Archives of Orthopaedic and Trauma Surgery (2019) 139:869–876
https://doi.org/10.1007/s00402-019-03180-0

HIP ARTHROPLASTY

Partial two-stage exchange at the site of periprosthetic hip joint infections

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Received: 1 February 2019 / Published online: 29 March 2019

Abstract

Introduction In the past 10 years an increasing number of studies about partial two-stage exchange arthroplasty in the management of periprosthetic hip infections have been published. The aim of the present work was to systematically review the current knowledge about this procedure, and critically verify the success as well as the complications of this treatment option.

Materials-methods A literature search was performed through PubMed until June 2018. Search terms were "partial two stage hip" and "partial retention hip", and "retaining well fixed hip".

Results A total of 7 studies reporting on a total of 80 patients could be identified. All studies had a level of evidence IV. The great majority of the studies reported on the isolated removal of the acetabular cup and placement of an antibiotic-loaded cement spacer head onto the retained, well-fixed stem. Most of the periprosthetic infections were caused by staphylococci. The infection eradication rate varied between 81.3 and 100% at a mean follow-up between 19 and 70 months. Poor outcome was observed at the site of MRSA infections.

Conclusions The partial two-stage exchange arthroplasty appears to be a possible option in the management of PJI when one prosthetic component is well-fixed so that their removal might result in significant bone loss and compromise of fixation at the time of the later prosthesis reimplantation, and the causative organisms are not multiresistant. The small numbers published about this protocol does not allow for a generalization of application and should be only applied in highly selected patients. Future studies with larger collectives and longer follow-ups are welcome to evaluate the clinical success of this option and its possible role in the management of PJI.

Keywords Hip infection · Periprosthetic infection · Two-stage arthroplasty · Partial two-stage exchange

Introduction

Periprosthetic hip infections pose a seldom but hazardous complication after total hip arthroplasty (THA). Treatment options mostly depend on the time of infection manifestation (early vs. low-grade vs. late infections). Although the exact time points of each infection type definition are not consistently accepted [1], orthopaedic surgeons still agree that early periprosthetic hip infections might be successfully treated by debridement, antibiotics, irrigation, and retention of the prosthesis (DAIR) [2]. At the site of low-grade- or late infections, treatment modalities always involve removal of the infected prosthesis, whereas some authors favor the one-stage- [3, 4] and others the two-stage exchange arthroplasty [5–7].

In some cases of periprosthetic hip infections, either the femoral component or the acetabular cup might be well-fixed, so that their removal might result in significant bone loss and compromise of fixation at the time of the later prosthesis reimplantation. Based on that fact, an increasing number of studies have been published in the past 10 years reporting on partial two-stage exchange showing similar infection control rates compared to those after usual spacer implantation [8–14].

The aim of the present work was to systematically review the current knowledge about partial two-stage exchange arthroplasty at the site of periprosthetic hip infections, and critically verify the success as well as the complications of this treatment option.

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Materials-methods

Inclusion of studies

A literature search was performed through PubMed until June 2018 (Fig. 1). Search terms were "partial two stage hip" and "partial retention hip", and "retaining well fixed hip". Only English studies were included. Reviews were excluded. Among the primarily identified studies, a search was carried out through the bibliography of each article for further identification of relevant studies. All publications were analyzed with regard to publication year, level of evidence, number of hips/patients treated, type of retained component, pathogen organism(s), surgical technique, antibiotic impregnation of the cement, time period between stages, complications between stages and after partial prosthesis reimplantation, respectively, systemic antibiotic therapy, length of follow-up, and rate of infection eradication.

Results

A total of 7 studies reporting on a total of 80 patients could be identified (Table 1) [8–14]. No study was published before 2009. All studies had a level of evidence IV. The great majority of the studies reported on the isolated removal of the acetabular cup and placement of an antibiotic-loaded cement spacer head onto the retained, well-fixed stem, whereas two studies also described techniques about retaining of the well-fixed cup and inserting a spacer into the femur. Three studies did not report about the fixation type of the retained component, whereas in the other four studies the great majority of the retained prosthetic components were cementless (Table 1).

