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High incidence of early periprosthetic joint infection following total hip arthroplasty with concomitant or previous hardware removal

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Abstract

Introduction Hardware removal preceding total hip arthroplasty may increase the risk of prosthetic joint infection (PJI). Whether hardware removal and total hip arthroplasty (THA) should be performed in a single- or two-stage procedure remains controversial. In this comparative retrospective study, the incidence of PJI following either single- or two-stage THA with hardware removal was assessed in a consecutive series.

Patients and methods All patients that underwent THA preceded by hardware removal from January 2006 until March 2018 were retrospectively reviewed and checked for the occurrence of early PJI. Recognized risk factors for PJI at the time of surgery were evaluated and the incidence of early PJI was compared between one- and two-stage THA regarding hardware removal.

Results 145 patients underwent THA and hardware removal (52 two-stage surgery and 93 single-stage surgery). There were no significant differences between both groups regarding pre-operative hemoglobulin levels, time interval between internal fixation and THA, antibiotic-loaded-cement use, BMI and ASA classification. Overall the incidence of early PJI was 6.9%. The incidence of PJI was 8.6% in the single-stage group versus 3.8% in the two-stage group ($P = 0.234$).

Conclusion Irrespective of single- or two-stage procedures, a high incidence of PJI was encountered. Despite non-significance, a trend towards a higher proportion of patients developing PJI after single-stage surgery was encountered. We recommend a two-stage surgical procedure regarding hardware removal and THA in patients that are expected to tolerate this surgical strategy. When considering a one-stage procedure, it should be preceded by a thorough pre-operative workup including joint aspiration and serum determination of inflammatory parameters. Multiple tissue samples should be obtained during hardware removal in either one- or two-stage procedures since the risk for development of PJI is relevant.

Keywords Hardware removal · Internal fixation · Osteosynthesis · Total hip arthroplasty · Periprosthetic joint infection

Introduction

The incidence of proximal femoral fractures has increased over the last decade and this injury is projected to affect up to 21 million people worldwide in the next 4 decades [1]. Primary (hemi-)arthroplasty is recommended for (displaced) femoral neck fractures in patients who are more than 60 years old [2]. However, internal fixation for intertrochanteric fractures or fractures of the femoral neck in younger patients remains a reliable treatment option. Still, up to 30% of internal fixations may fail requiring the need for secondary or salvage total hip arthroplasty (THA) [3]. Clinical outcomes tend to be inferior and complication rates higher following secondary THA when compared to primary THA for the treatment of proximal femoral fractures [3–6].

Periprosthetic joint infection (PJI) is the most serious example of these complications of THA and accounts for up to 15% of all failed THAs [7]. The reported incidence of PJI following primary elective THA ranges from 0.2 to 2.2% [8]. A recent systematic review reported on an increased risk for PJI following THA after internal fixation of a proximal femoral fracture [3]. However, new studies have addressed the outcomes of salvage THA after internal fixation finding no increased risk for (early) PJI [6, 9, 10]. Thus, there still appears to be a lack of consensus in the literature on a potential increased risk of PJI in case of concomitant hardware removal at time of THA. In addition, there is no consensus

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whether a one-stage procedure, combining implant removal and consecutive hip arthroplasty, or a two-stage procedure (with a certain time interval) should be advocated. Proponents of a two-stage procedure with hardware removal and the actual arthroplasty as separate surgical procedures mainly do so based on a study from 1997 that identified a 53% bacterial contamination rate at the time of elective removal of screws, plates or nails used for internal fixation (not limited to the hip joint) [11]. However, none of the cases included in that study demonstrated any clinical signs of infection following hardware removal. Therefore, the authors concluded that positive cultures obtained during hardware removal in the absence of clinical signs of infection are not meaningful [11]. Furthermore, they utilized swab cultures (instead of tissue cultures) which are nowadays considered inferior from their recognized tendency for false positivity.

