	No	SIFIF	D + RA	46	Short	MRSA	CNS	-	RA	29

(*) : IIIA and IIIB defect (using Paprosky classification), MI : muscular insufficiency (a decreased lateral femoral offset, negative vertical offset or limb length shortening), SIFIF : spacer insufficient fixation into femur. (**) : D : debridement, RA : resection arthroplasty. (***) : CNS : coagulase-negative staphylococci, E. Coli : Escherichia coli, P. aeruginosa : Pseudomonas aeruginosa, MRSA : Methicillin-resistant staphylococcus aureus, A. baumanii : Acinetobacter baumanii, C. tropicalis : Candida tropicalis. (****) : RA : resection arthroplasty, THA : total hip arthroplasty.

Table III. — Patients in whom the spacer was kept and not exchanged

Number of patient	ASA	Head spacer	Stem spacer	Cultures in the first stage (*)	Surgery in the interim period (**)	Cultures during surgery in the interim period	Final situation (***)	Follow-up (months)
1	III	46	Short	P.mirabilis, E. coli, Enterococcus	No	-	S	25 (Death)
2	III	46	Long	SA	No	-	S	18
3	III	60	Long	CNS, S.pneumoniae	No	-	S	46 (Death)
4	III	46	Long	SA, P. aeruginosa	No	-	S	11 (Death)
5	III	54	Long	CNS, P. aeruginosa	No	-	S	6 (Death)
6	III	54	Short	Corynebacterium	No	-	S	41
7	III	54	Short	CNS, C. albicans	RA	C. albicans	RA	26 (Death)
8	III	54	Long	CNS, P. aeruginosa	SR / RA	C. albicans	RA	24

(*) : P. mirabilis : Proteus mirabilis, E. Coli : Escherichia coli, SA : Staphylococcus aureus, CNS : coagulase-negative staphylococci, S. pneumoniae : Streptococcus pneumoniae, P. aeruginosa : Pseudomonas aeruginosa, C. albicans : Candida albicans. (**) : SR : spacer removal, RA : resection arthroplasty. (***) : RA : resection arthroplasty, S : spacer.

Table IV. — Patients who developed an acute infection of the spacer or infection was not solved during interim period

Number of patient	ASA	Head spacer	Stem spacer	Cultures in the first stage (*)	Surgery in the interim period (**)	Cultures during surgery in the interim period (***)	Final situation (****)	Follow-up (months)
1	III	46	Short	CNS, C. albicans	RA	CNS	RA	0 (Death, 20 days)
2	II	54	Long	CNS	RA	Negative	RA	60
3	II	46	Short	MRSA	SR	CNS, C. albicans	THA	62
4	III	54	Long	E. coli, P. acnes	SR	S. maltophilia	THA	37
5	II	46	Short	CNS	SR	E. coli, K. pneumoniae, CNS	S	11 (Death)

(*) : CNS : coagulase-negative staphylococci, C. albicans : Candida albicans, MRSA : Methicillin-resistant staphylococcus aureus, E. coli : Escherichia coli, P. acnes : Propionibacterium acnes. (**) : RA : resection arthroplasty, SR : spacer removal. (***) : S. maltophilia : Stenotrophonomas maltophilia, K. pneumoniae : Klebsiella pneumoniae. (****) : RA : resection arthroplasty, THA : total hip arthroplasty, S : spacer.

Table V. — Complications after the second stage (Re-infections and dislocations)

