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Failure analysis of articulating polymethyl methacrylate spacers in two-stage revision total hip arthroplasty

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Aims

Two-stage exchange revision total hip arthroplasty (THA) performed in case of periprosthetic joint infection (PJI) has been considered for many years as being the gold standard for the treatment of chronic infection. However, over the past decade, there have been concerns about its safety and its effectiveness. The purposes of our study were to investigate our practice, collecting the overall spacer complications, and then to analyze their risk factors.

Methods

We retrospectively included 125 patients with chronic hip PJI who underwent a staged THA revision performed between January 2013 and December 2019. All spacer complications were systematically collected, and risk factors were analyzed. Statistical evaluations were performed using the Student's *t*-test and Mann-Whitney U test.

Results

Our staged exchange practice shows poor results, which means a 42% mechanical spacer failure rate, and a 20% recurrent infection rate over the two years average follow-up period. Moreover, we found a high rate of spacer dislocation (23%) and a low rate of spacer fracture (8%) compared to the previous literature. Our findings stress that the majority of spacer complications and failures is reflecting a population with high comorbid burden, highlighted by the American Society of Anesthesiology grade, Charlson Comorbidity Index, and Lee score associations, as well as the cardiac, pulmonary, kidney, or hepatic chronic conditions.

Conclusion

Our experience of a two-stage hip exchange revision noted important complication rates associated with high failure rates of polymethylmethacrylate spacers. These findings must be interpreted in the light of the patient's comorbidity profiles, as the elective population for staged exchange has an increasing comorbid burden leading to poor results. In order to provide better results for this specific population, our conclusion suggests that comparative strategy studies are required to improve our therapeutic indication.

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Keywords: Hip, PMMA, Articulating spacer, Periprosthetic joint infection, Two-stage exchange, Complications, Failure

Introduction

Although total hip arthroplasty (THA) is a successful surgery in terms of alleviating pain and restoring functional activity in patients with advanced degenerative joint disease,[1] periprosthetic joint infection (PJI) remains one of the most feared complications.

The consequences are disastrous, representing a worldwide economic burden estimated at $753.4 million on the American healthcare system alone.[2] A devastating complication for patients, it may further severely limit joint function, and increases morbidity and mortality.[3]

Unfortunately, this complication is becoming more common, due to an increasing number of THAs[4] and a persistent PJI rate.[5] Indeed, despite continued progress and substantial efforts to develop preventive

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Table I. Patient demographic, clinical, and outcome characteristics.

Variable	Data	Range	95% CI
Demographic characteristics			
Mean age, yrs	65.93	31 to 88	63.757 to 68.095
Age < 45 yrs, n (%)	9 (7.44)		
Age > 70 yrs, n (%)	47 (37.9)		
Mean BMI first stage	26.92	17.70 to 44.90	25.844 to 27.992
BMI > 30 kg/m^2, n (%)	26 (28.89)		
Sex, n (%)			
Male	83 (62.4)		
Female	52 (36.8)		
Medical history			
Variable	**Data**	**Variable**	**Result, n (%)**
	4.07		
Mean CCI	± 2.529	**Alcohol use, n (%)**	
CCI ≥ 6, n (%)	33 (26.61)	Active	15 (12.61)
		Sober	4 (3.36)
		0	100 (84.03)
	2.43		
ASA score, mean (SD)	±0.753	**Tobacco use**	
1	11 (9.82)	Active	30 (25.0)
2	49 (43.75)	Sober	30 (25.0)
3	45 (40.18)	0	61 (50.0)
4	7 (6.25)		
5	0 (0.0)		
6	0 (0.0)		
	0.46	**Chronic dermatological disease**	5 (4.17)
Lee score, mean (SD)			
0	69 (59.48)		
1	24 (20.69)		
2	8 (6.9)		
3	1 (0.86)		
Allergic disposition, n (%)	30 (28.04)	Inflammatory arthritis, n (%)	6 (4.96)
Chronic pulmonary disease, n (%)	19 (15.7)	Osteoporosis, n (%)	4 (3.77)
Chronic cardiac disease, n (%)	10 (8.26)	Dementia, n (%)	9 (7.44)
Chronic liver disease, n (%)	9 (7.5)	Hemiplegia, n (%)	3 (2.52)
Chronic kidney disease, n (%)	16 (13.22)	Psychiatric, n (%)	22 (18.33)
HIV, n (%)	3 (2.59)	Hemophilia, n (%)	2 (1.67)
Diabetes, n (%)	25 (21.05)	Malignancy, n (%)	19 (15.57)
Implantable chamber, n (%)	24 (20.34)	Immunosuppressive drugs, n (%)	11 (9.17)
Pressure sore, n (%)	6 (5.04)	Anticoagulant drugs	16 (13.33)
Surgical history			
Variable	**Data**	**Range**	**95% CI**
Mean diagnostic delay, mnths	8.29	0.00 to 96.00	5.606 to 10.968
Mean time to reimplantation, mnths	4.69	2.00 to 18.00	4.093 to 5.282
Mean pevious hip surgeries	2.81	1.00 to 6.00	2.556 to 3.059
Previous DAIR, n (%)	42 (60.87)		
Macroscopic gross purulence, n (%)	31 (36.05)		
Extended trochanteric osteotomy, n (%)	51 (55.43)		
Sinus tract, n (%)	36 (31.86)		
Mean first stage operative time, mins	152.86	90.00 to 240.00	120.456 to 185.258
Mean first stage hospitalization time, days	16.07	3.00 to 150.00	12.997 to 19.147
First stage intensive care, n (%)	6 (4.80)		
Mean first stage blood transfusion	1.34 ±1.614		
Haematoma, n (%)			
Total	10 (8.06)		

