Single-stage versus two-stage revision of total hip replacement for contained periprosthetic infection

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Received 1 January 2016
Accepted 17 March 2016

The Egyptian Orthopaedic Journal
2016, 51:101–110

Objective
In this article, single-stage exchange arthroplasty for periprosthetic hip infection was compared with the two-stage revision protocol in patients without draining sinuses.
Background
Staged revision for periprosthetic infection of the hip is an accepted and widely used technique by many surgeons. However, single-stage exchange of the hip prosthesis remains an attractive option to some.
Patients and methods
Fifty-two patients with evidence of periprosthetic infection underwent preoperative aspiration of the affected hip. The organism was identified in 33/52 patients, and single-stage revision was performed. The remaining 19 patients underwent two-stage exchange arthroplasty. All patients had cemented cup and long cementless stem.
Results
At an average 4 years (range: 2–7 years) postoperatively, only one case of persistent infection was found in the single-stage group, which showed a success rate of 97%, in comparison with 95% success rate in the staged protocol.
Conclusion
Single-stage exchange achieves excellent success rates in patients with contained infection when the organism is identified preoperatively.

Keywords:
infection, single-stage revision, total hip replacement, two-stage revision

Egypt Orthop J 51:101–110

1110-1148

Introduction

Staged revision for periprosthetic infection of the hip is an accepted and widely used technique by many surgeons [1,2]. However, single-stage (SS) exchange of the hip prosthesis remains an attractive option to some because of the advantages of reduced risk for comorbidities, shorter treatment time and hospital stay, in addition to reduction in the cost of treatment [3–6].

There are many contradictory reports on the results of SS exchange hip arthroplasty, with high success rates in some and unfavorable results in others [7–9]. This contradiction may be related to the differences in the method of patient selection, technique of implant exchange between cemented and noncemented hips, and the postoperative antibiotic (AB) protocol [9].

The advantages of the staged revision strategy are better identification of the infecting organisms and doubling the chance of performing a thorough debridement of the infected tissues [10–12]. This, however, does not rule out the benefit of performing SS exchange in some patients [13]. The question remains: how can one define the category of patients who would benefit the most from each technique?

Manifestations of infection vary from late loosening of implants that might have lasted for many years to be discovered at the time of elective revision to an acute periprosthetic infection with draining sinuses and septicemia [14]. These manifestations are related to the patient's general condition, the infecting organism, local soft tissue condition, and bone defects [15].

It has been hypothesized that patients who present with active draining sinuses, general symptoms of acute infection, in addition to poor local soft tissue condition and previous multiple surgical procedures are those with an uncontained infection process. On the other hand, patients with periprosthetic infection of the hip who do not have the above findings are considered as patients with contained infection.

This research aimed at investigating whether patients with contained periprosthetic infection as defined above are good candidates for SS exchange arthroplasty.

 DOI: 10.4103/1110-1148.203142

Patients and methods

Fifty-two patients with contained periprosthetic infection of the hip according to the previous definition were included in this prospective study that was conducted between August 2006 and September 2012. Approval of the local research committee was obtained, as well as patients' consent for inclusion into the study.

Patients were subjected to preoperative aspiration of the hip in a sterile theater under radiographic control, and specimens collected were directly cultured on blood agar for 2 weeks.

On the basis of the culture results, the patients were divided into two groups. Patients with an organism identified in the culture were enrolled for SS exchange arthroplasty. The other group that showed negative culture results with no growth or for whom aspiration was not successful were scheduled for the two-stage (TS) revision protocol.

Preoperative assessment of patients' general condition was performed, bone defects on the femoral and acetabular sides were graded according to American Academy of Orthopaedic Surgeons classification, and Harris Hip Score (HHS) for hip function was recorded.

The single-stage revision

All patients were operated upon in the lateral decubitus position using the posterior approach described by Gibson–Kocher and extended trochanteric osteotomy as previously described [16].

The length of the osteotomy from the tip of the greater trochanter was determined according to the need to remove distally fixed cement mantles. In all cases, the exposure allowed removal of distal cement mantles and infected membranes.

In addition to removal of the implants and bone cement, extensive debridement of all infected tissues and membranes on the femoral and acetabular sides was performed, reaching viable bleeding tissues. On the acetabular side, special attention was given to removing the hip capsule, whereas on the femoral side meticulous debridement of the medullary canal, calcar area, and inner surface of the greater trochanter was regularly performed. A minimum of six tissue specimens were collected and sent for standard and extended (2 weeks) culture and AB sensitivity tests.