Number of patient	Complication after second stage	ASA	Head spacer	Stem spacer	Cultures in the first stage (*)	Cultures in the second stage	Surgery after second stage (**)	Cultures of complication in the second stage (***)	Final situation (****)	Follow-up (months)
1	Re-infection	II	46	Short	MRSA	ECN, Candida albicans	D	ECN, C. albicans E. faecium	THA	62
2	Re-infection	III	54	Long	SA	CNS	RA / D	Candida tropicalis / K. pneumoniae ECN E. faecalis	RA	30 (Death)
3	Re-infection	II	46	Long	CNS	Escherichia coli	D / D / R2S	Negative / E. cloacae / K. pneumoniae	THA	37
4	Re-infection	III	60	Long	CNS	CNS	D / R2S	SA / E. faecalis	RA	19
5	Dislocation	II	54	Long	CNS	Negative	CLRe / CR + SR	Negative	THA	12 (Death)
6	Dislocation	II	54	Long	CNS	Negative	CR	Negative	THA	41
7	Dislocation	II	46	Long	SA, CNS	Negative	ClRe	-	THA	47
8	Dislocation	I	46	Long	SA	Negative	CR	Negative	THA	12

(*) : MRSA : Methicillin-resistant staphilococcus aureus, SA : Staphilococcus aureus, CNS : coagulase-negative staphylococci. (**) : D : debridement, RA : resection arthroplasty, CR : cup revision, SR : stem revision, ClRe : closed reduction, R2S : repeat second stage replacement. (***) : C. albicans : Candida albicans, E. faecium : Enterococcus faecium, E. faecalis : Enterococcus faecalis, E. cloacae : Enterobacter cloacae, K. pneumoniae : Klebsiella pneumoniae. (****) : THA : total hip arthroplasty, RA : resection arthroplasty

(2.81%), and sequelae of septic native arthritis in one (1.41%).

In view of the results after the first-stage procedure, 52 patients (73.24%) underwent the second stage, six patients (8.45%) developed a dislocation (Table II), in eight (11.27%) the spacer was maintained (Table III), and five patients (7.04%) developed an acute infection of the spacer or the infection was not resolved after the first-stage procedure (Table IV). Four resection arthroplasties were performed in patients with a dislocation of the spacer while in one patient the cement spacer was removed and the definitive arthroplasty was implanted, and in one other case the spacer was retained because the patient was deemed to be medically unfit. Of the eight patients in whom the spacer was initially maintained a resection arthroplasty was performed in two. Two resection arthroplasties were performed in patients who developed an infection of the spacer during the interim period, and in three patients the spacer was removed and another was implanted. With regard to the results after the second-stage procedure the revision was successful in 44 patients (61.97%), a re-infection developed in four, and in four more the definitive prosthesis developed a mechanical complication (Table V). The mean time between the first and second-stage procedure was 5.12 months (1-16 months). The microorganisms responsible for the re-infection are shown in table V.

DISCUSSION

In this study, the infection eradication rate using two-stage replacement with a prefabricated spacer was 61.97%. Pignatti et al. *(23)*, Pattyn et al. *(22)* and Gil et al *(15)* all reported better eradication rates with the same type of spacer, with persistent infection or re-infection rates of 9/41, 2/61 and 5/35 patients respectively *(15,22,23)*. The success rate using this type of prefabricated spacer ranges from 70-95% *(15,21-23,25,26)*. The eradication rates reported by Biring et al. *(6)* and Hsiech et al. *(16)*, using the Prostalac system or handmade were better than ours. Therefore, prefabricated spacers do not appear to perform better than Prostalac or handmade ones in terms of healing the hip infection. On the other hand, the infection eradication rate of 61.97% with two-stage revision appears low when compared with the reports of success rates of around 90% *(17)*. Some revisions only consider patients who have completed the second-procedure, but if the success rate is calculated taking into account patients who initiated a two-stage revision (but did not complete it) it would be lower. Recently, Berend et al. *(5)* reported an overall success rate with two-stage