Continued

Table I. Continued

Variable	Data	Range	95% CI
Demographic characteristics			
First stage	5 (4.0)		
Second stage	3 (2.4)		
Mean weightbearing	0.29	0.00 to 1.00	0.192 to 0.384
Mean second stage operative time, min	143.08	60.00 to 210.00	115.857 to 170.297
Mean second stage hospitalization time, days	10.61	4.00 to 33.00	9.448 to 11.779
Second stage intensive care	4 (3.2)		
Second stage blood transfusion	1.17	0.00 to 8.00	0.788 to 1.545
Radiological data			
Mean leg length discrepancy, mm	13.91	-24.00 to 187.00	7.825 to 19.987
Mean implant offset	39.44	0.00 to 64.00	37.545 to 41.336
Offset < 30 mm, n (%)	10 (9.71)		
Offset > 45 mm, n (%)	20 (19.42)		
Mean spacer's length	197.07	35.25 to 340.00	186.453 to 207.688
Length < 150 mm, n (%)	16 (14.29)		
Mean mismatch head/acetabulum	6.15	0.00 to 50.00	4.767 to 7.541
Mismatch < 4 mm, n (%)	50 (50.51)		
Mismatch > 8 mm, n (%)	25 (25.5)		
Meam head/neck ratio	2.04	1.09 to 3.29	1.968 to 2.113
H/N < 1.7, n (%)	19 (17.92)		
H/N > 2.4, n (%)	13 (12.15)		
Biological data			
First stage			
Mean albumin, g/l	34.16	19.20 to 46.10	31.712 to 36.616
Mean Hba1c, %	6.66	5.00 to 11.60	4.872 to 8.446
Mean WBC	8.53	1.90 to 24.00	7.792 to 9.277
WBC > 12, g/dl, n (%)	7 (8.24)		
Mean PMN, G/l	6.22	2.10 to 22.00	5.412 to 7.021
Mean CRP	58.64	3.00 to 343.50	42.420 to 74.856
CRP > 70 mg/l, n (%)	16 (20.25)		
Mean Δ Hb, g/dl	2.65	0.00 to 11.90	2.234 to 3.060
Second stage			
Mean albumin, g/l	38.12	24.20 to 48.70	34.919 to 41.319
MeanWBC	6.95	0.00 to 15.29	6.318 to 7.572
WBC > 12 G/l, n (%)	6 (7.59)		
Mean PMN (G/l)	5.03	0.00 to 12.32	4.401 to 5.655
Mean CRP	21.09	1.2 to 64.90	12.213 to 29.965
CRP > 40 mg/l, n (%)	7 (11.48)		
Mean Δ Hb, g/d	2.78	0.00 to 10.70	2.431 to 3.132

CCI, Charlson Comorbidity Index; CI, confidence interval; CRP, C-reactive protein; DAIR, debridement, antibiotics, irrigation, and retention; Hb, haemoglobin; Hba1c, glycosylated haemoglobin; PMN, polymorphonuclear neutrophil; WBC, white blood cell.

strategies, the rate of PJI continues to range between 1% and 2%.[6]

Nevertheless, despite the urge for effective strategies, the best treatment for chronic PJI remains controversial. Presently, two-stage exchange arthroplasty is the popular surgical treatment for the surgical management of PJI.[7] However, to date, there are no randomized clinical trials that provide indications or contraindications for two-stage exchange arthroplasty.[8,9] Additionally, there is a variability in the reported rates in specific complication,[10–13] in morbidity and mortality,[3,10,14] and success in eradicating infection.[8,11,12,14]