Once the debridement had been completed, intravenous infusion of AB was commenced. Patients' drapes, surgeons' gowns, and surgical instruments were replaced by newly sterile equipment.

Assessment of acetabular bony defects was performed and impaction graft for acetabular defects was performed using a fresh frozen femoral head allograft. The graft was prepared by removing all attached soft tissues and cartilage and then dividing the remaining cancellous bone using a power saw and manual rongeurs into bone chips 8–12 mm in size. ABs in powder form (Fig. 1) were mixed with the cancellous chips of each femoral head allograft [17–19]. The bone chips were then impacted progressively in layers into the acetabular defects until they were fully seated and filled the defects [20,21] (Fig. 2a–c).

Acetabular defect grades III and IV were augmented by a Burch-Schnieder cage with superior and posterior screw fixation (Zimmer GmbH, Winterthur, Switzerland).

High cross-linked all polyethylene cups with an inner diameter of 32 mm were cemented in all acetabulae (ZCA, longevity cross-linked all poly cup; Zimmer GmbH) using standard high-fatigue gentamycin-loaded bone cement. The powder of one vial from the mentioned AB was added to each pack of 40 g bone cement after 1 min from the beginning of the mixing process [22–24].

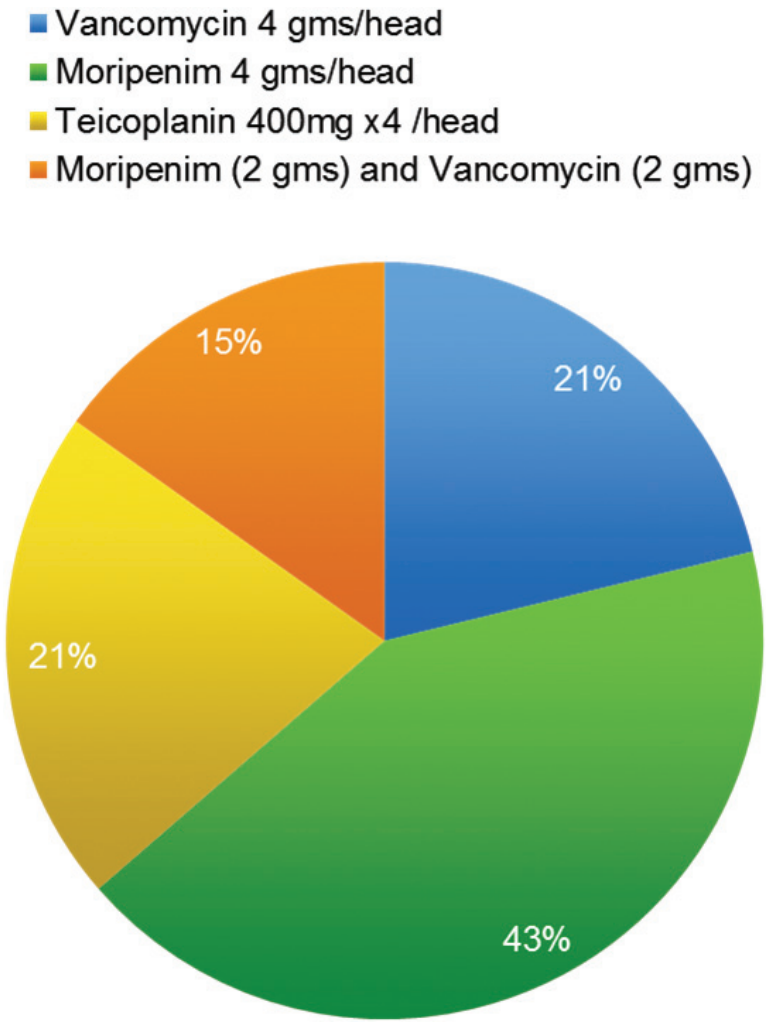
On the femoral side straight Wagner SL revision cementless stems (Zimmer GmbH) were inserted into all femora, having accepted the height and rotation of the trial prosthesis. A 32 mm outer diameter cobalt chrome heads were selected in all cases.

Reattachment of the osteotomized trochanter was finally performed using stainless steel (Ortron; DePuy Synthes Companies Codman. A division of Johnson & Johnson Medical Ltd., Pinewood Campus, Nine Mile Ride, Wokingham, RG40 3EW, United Kingdom) doubled wires and soft tissue repair of the external rotators using Ethibond No. 5 (Ethicon, J&J, USA) transosseous sutures.