Table VI. — Results after first-stage procedure using Spacer-G

Author	Number of hips	Infection cured	Debridement and new spacer reimplanted	Resection arthroplasty	Maintain Spacer	Death	Dislocation	Fracture of the spacer	Perispacer fracture
Magnan et al 2001	10	8	-	2	-	-	1	-	-
Minelli et al 2004	20	17	-	3	-	-	-	-	-
D'Angelo et al 2005	12	11	-	1	-	-	1	-	-
Regis et al 2009	1	0	-	-	1	-	-	1	
Gil et al 2010	35	35	-	-	-	-	7	-	-
Pignatti et al 2010	41*	40	9	1	-	-	2	1	-
D'Angelo et al 2011	28	27	-	1	-	-	3	-	-
Pattyn et al 2011	61	61	6	-	-	-	10	-	7
Romano** et al 2011	20	20	-	-	-	-	2	-	-
Neumann et al 2012	44	42	-	-	-	2	3	-	3
Romano et al 2012	183	183	3	-	-	-	30	-	-
Degen et al 2012	33	32	2	-	1	-	-	-	-
Total	488	476	20	8	2	2	59	2	10

(*) : Spacer G was not implanted in 5 hips. (**) : Spacer implanted after septic arthritis or after osteosynthesis.

Table VII. — Results after second-stage procedure using Spacer-G

Author	Number of hips	Reimplanted	Re-infection *	Persistent infection**	Dislocation	Aseptic loosening	Periprosthetic fracture	Other ***	Death	Patients lost during follow-up
Magnan et al 2001	10	8	-	-	-	-	-	-	-	-
Minelli et al 2004	20	17	-	-	-	-	-	-	-	-
D'Angelo et al 2005	12	11	-	-	-	-	-	-	-	
Regis et al 2009	1	0	-	-	-	-	-	-	-	-
Gil et al 2010	35	35	3	4	0	-	2	-	3	-
Pignatti et al 2010	41****	40	-	-	2	2	-	1	-	-
D'Angelo et al 2011	28	27	-	-	-	-	-	-	-	-
Pattyn et al 2011	61	61	2	-	2	-	-	1	-	-
Romano** et al 2011	20	20	-	1*****	-	1*****	-	-	1	-
Neumann et al 2012	44	42	1	-	1	1	-	-	-	-
Romano et al 2012	183	183	-	10	4	4	-	-	10	11
Degen 2012	33	32	2	-	1	-	-	-	-	-
Total	488	476	8	15	10	8	2	2	14	11

(*) : Re-infection : different microorganism isolated from the first to the second-stage procedure. (**) : Persistent infection : the same microorganism was isolated in both procedures. (***) : Other : other surgical complications. (****) : Spacer-G was not implanted in 5 hips. (*****) : The same patient.

revision of 90%, although this rate refers to patients who had undergone the second procedure rather than all the patients who had initiated the two-stage revision. Including all patients who initiated two-stage revision, the success rate would be 81.3% and might even fall to 76% if mortality is included in this overall success rate *(5)*.

The Spacer-G helps to shorten mean hospital stay, improves joint function, encourages early mobilization with partial weight bearing, and maintains

leg length and tissue planes to prepare the surgical area for second-stage reimplantation *(26)*. The possible mechanical complications of articulating spacers reported in the literature are dislocation, fracture of the spacer stem, perispacer fracture and acetabular bone erosion *(4,17)* (Table VI). Of these, dislocation is the most common and serious and has an overall reported rate of around 12.09% (Table VII). In our study, the dislocation rate was 8.45%, better than the rates reported by Pattyn et al. *(22)* and Romano et al *(26)*. Patients with dislocations presented a poorer clinical outcome than those without. In four out of six dislocations a resection arthroplasty had to be performed *(7)*. Nevertheless, the clinical success rates reported by Romano et al. *(26)*, and Pattyn et al. *(22)* after dislocation of the spacer were better than ours. In those studies, patients with a dislocation of the spacer were not reoperated ; they walked with crutches in order to keep weight bearing to a minimum and later, when inflammatory test parameters were normalized and in the absence of any clinical infection symptomatology, they received the definitive prosthesis *(26,22)*. After this study, this procedure was successfully implemented at our third level teaching hospital.