The recent literature has brought to light inferior clinical and perioperative outcomes as a result of mechanical complications, as well as a higher risk of reinfection,[15] lower survivorship, and functional outcomes after spacer exchange.[16] Moreover, given the substantial number of patients who never undergo reimplantation, the staged revision does not result to previously reported high rates of cure.[14,17,18] Brown et al[10] has reported mortality rates similar to prostatectomy or kidney transplant. Furthermore, the literature emphasizes the high rates of spacer retention,[19] leading to frequent aseptic failure and poor outcome,[20,21] along with the high rates of persistent

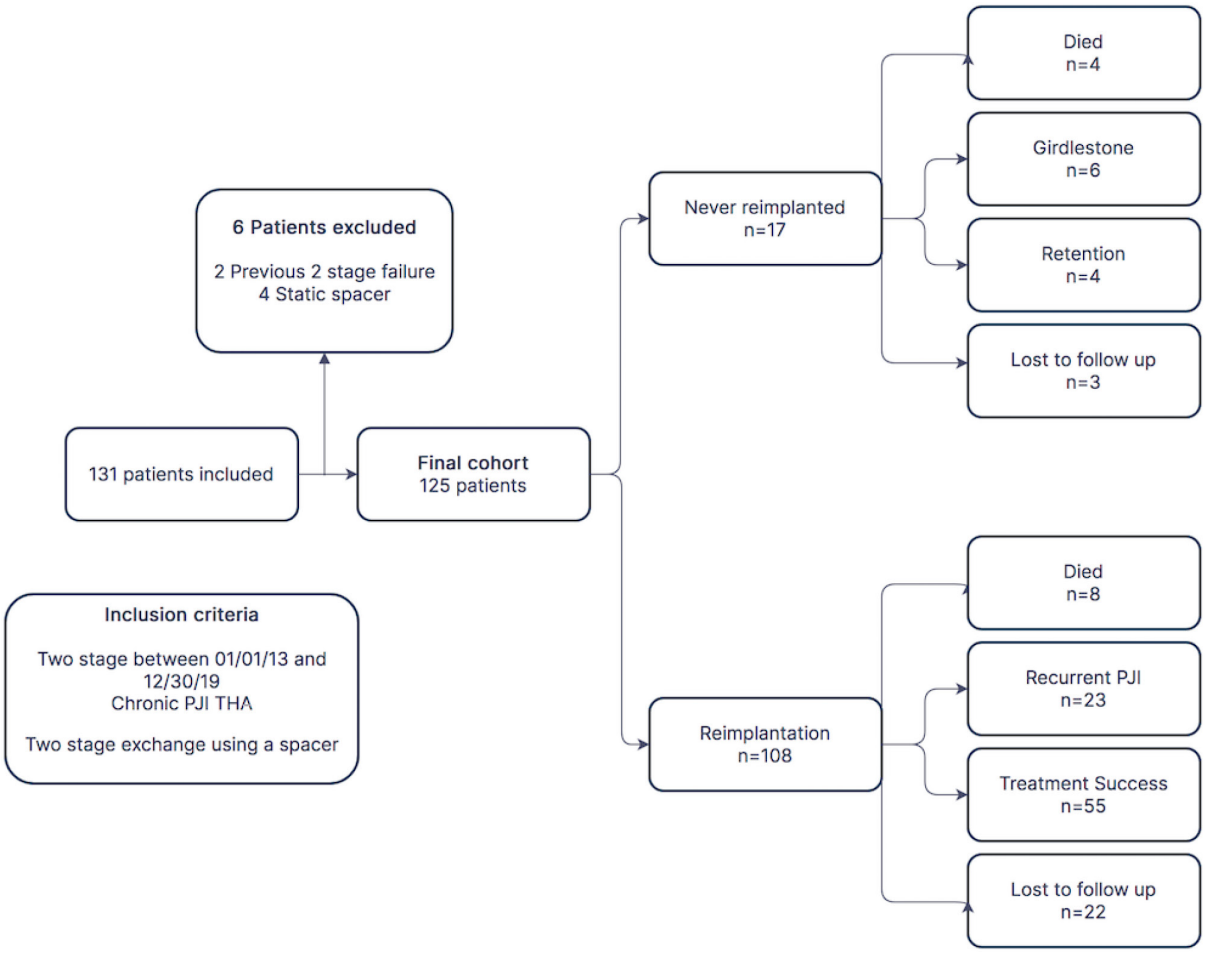

Fig. 1
Flowchart depicting the outcomes of the final cohort.

infection,[11,21] representing a dramatic scenario, leading to poor therapeutic possibilities.[22,23]

Based on these findings, this study was conducted in order to investigate our practice of a two-stage exchange strategy. Therefore, our purposes were to provide a complete picture of the overall spacer complications, and expand on this analysis by assessing the risk factors of two-stage exchange arthroplasty failure of our practice.