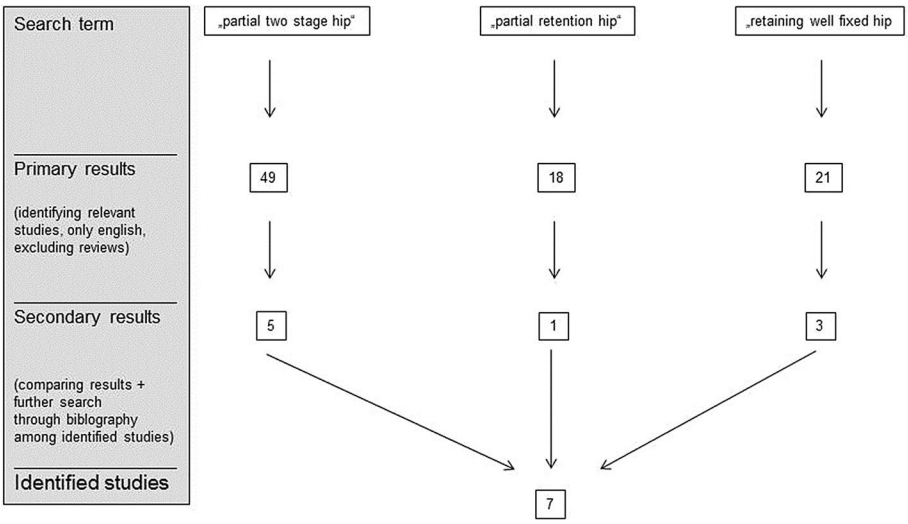

Fig. 1 Literature search for identification of studies about partial two-stage exchange at the site of periprosthetic hip joint infections

Table 1 Demographic data of identified studies

Study	Publication year	Level of evidence	No. of patients/hips	Retained component	Type of retained component
Faroug et al. [14]	2009	IV	2/2	1× cup 1× stem	1× cementless 1× cemented
Anagnostakos et al. [8]	2010	IV	12/12	All stems	n.r.
Lee et al. [10]	2013	IV	19/19	All stems	Cementless
Ekpo et al. [11]	2014	IV	19/19	All stems	15× cementless 4× cemented
Lombardi et al. [12]	2014	IV	7/7	All stems	n.r.
Fukui et al. [13]	2015	IV	5/5	All stems	Cementless
Chen et al. [9]	2017	IV	16/16	15× stem 1× cup	n.r.

n.r. not reported

Diagnostic imaging and testing of the stability of the retained implant

With regard to the extent of the infection and the proof of the stability of the retained component, various preoperative imaging techniques and intraoperative methods have been used. Chen et al. defined loosening of the cup as migration of > 2 mm or large radiolucent zone around the component, whereas loosening of the stem was defined as the presence of at least one criterium (subsidence of > 2 mm, complete radiolucent line along the stem surface > 2 mm, and endosteal scalloping or migration of the prosthesis) [9]. Fukui et al. [13] confirmed the stability by means of radiographs, computed tomography, magnetic resonance tomography, bone scintigraphy, and in unclear cases fluorodeoxyglucose positron-emission tomography (FDG-PET) scan to accurately assess the extent of infection. The importance of antigranulocyte scintigraphy was also stated by Anagnostakos et al. [8]. Regarding the stability of the retained implant, Chen et al. reported that intraoperative difficulty of removing the implant without the aid of osteotomy was interpreted as fixation of the implant [9]. Lee et al. [10] tried to remove the stem by making a cleavage between the stem and the proximal femur using thin osteotomes and gauges, and the pulling out the stem using a stem extractor. If that failed, the stem was left in situ. Anagnostakos et al. [8] mentioned that the stem stability was confirmed intraoperatively, however, the exact technique of intraoperative testing was not stated.

Microbiological findings

Most of the periprosthetic infections were caused by staphylococci (Table 2). Methicillin-resistant Staphylococcus aureus (MRSA) infections were seen in only two studies. Fungal infections were reported in only one study. Culture-negative infections were present in 4 out of 7 studies. All microbiological data are summarized in Table 2.