Staged revision protocol

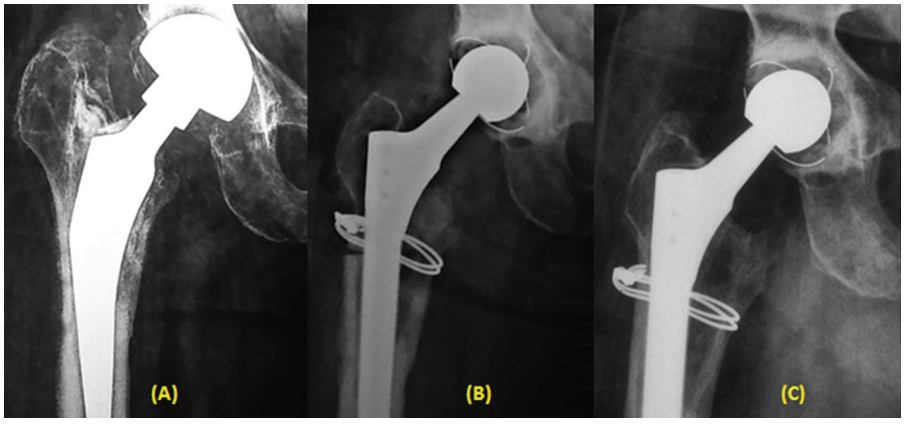
In the staged revision protocol, all the steps mentioned previously till the infusion of AB at the end of the debridement were followed. Then a handmade cement spacer with an internal metal splint was fashioned to fill the acetabulum and be stable within

Figure 1



Types of antibiotic powders added to the fresh frozen allograft.

Figure 2



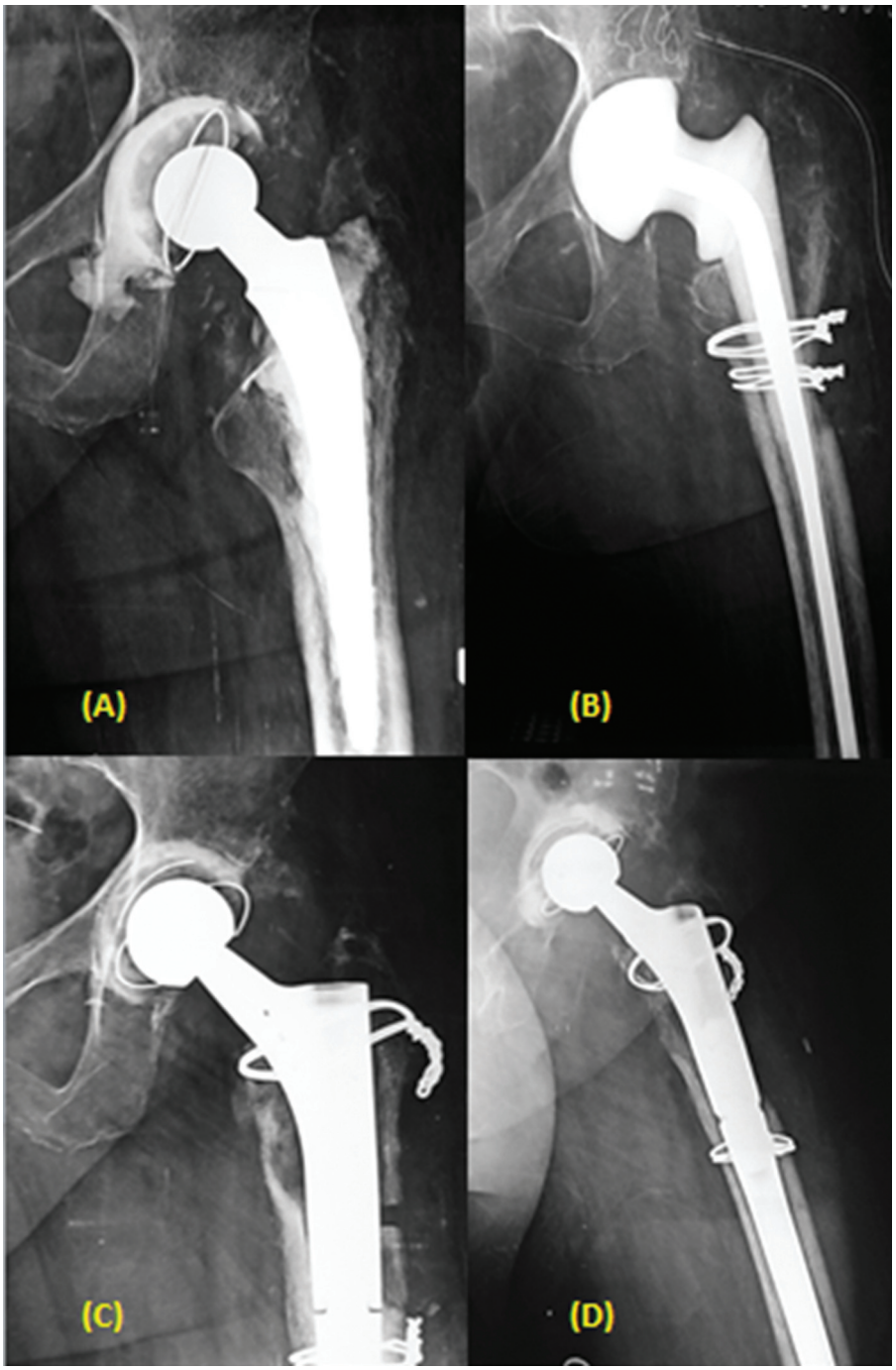
(a) Radiography of a case of infected cemented hemiarthroplasty with loose stem and grade IIA acetabular defect. (b) After single-stage exchange with impaction graft through trochanteric osteotomy. (c) At 2 years' follow-up with full bony union of the trochanteric osteotomy and incorporation of the impaction graft.

