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A cement spacer for two-stage revision of infected implants of the hip joint

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Summary. *We report the technical details and clinical results of twelve patients who had deep infections of implants in the hip joint and were treated by two-stage revision, using a gentamicin-loaded, hand-moulded cement spacer inserted for the period between resection and reimplantation arthroplasty. During management with the spacer, usually for 4 months, patients were almost free of pain and mobile with good leg control, spending 2/3 of the treatment period at home. Six of twelve spacers failed locally due to dislocation [5] or cement fracture [1], and more than two further episodes of surgery were required in 3 patients. Problems with dislocation of the spacer were significantly higher when the head to neck offset was lacking (P<0.05) or when anchorage in the femoral shaft was poor. Nevertheless, infection after reimplantation arthroplasty did not occur by the time of follow-up (2.2 years). Based on these data, we consider that the use of the cement spacer is a promising approach to the treatment of complicated infections of the hip joint.*

Résumé. *Cet article rapporte les détails techniques et les résultats cliniques de douze cas d'infection profonde de la hanche traités par révision chirurgicale en deux temps et utilisant un fantôme en ciment chargé de gentamycine et modelé à la main, mis en place temporairement dans l'intervalle entre la résection de la prothèse infectée et la réimplantation d'une nouvelle. Pendant ce traitement (4 mois) les patients furent pratiquement indolores, mobilisés et ayant bon contrôle du membre, et purent demeurer pendant les 2/3 du temps de traitement à domicile. Six des 12 fantômes échouèrent localement, ceci du à une luxation ou à une fracture du ciment, nécessitant une troisième intervention dans 3 cas. Une luxation du fantôme était due à un manque d'offset tête-col (P<0,05) ou à un ancrage insuffisant dans le fût fémoral. Par contre aucune des prothèses ne s'infectèrent aprés la réimplantation. Sur la base des ces résultats nous proposons le concept du fantôme en ciment temporaire pour améliorer sur le point biologique aussi bien que mècanique le traitement des infections de hanche.*

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Introduction

The contemporary literature favours two-stage resection/reimplantation arthroplasty over other methods for the control of active infection and in order to provide good function in deep seated infection of hip joint implants [2–4, 23, 24, 27]. During the interval between the two procedures [16], however, the patient may be uncomfortable, discouraged, and often confined to the hospital with limited mobility and activity. Delayed reimplantation procedures after a Girdlestone-like procedure are technically demanding due to scar formation, shortening, disuse osteoporosis, and the distorted anatomy.

A cement spacer (gentamicin-loaded PMMA) has been tested in twelve patients with complicated infections of the hip joint. It has two functions namely biological, as a source for the sustained release of gentamicin for local eradication of the infection, and mechanical, to provide the patient with comfort and mobility. The spacer also reduces the dead space and soft tissue shortening after resection of infected tissues thereby facilitating easier reimplantation.

Table 1. Patients

Case	Age, sex	Medical status	Previous orth. diagnosis	No. of prev. OPs	Type of implant	Time since first/ last OP (month)
A	63, male	Renal insuff., poliomyelitis	Femoral neck fracture	1	Blade plate	3/3
B	74, male	Cardiac disease	Coxarthrosis	4	THA	36/8
C	65, male	Healthy	Coxarthrosis	1	THA	60/60
D	38, male	Healthy	Femoral neck fracture	1	DHS	5/5
E	60, male	Diabetes m.	Coxarthrosis	3	THA	144/32
F	71, male	Urosepsis	Coxarthrosis	1	THA	12/12
G	39, male	Malaria	Femoral head necrosis	2	Hemiprosthesis	132/119
H	53, fem.	Healthy	Coxarthrosis	4	THA	264/5
I	80, male	Cerebrovascular insufficiency	Coxarthrosis	1	THA	24/24
J	70, male	Diabetes m.	Coxarthrosis	1	THA	132/132
K	57, male	Recurrent infections	Femoral neck fracture	1	Screws	1/1
L	52, male	Schizophrenia	Septic coxitis	0	None	–/–