Surgical technique and systemic antibiotic therapy between stages

All studies emphasized the importance of the surgical debridement, pulsatile lavage, and mechanical cleansing/scrubbing of the surface of the retained component.

Great variations were observed in the manufacture of the spacer head that was placed onto the retained stem. These heads have been produced by means of commercially available moulds, custom-made moulds, modified techniques depending on the head diameter or were hand-molded (Table 2). Five different cement types have been used for spacer (head) production. For local antibiotic therapy, aminoglycosides (gentamicin, tobramycin) in combination with vancomycin was the most frequent combination utilized for impregnation of the bone cement, whereas various combinations of the particular antibiotic dosage have been used (Table 2). The maximum antibiotic/cement-ratio was 22% (4.8 g tobramycin + 4 g vancomycin/40 g cement), and was reported by two studies [11, 12] (Table 2). Fukui et al. [13] reported that besides the spacer head implantation, additional radical curettage of osteolytic lesions of the proximal femur was carried out until an area of bone ingrowth between the proximal part of the femur and the porous area of the uncemented stem was confirmed. The curetted space was then filled with antibiotic-impregnated alpha-tricalcium phosphate cement.

The mean time period between the first and second stage ranged between 7 weeks and 6.7 months (Table 2). Almost all studies applied a postoperative systemic antibiotic therapy over 6 weeks (Table 2).

Complications between stages

Spacer dislocations were observed in two studies [8, 14]. One study stated that no complications occurred during the interim phase [12], whereas another one mentioned that no major complications were observed [13]. Three studies did not provide any information about complications between the stages (Table 3).

Clinical outcome and infection eradication

At the second stage, most patients were reimplanted with cementless components, whereas three studies did not provide any information about this. A continuation of the systemic antibiotic therapy after the second stage was reported in only two studies, and in those studies systemic antibiotics were applied for 1–3 days (Table 3).

The infection eradication rate varied between 81.3 and 100% at a mean follow-up between 19 and 70 months (Table 3). In the two studies with reported MRSA infections, the success of the partial two-stage protocol was low (1/2 failures in the study of Ekpo et al. [11] and 2/3 failures in the study of Chen et al. [9]). In all studies, almost all treatment failures were then managed by "classic" two-stage procedure with removal of all prosthetic components.

Four studies measured the functional outcome by means of the Harris Hip Score (HHS). At the latest follow-up, Lee et al. reported of a mean HHS of 89 (65–94) points, whereas Ekpo et al. [11] and Lombardi et al. [12] observed a mean HHS of 68 (31–100) and 71.8 (44–90), respectively. Fukui et al. [13] observed an improvement of the HHS from 63 to 86 (78–93) points.

Table 2 Microbiological findings, data about surgical treatment, and antibiotic therapy

Study	Pathogen organism	Spacer head technique	Cement impregnation	Cement used	Mean time period between stages	Length of systemic antibiotic therapy between stages
Faroug et al. [14]	1× CNS 1× CNS, Ps. aeruginosa, diptheroid and coliform bacilli	Hand-molded	2 g vancomycin/40 g cement	CMW	n.c.r.	6 weeks
Anagnostakos et al. [8]	6× S. epidermidis 4× S. aureus 2× E. faecalis 2× C. albicans 2× hemol. Streptococci 1× Str. agalactiae	Custom-made mould	12 × 0.5 g gentamicin + 2 g vancomycin/40 g cement 1 × 0.5 g gentamicin + 0.4 g teicoplanin/40 g cement	Palacos	88 (35–270) days	6 weeks (4 weeks i.v. + 2 weeks p.o.)
Lee et al. [10]	7× S. aureus 5× CNS 2× Streptococci 1× Enterococci 4× culture-negative	Hand-molded	1 g vancomycin + 1 g tobramycin + 1 g cefotaxime/40 g cement	Simplex	6.7 (1–24) months	4–6 weeks i.v.
Ekpo et al. [11]	4× S. epidermidis 3× MRSA 2× CNS 2× beta hemolytic Streptococcus group B 1× A. prevotii 1× Y. enterocolitica 1× Enterococcus 1× gram-positive Streptococcus 1× Str. bovis 4× culture-negative	By means of a pediatric ear and ulcer syringe for smaller heads (44 mm diameter), a bulb type irrigation syringe for larger heads (52 mm diameter), and commercially-available spacer moulds	3–4 g vancomycin + 3.6–4.8 g tobramycin/40 g cement	Palacos or Cobalt	8.4 (5–19) weeks	Minimum 6 weeks i.v. for positive cultures; 6 weeks for negative
Lombardi et al. [12]	3× S. aureus 1× CNS 1× alpha hemolytic Streptococcus mitas/oralis 2× culture-negative	Commercially-available spacer moulds	3–4 g vancomycin + 3.6–4.8 g tobramycin/40 g cement	Palacos or Cobalt	7.1 (6–9) weeks	Minimum 6 weeks i.v.
Fukui et al. [13]	3× coagulase-negative Staphylococcus 1× Peptostreptococcus micros 1× Proprionibacterium acnes	Commercially-available spacer moulds	1 g vancomycin + 1 g tobramycin + 1 g cefotaxime/40 g cement	Simplex	2.9 (2–5) months	4-6 weeks i.v.

