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Antibiotic-loaded hip spacers in two-stage revision for chronic hip periprosthetic joint infection: comparative outcomes in a multimorbid rheumatic cohort from 2008 to 2023

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Abstract

Background: Periprosthetic joint infection (PJI) after total hip arthroplasty causes repeated surgery, prolonged antimicrobial therapy, functional decline, and high morbidity. Management is difficult in complex multimorbid patients with inflammatory rheumatic disease because immunosuppression, overlapping comorbidities, and disease flares may obscure diagnosis and compromise recovery. We described the institutional burden of chronic hip PJI requiring spacer-based two-stage revision and compared articulating versus static antibiotic-loaded hip spacers.

Methods: We performed a single-center retrospective cohort study of consecutive adults treated from 2008 to 2023 for chronic hip PJI with implant removal, antibiotic-loaded spacer placement, and planned two-stage revision. Patients were grouped by spacer construct. Spacer choice was pragmatic and non-randomized, reflecting intraoperative anatomy, rehabilitation potential, surgeon assessment, and construct/material availability. Functional outcomes, pain, range of motion, perioperative variables, microbiology, failure patterns, comorbidity burden, and follow-up were evaluated using complete-case denominators.

Results: Among 511 hip arthroplasty procedures, 31 chronic hip PJI cases requiring spacer-based two-stage revision were identified, corresponding to 6.1% of recorded hip procedures (95% CI, 4.3–8.5%). Two patients declined participation, leaving 29 patients for comparative analysis; 22 (75.9%) received an articulating spacer, and 7 (24.1%) received a static spacer. Source-case comorbidity coding showed frequent multimorbidity, including rheumatic disease, diabetes, hypertension, steroid exposure, hypothyroidism, and neoplasia. Mean follow-up was 7.9 +/- 4.8 years in the articulating group and 10.8 +/- 6.9 years in the static group. The articulating group improved significantly in WOMAC, Harris Hip Score, and NPRS, whereas functional changes in the static group were limited. In reimplanted patients, static spacers were associated with greater blood loss, longer operative time, and higher residual pain. Staphylococcus aureus was the most frequent isolate.

Conclusions: Chronic hip PJI requiring spacer-based two-stage revision represented a clinically relevant burden in this complex tertiary referral cohort. Articulating spacers were associated with greater improvements in function and pain than static spacers, but findings remain exploratory and require confirmation in larger matched or prospective cohorts.

Clinical trial number: not applicable.

Background

Periprosthetic joint infection (PJI) is among the most severe complications following total hip arthroplasty, often requiring repeated operations, prolonged antimicrobial therapy, and complex reconstruction. Recent overviews emphasize improved diagnostic algorithms and host-directed strategies, while acknowledging persistent gaps in prevention, durable eradication, and functional recovery [1]. Antibiotic-loaded spacers remain central to two-stage revision, but spacer choice continues

to be debated. Existing literature includes comparative studies of static and articulating spacers, PROSTALAC and other articulating constructs, spacer-related technical modifications, retained spacer cases, attrition after staged exchange, and adjunctive antimicrobial strategies [2–10]. Although much of this evidence is drawn from mixed hip/knee or knee cohorts, it provides the functional rationale for preserving joint motion and soft-tissue tension between stages.

Host factors are equally important. Risk-factor studies and clinical reviews have associated PJI with medical comorbidity, inflammatory arthritis, atypical or fungal pathogens, and complex local or systemic conditions [11–18]. Inflammatory rheumatic disease is particularly challenging because symptoms and laboratory abnormalities may overlap with disease flares, while immunosuppressive therapy can alter clinical presentation, wound healing, infection control, and rehabilitation capacity. In tertiary referral practice, these patients frequently have more than one rheumatic diagnosis or overlapping systemic comorbidities, which may increase surgical complexity and limit the size of well-characterized outcome cohorts.

Contemporary reviews of articular spacers, diagnostic tests in inflammatory disease, antimicrobial timing, antirheumatic medication management, and debridement or revision strategies emphasize individualized treatment based on pathogen profile, bone loss, soft-tissue envelope, host reserve, and reimplantation feasibility [19–26]. Hip-specific literature further highlights distinct mechanical risks, including instability, spacer fracture, dislocation, bone loss, and difficulty completing second-stage reconstruction. Alternative constructs, spacer-free pathways, salvage options, custom-made articulating hip spacers, and cemented prosthesis spacers have therefore been proposed for selected cases [27–34]. Diagnostic frameworks and comparative evidence, including IDSA guidance, the 2018 MSIS/ICM criteria, EBJIS criteria, a randomized hip-spacer trial, attrition reports, international consensus statements, and rheumatoid arthritis PJI data, support cautious interpretation of small retrospective cohorts [35–41].