Table 2. Infections

Case	Clinical symptoms	BSR/CRP	Organisms	Duration of infection (month)	Classfication Stage I–III[a]
A	Sinus	–[b]/–[b]	coryneb. xerosis /coag.-neg. staph.	3	I
B	Sinus/osteomyelitis	–[b]/–[b]	coag.-neg. staph.	10	I
C	Fascitis/sepsis	50/20	streptococcus[c]	2	III
D	Instability	38/26	coag.-neg. staph.	<1	I
E	Osteitis	40/32	coag.-neg. staph. /bacillus species	36	I
F	Sepsis		staph. aureus[c]	1	III
G	Protrusion	25/–[b]	kleb. pneumoniae	(unknown)	III
H	Sinus	55/20	coag.-neg. staph.[d]	5	I
I	Sinus	92/–[b]	coag.-neg. staph.[d] /entero. faecalis	24	I
J	Sepsis	–[b]/–[b]	*Staph. aureus*	12	III
K	Sepsis	34/50	citrob. diversus	<1	I
L	Septic coxitis	75/–[b]	*Staph. aureus*	<1	III

[a] Coventry [10]; [b] No information available; [c] Obtained from blood cultures, no local growth; [d] Organisms resistant to gentamicin

Material and methods

Patients

Between November 1992 and November 1996, twelve two-stage revision arthroplasties using a gentamicin-loaded PMMA spacer were performed in eleven males and one female with deep sepsis of the hip (Table 1). The mean age was 60 years (range: 38 to 80 years). Infected implants had been in place on average for 41 months (range: 3 to 132 months) and between 0 and 4 previous operations had been performed. Periprosthetic infections had been present for an average of 12 months (range: 1 to 36 months) and were classified according to Coventry [10] as follows: Stage I – suppurative infection during the neosurgical period (1–3 weeks), Stage II – indolent, delayed infection, seen during the first year after operation and Stage III – occurring after the first postoperative year. In addition to low-grade, creeping infection, haematogenous infection may occur at an indefinite time after the operation (Table 2).

In four patients, one with an early infection (stage I) and three with haematogenous infection (stage III), emergency surgery had to be performed due to life threatening sepsis. Eight of twelve patients had severe underlying medical problems which affected the local prognosis (Table 1). In all patients, the diagnosis of deep infection was based on clinical as well as radiological evidence, together with cultures obtained at preoperative joint aspiration or surgery (Table 2). Two patients died before reimplantation, their deaths being unrelated to the treatment for the infected implant or the further infection.

Resection arthroplasty and cement spacer

The decision to perform a two-stage revision arthroplasty was based on the general and local condition of the patients. With the patient placed in the lateral position in eleven instances, and once in the supine position, a straight lateral approach was used, which was extended to a Kocher-Langenbeck approach

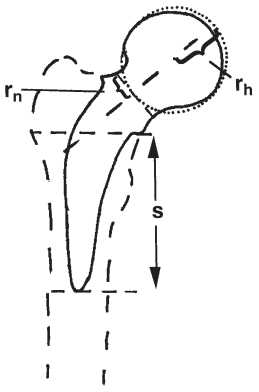

Fig. 1. Measurements used for the quantitative description and comparison of spacers: (r_h) radius of the spacer head, (r_n) radius of the spacer neck, and (s) depth of spacer anchorage in the medullary canal

if necessary. Osteotomy of the greater trochanter with the vastus lateralis still attached, as described by Schneeberger et al. [30], facilitated the removal of the cemented femoral component in the majority of the patients. This procedure allowed direct access to the periacetabular region and a tumour-like excision of all infected tissues and implant material. For the remaining patients a transgluteal or Watson-Jones approach was used.

In all instances tissues were resected for bacterial cultures and the wounds were thoroughly irrigated with large quantities of a Ringer's physiological solution. The infecting organisms were isolated in 10 out of 12 instances and coagulase-negative staphylococci and *Staphylococcus aureus* were found most commonly. In three patients mixed infections were present. In eight, organisms cultured from specimens taken at resection were sensitive to gentamicin. Bacterial cultures from two patients did not reveal any organisms, although clinical symptoms, earlier bacterial cultures and the surgical features strongly suggested infection (Table 2).

On average, two packs of gentamicin-loaded PMMA (Palacos R, 40 g polymer and 0.5 g gentamicin, Essex Chemie AG, Switzerland) were used for the cement spacer. The material was moulded by hand and either attached to the femoral component at the neck or placed intramedullary, or fitted into the acetabulum without fixation to the femur. For internal reinforcement, plates or screws were inserted into the cement before polymerisation (Fig. 2). Before reimplantation arthroplasty, patients were mobilised on crutches but instructed to not load the operated hip with more than 15 kg of weight.