Table 2 (continued)

Study	Pathogen organism	Spacer head technique	Cement impregnation	Cement used	Mean time period between stages	Length of systemic antibiotic therapy between stages
Chen et al. [9]	3× Proprionibacterium species 3× MRSA 2× coagulase-negative Staphylococci 2× Peptostreptococcus species 1× *E. coli* 1× Salmonella group D 1× Peptostreptococcus species + Enterococcus species 3× culture-negative	Hand-molded	15/16× 160 mg gentamicin + 4 g vancomycin/40 g cement 1/16 2 g ceftriaxon/40 g cement	Simplex	3.1 (2–5) months	i.v. as long as the drain in situ + p.o. until 6. postop. week

n.c.r. not clearly reported, *CNS* coagulase-negative Staphylococci, *MRSA* methicillin-resistant Staphylococcus aureus

Discussion

Orthopedic surgeons agree that at the site late periprosthetic joint infections (PJI) the infected prosthesis has to be removed to gain infection control [15]. The description of a partial two-stage approach with retention of one prosthetic component contradicts previous knowledge about the management of chronic periprosthetic hip joint infections, especially at reported success rates of 81–100% [8–14].

The theoretical advantages and disadvantages of this procedure are apparent. Shorter operation time, less blood loss, prevention of significant bone loss or emergence of fractures at well-fixed implants, and compromise of fixation at the time of the later prosthesis reimplantation are only some of the advantages to mention. On the other side, the persistence of infection and no possibility of adequate restoration of the joint anatomy (e.g., femoral offset) when the stem is retained, involve problems that have to be considered, when such an approach is chosen.

Another topic might regard the economic impact of such a procedure. Compared with primary total hip arthroplasties, revision procedures for infection are associated with longer operative time, more blood loss, higher number of complications, longer period of hospitalization, a higher number of total operations, more outpatient visits, and greater total hospital costs [16]. It has been reported that periprosthetic infections after THA resulted in an increased episode cost by approximately threefold, mean hospitalization period twofold, and led to a higher median number of readmissions [17]. The costs are higher for revision THA for PJI than for any other diagnosis except for periprosthetic fracture [18]. In a comparative study about the epidemiology of revision joint arthroplasty, failed THA posed greater clinical and economic burdens than failed TKA [19]. At the site of methicillin-resistant organisms, significantly higher costs of care were seen at a mean of $107,264 per case compared with $68,053 for treating PJI caused by sensitive organisms [20]. Based on these facts, a partial two-stage exchange arthroplasty appears to be an attractive option, and might even have a positive impact on the economic burden compared with the classic two-stage protocol.