Methods

Patient demographic characteristics. Following institutional review board approval, we retrospectively retrieved records for 28,717 THA PJI from our database coding system who fit the criteria «removal of total hip prosthesis» coupled with «insertion of a cement spacer». Overall, 131 patients met the inclusion criteria for a two-stage exchange for THA PJI between the 1 January 2013 and 31 December 2019, performed in three university hospitals. After exclusions of the static spacers (four patients) and the failure of a previous two-stage procedure (two patients), 125 patients were included in the final cohort.

Primary outcome: overall of staged-exchange complication. A retrospective chart review was performed, identifying the general spacer complications, the specific spacer complications, and the failure of staged exchange procedure.

General complication. First, general complications have been reported, either as a medical or surgical complication. A medical complication was reported if a specific medical care was required while the patient's postoperative hospital stay. The surgical complications were assessed using the five-level Clavien-Dindo classification,[24] which assigns a score based on the importance of the treatment's complication.

Specific spacer complication. Specific spacer complications were then analyzed, in the form of mechanical complications and spacer exchange for persistent infection. Mechanical complications were noted, based on radiological analysis or any reference in the medical record, and spacer exchange was reported based on the associated surgical report.

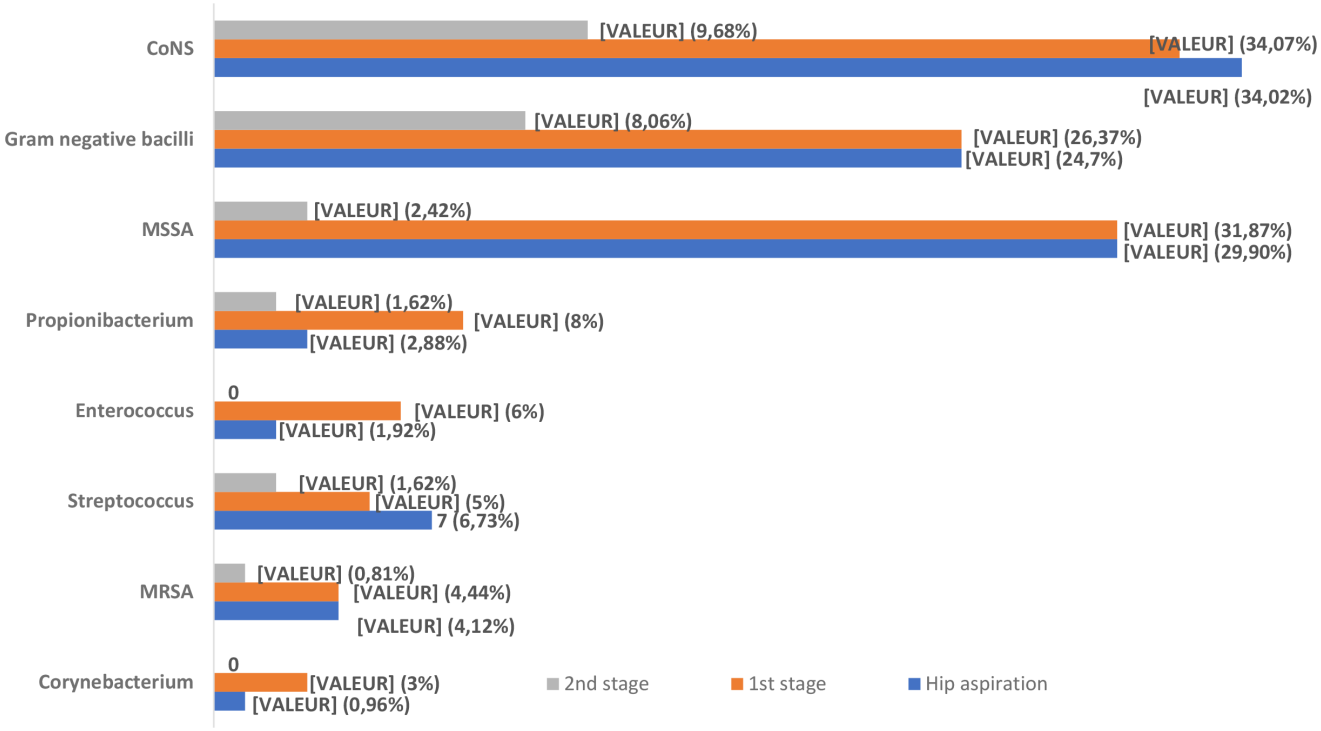

Fig. 2
Overall organism at each stage of the staged exchange procedure.