Reimplantation arthroplasty

The timing of the reimplantation arthroplasty was dependent on control of the infection and the clinical symptoms. Routine laboratory tests such as bacterial cultures, the blood sedimentation rate (BSR, mm after 1 h) and C-reactive protein (CRP, mg/1) were performed throughout treatment with the spacer. The quality of mobility during spacer treatment was graded as poor, fair, good and excellent and listed with the required external aid. Data on the geometry of the spacer were obtained from AP radiographs of the pelvis, as schematically represented in Fig. 1. The radius of the femoral head (r_h) and neck (r_n) together with the distance between the most proximal point of the medial cortex and the most distal location of cement in the femoral shaft (s) were measured (mm).

At reimplantation the pre-existing surgical approach was used. After resecting scar tissue and obtaining material for bacterial cultures, the spacer was removed and a fresh prosthesis introduced. The decision concerning the implant to be used was based on the quality of the residual bone stock.

Statistics

Quantitative data are given as single values or represented by means and standard deviations. Statistical comparisons were performed by the Mann-Whitney non-parametric test.

Results

The mean duration between the resection and revision in which the spacer was used was 4 months (range: 2 to 7 months) depending upon the status of infection. An average 35% of this period patients spend in the hospital (range: 15–100%). In one patient (1) who did not undergo reimplantation, the spacer remained in place for 2 years. Nine of twelve patients were mobile on crutches during their spacer treatment and almost free of pain (Table 3). Despite the recommended maximum joint loading of 15 kg, one patient (C) undertook mountaineering with the spacer in place with consequent wear of his acetabular bone stock.

Table 3. Spacer treatment

Case	Spacer/Hosp.: (month/%)	Mobility	Results:		
			BSR/CRP	Complications	Number of surgeries
A	7/44%	Fair, wheelchair	20/5	Dislocation, haematoma	4
B	4/28%	Good, crutches	18/13	Fracture of spacer	2
C	4/24%	Excellent, none	–[c]/6	Protrusion of spacer	2
D	4/18%	Good, crutches	13/5	No	2
E	5/15%	Good, crutches	13/11	No	2
F	7/18%	Good, crutches	50/–[c]	Dislocation	2
G	2/24%	Excellent, crutches	38/10	No	2
H	4/30%	Good, crutches	12/3	No	2
I	(24)[a]	Fair, crutches	[a]	(Dislocation)[a]	(1)[a]
J	(0)[b]	[b]	[b]	(no)[b]	(1)[b]
K	5/50%	Fair, crutches	20/8	Dislocation	4
L	2/100%	Poor, bedridden	22/<3	Dislocation	6

[a] Patient did not medically qualify for reimplantation and died two years after spacer implantation from causes unrelated to infection or local treatment.

[b] Patient died shortly after implantation of the spacer due to heart failure unrelated to infection or local treatment.