At the other end of the spectrum, Klatte et al. performed a retrospective study to specifically address the safety of one-stage secondary THA regarding infection and found it to be a safe procedure with not a single case of PJI [10]. Because of these controversies in the literature, the aim of this retrospective study was to further elucidate on (1) the incidence of early PJI with (salvage) THA following hardware removal and to (2) compare the incidences of early PJI following either single-stage or two-stage THA with hardware removal.

Materials and methods

We retrospectively reviewed all patients that underwent secondary THA following hardware removal from January 2006 until March 2018. A total of 6275 THA patients were retrieved from our electronic database and subsequently the database was filtered for patients where hardware removal was performed prior to, or at time of the THA. A chart review was performed on the included patients and patients with hardware removal from any location other than the involved hip or femur for THA were excluded. The indication for and the type of osteosynthesis were recorded together with comorbidities according to the American Society of Anaesthesiologists' (ASA) classification, body mass index (BMI), pre-operative hemoglobulin levels, and surgery duration. In case intra-operative tissue cultures were taken at the time of hardware removal, it was registered. The choice for a single- or two-stage approach was solely based on the surgeon's or the patient's preferences after informed consent.

In all patients, a posterolateral approach was used for THA implantation. Hardware removal was performed utilizing the previous incision in two-stage procedures and where possible through the (lengthened when necessary) posterolateral incision in one-stage procedures, otherwise through separate incision(s). Poor bone quality as quantified by DEXA and age > 75 years were indications for cemented THA (Exeter®; Stryker Howmedica). The used bone cement (Palacos G®; Heraeus) contained gentamycin. Otherwise an uncemented THA (Zweymuller®; Zimmer up to 2014 and from then on CLS Spotorno®/Allofit; Zimmer) was performed. All patients received perioperative antibiotic prophylaxis with 2 g of Cefazolin within 1 h before the start of surgery followed by 1 g every 6 h over the course of 24 h. Physical therapy was commenced on the day of surgery when possible depending on patient factors.

Early PJI (< 3 months post-operatively) was suspected in case of a combination of elevated and increasing C-reactive protein levels, persistent wound leakage or fever and the absence of other foci. In these cases, debridement, antibiotics and implant retention (DAIR) was performed and a minimum of six intra-operative tissue cultures were obtained. DAIR consisted of lavage with 6 l of NaCl combined with replacement of the prosthetic head and liner. The diagnosis of PJI was confirmed by the presence of two or more positive intra-operative tissue cultures with an identical pathogen taken during initial DAIR for suspected PJI according to the musculoskeletal infection society (MSIS) criteria [6]. Involved pathogens were recorded. The occurrence of other post-operative complications (within 3 months after surgery) was retrospectively analysed along with the total length of stay (LoS) (combining the LoS of the admittance for hardware removal and THA in case of a two-stage procedure).

Data were analysed using SPSS© version 23. Chi-square and Student's *t* tests were used. *P* values < 0.05 were considered statistically significant. This study received approval of the local Committee for Research Involving Human Subjects that granted a waiver of informed consent.

Results

148 patients were identified where THA was preceded by hardware removal, either in a one- or a two-stage procedure. One patient was excluded for undergoing hemiarthroplasty instead of THA and two patients were excluded because they underwent THA on the contralateral side.

Thus, 90 women and 55 men were included. In 93 patients (mean age 66, range 41–98), a one-stage procedure was performed, whereas in 52 patients (mean age 62, range 23–83) the THA was preceded by hardware removal at an earlier moment. The mean time interval between internal fixation and subsequent THA was 4 years and 8 months (range 2 months–49 years). There were no significant differences between both groups in pre-operative hemoglobulin levels, time interval between internal fixation and THA placement, used fixation devices, cemented or uncemented THA, ASA classification and BMI. Operation time ($P < 0.000$) and patient age ($P = 0.038$) differences were statistically

significant. Also, non-union and cutout of implants as an indication for THA were significantly more prevalent in the one-stage group whereas congenital hip dysplasia as the indication for internal fixation (after osteotomy) was significantly more prevalent in the two-stage group. Tables 1 and 2 provide a complete overview of patient characteristics for both study groups.