The causes of spacer dislocation have been described in the literature *(1,4)*. It may occur if the patient is not compliant or cannot tolerate partial weight bearing of the operated extremity, if the spacer is insufficiently fixated onto the proximal femur, if the spacer head is too small, if large acetabulum bone defects do not allow for a normal spacer articulation, or if there is muscular insufficiency. Muscular deficiency is the absence of an adequate abductor muscle tension. It could be present pre-operatively or developed after the implantation the spacer. A decreased lateral femoral offset, negative vertical offset or limb length shortening might be causes of muscular weakness *(4,7)*. Clinically, its presence could cause hip pain and dislocation under certain circumstances. In our previous study *(7)*, although these factors were not statistically relevant, in some circumstances their presence was enough to produce dislocation of the spacer *(7)*. Recently, Romano et al. *(26)* and Anagnostakos et al. *(2)* reported another potential etiological factor for dislocation of the spacer : a decrease in the horizontal offset of the hip. In our series, some patients with decreased femoral offset developed spacer dislocation. This is one of the potential drawbacks of the Spacer-G, as it has a fixed horizontal offset, which may be lower than the anatomy of patient requires and cannot be modified. The horizontal femoral offset of the Spacer-G increases progressively according to the head diameter and femoral size. Although Anagnostakos et al. *(2)* has described how to adjust the horizontal offset of the spacer, this methodology is only useful for handmade spacers and not for prefabricated spacers such as the Spacer-G.

We did not observe any fractures in the stem of the spacer, thanks to its metal endoskeleton. This complication has been reported in spacers without a metal endoskeleton *(1,17)* though only very rarely (0.004%) in the literature reviewed (Table VI). The fracture of the metal endoskeleton of prefabricated spacers like the Spacer-G has been reported when they have been used as a definitive prosthesis over a period of many years *(24)*.

Perispacer fracture is another mechanical complication that we did not observe. This complication is extremely uncommon (0.025%) (Table VI), and so its management is not standardized. Pattyn et al. *(22)* reported seven perispacer fractures, although most of them occurred during the implant removal and were not related to the use of a cement spacer *(22)*. Treatment was not performed immediately and was usually managed during the second-stage procedure, using modular revision stems and cable wires. Neumann et al. *(21)* described two perispacer fractures which required a revision surgery with open reduction and internal fixation without removal of the spacer, and later both cases underwent a successful second-stage procedure *(21)*.

Acetabular bone erosion was observed in patients in whom the spacer was maintained for a long period of time (more than one year), that is, when the spacer was used as a definitive prosthesis *(14)*. This is because the Spacer-G was not designed with this aim in mind. This could be one of the most important differences between partial and total mobile spacers. Although partial articulating spacers achieve successful infection eradication rates and improve joint function during the interim

period, when they are used as a definitive prosthesis the functional result may be poor due to acetabular bone erosion or fracture of the spacer *(14,24)*. Nevertheless, when total articulating spacers are used as a definitive prosthesis the functional results may be satisfactory *(8)*. Choi et al. *(8)* reported good functional results in patients in whom the total mobile spacer was maintained unexpectedly.

In 73.24% of patients, infection resolved after the first-stage procedure, during which a definitive prosthesis was implanted. Eight patients developed complications after the second-stage procedure (four re-infections and four mechanical complications). Therefore, we could say the success rate after second-stage revision in our study was 61.97%, a rate similar to the one reported by Choi et al. *(9)*. The success rate after second stage replacement reported by Sanchez-Sotelo et al. *(26)*, based on the reinfection rate after first-stage procedure, mortality and the mechanical complications, was 75% at ten-year follow up. Therefore, surgeons should place emphasis on the second stage in order to avoid reinfection and mechanical failure during follow-up. Sanchez-Sotelo et al. *(27)* concluded that even though two-stage reimplantation was associated with a high rate of early success in the treatment of deep infection after total hip arthroplasty, it was also associated with a modest rate of recurrent infection or mechanical failure *(27)*. The two most frequent complications after second-stage replacement were re-infection and dislocation (Table VII). For this reason, correct antibiotic prophylaxis is extremely important during the second-stage procedure in order to prevent re-infection. Tissue samples should also be taken once again in order to identify a re-infection or persistent infection *(19)*.