the femoral medullary canal. Reattachment of the greater trochanter was then performed using Ethibond No. 5 (Fig. 3a–d).

Postoperative antibiotic protocol

In the case of SS revision, intravenous infusion of ABs according to the preoperative culture results was

Figure 3



(a) A case of infected total hip replacement with loose cup and stem. Periosteal reaction is clear around the proximal femur. (b) After the first stage with spacer in place. (c) Postoperative radiography following the second stage. (d) Three years' follow-up radiography with stable cup and stem.

commenced intraoperatively and continued until tissue biopsy culture results were available. In all cases, a minimum of 2 weeks of intravenous AB infusion of the suitable AB was given (Table 1). After the fourth week, oral AB was continued for another 6–8 weeks according to the sensitivity test of the organism (Table 1).

For patients enrolled in the staged protocol, the usual combination of ABs was meropenem, rifampicin, and ciprofloxacin until the culture results were available, when the type and dose of ABs were amended. Patients were continued on the AB for 6 weeks. Then ABs were stopped for 2 weeks before the second stage.

The technique for reimplantation in the staged protocol patients was exactly the same as that performed for the SS patients. Further, AB was given after the second stage for 6–8 weeks as described in the earlier section.

Table 1 Data for patients received single-stage revision

Patient's ID number	Patient's age (years)	Patient's sex	Prosthesis revised	Comorbidities	Aspiration result	Organism identified during debridement	Systemic antibiotic protocol	Follow-up (ms)
1	63	Female	Cemented hemiarthroplasty	DM, hepatic	*Klebsiella* spp., *Staphylococcus aureus*	*Klebsiella* spp., *Staphylococcus aureus*	Meropenem, ciprofloxacin and linozolid	72
2	67	Male	Cementless THR	DM	*Escherichia coli*	*Escherichia coli*	Meropenem	72
3	62	Female	Cemented hemiarthroplasty	DM, hepatic	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Teicoplanin and rifampicin	72
4	57	Male	Cementless hemiarthroplasty	Hepatic, anemia	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem then levofloxacin	72
5	55	Male	Cementless THR	Hepatic, anemia	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem then levofloxacin	72
6	67	Male	Cementless THR	Smoker	MRSA	MRSA	Vancomycin then linozolid	60
7	66	Male	Cementless THR	–	MRSA	MRSA	Vancomycin then linozolid	60
8	65	Male	Cementless THR	–	*Escherichia coli*	*Escherichia coli*	Moreoenem and ciprofloxacillin	60
9	66	Male	Cementless THR	–	*Escherichia coli*	*Escherichia coli*	Meropenem and ciprofloxacin	60
10	67	Male	Cementless THR	–	*Escherichia coli*	*Escherichia coli*	Meropenem and ciprofloxacin	60
11	54	Male	Cemented hemiarthroplasty	DM, hepatic	*Pseudomonas aeruginosa*	*Pseudomonas aeruginosa*, *Staphylococcus aureus*	Meropenem and amikacin then ciprofloxacin	60
12	41	Female	Cemented hemiarthroplasty	Rheumatoid	MRSA	MRSA	Vancomycin then linozolid	56
13	44	Female	Cemented hemiarthroplasty	Smoker	MRSA	MRSA	Vancomycin then linozolid	56
14	65	Male	Cemented hemiarthroplasty	No	MRSA	*Staphylococcus epidermidis*, MRSA	Teicoplanin and rifampicin	48
15	62	Female	Cemented hemiarthroplasty	No	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem and ciprofloxacin	48
16	65	Female	Cemented hemiarthroplasty	Renal impairment (creatinine 2) and HCV positive	*Escherichia coli*	*Staphylococcus aureus*, *Escherichia coli*	Meropenem then rifampicin and ciprofloxacin	48
17	61	Female	Cemented hemiarthroplasty	HCV positive	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Teicoplanin and rifampicin	48
18	58	Female	Cemented hemiarthroplasty	DM, hepatic	*Klebsiella* spp., *Staphylococcus aureus*	*Klebsiella* spp., *Staphylococcus aureus*	Meropenem, linozolid and ciprofloxacin	48
19	65	Male	Cemented hemiarthroplasty	No	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Teicoplanin and rifampicin	48
20	62	Male	Cemented hemiarthroplasty	DM, hepatic	*Klebsiella* spp., *Staphylococcus aureus*	*Klebsiella* spp., *Staphylococcus aureus*	Meropenem	48
21	50	Male	Cemented THR	No	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Meropenem and rifampicin	36
22	67	Female	Cemented hemiarthroplasty	DM, hepatic	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Teicoplanin and rifampicin	36
23	63	Female	Cemented hemiarthroplasty	DM, HCV positive	*Klebsiella* spp., *Staphylococcus aureus*	*Klebsiella* spp., *Staphylococcus aureus*	Meropenem, ciprofloxacin and rifampicin	36