Overall, 11 patients underwent DAIR for suspected postoperative surgical site infection (SSI). Among these patients, nine were diagnosed as PJI by means of two or more positive intra-operative tissue cultures demonstrating identical pathogens. Additionally, one patient was revised for instability due to malpositioning of the cup 3 weeks after THA implantation, five out of six tissue cultures taken during

Table 1 Overview of patient characteristics and statistical differences between the single- and two-stage surgery groups

	One-stage surgery		Two-stage surgery		*P* value
	Number	Percentage	Number	Percentage	
Indication for primary surgery					
Femoral neck fracture	59	63.4	33	63.5	0.572
Pertrochanteric fracture	24	25.8	13	25.0	0.540
Subtrochanteric fracture	6	6.5	3	5.8	0.588
Acetabular fracture	1	1.1	0	0	0.641
Epiphysiolysis	2	2.2	0	0	0.410
Hip dysplasia	0	0	3	5.8	0.044*
Pathological fracture	1	1.1	0	0	0.641
Fixation device					
Screws	13	14.0	7	13.5	0.572
Intramedullary nail	27	29.0	16	30.8	0.485
Dynamic hip screw	52	55.9	25	48.1	0.232
Angled blade plate	1	1.1	2	3.8	0.292
Fixation plate and screws	0	0	2	3.8	0.127
Indication for secondary THA					
Osteoarthritis	18	19.4	15	28.8	0.136
New fracture	3	3.3	6	11.5	0.054
Femoral head necrosis	17	18.3	10	19.2	0.527
Non-union	21	22.6	4	7.7	0.017*
Mal-union	18	19.4	15	28.8	0.136
Cutout of implants	16	17.2	2	3.8	0.014*
Type of THA					
Cemented	38	41	17	33	0.214
Uncemented	55	59	35	67	0.214
ASA classification					
1	9	9.7	10	19.2	0.086
2	55	59.1	27	51.9	0.252
3	17	18.3	11	21.2	0.416
4	10	10.8	4	7.7	0.389
Unknown	2	2.2	0	0	0.410
BMI					
Underweight (< 18.5)	3	3.2	3	5.8	0.369
Normal weight (18.5–24.9)	38	40.9	22	42.3	0.501
Overweight (25–29.9)	37	39.8	16	30.8	0.184
Obese (30–39.9)	11	11.8	10	19.2	0.410
Morbidly obese (> 39.9)	2	2.2	0	0	–
Unknown	2	2.2	1	1.9	0.708
Gender					
Male	30	32.3	25	48.1	0.045*
Female	63	67.7	27	51.9	0.045*

P values were calculated using the Chi-square test. Asterisks indicate significant values

Table 2 Overview of patient characteristics and statistical differences between the single- and two-stage surgery groups with the corresponding units between brackets

	One-stage surgery		Two-stage surgery		*P* value
	Mean	Range	Mean	Range	
Pre-operative hemoglobulin level (mmol/l)	8.4	5.8–10.8	8.6	6.4–11.1	0.219
Surgery duration (min)	91	43–190	70	32–146	0.000*
Time from osteosynthesis to THA (months)	56	0–422	33	2–587	0.095
Age (years)	66	41–98	62	23–83	0.038*

P values were calculated using the independent sample Students' *t* test. Asterisks indicate significant values

Table 3 Isolated pathogens in patients that underwent DAIR for suspected acute PJI with their corresponding incidence

Isolated pathogen	Incidence (*n*)	Percentage (%)
Staphylococcus epidermidis	3	27
Pseudomonas aeruginosa	2	18
Corynebacterium species	2	18
Enterococcus faecalis	2	18
Staphylococcus aureus	1	9
Beta-hemolytic *Streptococcus* (Group C)	1	9
Enterobacter cloacae	1	9
Staphylococcus lugdunensis	1	9
Total isolated pathogens	11	100

revision surgery (due to a purulent aspect of the synovial fluid) demonstrated *S. aureus* and this case was, therefore, also diagnosed as early PJI. This yields an overall incidence of early PJI of 6.9% (10 out of 145). In the single-stage and two-stage procedures, the incidence of early PJI was 8.6% and 3.8%, respectively ($P=0.234$). In four cases, polymicrobial PJI was identified. All but a single patient were treated successfully by means of DAIR followed by antibiotic treatment. The one case where PJI was diagnosed after revision for instability was treated successfully by a course of antibiotics following revision surgery.