The main limitation of the present study is its retrospective design. The second limitation is that the antibiotic therapies and organism resistances are not listed, because the study focused on the mechanical complications of the Spacer-G such as dislocation, fracture of the spacer stem, perispacer fracture and acetabular bone erosion.

In conclusion, the two-stage revision surgery using the Spacer-G is not a minor surgery. Surgeons must assess a range of variables such as antibiotic prophylaxis, extensive debridement, oral antibiotic therapy according to the microbiology results and correct mechanical reconstruction. Mechanical complications like dislocation and re-infection may pose serious problems for patients during either the first or the second stage of the procedure.

Previous presentations

This manuscript has been orally presented at the annual congress of the "Sociedad Española de Cirugía de Cadera" (SECCA), in Zaragoza (Spain) on June 25th 2015.

REFERENCES

1. **Anagnostakos K, Jung J, Schmid NV, Schmitt E, Kelm J.** Mechanical complications and reconstruction strategies at the site of hip spacer implantation. *Int J Med Sci.* 2009 ; 6 : 274-9.
2. **Anagnostakos K, Lorbach O, Orth P, Koch K.** A simple technique for adjustment of the femoral offset at the site of hip spacer implantation. *J Surg Tech Case Rep*. 2013 ; 5 : 18-20.
3. **Anagnostakos K, Fürst O, Kelm J.** Antibiotic-impregnated PMMA hip spacers : Current status. *Acta Orthop*. 2006 ; 77 : 628-37.
4. **Barreira P**, **Leite P**, **Neves P**, **Soares D**, **Sousa R**. Preventing mechanical complications of hip spacer implantation : technical tips andpearls. *Acta Orthop Belg.* 2015 ; 81 : 344-8.
5. **Berend KR, Lombardi AV, Morris MJ, *et al.*** Two-stage treatment of hip periprosthetic joint infection is associated with a high rate of infection control but high mortality. *Clin Orthop Relat Res*. 2013 ; 471 : 510-8.
6. **Biring GS, Kostamo T, Garbuz DS, Masri BA, Duncan CP**. Two-stage revision arthroplasty of the hip for infection using an interim articulated Prostalac hip spacer : a 10- to 15-year follow-up study. *J Bone Joint Surg Br.* 2009 ; 91 : 1431-7.
7. **Bori G, García-Oltra E, Soriano A, *et al.*** Dislocation of Preformed Antibiotic-Loaded Cement Spacers (Spacer-G) : Etiological Factors and Clinical Prognosis. *J Arthroplasty*. 2014 ; 29 : 883-8.
8. **Choi HR, Freiberg AA, Malchau H, Rubash HE, Kwon YM.** The fate of unplanned retention of prosthetic articulating spacers for infected total hip and total knee arthroplasty. *J Arthroplasty.* 2014 ; 29 : 690-3.
9. **Choi HR, Kwon YM, Freiberg AA, Malchau H.** Comparison of One-Stage Revision With Antibiotic Cement Versus Two-Stage Revision Results for Infected Total Hip Arthroplasty. *J Arthroplasty.* 2013 ; 28 : 66-70.
10. **D'Angelo F, Negri L, Binda T, Zatti G, Cherubino P.** The use of a preformed spacer in two-stage revision of infected hip arthroplasties. *Musculoskelet Surg*. 2011 ; 95 : 115-20.