Despite these developments, real-world data remain limited regarding the institutional burden of chronic hip PJI requiring spacer-based staged revision and the comparative outcomes of articulating versus static hip spacers in complex hosts. The present study addressed this practical gap by describing the frequency of chronic hip PJI requiring two-stage revision with antibiotic-loaded spacer placement and by evaluating functional outcomes, pain, blood loss, operative time, microbiology, and failure patterns according to spacer construct in a retrospective cohort enriched for inflammatory rheumatic disease and spanning 2008 to 2023.

Methods

We conducted a single-center retrospective observational cohort study at a tertiary referral center in Mexico. The study period spanned January 2008 to December 2023, and eligible cases were identified through the institutional arthroplasty registry and hip-specific surgical records. The institutional arthroplasty registry recorded 975 hip and knee arthroplasty procedures. Hip procedures were identified

using the anatomical-region code and, when needed, by cross-checking uncoded records against hip-specific surgical registries, yielding 511 hip arthroplasty procedures. Eligible cases for the outcome cohort were adults older than 18 years, of any sex, with a prior total hip arthroplasty and chronic hip PJI who required exchange arthroplasty rather than debridement with implant retention. Chronic PJI was defined clinically by a delayed or late infectious presentation requiring prosthesis removal and staged reconstruction. Included cases were confirmed according to clinical, laboratory, microbiological, and radiographic criteria available at the time of treatment, including IDSA guidance, the 2018 MSIS/ICM criteria, and the EBJIS definition when applicable [35–37]. Patients who declined participation were retained in the source-case count but excluded from comparative outcome analyses. Acute infections managed with implant retention and cases without hip spacer placement were not included.

Patients were categorized according to the spacer construct used at first-stage revision: articulating hip spacer (Group 1) or static hip spacer (Group 2). Spacer selection was pragmatic and non-randomized. It reflected intraoperative assessment of bone stock, acetabular and femoral defects, soft-tissue envelope, abductor function, stability after debridement, expected rehabilitation potential, and the availability of appropriate spacer materials or constructs in a tertiary referral hospital with variable resource constraints. Articulating spacers were used when local anatomy allowed for a stable, motion-preserving construct, particularly in patients with low-to-moderate bone loss, compatible with Paprosky femoral types I–II and acetabular types I–II defects. Static spacers were used when a stable articulating construct was not considered feasible or when construct availability, stability concerns, soft-tissue compromise, or rehabilitation limitations favored a non-articulating interim construct.

First-stage surgery consisted of implant removal, extensive debridement, irrigation, tissue sampling for culture, and placement of an antibiotic-loaded cement spacer. The infectious diseases team guided antimicrobial therapy based on microbiology and clinical response. Reimplantation was considered after completion of the planned antimicrobial course when the wound was healed, there was no sinus tract or persistent drainage, pain and local inflammatory findings had improved, and inflammatory markers showed a favorable downward trend or normalization. When persistent infection was suspected, further evaluation, including repeat aspiration and/or repeat debridement, was considered before reimplantation. The interval between stages was individualized according to host factors, pathogen profile, wound healing, and laboratory trends rather than a fixed time threshold alone.

Comparative primary outcomes were functional recovery and pain, assessed using the Western Ontario and McMaster Universities Osteoarthritis Index (WOMAC), the Harris Hip Score (HHS), and the Numeric Pain Rating Scale (NPRS). Secondary outcomes included hip range of motion (ROM), intraoperative blood loss, operative time at each surgical stage, microbiological profile, reimplantation status, clinically relevant failure patterns, and available comorbidity/immunosuppression variables. Failure patterns included unplanned surgery, spacer-related complications, inability to proceed to reimplantation, or salvage procedures.

Radiographic assessment was performed using available anteroposterior pelvis and hip radiographs. Radiolucent lines and component loosening were recorded descriptively by acetabular DeLee and Charnley zones and femoral Gruen zones when documentation was available. Radiographic loosening was not used as a mandatory inclusion criterion; instead, it was analyzed as part of the failure pattern and is reported in the Results section.

Given the retrospective design and non-randomized spacer selection, this study is susceptible to selection bias, confounding by indication, and material-availability bias. To reduce selection bias, all eligible consecutive cases identified during the study period were screened. To reduce information bias, standardized functional scores and objective perioperative data were extracted from institutional records. No formal sample size calculation was performed because the study used all available eligible cases from a long-period tertiary referral registry and was considered exploratory and hypothesis-generating. No matching or multivariable adjustment was performed because of the small and imbalanced groups. Loss to follow-up was addressed using the last available documented assessment. Analyses were performed on complete cases for each outcome, and denominators are reported when documentation differed across variables.