The single patient in which DAIR followed by antibiotic treatment proved unsuccessful eventually underwent a successful two-stage revision. All cultured pathogens are listed in Table 3.

No significant differences regarding early general complications or total length of stay were encountered between the one- and two-stage subgroups (Tables 4, 5).

Discussion

Overall, the incidence of early PJI in this study was 6.9%, which is substantially higher than the commonly reported overall incidence rate of 0.2–2.2% of PJI after elective THA without earlier interventions. These results support the notion of an increased risk of PJI following hardware removal, which has been incidentally reported in previous literature [12, 13]. This, however, contradicts the findings of several other studies that identified no increased risk of PJI following THA after hardware removal [6, 9, 10]. PJI remains a serious complication following THA. Due to the increasing number of patients requiring salvage THA after previous internal fixation of proximal femoral fractures, it is important to establish consensus on the potentially higher risk of PJI and whether a one- or two-stage procedure should be advocated [1, 10, 11]. To date, the reported incidence of PJI following secondary THA after earlier internal fixation

Table 5 Overview of the occurrence of post-operative complications between the single- and two-stage surgery groups

Complications	One stage *n* (%)	Two stage *n* (%)	*P* value
Luxation(s)	4 (4.3%)	2 (3.8%)	0.631
Transient renal failure	1 (1.1%)	0 (0%)	0.641
Urinary tract infection	1 (1.1%)	0 (0%)	0.641
Acute decompensated heart failure	2 (2.2%)	0 (0%)	0.410
Pneumonia	2 (2.2%)	2 (3.8%)	0.358
Hematoma	1 (1.1%)	0 (0%)	0.641
Periprosthetic fracture	1 (1.1%)	0 (0%)	0.641
Total	12 (12.9%)	4 (7.7%)	0.251

P values were calculated using the Chi-square test. Asterisks indicate significant values

Table 4 Comparison of the means for the total length of stay regarding one-stage and two-stage procedures

	One-stage surgery			Two-stage surgery			*P* value
	Mean	Range	S.D.	Mean	Range	S.D.	
LoS (days)	9.268	1–67	10.08	7.140	1–45	7.36	0.191

LoS length of stay, *S.D.* standard deviation

P values were calculated using the independent sample Students' *t* test. Asterisks indicate significant values

varies from 0 to 7.5% which indicates a lack of evidence regarding the subject [10, 12, 13].

The apparent discrepancy between our results and other recent studies could be attributed to differences in patient population between studies or a negative selection bias since our study was conducted in a large general teaching hospital and not in a tertiary orthopaedic referral centre. The latter is supported by the fact that the proportion of patients with ASA classification 3 and 4 in our study is substantially higher when compared to, for example, the study performed by Klatte et al. (29% vs. 15%) [10]. Furthermore, Tetsunaga et al. did not include ASA 4 patients, and Hernandez et al. did not report on ASA classifications entirely [6, 9]. Furthermore, most earlier studies did not use well-defined criteria for PJI (MSIS 2011) which makes interpretation of and comparison with these results difficult. All in all, we argue that the risk of PJI may very well be increased when performing secondary THA following previous or concomitant hardware removal in the context and patient population of a large general teaching hospital.

The choice for either a concomitant or separated procedure regarding hardware removal and THA remains subject to debate and high-level evidence to support either strategy is lacking. Klatte et al. (2013) specifically addressed the safety of one-stage procedures regarding hardware removal and THA. They concluded there is no increased risk for PJI in one-stage hardware removal and THA with a PJI incidence of 0% [10]. With a reported incidence of PJI after a primary elective THA of up to 2.2% as reported by for instance Phillips et al. (2009), we tend to interpret the 0% by Klatte et al. as rather optimistic [8, 10]. Also, no comparison with a two-stage procedure was made. In our study, the 3.8% incidence of early PJI after a two-stage procedure may suggest superiority over a one-stage procedure. However, from the limited amount of PJI cases available, this difference was not significant. As for confounding factors only two recognized risk factors for PJI were significantly different between both groups (Table 3): surgery duration and patient age, whereas BMI and ASA classification were comparable. Surgery duration was longer for the single-stage surgery group for obvious reasons since it required additional surgical proceedings. Next to early PJI, the incidence of other early postoperative (general) complications did not seem to differ between either the one- or the two-stage group (Table 5). The same applies to the total length of stay whilst taking both the hardware removal as well as the THA into account (Table 4).