11. **D'Angelo F, Negri L, Zatti G GF.** Two-stage revision surgery to treat an infected hip implant. A comparison between a custom-made spacer and a pre-formed one. *Chir Organi Mov*. 2005 ; 90 : 271-9.
12. **Della Valle CJ, Bogner E, Desai P, *et al.*** Analysis of Frozen Sections of Intraoperative Specimens Obtained at the Time of Reoperation After Hip or Knee Resection Arthroplasty for the Treatment of Infection. *J Bone Joint Surg Am*. 1999 ; 81 : 684-9.
13. **Degen RM, Davey JR, Davey JR, *et al.*** Does a prefabricated gentamicin-impregnated, load-bearing spacer control periprosthetic hip infection? *Clin Orthop Relat Res*. 2012 ; 470 : 2724-9.
14. **García-Oltra E, Bori G, Tomas X, *et al.*** Radiological evaluation of acetabular erosion after antibiotic-impregnated polymethylmethacrylate spacer (Spacer-G). *J Arthroplasty.* 2013 ; 28 : 1021-4.
15. **Gil S, Marqués F, Rigol P, *et al.*** Two-stage revision of hip prosthesis infection using a hip spacer with stabilising proximal cementation. *Hip Int.* 2010 ; 20 :S 128-34.
16. **Hsieh PH, Shih CH, Chang YH, *et al.*** Two-stage revision hip arthroplasty for infection : comparison between the interim use of antibiotic-loaded cement beads and a spacer prosthesis. *J Bone Joint Surg Am*. 2004 ; 86-A : 1989-97.
17. **Jacobs C, Christensen CP, Berend ME.** Static and mobile antibiotic-impregnated cement spacers for the management of prosthetic joint infection. *J Am Acad Orthop Surg*. 2009 ; 17 : 356-68.
18. **Magnan B, Regis D, Biscaglia R, Bartolozzi P.** Preformed acrylic bone cement spacer loaded with antibiotics : use of two-stage procedure in 10 patients because of infected hips after total replacement. *Acta Orthop Scand.* 2001 ; 72 : 591-4.
19. **Muñoz-Mahamud E, Soriano A, Combalia A, *et al.*** Comparison of bacterial results from conventional cultures of the periprosthetic membrane and the synovial or pseudocapsule during hip revision arthroplasty. *Arch Orthop Trauma Surg.* 2014 ; 134 : 577-83.
20. **Muñoz-Mahamud E, Casanova L, Font L, Fernández-Valencia JA, Bori G.** Septic arthritis of the hip caused by nontyphi Salmonella after urinary tract infection. *Am J Emerg Med*. 2009 ; 27 : 373.e5-373.e8.
21. **Neumann DR, Hofstaedter T, List C, Dorn U.** Two-Stage Cementless Revision of Late Total Hip Arthroplasty Infection Using a Premanufactured Spacer. *J Arthroplasty.* 2012 ; 27 : 1397-401.
22. **Pattyn C, De Geest T, Ackerman P, Audenaert E.** Preformed gentamicin spacers in two-stage revision hip arthroplasty : functional results and complications. *Int Orthop*. 2011 ; 35 : 1471-6.
23. **Pignatti G, Nitta S, Rani N, *et al.*** Two stage hip revision in periprosthetic infection : results of 41 cases. *Open Orthop J*. 2010 ; 4 : 193-200.
24. **Regis D, Sandri A, Magnan B, Bartolozzi P.** Six-year follow-up of a preformed spacer for the management of chronically infected total hip arthroplasty. *Arch Orthop Trauma Surg.* 2010 ; 130 : 1111-5.
25. **Romanò CL, Romanò D, Meani E, Logoluso N, Drago L.** Two-stage revision surgery with preformed spacers and cementless implants for septic hip arthritis : a prospective, non-randomized cohort study. *BMC Infect Dis*. 2011 ; 11 : 129.
26. **Romanò CL, Romanò D, Albisetti A, Meani E.** Preformed antibiotic-loaded cement spacers for two-stage revision of infected total hip arthroplasty. Long-term results. *Hip Int*. 2012 ; 22 : S46-53.
27. **Sanchez-Sotelo J, Berry D. Hanssen AD, Cabanaela ME.** Midterm to long-term followup of staged reimplantation for infected hip arthroplasty. *Clin Orthop Relat Res.* 2009 ; 467 : 219-24.
28. **Younger AS, Duncan CP, Masri BA, McGraw RW.** The outcome of two-stage arthroplasty using a custom-made interval spacer to treat the infected hip. *J Arthroplasty.* 1997 ; 12 : 615-23.