Probably, the greatest concern about the partial two-stage approach regards the adherence of the biofilm to the implant. Generally, biofilms make it difficult to diagnose and treat PJI [21]. While the precise frequency of biofilms in chronic PJI is not known, it has been reported that chronic infections are present mostly in a biofilm state [21]. According to literature data, biofilm adherence takes 36 h to 3 weeks [22]. Following the argument that biofilm formation cannot be adequately addressed in partial

Table 3 Complications between stages and outcome at the site of partial two-stage protocol in the management of periprosthetic hip infections

Study	Complications between stages	Type of reimplanted components	Systemic antibiotic therapy after the second stage	Infection eradication rate (%)	Mean follow-up (months)
Faroug et al. [14]	1/2 spacer dislocation	1× cementless 1× cemented	n.r.	100	39 (36–42)
Anagnostakos et al. [8]	2/12 × draining sinus 1/12 × spacer dislocation	7/12 cementless 4/12 cemented 1/12 spacer retained	n.r.	91.6	55 (12–83)
Lee et al. [10]	n.r.	All cementless	Cefazolin i.v. for 3 days	88.2	48 (24–96)
Ekpo et al. [11]	n.r.	n.r.	n.r.	89.5	48 (24–132)
Lombardi et al. [12]	None	n.r.	n.r.	85.7	19 (4–36)
Fukui et al. [13]	No major complications (fractures, dislocations, deep vein thrombosis, pulmonary embolism)	All cementless	n.r.	100	50 (42–60)
Chen et al. [9]	n.r.	n.r.	Cefazolin i.v. for 1 day	81.3	70 (38–103)

n.r. not reported

revision arthroplasty, it is commonly believed that the risk of recurrent infection is increased if all implants are not removed [23, 24]. However, advocates of the partial two-stage protocol state that successful integration between bone and the implant may act as a barrier to preventing bacterial migration and subsequent infection [10]. Chen et al. [9] considered that the integration of bone into the prosthesis was already complete before the bacterial adhesion occurred in their series since the complaints of the patients did not occur within the first 6 months after primary arthroplasty. As all reported cases are retrospective, the role of biofilm formation is questionable.

The critical review of the partial two-stage procedure is essential to evaluate the success of this option and the possibility of inclusion into the arsenal against PJI. The selection of the patients and the correct indication seem to be important factors. Among the identified studies, all authors agreed that a well-fixed implant has to be present, although great variations were found with regard to the pre- and intraoperative testing of the stability of the implant. However, other authors have reported good to excellent results by use of a transfemoral or extended trochanteric osteotomy to remove the stem [25], whereas the risks of a higher complication rate during surgery [26] and the possibility of recurrent infection due to sequestrum formation as a sequela of extensive soft tissue dissection and devascularization of the proximal femur [10] have to be outweighed.

The pathogen organisms and their antibiotic sensitivity profile are also of importance. Chen et al. [9] recommended that partial component-retained two-stage reconstruction could be an alternative treatment option for infection after THA with a radiographically and clinically well-fixed component in selected patients who are not immunocompromised and are infected by a low-virulence organism. Although the microbiological data of the identified studies cannot be sufficiently analyzed due to the retrospective design of the studies, a higher failure rate could be observed at the site of MRSA infections [9, 11]. Moreover, the combination of the local and systemic antibiotic therapy is crucial to achieve infection control. Six out of the seven identified studies impregnated the cement with at least two antibiotics (Table 2), hence covering a broad antimicrobial spectrum. The partly impregnation with high doses of two antibiotics provides a synergistic effect regarding the height and length of the locally eluted amount of antibiotics [27]. In combination with the systemic antibiotic therapy over a time period of at least 6 weeks, which is regarded to be adequate in the management of PJI [28], the reported infection eradication rates of 81.3–100% might be explained. However, it could be possible that with an increasing patients' number and longer follow-ups these rates might decrease. The total number of 80 patients in 7 studies does not allow for generalization of conclusions.

The present results cannot be directly compared with other total single- or two-stage studies due to inhomogeneities in the patients' collectives, surgical technique and peri- as well as postoperative treatment. A multicenter randomized controlled trial such as the INFORM trial would be of great benefit to exactly establish the indications for each treatment option [29]. A recent meta-analysis from that group showed reinfection rates of 8.2% and 7.9% in single-stage and two-stage revision hip arthroplasty, respectively [30]. In another meta-analysis, Lange et al. calculated a risk of reinfection of 10.4% for two-stage and 13.1% for one-stage septic revision [31]. The success rates of the partial two-stage exchange arthroplasty are similar to the ones after one- or two-stage treatment, however, they cannot be directly compared as afore mentioned.