[c] No information available

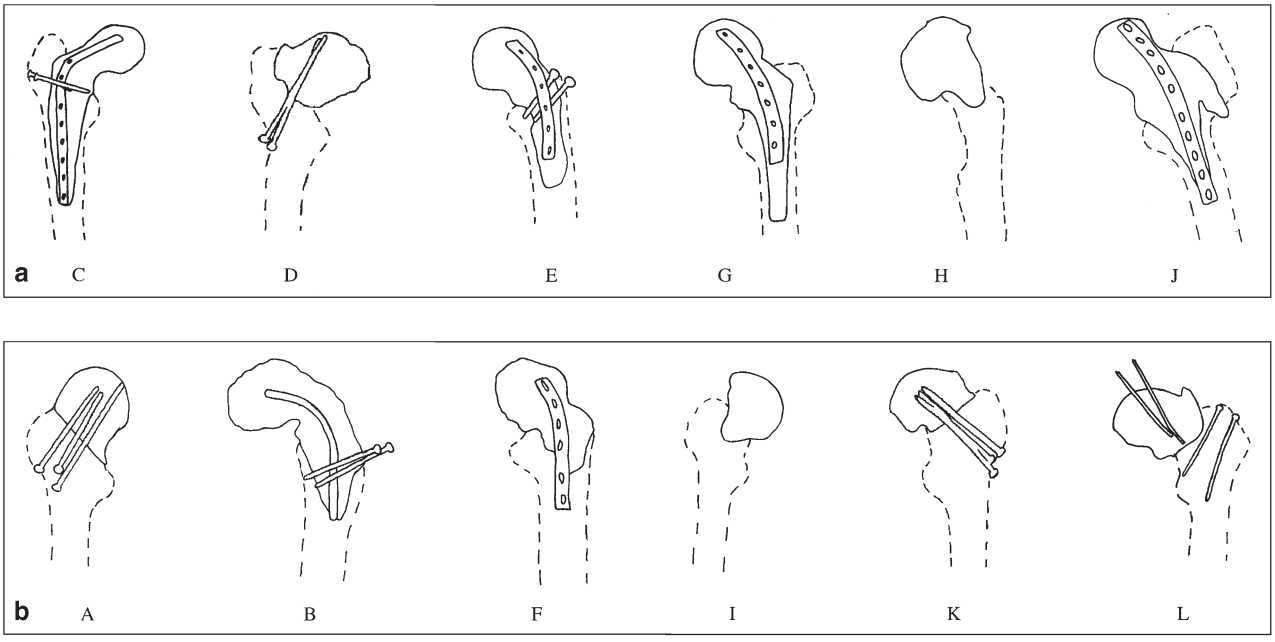

Fig. 2. Schematic drawings obtained from AP radiographs of all implanted spacers. **a** Complication-free spacers, **b** Locally failed spacers

During treatment, six spacers failed (Figure 2), five by dislocation and one by fracture. Revision was then carried out in three of these patients and the others were treated conservatively by immobilisation until the definitive procedure. One patient (I), whose spacer dislocated from the femoral shaft one year after implantation, remained medically unfit for revision because of severe cerebrovascular insufficiency and died two years after removal of the infected prosthesis. A second patient (L) with schizophrenia was severely agitated and dislocated repeatedly, requiring 6 operations and finally a Girdlestone resection arthroplasty.

The geometry of the spacer had a significant impact on its fate. In spacers which were free of complications there were no significant differences in the radius of the neck and head of the spacer compared to the contralateral side (0.76±0.05), as analysed from AP radiographs of the pelvis. The neck to head-ratio was 0.73±0.14, whereas this was significantly increased in dislocating spacers (0.96±0.19, $P<0.05$). A second factor associated with failure was an insufficiently deep anchorage in the intramedullary canal, being 22±33 mm (range: 0 to 71 mm) in the failure group, while complication-free spacers were on average attached to a depth of 57±41 mm (range: 0 to 107 mm). Interestingly, dislocation of the spacer from the femoral shaft did not correlate with the activity level of patients.

During treatment with the cement spacer the erythrocyte sedimentation rate dropped from 50 mm (range: 25 to 92 mm) at resection to 28 mm (12 to 50 mm, $P<0.05$) at reimplantation. In the same way, the CRP decreased from 30 mg/l (range: 20 to 50 mg/l) to 7 mg/l (3 to 13 mg/l, $P<0.005$). Bacterial cultures obtained at reimplantation were negative in seven of nine patients. In two patients (A and G), bacterial cultures revealed a coagulase-negative staphylococcus which was resistant to gentamicin, although in both patients the intraoperative appearances did not suggest ongoing infection.

After an average follow-up of 27 months from reimplantation arthroplasty, all 9 patients were mobile and infection had not recurred. In one patient (K), a new haematogenous streptococcal infection, initially citrobacter diversus, developed after a bout of pneumonia.

Discussion

In the treatment of periprosthetic hip infection, retention of components is an alternative for a small proportion of patients. The indications are a brief duration of symptoms, gram-positive organisms sensitive to antibiotics, no loosening of the prosthesis and absence of excessive scarring [11, 14]. This approach, however, is associated, with a significant failure rate [19]. The poor functional recovery [6, 18] compared to that following reimplantation makes only a few patients suitable for a definitive Girdlestone resection arthroplasty. The current management for deep infections of the hip-joint requires meticulous debridement and removal of all foreign material including the implant and cement. Thereafter, one [32] or two-stage revision arthroplasties [26], in combination with the administration of local and/or systemic antibiotics, have been advocated. For a one-stage arthroplasty the organism should be sensitive to antibiotics, the host should have few risk factors for infection and there should be adequate bone and soft tissue support for the reconstruction of the hip after successful debride-

