

**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, 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. A devastating complication for patients, it may further severely limit joint function, and increases morbidity and mortality.

Unfortunately, this complication is becoming more common, due to an increasing number of THAs and a persistent PJI rate. Indeed, despite continued progress and substantial efforts to develop preventive
**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/m², n (%)                         | 26 (28.89) |              |              |
| Sex, n (%)                                    |            |              |              |
| Male                                          | 83 (62.4)  |              |              |
| Female                                        | 52 (36.8)  |              |              |
| **Medical history**                           |            |              |              |
| Mean CCI ± 2.529                              |            |              |              |
| CCI ≥ 6, n (%)                                | 33 (26.61) |              |              |
| **ASA score, mean (SD)**                      | ±0.753     |              |              |
| 1                                             | 11 (9.82)  |              |              |
| 2                                             | 49 (43.75) |              |              |
| 3                                             | 45 (40.18) |              |              |
| 4                                             | 7 (6.25)   |              |              |
| 5                                             | 0 (0.0)    |              |              |
| 6                                             | 0 (0.0)    |              |              |
| Lee score, mean (SD)                          | 0.46       |              |              |
| 0                                             | 69 (59.48) |              |              |
| 1                                             | 24 (20.69) |              |              |
| 2                                             | 8 (6.9)    |              |              |
| 3                                             | 1 (0.86)   |              |              |
| Allergic disposition, n (%)                   | 30 (28.04) |              |              |
| Chronic pulmonary disease, n (%)              | 19 (15.7)  |              |              |
| Chronic cardiac disease, n (%)                | 10 (8.26)  |              |              |
| Chronic liver disease, n (%)                  | 9 (7.5)    |              |              |
| Chronic kidney disease, n (%)                 | 16 (13.22) |              |              |
| HIV, n (%)                                    | 3 (2.59)   |              |              |
| Diabetes, n (%)                               | 25 (21.05) |              |              |
| Implantable chamber, n (%)                    | 24 (20.34) |              |              |
| Pressure sore, n (%)                          | 6 (5.04)   |              |              |
| **Surgical history**                          |            |              |              |
| Mean diagnostic delay, mnths                  | 8.29       |              |              |
| Time to reimplantation, mnths                 | 4.69       |              |              |
| Mean previous hip surgeries                   | 2.81       |              |              |
| Previous DAIR, n (%)                          | 42 (60.87) |              |              |
| Macroscopic gross purulence, n (%)            | 31 (46.05) |              |              |
| 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|              |              |
| Total                                         | 10 (8.06)  |              |              |

Continued
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,10–11 in morbidity and mortality,3,10,14 and success in eradicating infection.8,11,12,14

| 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)|           |                 |
| Mean 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 |
| Mean WBC                      | 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.

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 al10 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
infection,\textsuperscript{11,21} representing a dramatic scenario, leading to poor therapeutic possibilities.\textsuperscript{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,\textsuperscript{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.
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 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 pre-anesthesia 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, and the Lee score for perioperative cardiac events.

In addition, an age-adjusted Charlson Comorbidity Index (CCI) score 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, 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 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, 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/m² (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),
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 I. Summary of the spacer complication in the cohort.

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

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 hae-matoma 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
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%. 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. 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%. Our spacer dislocation rate of 23.1% appears to be consistent with the literature, although we reported more femoral fractures and a lower rate of spacer fractures. Moreover, we reported a higher spacer exchange rate of 16.67% than the literature’s results, ranging from 5% to 14%; 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%. Furthermore, after a follow-up of 15.6 months, our death rate of 8.8% was similar to the literature’s rates, ranging from 5% to 14%; nevertheless, the reason behind this difference remains unclear.

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.

### 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          | 0.0003  |
| **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 mths| 0.1      | 0.008   |
| Time to reimplantation, > 8 mths  | 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  | 12.33      | 0.036   |

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.
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, leading to a similar change in the staged revision population profile,21 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 replacement 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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Author information:
- M. Jaubert, MD
- M. Le Baron, MD, Writing
- Institute for Locomotion, Department of Orthopedics and Traumatology, Northern Hospital, Marseille, France.
- C. Jaquet, MD, Investigation
- A. Couvreur, MD, Investigation
- M. Fabre-Aubrespy, MD, Resources
- M. Ollivier, MD, PhD, Supervision
- J-N. Argenson, MD, PhD, Writing – review & editing
- Institute for Locomotion, Department of Orthopedics and Traumatology ISM, CNRS, Aix-Marseille University, St. Marguerite Hospital, Marseille, France.
- X. Flecher, MD, PhD, Writing – review & editing, Institute for Locomotion, Department of Orthopedics and Traumatology ISM, CNRS, Aix-Marseille University, St. Marguerite Hospital, Marseille, France.

Author contributions:
- M. Jaubert: Writing – original draft.
- M. Le Baron: Writing – original draft.
- C. Jaquet: Investigation.
- A. Couvreur: Investigation.
- M. Fabre-Aubrespy: Resources.
- X. Flecher: Writing – review & editing.
- M. Ollivier: Supervision.
- J-N. Argenson: Writing – review & editing.

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