Failure of staged exchange procedure. Finally, two-stage revision failures were reported as the occurrence of death, spacer retention, and recurrent PJI. Death was reported during the interstage and after the second stage follow-up based on the medical record and a national database search. The retention of the spacer was defined as the inability to complete the second stage.

We stressed that recurrent PJI was judged according to the criteria published by Diaz-Ledezma et al[25] after a Delphi based international and multidisciplinary consensus.

Secondary outcome: Independent significant risk factors for outcomes. From our statistical institutional database, queries were performed to retrieve patient medical records to collect host demographic characteristics and comorbidity. Moreover, we collected from the preanesthesic consultation, and clinical risk-stratification classification systems to provide an overall understanding of the patient's health status, such as the American Society of Anesthesiologists (ASA) physical status classification to assess perioperative risk,[26] and the Lee score for perioperative cardiac events.[27]

In addition, an age-adjusted Charlson Comorbidity Index (CCI) score[28] was calculated using a standardized online medical calculator, to estimate mortality risk and disease burden over one-year.

Relying on a previous analysis of the literature, preoperative biological data from first stage and second stage, and radiological spacer data after first stage,[29] were collected as potential complication risk factors,.

Finally, we reported the organism of PJI hip aspiration, and of the surgical samples from the first and second stages, based on the classification of organisms used by Rava et al[9] in their systematic review of two-stage exchange procedures.

Statistical analysis. Descriptive statistics for spacer complications are presented as means and standard deviations (SDs) for continuous variables and as frequencies and percentages for categorical variables. Student's *t*-test and Mann-Whitney tests were used to compare groups. Univariate analysis using Fisher's exact test was used to determine the association between spacer complication and independent risk factors. All statistical analysis were performed using the online software Easymedstat version 3.9,[30] and significance was set at $p < 0.05$.

Results

Patient demographic and outcome characteristics. During the study period, 125 patients were treated with a two-stage revision THA; 62.4% (78/125) were male, mean age was 64.8 years (31 to 88;SD 12.2), with 37.9% (47/124) aged above 70 years, and mean BMI was 26.9 kg/m^2 (17.70 to 44.9; SD 5.2). The mean CCI score was 4.1 (00 to 11; SD 2.5), and 26.1% of patients (33/124) had a score above 6. The mean ASA score was 2.4 (1 to 4; SD 0.8),

Table II. Summary of the spacer complication in the cohort.

Variable	General complication, n (%)	Spacer complication, n (%)		Two-stage exchange failure, n (%)	
		Spacer dislocation	27 (23.08)	**Recurrent PJI**	23 (21.3)
Clavien-Dindo global		Mean time, days	34.39± 49.823		
0	64 (51.61)				
1	0 (0.0)				
2	45 (36.25)				
3	36.25 (0.81)				
4	1 (8.87)				
5	11 (2.42)				
Clavien-Dindo first stage		**Femoral fracture**	31 (13.48)	**Death**	4 (3.42)
0	4 (67.74)	First stage	13 (26.27)		
1	0 (0.0)	Interstage	6 (23.08)		
2	32 (25.81)	First stage + interstage	20 (16.13)		
3	0 (0.0)	Second stage	5 (19.23)		
4	6 (4.84)				
5	2 (1.61)				
Clavien-Dindo second stage		**Spacer fracture**	14 (11.29)	**Spacer retention**	4 (3.42)
0	91 (73.39)				
1	0 (0.0)				
2	30 (24.19)				
3	0 (0.0)				
4	1 (0.87)				
5	2 (51.61)				
Medical complication	25 (20.16)	**Acetabular fracture**	5 (4.35)		
Antibiotic complication	21 (14.0)	**Spacer migration**	5 (4.10)		
Antibiotic side-effects	14 (11.29)	**Spacer exchange**	20 (16.67)		
		Mean time, days	220.94 ± 302.838		
Antibiotic allergic reaction	7 (5.6)	**Time to reimplantation**			
		0 to 2 mnths	14 (11.29)		
		2 to 4 mnths	52 (49.06)		
		4 to 8 mnths	29 (27.36)		
		> 8 mnths	11 (10.28)		

46.4% of patients (52/125) had a score above 3, and the mean Lee score was 0.5 (0 to 4; SD 0.8). Table I illustrates the patient's demographic, clinical, and outcome characteristics.

The mean reimplantation time was 4.7 months (2 to 18; SD 3.1), and the mean follow-up was 2.1 years (0.4 to 6.04; SD 1.5). At the latest follow-up, we reported a 30.4% (38 patients) rate of lost to follow-up, which led to a search of a national database to reduce this result to 20% (25 patients). Figure 1 depicts the outcome of the final cohort.