(*Continued*)

Table1 (*Continued*)

Patient's ID number	Patient's age (years)	Patient's sex	Prosthesis revised	Comorbidities	Aspiration result	Organism identified during debridement	Systemic antibiotic protocol	Follow-up (ms)
24	64	Male	Cemented hemiarthroplasty	No	MRSA	MRSA	Vancomycin then linozolid	36
25	64	Female	Cemented hemiarthroplasty	No	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem and levofloxacin	36
26	65	Female	Cemented hemiarthroplasty	Renal	*Escherichia coli*	*Escherichia coli*	Meropenem and ciprofloxacin	36
27	64	Female	Cemented hemiarthroplasty	DM, hepatic	*Staphylococcus epidermidis*	*Staphylococcus epidermidis*	Teicoplanin and rifampicin	36
28	57	Male	Cementless hemiarthroplasty	Hepatic, anemia	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem then levofloxacin	36
29	73	Female	Cementless THR	DM	*Staphylococcus aureus*	*Staphylococcus aureus*	Vancomycin then linozolid	24
30	57	Male	Cementless hemiarthroplasty	Hepatic HCV positive, anemia	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem then levofloxacin	24
31	56	Male	Cementless hemiarthroplasty	Smoker	*Klebsiella* spp.	*Klebsiella* spp.	Meropenem then levofloxacin	24
32	65	Male	Cemented THR	No	*Pseudomonas aeruginosa*	*Pseudomonas aeruginosa*	Meropenem and ciprofloxacin	24
33	56	Male	Cementless hemiarthroplasty	Hepatic, anemia	*Staphylococcus aureus*	*Staphylococcus aureus*	Vancomycin then linozolid	24

Details of organisms identified by preoperative aspiration and tissue specimens during surgery. A summary of previous surgery and other comorbidities are given. DM, diabetes mellitus; HCV, hepatitis C virus; MRSA, methicillin-resistant *Staphylococcus aureus*; THR, total hip replacement.

Patients were allowed touch weight bearing (WB) mobilization from the second postoperative day onward for 6 weeks. Partial WB gradually progressed from the 6th to the 12th week, when full WB was permitted.

Laboratory assessment of the patients' erythrocyte sedimentation rate (ESR) and C-reactive protein (CRP) was conducted on a weekly basis during the first 6 weeks, then every 2 weeks for another 6 weeks, and then at 6 and 12 months from surgery. Similarly, radiographs were taken immediately postoperatively and then at 3, 6, and 12 months. The HHS was recorded at the end of 6 and 12 months, and then annually.

Patients who could not attend checkups after the second postoperative year were contacted by phone, and details of any change in their condition were recorded.

The Wilcoxon matched-pairs signed-ranks test was used to compare preoperative with postoperative results and SS patients with TS patients.