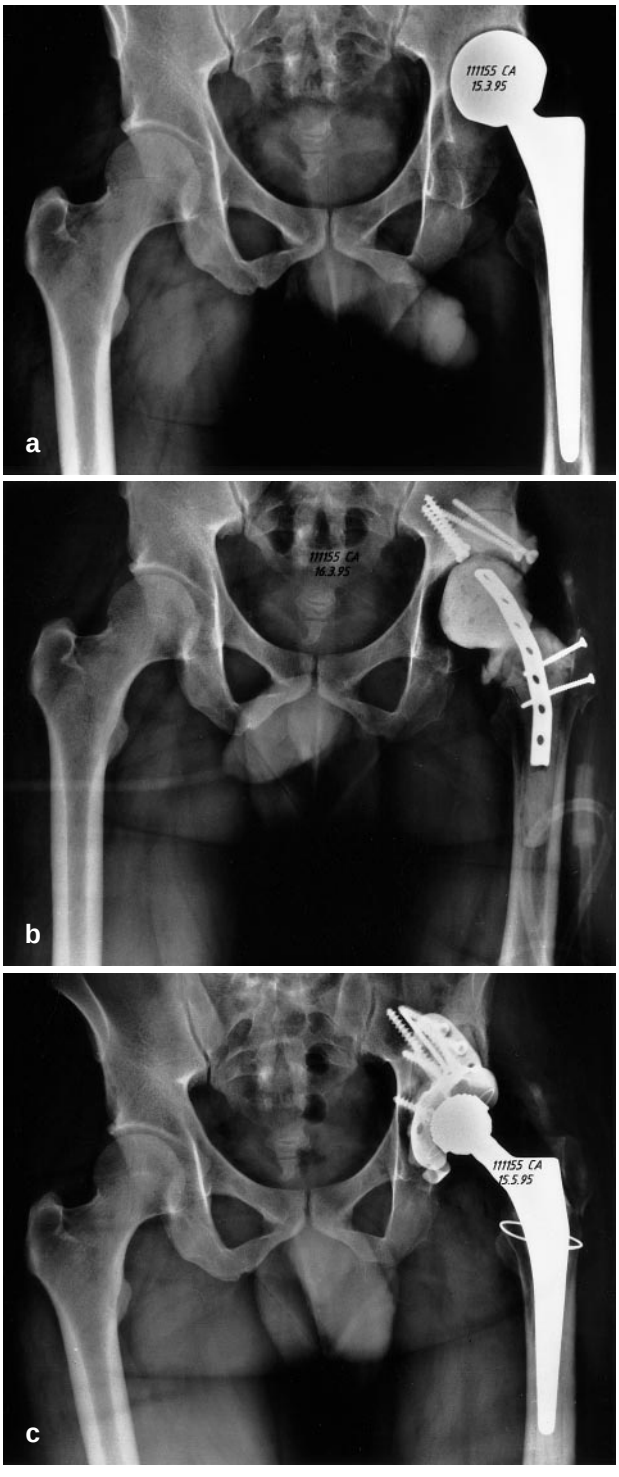

Fig. 3. AP radiographs of patient G. **a** Infected hemiprosthesis with acetabular protrusions; **b** transient cement spacer; **c** after reimplantation of a THA

ment [17]. If these criteria are not met, a two-stage procedure is recommended.

For two-stage procedures, a Girdlestone-like arthroplasty represents the most common situation between each operation. A variation of the two-stage exchange arthroplasty has been described in which the dead space created at the time of resection arthroplasty is filled with antibiotic-loaded cement beads [21]. In this instance, the beads are not used for mechanical fixation or support, but solely to fill the dead space with a high local concentration of antibiotic. Delayed reimplantation arthroplasty is difficult due to significant soft tissue shortening, and extensive blood loss during release and removal of scar tissue and/or damage to the sciatic nerve might complicate the operation [31]. Restoration of limb length and movement of the hip is often not accomplished and dislocation after surgery is frequent [20]. In order to avoid these problems, we have used a temporary cement spacer which accelerates rehabilitation, maintains the patient's mobility (Figs. 3, 4), and keeps surgical options open prior to the reimplantation procedure [5].