The main infecting organisms in the diagnostic hip aspiration, were coagulase-negative staphylococcus (CoNS) in 34.02% cases (33/97), methicillin-sensitive *Staphylococcus aureus* (MSSA) in 29.9% cases (29/97), and gram-negative bacilli in 24.7% cases (24/97).

At the time of first stage, the most common organisms were CoNS in 34.07% of cases (31/91), MSSA in 31.87% cases (29/91), and gram-negative bacilli in 26.37% of cases (24/91). Figure 2 reports the overall organism at each stage of the procedure.

Primary outcome: Overall of staged-exchange complication. Table II summarizes the overall spacer complication for this study.

General complication. First, for general complications, 20.2% (31/124) of medical complications, and a 49.2% (61/124) of surgical complications were reported. Table III presents the Clavien-Dindo complication grade at each stage of the procedure.

Specific spacer complication. Second, concerning specific spacer complication, we report the occurrence of mechanical complications in 52 of 125 cases (41.6%),

Table III. Summary of the grades of complications according to Clavien-Dindo classification.

Grade	Global, n (%)	First stage	Second stage
Minor (I-II)	45 (36.0)	32 (25.6)	30 (24.0)
0	64 (51.2)	84 (67.2)	91 (72.8)
I	0 (0.0)	0 (0.0)	0 (0.0)
II	45 (36.0)	32 (25.6)	30 (24.0)
Major (III-IV-V)	15 (12.0)	8 (6.4)	6 (4.8)
III	1 (0.8)	0 (0.0)	0 (0.0)
IV	11 (8.8)	6 (4.8)	1 (0.8)
V	3 (2.4)	2 (4.8)	5 (4.0)

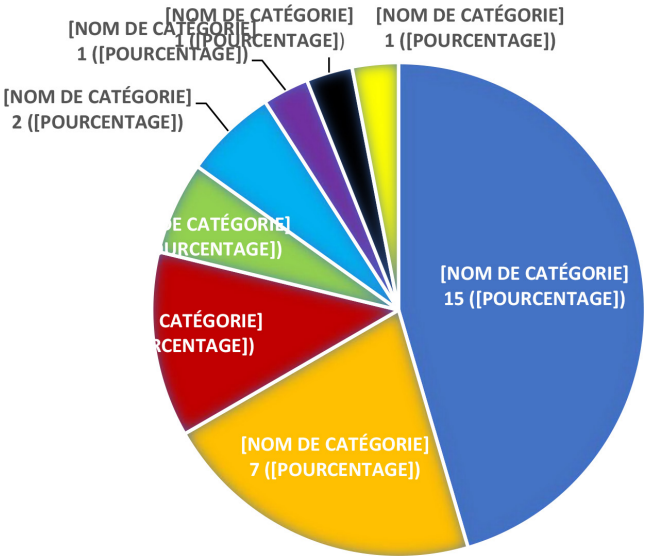

Fig. 3
Overall recurrent periprosthetic joint infecting organism.

which were mostly spacer dislocations in 27/125 cases (23.08%), with a mean of 34.39 days, and femoral fractures in 31 of 125 cases (26.27%). Moreover, during the interstage, spacer exchange for persistent infection occurred in 20/120 cases (16.67%).

Failure of staged exchange procedure. Finally, we reported as failures of two-stage exchange, a 3.2% (4/125) death rate during the interstage period, and a 10.18% (11/108) death rate after reimplantation, for a mean follow-up of 15.6 months when taking into account the patients never reimplanted. In addition, we report an overall incidence of spacer retentions for the cohort of 3.4% (4/125), and of recurrent PJIs of 21.3% (23/118) when excluding the patients never reimplanted. Concerning the recurrent PJI, 21.7% (5/23) were considered as a persistent infection, presenting the same organism at the time of initial resection arthroplasty or previous hip aspiration, and 30.4% (7/23) were considered as a reinfection. Figure 3 provides a summary of the organism at each stage.

Secondary outcome: Independent significant risk factors for outcomes. A full summary of the independent significant risk factors associated with our studied outcomes is reported in Table IV.

General complication. Concerning general complications, medical complications were associated with age (odds ratio (OR) 2.994; $p < 0.010$), ASA score ($p < 0.027$), CCI (OR 2.994; $p < 0.010$), CCI > 6 (OR 2.636; $p < 0.034$), chronic congestive heart failure (OR 5.438; $p < 0.01$), chronic lung disease (OR 6.007; $p < 0.0007$), and death (OR 9.86; $p < 0.047$). Surgical complications were associated with age (OR 2.492; $p < 0.046$) and chronic lung disease (OR 7.03; $p < 0.001$).