Results

Fifty-two patients of an average age of 61 years (range: 41–73 years) were included in this study. All patients had contained periprosthetic infection. Twenty-three patients were female and 29 were male. These patients were divided between two treatment protocols – SS and TS revision – according to the preoperative aspiration results and were followed up for an average of 4 years (range: 2–7 years).

Preoperative aspiration

The aspiration was successful in revealing the organism preoperatively in 33 patients, whereas in 19 patients the culture results were either negative (nine samples) or adequate samples to be processed could not be collected (10 patients).

In cases where the infecting organism was identified by preoperative aspiration, the same organism was confirmed by the tissue specimen cultures that were collected at the time of surgery in all cases. However, additional microbes were detected in three patients (Table 1).

Infection control

At the latest follow-up, 32 (97%) out of 33 patients from the SS revision group were free of infection, whereas the TS protocol for revision successfully eradicated infection in 18 (95%) out of 19 patients.

Bone defects and impaction graft

Impaction graft was performed in all patients of the SS revision group and in 11 of the 19 patients of the TS revision group. The magnitude of bone defects is shown in Figure 4a and b. Radiological assessment of graft incorporation was made using the criteria applied in previous reports [25,26]. No case of graft resorption or lysis was observed in these patients. Incorporation and maturation of the graft within the previous defects was recorded in 31 out of 44 patients who had the impaction graft (Fig. 2c). It was not possible to observe trabecular arrangement within the graft in cases where a metal cage had been inserted. Using the criteria described by DeLee and Charnley [27] radiolucent lines were seen in zone II in three patients and in zone I in two patients.

Trochanteric union

Bony union of the extended trochanteric osteotomy was reported in 31/33 patients in the SS and in 14/19 patients in the TS group (Fig. 2c). Three hips in the TS group had proximal migration of the trochanter by more than 10 mm. None of the patients in the SS group had proximal migration of the trochanter.

Functional results

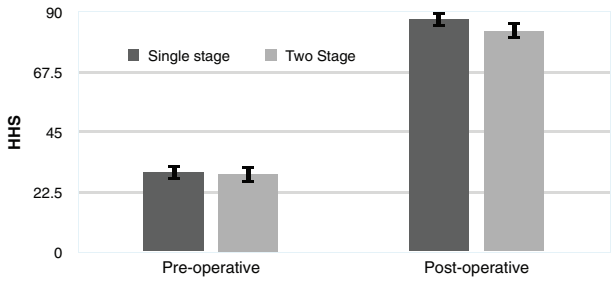
The HHS significantly improved from the preoperative to the postoperative period (Fig. 5). There was no difference in the preoperative scores between patients who received SS and those who received the TS protocol. However, significant difference was observed in the postoperative HHS of patients who received SS versus those who received TS, with the SS patients achieving better results ($P<0.002$).

Complications

One patient in the SS group had a single dislocation that was reduced by closed reduction and continued to be stable afterward. Two patients in the TS revision group had dislocation; in one of them the instability was recurrent and a hip brace was used.

One patient from the SS group had hematoma formation at the wound site that was derided in the theater 1 week postoperatively and the patient had an uneventful recovery.