Data were collected in Microsoft Excel and analyzed using IBM SPSS Statistics (IBM Corp., Armonk, NY, USA). Continuous variables were summarized as mean +/- standard deviation or median and interquartile range, as appropriate. Registry proportions were reported with 95% Wilson confidence intervals. Between-group comparisons were performed using the independent-samples Student t-test for normally distributed variables and the Mann-Whitney U test for non-normally distributed variables. Categorical variables were compared using the chi-square test or Fisher exact test, as appropriate. A p-value < 0.05 was considered statistically significant. No formal sensitivity analyses were conducted. Follow-up duration was defined as the interval from spacer placement for PJI treatment to the last available clinical or radiographic assessment documented in the institutional record.

This retrospective study involved human data and was reviewed and approved by the Comité de Bioseguridad (Biosecurity Committee) of the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán on May 23, 2025 (reference SEN-5628-25-26-1). The study was conducted in accordance with the Declaration of Helsinki and applicable institutional regulations for retrospective clinical research. The requirement for written informed consent was waived by the same committee because the study involved the retrospective analysis of de-identified clinical data.

Results

From January 2008 to December 2023, the institutional arthroplasty registry recorded 975 hip and knee arthroplasty procedures. After anatomical-region coding and cross-checking of relevant uncoded records against hip-specific surgical registries, 511 hip arthroplasty procedures were identified as the source population. Thirty-one chronic hip PJI cases requiring implant removal, antibiotic-loaded spacer placement, and planned two-stage revision were identified, corresponding to 6.1% (31/511) of hip

arthroplasty procedures recorded during the study period (95% CI, 4.3–8.5%). The methodology for selecting eligible patients is shown in Fig. 1.

The diagram summarizes the methodology for our population of patients with chronic hip PJI in our medical unit.

Twenty-nine patients met the inclusion criteria for the outcome cohort. Articulating hip spacers were used in 22 cases (75.9%) and static hip spacers in 7 cases (24.1%). In the second-stage reimplantation analyses, only patients who underwent reimplantation and had available operative records were included (articulating: n = 12; static: n = 4). Follow-up was available for all included patients at the time of cohort closure. Mean follow-up was 7.9 +/- 4.8 years (median 6.4 years; IQR 5.4–10.4) in the articulating group and 10.8 +/- 6.9 years (median 14.4 years; IQR 7.4–14.9) in the static group. All patients managed with articulating spacers had low-to-moderate bone loss compatible with Paprosky femoral type I-II and acetabular type I-II defects; advanced Paprosky type III-IV acetabular or femoral defects were not represented among articulating-spacer cases.

The mean age was 43 years, the mean body mass index was 26.8 +/- 5.3 kg/m2, and most patients were female (72.4%). The right side was affected in 18 cases (62.1%) and the left side in 11 cases (37.9%). The demographic distribution is summarized in Table 1.

Table 1
Demographic distribution of hip periprosthetic joint infection

Study population	**Results (n = 29)**
Age (years)	43
BMI (kg/m2)	26.8 +/- 5.3
Female	21 (72.4%)
Male	8 (27.6%)
Right side	18 (62.1%)
Left side	11 (37.9%)
Articulating hip spacer	22 (75.9%)
Static hip spacer	7 (24.1%)
Follow-up, articulating group (years)	7.9 +/- 4.8; median 6.4 (IQR 5.4–10.4)
Follow-up, static group (years)	10.8 +/- 6.9; median 14.4 (IQR 7.4–14.9)

Continuous variables are presented as mean +/- standard deviation unless otherwise specified, and categorical variables as n (%). Follow-up values are presented as mean +/- SD and median (IQR) based on institutional follow-up available at data closure.

The registry-identified chronic hip PJI source cases represented a medically complex population (Table 2). Among the 31 identified cases, rheumatic disease was coded in 21 (67.7%), at least one non-rheumatic systemic comorbidity in 20 (64.5%), steroid exposure in 12 (38.7%), and two or more coded comorbidity/exposure factors in 19 (61.3%).