Due to the complexity, costs, morbidity and mortality of the two-stage treatment, additional modified one-stage/two-stage procedures besides the partial two-stage exchange arthroplasty have been proposed in the past years in the management of periprosthetic hip joint infections [32–35]. El-Husseiny et al. [32] reported on their experience using partial component retention as part of a definitive single-stage revision in highly selective patients. Inclusion criteria involved patients who were not immunocompromised, no sinus track, known organism, complex implant that was well fixed with radiography, CT and with intraoperative assessment by an experienced revision arthroplasty surgeon. No distinction was made among acute, chronic, or recurrent infections at the time of surgical decision-making. The decision was based primarily on the anatomic factors related to the implant and on the host and whether the host could withstand major surgery. In a collective of 18 patients, the rate of infection eradication was 83% at a median follow-up of 7.1 (5–9.9) years. All failures were then treated by a standard two-stage protocol. Their results were confirmed by the study of Ji et al. [33]. At an average of 5 [2–15] years, an infection control rate was observed in 87% of the cases (27 out of 31 patients). All failures occurred at an average of 15 months. Fink et al. [34] reported on single-stage acetabular revision during two-stage revision for infected hip arthroplasties. 97% of the cases were free of infection at a mean follow-up of 42 months. Morley et al. [35] published their results about the preservation of the original femoral cement mantle during the management of infected cemented THA by two-stage revision. They hypothesized that during the lavage and the mechanical cleansing, antibiotic encased in the original cement mantle will become available for elution [36]. Since the cement-in-cement technique is an accepted treatment option in the management of aseptic revisions [37], the authors wondered, whether this technique might also be applicable at the site of septic revisions. At a mean follow-up of 82 months an infection eradication rate of 93% could be observed [35]. However, in contrast to the results of Morley et al. [35], Leijtens et al. [38] reported disappointing results in 10 retrospective cases that were also treated with a cement-in-cement revision at the site of hip PJI. At a mean follow-up of 26.3 (5–54) months infection control was achieved in only 20% of the cases. The authors attributed the differences in the infection eradication rate to a more multi-morbid collective compared with the one described by Morley et al. [35], differences in the surgical technique i.e., standardized technique of reaming up the retained cement as well as the postoperative antibiotic therapy.

It should be emphasized that a partial one- or two-stage protocol accounts only for a small percentage of the patients suffering from PJI and should not be widely applied. In the study of El-Husseiny et al. [32], only 6% (18 out of 293) of the total number of patients in a time period of 11 years have been treated by this approach. Fink et al. [34] used their regime in 15% of the cases (35 out of 225) in a time period of 5 years. Morley could apply their technique in 11% of their patients (15 out of 131) in a time period of 13 years [35]. In the included studies of the present review, the exact percentage of the patients who were treated by a partial two-stage protocol is unfortunately not reported. Nevertheless, the small number of patients treated in such a fashion in the aforementioned studies reflects the strict selection of cases for these techniques.

In conclusion, the partial two-stage exchange arthroplasty appears to be a possible option in the management of PJI when one prosthetic component is well-fixed so that their removal might result in significant bone loss and compromise of fixation at the time of the later prosthesis reimplantation, and the causative organisms are not multiresistant. Based on our results, MRSA infections are not a good indication for this treatment. The small numbers published about this protocol does not allow for a generalization of application and should be only applied in highly selected patients. Since this approach as well as other modified techniques has been highly criticized in literature [39, 40], each orthopedic surgeon should individually decide whether to retain or remove the implant. Future studies with larger collectives and longer follow-ups are welcome to evaluate the clinical success of this option and its possible role in the management of PJI.

Compliance with ethical standards

Conflict of interest The authors declare that they have no conflict of interest. The study had no financial support.

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