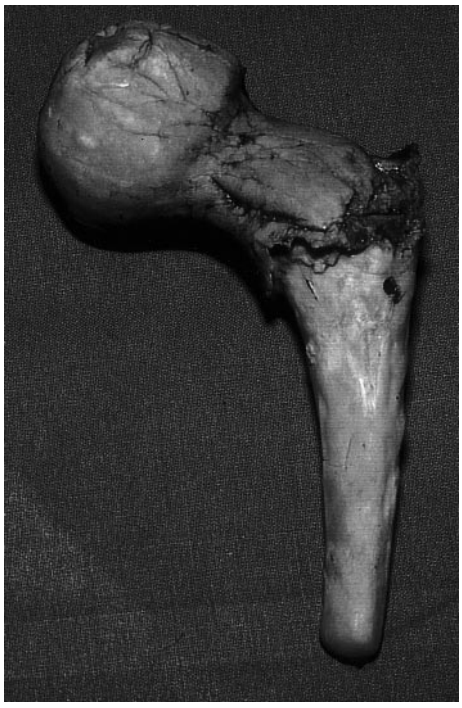

Fig. 4. Spacer of patient G removed en bloc at reimplantation two months after insertion

Our patients were managed by two-stage revision arthroplasty. Using this approach, all patients (9/12) who had a fresh prosthesis were mobile and no re-infection occurred up to 27 months after the procedure. Although a direct comparison between different techniques is difficult, infection control in the nine patients undergoing reimplantation was superior to that achieved with other two-stage procedures, where the success rate ranged between 73 and 93% [3, 7, 9, 25, 29]. Six of twelve spacers failed locally due to geometrical shortcomings. These local complications should be avoidable by proper shaping of the spacer using radiographs of the contralateral hip or earlier pelvic films, and providing a sufficiently deep anchorage in the femoral shaft. Although one spacer containing a plate fractured (B), we believe that the use of internal reinforcement by screws and plates minimised the number of fractures.

In addition to maintaining hip geometry, the spacer serves as a source for the sustained release of gentamicin. Spacers should be removed when the infection has been controlled, which had occurred, on average, after a period of 4 months. Prolonged treatment is not advantageous, since the antibiotic release of gentamicin-cement drops significantly after two weeks due to elution of the antibiotic and encasement of the foreign material by fibrous tissue membranes [28]. Despite the successful eradication of infection, in our patients spacer treatment can be improved by the use of antibiotics for which the joint infecting organisms are most sensitive [13].

Use of the spacer is inexpensive and improves patient comfort between the two operations, reduces the length of hospital stay and eases reimplantation. It compares favourably with other procedures such as implantation of antibiotic releasing beads [8, 15], a crude facsimile [1, 22], or an expansile modular prosthesis coated with antibiotic-loaded bone cement [12, 33].