Specific spacer complication. Regarding the specific spacer complication, our study found a significant association between the occurrence of a spacer dislocation and an offset < 30 mm (OR, 5.83; $p < 0.012$), as well for a spacer length < 150 mm (OR 4.86; $p < 0.011$).

Furthermore, the main risk factors significantly associated with an increased risk of spacer exchange were on the one hand: ASA score ($p < 0.012$), chronic liver disease (OR 2.6; $p < 0.001$), time to reimplantation > 8 months (OR 20.88; $p < 0.0001$).

On another hand, we recorded as increased risk factors the presence in the hip aspiration of a gram-negative bacilli (OR 3.7; $p < 0.026$), or in the first stage's surgical samples of methicillin-resistant *Staphylococcus aureus* (MRSA) (OR 17.294; $p < 0.012$), or a drug-resistant organism (OR 8.8; $p < 0.0008$).

Failure of staged exchange procedure. Finally, concerning two-stage exchange failure, we report for the occurrence of death during the interstage, significant associations with age > 70 years ($p < 0.015$), Lee score ($p < 0.0009$), chronic congestive heart failure (OR 12.354; $p < 0.036$), anticoagulant drug use (OR 22.385; $p < 0.008$) and haematoma after first stage (OR 39.0; $p < 0.007$).

As well, we report significant independent risk factors for spacer retention, including; ASA score ($p < 0.036$), pressure sores (OR 27.5; $p < 0.012$), and dementia (OR 15.571; $p < 0.0279$).

Additionally, we point out in one hand, several independent significant risks for recurrent PJI as, ASA score (OR 2.338; $p < 0.009$) and chronic liver disease (OR 10.471; $p < 0.001$).

And on the other hand, the presence in the diagnostic PJI hip aspiration of a gram-negative bacilli (OR 3.674; $p < 0.027$) and the presence in the first stage's surgical samples of a MRSA (OR 13.95; $p < 0.02$) or a drug resistant organism (OR 7.22; $p < 0.002$).

Discussion

The review of our practice of a two-stage revision THA for PJI emphasizes a procedure with a high risk of general and specific spacer complications, as well as high-staged exchange procedure failures.

Primary outcome: overall of staged-exchange complication

Table IV. Summary of independent significant risk factors for studied outcomes.

Risk factor	Odds ratio	P-value
Medical complication		
Age	2.5	0.01
ASA score	X	0.027
CCI	2.99	0.01
CCI > 6	2.64	0.034
Chronic congestive heart failure	5.44	0.01
Chronic lung disease	6.007	0.0007
Dementia	4.35	0.04
Implantable chamber	2.8	0.03
WBC	1.7	0.012
WBC > 12	6.36	0.042
PMN	3.13	0.01
Haemoglobin loss	0.16	0.004
Death	9.86	0.047
Clavien-Dindo	16.97	0.0001
Surgical complication		
Age	2.49	0.046
Chronic lung disease	7.03	0.001
Medical complication	16.97	0.0001
Spacer dislocation		
Offset < 30 mm	5.83	0.012
Spacer length < 150 mm	4.86	0.011
Femoral fracture		
Osteoporosis	X	.0003
Spacer exchange		
ASA score	X	0.012
Chronic liver disease	2.6	0.001
First stage - sinus tract	4.27	0.011
Anticoagulant drug use	4.06	0.023
Implantable chamber	4.27	0.006
Time to reimplantation	X	0.0005
Hip aspiration - Gram-negative bacilli	3.7	0.026
First stage - *Staphylococcus aureus*	X	0.03
First stage - MRSA	17.29	0.01
First stage - antibiotic-resistant organism	8.8	0.0008
Medical complications	16.97	0.02
Recurrent PJI	9.773	0.0001
Time to reimplantation, 0 to 2 mnths	0.1	0.008
Time to reimplantation, > 8 mnths	20.8	0.0001
Recurrent PJI		
ASA score	X	0.009
Chronic liver disease	10.47	0.001
Chronic dermatological disease	7.18	0.047
second stage - CRP> 40mg/l	7.67	0.042
Hip aspiration - gram-negative bacilli	3.67	0.027
First stage - drug-resistant organism	7.22	0.002
First stage - MRSA	13.95	0.02
First stage - *Staphylococcus aureus*	X	0.03
Spacer exchange	9.77	0.0001
Death		
Age > 70 yrs	X	0.015
Lee score	X	0.0009
Chronic congestive heart failure	12.35	0.036
Anticoagulant drug use	22.38	0.008
First stage - haematoma	39	0.007
Medical complication	11.74	0.033
first stage - Clavien-Dindo	X	0.0001
Retained spacer		
ASA score	X	0.036
Pressure sores	27.5	0.012
Dementia	15.57	0.0279

ASA, American Society of Anesthesiology; CCI, Charlson Comorbidity Index; CRP, C-reactive protein; MRSA, methicillin resistant *staphylococcus aureus*; PMN, polymorphonuclear neutrophil; WBC, white blood cell.