Figure 5

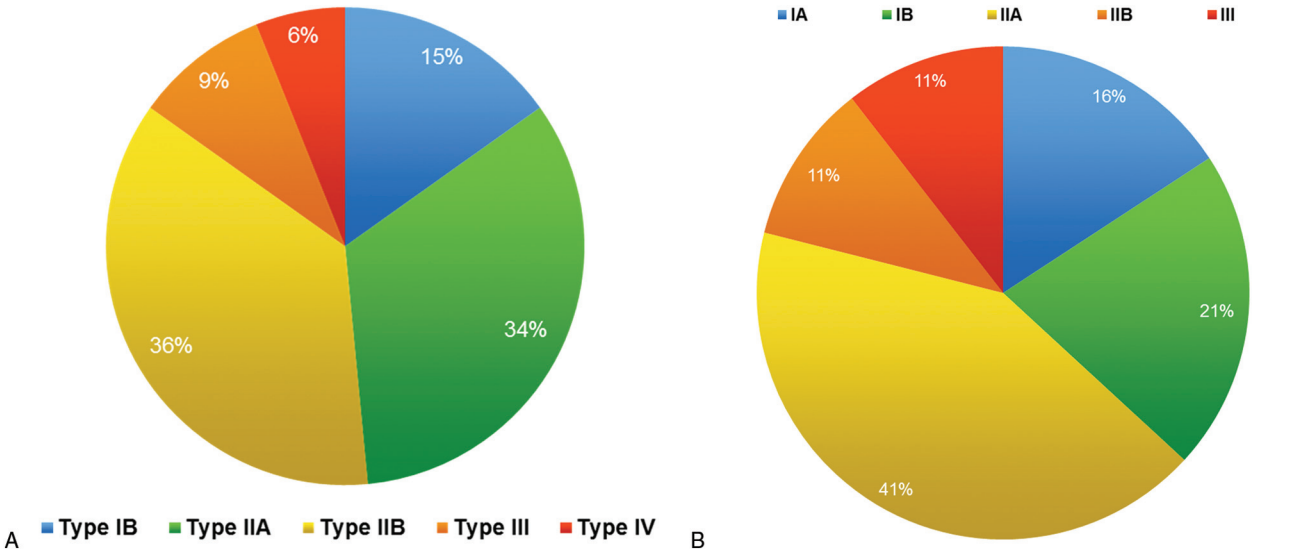


Graph 3

	Pre-operative	Post-operative
Single stage	29.8 (2.7)	87 (4.3)
Two stage	29 (2.9)	82.9 (4.8)

Harris Hip Score (HHS) results in patients who received single-stage and two-stage revision comparing preoperative with postoperative results. Significant difference was observed in the results of patients who underwent single-stage versus those who underwent two-stage revision.

Figure 4



(a) Grades of acetabulum bone defects in patients who received single-stage revision. (b) Grades of acetabulum bone defects in patients who received two-stage revision.

Two patients in the TS group had intraoperative fractures in the form of extension of the trochanteric osteotomy in one and split along the medial wall of the proximal femur in another. The same type of split was also seen in one patient in the SS group. All fractures were united with the use of circular wires, extending the period of partial WB to 12 weeks.

There were two patients (one patient in each group) who died at 4 and 5 years postoperatively from heart attacks and no patient died during the course of treatment.

Discussion

One of the challenges faced by orthopedic surgeons is defining the best indication for a SS revision. Distinguishing patients who would most benefit from a SS exchange has implications on the cost of this type of surgery as well as on the patients' functional outcome and their quality of life.

As correctly stated, infection is the underlying cause of many painful pathologies in joint arthroplasty [14] and therefore should not be overlooked. With this concept in mind, the spectrum of cases that are now considered to have periprosthetic infection, in addition to another indication for revision, is on the rise [13,14,28–31]. It would then be necessary to differentiate between two categories of patients: the first are those presenting with local or systemic manifestations of uncontrolled and virulent infection; the second group consists of those with evidence of infection that has affected the status of their prosthesis without resulting in systemic manifestations or local draining sinus. In this article the first group of patients was defined as having an uncontained infection process. This category of patients would be better off being treated with a staged revision protocol and therefore were not included in this study.

The second group of patients was identified to have periprosthetic infection diagnosed through the history of delayed wound healing, early loosening of their hip implants, radiological evidence of infection, as well as elevated ESR more than 30 and CRP more than 10. However, none of these patients had an active draining sinus or evidence of septicemia. These patients were defined as patients with contained periprosthetic infection.

Successful eradication of infection would only happen through adequate debridement of all infected tissues as well as implants in addition to, and equally important, delivering the correct AB in the appropriate dose [6,8]. Therefore, defining the infecting organism preoperatively is an essential step in the selection criteria for a SS revision [3].

The value of preoperative aspiration has been emphasized in many studies [32–35]. This procedure is established in the American Academy of Orthopaedic Surgeons paradigm for diagnosis of infection [36]. The limitation is still on the ability to identify an organism preoperatively in the cases known to be infected. Williams *et al.* [37] reported the overall accuracy of preoperative hip aspiration in defining the infecting organism as 90.1% with 84% sensitivity and 94% specificity.

In another study of the same group the positive predictive value of hip aspiration in the radiology department was 74%, whereas the negative predictive value was 94% [38].

In this study, preoperative aspiration has been successful in identifying the organism in 33/52 (63%) patients. In 10/52 (19%) patients, the aspiration was not successful in collecting enough material for culture. The majority of these cases were at the beginning of the study, and the inability to collect specimens may be related to the early part of the learning curve for the aspiration procedure. The specificity of the positive results was 91%, as additional organisms were discovered from the culture results of the specimens collected during surgery in three patients. Only one of these three patients had recurrence of infection at 6 months postoperatively. Improving the accuracy and specificity of preoperative aspiration is an important task that may influence decision making and results in the future.