References

1. Abendschein W (1992) Salvage of infected total hip replacement: use of antibiotic/PMMA spacer. Orthopedics 15:228–229
2. Antti-Poika I, Santavirta S, Konttinen YT, Honkanen V (1989) Outcome of the infected hip arthroplasty. Acta Orthop Scand 60:670–675
3. Balderston RA, Hiller WDB, Iannotti JP, Pickens GT, Booth RE, Gluckman SJ, Buckley RM, Rothman RH (1987) Treatment of the septic hip with total hip arthroplasty. Clin Orthop 221:231–237
4. Bittar ES, Petty W (1982) Girdlestone arthroplasty for infected total hip arthroplasty. Clin Orthop 170:83–87
5. Booth RE, Lotke PA (1989) The result of spacer block technique in revision of infected total knee arthroplasty. Clin Orthop 248:57–60
6. Bourne RB, Hunter GA, Rorabeck CH, Macnab JJ (1984) A six-year follow-up of infected total hip replacement managed by Girdlestone's arthroplasty. J Bone Joint Surg [Br] 66:340–343
7. Buchholz HW, Elson RA, Engelbrecht E, Lodenkämpfer H, Röttger J, Siegel A (1981) Management of deep infection of total hip replacement. J Bone Joint Surg [Br] 63:342–353
8. Calhoun J, Eng M, Daum W, Mader J, Koulisis C, Evans EB (1988) Failure of bipolar hip arthroplasty secondary to retained antibiotic-impregnated polymethymethacrylate beads. J Bone Joint Surg [Am]70:1246–1248
9. Colyer RA, Capello WN (1994) Surgical treatment of the infected hip implant. Two-stage reimplantation with a one-month interval. Clin Orthop 298:75–79
10. Coventry MB (1975) Treatment of infections occurring in total hip surgery. Orthop Clin North Am 6:991–1003
11. Del Sel HJ, Charnley J (1979) Total hip replacement following infection in the opposite hip. Clin Orthop 141: 138–142
12. Duncan CP, Beauchamp C (1993) A temporary antibiotic-loaded joint replacement system for management of complex infections involving the hip. Orthop Clin North Am 24:751–759
13. Duncan CP, Masri BA (1994) The role of antibiotic-loaded cement in the treatment of an infection after a hip replacement. J Bone Joint Surg [Am] 76:1742–1751
14. Tsukayama DT, Estrada R, Gustilo RB (1996) Infection after total hip arthroplasty. A study of the treatment of one hundred and six infections. J Bone Joint Surg [Am] 78: 512–523
15. Fiddian NJ, Sudlow RA, Browett JP (1984) Ruptured femoral vein. A complication of the use of gentamicin beads in an infected excision arthroplasty of the hip. J Bone Joint Surg [Br] 66:493–494
16. Garvin KL, Evans BG, Salvati EA, Brause BD (1994) Palacos gentamicin for the treatment of deep periprosthetic hip infections. Clin Orthop 298:97–105
17. Garvin KL, Hanssen AD (1995) Infection after total hip arthroplasty, past, present and future. J Bone Joint Surg [Am] 77:1576–1588
18. Grauer JD, Amstutz HC, O'Carroll PF, Dorey FJ (1989) Resection arthroplasty of the hip. J Bone Joint Surg [Am] 71:669–678
19. Gristina AG, Costerton JW (1985) Bacterial adherence to biomaterials and tissue. The significance of its role in clinical sepsis. J Bone Joint Surg [Am] 67:264–273
20. Harkess JW (1992) Arthroplasty of the hip. In: Crenshaw AH (ed) Campbell's operative Orthopedics. Mosby Year Book, St. Louis
21. Hovelius L, Josefsson G (1979) An alternative method for exchange operation of infected arthroplasty. Acta Orthop Scand 50:93–96
22. Ivarsson I, Wahlström O, Dierf K, Jacobson SA (1994) Revision of infected hip replacement. Two-stage procedure with a temporary gentamicin spacer. Acta Orthop Scand 65:7–8
23. Lieberman JR, Callaway GH, Salvati EA, Pellicci PM, Brause BD (1994) Treatment of the infected total hip arthroplasty with a two-stage reimplantation protocol. Clin Orthop 301:205–212
24. Maderazo EG, Judson S, Pasternak H (1988) Late infections of total joint prostheses: A review and recommendations for prevention. Clin Orthop 229:131–142
25. McDonald DJ, Fitzgerald RH, Ilstrup DM (1989) Two-stage revision of a total hip arthroplasty because of infection. J Bone Joint Surg [Am] 71:828–834
26. Nelson CL, Evans RP, Blaha JD, Calhoun J, Henry SL, Patzakis MJ (1993) A comparison of gentamicin-impregnated polymethylmethacrylate bead implantation to conventional parenteral antibiotic therapy in infected total hip and knee arthroplasty. Clin Orthop 295:96–101
27. Salvati EA, Chekofsky KM, Brause BD, Wilson PD (1982) Reimplantation in infection: A 12-year experience. Clin Orthop 170:62–75
28. Salvati EA, Callaghan JJ, Brause BD, Klein RF, Small RD (1986) Reimplantation in infection. Elution of gentamicin from cement and beads. Clin Orthop 207:83–93
29. Sanzen L, Carlsson AS, Josefsson G, Lindberg LT (1988) Revision operations on infected total hip arthroplasties. Two to nine-year follow-up study. Clin Orthop 229:165–172
30. Schneeberger AG, Murphy SB, Ganz R (1997) Die digastrische Trochanterosteotomie. Operat Orthop Traumatol 9:1–15
31. Steinbrink K (1990) The case for revision arthroplasty using antibiotic-loaded acrylic cement. Clin Orthop 261: 19–22
32. Wroblewski BM (1986) One-stage revision of infected cemented total hip arthroplasty. Clin Orthop 211:103–107
33. Zilkens KW, Casser HR, Ohnsorge J (1990) Treatment of an old infection in a total hip replacement with an interim spacer prosthesis. Arch Orthop Trauma Surg 109:94–96