Table 2
Systemic comorbidity and immunosuppressive exposure profile among registry-identified chronic hip PJI source cases

Coded variable	Frequency n/N (%)
Rheumatic disease	21/31 (67.7)
At least one non-rheumatic systemic comorbidity	20/31 (64.5)
Diabetes mellitus	12/31 (38.7)
Hypertension	9/31 (29.0)
Hypothyroidism	6/31 (19.4)
Neoplasia	2/31 (6.5)
Hepatopathy	1/31 (3.2)
HIV infection	1/31 (3.2)
Steroid exposure	12/31 (38.7)
Biologic therapy	1/31 (3.2)
Two or more coded comorbidity/exposure factors	19/31 (61.3)

Categories are not mutually exclusive. Non-rheumatic systemic comorbidity included diabetes mellitus, hypertension, hypothyroidism, neoplasia, hepatopathy, or HIV infection. Coded comorbidity/exposure factors included rheumatic disease status, each listed systemic comorbidity, steroid exposure, and biologic therapy.

Rheumatic and musculoskeletal diagnoses in the comparative outcome cohort were not mutually exclusive (Table 3). Rheumatoid arthritis and femoral avascular necrosis were the most common conditions, followed by osteoarthritis, juvenile idiopathic arthritis, axial spondylarthritis, systemic lupus erythematosus, Sjogren syndrome, psoriatic arthritis, Still's disease, and gout. Overall, the cohort represents a surgically complex, multimorbid referral population rather than mutually exclusive single-disease groups.

Table 3
Rheumatic and musculoskeletal diagnoses in patients with hip PJI

Comorbidities	Frequency n/N (%)
Rheumatoid arthritis	9/29 (31.0)
Femoral avascular necrosis	9/29 (31.0)
Osteoarthritis	7/29 (24.1)
Juvenile idiopathic arthritis	6/29 (20.7)
Axial spondylarthritis	4/29 (13.8)
Systemic lupus erythematosus	2/29 (6.9)
Sjogren syndrome	2/29 (6.9)
Psoriatic arthritis	1/29 (3.4)
Still disease	1/29 (3.4)
Gout	1/29 (3.4)

Diagnoses are not mutually exclusive; therefore, a single patient may be counted in more than one category.

The primary THA fixation method was cemented (58.6%), followed by uncemented (31.0%) and hybrid (10.3%). Radiographic loosening was not universal and was therefore described as a failure pattern rather than an inclusion requirement. Among cases with available documentation, aseptic loosening was recorded in 11/22 (50.0%) and septic loosening in 5/12 (41.7%). Other documented failure patterns included chronic residual pain, dislocation, periprosthetic fracture, polyethylene wear, and sciatic nerve injury (Table 4).

Table 4
Frequency of complications associated with THA failure.

Complications	Frequency n/N (%)
Aseptic loosening	11/22 (50.0)
Chronic residual pain	5/13 (38.5)
Septic loosening	5/12 (41.7)
Dislocation	4/15 (26.7)
Periprosthetic fracture	2/13 (15.4)
Polyethylene wear	2/13 (15.4)
Sciatic nerve injury	1/12 (8.3)

Complications are not mutually exclusive. Denominators differ according to available documentation.

Functional status was evaluated using HHS, with higher scores indicating better function. Symptom severity and functional limitation were assessed using the WOMAC, with higher scores indicating greater impairment. Pain was assessed using the 0–10 NPRS. Individual change was estimated as postoperative minus preoperative value; therefore, a positive change indicates improvement in HHS, whereas a negative change indicates improvement in WOMAC and NPRS. Functional and pain outcomes are reported in Table 5. The articulating spacer group showed significant within-group improvement in WOMAC, HHS, and NPRS. The static spacer group showed significant improvement in pain, but functional changes were limited. Between-group comparisons of change favored articulating spacers for WOMAC, HHS, and NPRS; however, these findings should be interpreted cautiously because the groups were small and imbalanced.

Table 5
Functional and pain outcomes by spacer construct

Spacer construct	Preoperative	Postoperative	Change	Within-group p	Between-group p
WOMAC					
Articulating	79.01 +/- 10.41	35.23 +/- 21.38	-43.78 +/- 22.08	< 0.001	< 0.001
Static	74.71 +/- 5.53	72.69 +/- 7.10	-2.03 +/- 9.25	0.583	
HHS					
Articulating	34.91 +/- 6.48	76.54 +/- 7.88	39.72 +/- 11.37	< 0.001	< 0.001
Static	35.23 +/- 7.31	35.54 +/- 8.52	0.31 +/- 11.88	0.946	
NPRS					
Articulating	8.50 +/- 0.91	2.09 +/- 1.63	-6.41 +/- 1.97	< 0.001	0.002
Static	9.43 +/- 0.79	5.14 +/- 1.35	-4.29 +/- 1.11	< 0.001	

Values are presented as mean +/- standard deviation. Change was calculated as postoperative minus preoperative value. Lower WOMAC and NPRS scores indicate better outcomes, whereas higher HHS scores indicate better hip function; therefore, negative change values indicate improvement for WOMAC and NPRS, and positive change values indicate improvement for HHS. Within-group p values compare preoperative and postoperative values within each spacer construct. Between-group p values compare change scores between articulating and static constructs and are shown once per outcome.