General complication. Concerning the general complication, we demonstrated a high rate of medical complication located in the high range reported in the literature, with results ranging from 8.8% to 46.3%.[14,31,32] In addition, our study found a significant rate of surgical complications of 48.8%, compared with an average rate of 35.2% for global orthopaedic surgeries.[24]

Specific spacer complication. Regarding the specific spacer complication, we observed an overall spacer-related mechanical complication rate of 41.6%, also within the higher literature range, for results ranging from 19.6% to 40.8%.[31,33] Our spacer dislocation rate of 23.1% appears to be consistent with the literature,[9] although we reported more femoral fractures and a lower rate of spacer fractures.[29,33] Moreover, we reported a higher spacer exchange rate of 16.67% than the literature's results, ranging from 5% to 14%;[19] nevertheless, the reason behind this difference remains unclear.

Failure of staged exchange procedure. For two-stage revision failures, we reported a mortality rate of 3.2%, which is consistent with the literature's rates ranging from 2.6% to 7%.[14,19] Furthermore, after a follow-up of 15.6 months, our death rate of 8.8% was similar to the literature's rates,[3,14,19] ranging from 6.5% to 10.6% after a one year follow-up.

Additionally, our study reported a 3.2% retention rate, while the literature evidenced a wide range of rate ranging from 13.5% to 68%,[19–21] which underlies the lack of consensual definition.

Finally, we reported a relatively high recurrent PJI rate of 21.3% compared to the 10.4% rate reported by Lange et al[8] in their meta-analysis. Despite the use of a consensual definition,[25] we assume that this high rate results from the exclusion of the patients never reimplanted, and the inclusion of the patients considered as reinfected.

Secondary outcome: independent significant risk factors for outcomes. Regarding the risk factor analysis, our study reports a specific patient comorbidity profile, based on age, clinical risk-stratification systems, and chronic organ failure, which appears to be significantly associated with substantial staged exchange complication and failures.

The existing literature supports our conclusion, as spacer exchange is reported to be associated with CCI score,[16] and chronic kidney and liver diseases.[19] Moreover, concerning the occurrence of death within one year, Cancienne et al[19] were able to identify an age above 85 years, liver, cardiac, and pulmonary diseases as risk factors. Additionally, spacer retention appears to be associated with advanced age, ASA grade, CCI score,[21] and congestive heart failure.[19] Finally, as well for recurrent PJI published data, association was found with the CCI,[34] McPherson C3 score,[12] and heart diseases.[11]

Taking into account these results, it appears that high comorbid burden among patients undergoing a staged exchange procedure leads to poor results.

Meanwhile, the elective arthroplasty patient population is ageing and is associated with increasing comorbidity indices,[4] leading to a similar change in the staged revision population profile,[35] as evidenced by our study, with a 40% rate of patients aged above 70 years, and half our population with an ASA grade above 3.

Thus, the fair results reported in this analysis regarding our practice of staged exchange arthroplasty for PJI need to take into account the high comorbidity profile of our population. As a result, our study highlights the need to consider specific care concerning chronic PJI for this specific population in order to provide better results.

Limitations. There are several limitations in this study, many of which common to most of the studies. First, the retrospective nature leads to unavoidable memory bias and data loss. Second, we acknowledge a high rate of lost to follow-up that might underestimate our results, despite a national database search to limit bias. Finally, our multicentric study design introduces a heterogeneity of practice. However, we do not believe that this weakens our findings, as all practices have been standardized by a reference centre for the management of complex bone and joint infections.

Despite the aforementioned limitations, the present study is the first to the best of our knowledge to provide a complete picture of the overall clinical impact of PJI in total joint replacment in order to evaluate the complex interplay between risk factors and the outcome of this procedure.[19]

In conclusion, the analysis of our practice reports a high-risk procedure, with a 20% rate of medical complications, a 49% rate of surgical complications, a 42% rate of mechanical complications, and a high risk of failure for a quarter of our study cohort.

Our findings identify the age, the clinical risk-stratification systems, and chronic organ failure as key predictors of high risk of complication and failure during a two-stage procedure. Therefore, these poor results should be interpreted with caution, reflecting an increasing comorbidity burden among our population with chronic PJI.

As pointed out in our study, the increase in chronic PJI THA in a population of elective arthroplasty patients with higher medical comorbidities seems to be a new challenge for orthopaedic surgeons. Our results imply that further studies comparing different strategies for chronic PJI THA in this specific population are required to improve our therapeutic indications and provide better results.

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