Besides recognized risk factors, it was noted that avascular necrosis of the femoral head and non-union or cutout of implants was a significantly more common indication for THA in the one-stage group (Table 1). One can only speculate whether the presence of avascular necrosis or non-union could predispose to early PJI following THA. A pre-existent low-grade infection of the fixation device may indeed predispose towards a non-union [14] and previous studies have addressed the possible high incidence of bacterial contamination of orthopaedic implants by means of positive intra-operative cultures and their relevance [10, 11]. However, in our opinion these speculations are not likely to have played an important role.

An important limitation of this study is its retrospective design and the fact that the included number of patients is too low to establish a significant difference on the incidence of PJI between one-stage and two-stage procedures. This makes the notion of a two-stage procedure as a possibly superior treatment strategy regarding PJI unreliable, especially considering the statistically non-significant difference. Unfortunately, the studied cohort could not be increased because of the inability of our computerized database to identify surgical procedures preceding 2006. On the other hand, this is a recognized limitation of studies focussing on issues with low incidence and high complexity [15]. This limitation also accounts for the limited amount of studies available so far. Furthermore, the choice for either a one- or two-stage procedure was not protocolized and as such subject to several confounding factors in patient selection. Therefore, the introduction of selection bias is eminent. This effectively leads towards a preference for one-stage procedures in patients with severe and acute onset of pain. The latter is supported by our data demonstrating an increased incidence of non-union and cutout of implants as the indication for a one-stage procedure (Table 1). However, these confounding factors are not likely to have influenced the primary outcome parameter of early PJI. Also, the fact that patients were included over a rather long period of time from a reliable prospective database is a strength of the study. In addition, the patient population from a large teaching hospital reflects a realistic representation of daily practice without exclusion of patients with relevant comorbidities.

In conclusion, we encountered a high incidence of PJI after salvage THA following implant removal after earlier internal fixation. This incidence supports the few available studies in the higher range of reported PJI. The trend towards a patient population with comorbidities and a relatively high ASA classification may have played a role in the discrepancy with the literature reporting lower incidences of PJI. In addition, other studies may have had a negative selection bias whereas in our study all PJIs were classified according to the latest MSIS criteria and proven by intra-operative tissue cultures. Based on our findings, we recommend that the incidence of PJI following salvage THA after internal fixation should not be underestimated, especially in a general patient population where comorbidities are common. Looking at our data, we cannot provide a firm recommendation regarding the choice for either a one- or two-stage procedure. The eventual decision should be individualized and shared with

the patient weighing the balance between the extra demand for surgery in case of a two-stage procedure against a potentially limited benefit of a lower chance of PJI. However, from the results of this study with a high percentage of PJI in both groups we decided to consider and approach these procedures as revisions for suspected infection. Prior to subsequent THA we advise a thorough workup including a low threshold for joint aspiration for culturing and to evaluate blood serum infection parameters. During either hardware removal or THA implantation, obtaining six tissue cultures should be considered. In case these cultures prove positive, adequate prolonged antibiotic treatment for either osteomyelitis or PJI should be initiated. When considering a single-stage procedure, additional modern intra-operative diagnostic tests using alpha-defensin as a marker for PJI might be of additional value for excluding pre-existent infection.

Well-designed multi-centre studies, for example, using national joint registries, comparing either one- or two-stage strategies should be performed to further establish the optimal surgical strategy in this challenging subgroup of patients.

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Compliance with ethical standards

Ethical approval This study received approval of the local Committee for Research Involving Human Subjects that granted a waiver of informed consent due to its retrospective nature.

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