One of the observations that was made in the hips that received SS revision was that infected tissues were found only after incising the iliotibial tract, and in 29 cases infected tissues were found deep to the muscle envelop of the hip. Infected membranes were at the prosthesis bone interface and in the hip capsule. It was also noted that pus and infected membranes tracked through the gluteus medius muscle fibers to the superficial surface of the greater trochanter when the previous approach was an anterolateral approach. Pus and infected membranes were retrieved when the short external rotators and vastus lateralis muscles were reflected. In many cases acetabular and/or femoral bone erosion was noticed, but the infection remained within the muscle envelop.

This observation raised the idea of calling this type of infection as contained infection, as it remained confined to the hip space even though the actual hip space had extended to penetrate the floor of the acetabulum or the femoral cortices. Debridement of all infected tissues in this case will leave the hip within well-perfused soft tissue envelop without dead space. Adding the AB-loaded cancellous graft within that confined space would create a suitable environment for defending the new implant against colonization by bacteria or formation of biofilm.

In contrast, hips with draining sinuses and fibrotic muscles have infected tissues spreading through all soft tissue planes. The extent of the infection process cannot be predicted and the necessary aggressive debridement is likely to leave behind a dead space. Therefore, the nonconfined infection process was called as uncontained infection.

In this series, high doses of local AB (vancomycin and meropenem) (Fig. 1) were added to the fresh frozen allograft. AB-impregnated cancellous graft was successfully used in previous studies [39,40] and was found to deliver locally a very high concentration of the ABs that can affect not only the planktonic form of bacteria but also the sessile clusters and biofilm colonization [6].

The most commonly used AB for impregnation of cancellous graft is vancomycin [8,39]. It was found to elute locally from bone graft and deliver very high concentrations that are several folds above the MIC of the sensitive bacteria, especially the methicillin-resistant *Staphylococcus aureus* [17]. However, in this series other gram-negative bacteria like *Escherichia coli* and *Klebsiella* spp. were identified in many cases preoperatively (Table 1). The combination of vancomycin and meropenem was found to have a synergistic effect and had been previously tested and delivered in conjunction with bone cement [22,23,41]. Therefore, the choice of AB added to cancellous bone graft was according to the preoperative identification of the infecting organism and its sensitivity profile. This is likely to improve the efficacy of the local AB and increase its ability on defending the new implant and inhibit colonizing the biofilm.

Various strategies have been employed to overcome bone defects in the setting of revision hip arthroplasty, including filling defects with bone cement, which is usually associated with early loosening, bulk or impaction graft [42], and finally the tantalum metal augments [43]. Although there is increasing interest in the use of Tantalum augments to provide structural support and enhance the implant stability [44], in itself the augments do not have a role in eradicating infection [43]. Cancellous impaction graft does not only provide a biologic fill for acetabular defects that would increase the bone stock but plays a role in cases of infection as a good carrier for the AB [8,18].

Postoperative AB protocol was decided according to the type of the infecting organism. A minimum of 2 weeks on intravenous AB was given to all cases in the SS. Oral AB when organism sensitivity profile allowed was then given for 4–8 weeks. In 32/33 patients the CRP was less than 6 by the fourth week, which is in addition to reduction of the ESR curve in all cases.The limitations of this study are the small number of patients and the fact that patients were not randomized into groups as per treatment. However, it has tested a protocol for patients' selection and has reported its outcome.

It was not possible to test the effect of using large doses of ABs to the BG on the other body systems. However, these AB are widely used in the treatment of periprosthetic infection and have been previously tested with bone cement both *in vitro* and *in vivo* with no reported adverse effects [39].

In this study, patients' inclusion into the SS revision group was determined by the extent of the infection process and preoperative identification of the organism. The strict selection criteria for this group of patients resulted in a 97% success rate at an average of 4 years' (range: 2–7 years) follow-up. Previous studies that employed the SS exchange strategy achieved variable rates of success from 54% [1] to 90% [6] but included patients with uncontained infection and without prior identification of the organism. When a standard protocol for patients' selection was followed higher rates of success were achieved [3,13].

Conclusion

The benefit of SS revision to the patients, the health system, and to the society is remarkable when compared with the TS exchange. The challenge has always been on achieving similar or higher rates of success in the eradication of infection when compared with the TS reimplantation protocol. Restricting the SS revision protocol to patients with contained periprosthetic infection with prior identification of the organism seems to achieve excellent results at

mid-term follow-up. It remains to be seen whether this strategy will stand the test of time.

Financial support and sponsorship
Nil.

Conflicts of interest
There are no conflicts of interest.

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