Perioperative variables are summarized in Table 6. During primary surgery, blood loss and operative time did not differ significantly between groups. During first-stage surgery, the static spacer group had greater blood loss, whereas the articulating spacer group had longer operative time. In the reimplantation subset, static spacer cases were associated with greater blood loss, longer operative time, and higher residual NPRS at final follow-up (Fig. 2).

Table 6
Intraoperative blood loss, operative time, and post-reimplantation pain by spacer type across surgical stages in two-stage revision total hip arthroplasty.

Stage	Outcome	Group 1: articulating	Group 2: static	P value
Primary surgery	Blood loss (mL)	754.5 +/- 177.7 (n = 20)	692.9 +/- 210.9 (n = 7)	0.506
Primary surgery	Operative time (min)	126.7 +/- 20.1 (n = 21)	124.3 +/- 21.5 (n = 7)	0.802
First-stage surgery	Blood loss (mL)	745.5 +/- 283.2 (n = 20)	972.9 +/- 118.4 (n = 7)	0.007
First-stage surgery	Operative time (min)	99.5 +/- 10.0 (n = 22)	78.6 +/- 9.0 (n = 7)	< 0.001
Second-stage surgery	Blood loss (mL)	362.5 +/- 52.8 (n = 12)	935.0 +/- 139.9 (n = 4)	0.003
Second-stage surgery	Operative time (min)	90.8 +/- 9.0 (n = 12)	160.0 +/- 16.3 (n = 4)	0.002
Second-stage surgery	Pain NPRS at last follow-up	1.7 +/- 1.6 (n = 12)	5.8 +/- 1.3 (n = 4)	0.001

Values are mean +/- standard deviation (n). Comparisons used independent-samples Student t-test with Welch correction for unequal variances when appropriate.

Boxes show interquartile ranges with median lines; whiskers show dispersion; points indicate outliers. (A) Blood loss during first-stage surgery. (B) Blood loss during second-stage reimplantation. (C) Operative time during first-stage surgery. (D) Operative time during second-stage reimplantation.

Hip range of motion and pain in the reimplantation subset are shown in Table 7. Most baseline ROM measures were similar between groups, although baseline extension and pain differed. At the final follow-up, the static group reported higher levels of residual pain. Both groups improved overall, but pain reduction was greater in the articulating spacer group.

Table 7
Hip range of motion and pain by spacer type in the reimplantation subset.

Outcome	Group 1: articulating	Group 2: static	P value
Baseline outcomes			
Flexion, degrees	80.0 ± 12.1 (n = 12)	82.5 ± 5.0 (n = 4)	0.570
Extension, degrees	-3.3 ± 4.9 (n = 12)	0.0 ± 0.0 (n = 4)	0.039
Abduction, degrees	27.9 ± 5.4 (n = 12)	20.0 ± 8.2 (n = 4)	0.146
Adduction, degrees	9.2 ± 5.1 (n = 12)	8.8 ± 2.5 (n = 4)	0.834
Internal rotation, degrees	22.1 ± 4.0 (n = 12)	17.5 ± 5.0 (n = 4)	0.165
External rotation, degrees	10.8 ± 7.6 (n = 12)	6.2 ± 4.8 (n = 4)	0.194
NPRS	8.6 ± 1.1 (n = 12)	9.8 ± 0.5 (n = 4)	0.013
Final follow-up outcomes			
Flexion, degrees	101.7 ± 7.2 (n = 12)	97.5 ± 5.0 (n = 4)	0.237
Extension, degrees	-9.2 ± 2.9 (n = 12)	0.0 ± 0.0 (n = 4)	< 0.001
Abduction, degrees	37.8 ± 5.0 (n = 12)	36.2 ± 7.5 (n = 4)	0.714
Adduction, degrees	18.3 ± 2.5 (n = 12)	12.5 ± 6.5 (n = 4)	0.167
Internal rotation, degrees	29.2 ± 4.7 (n = 12)	28.8 ± 2.5 (n = 4)	0.825
External rotation, degrees	37.1 ± 4.5 (n = 12)	30.0 ± 7.1 (n = 4)	0.136
NPRS	1.7 ± 1.6 (n = 12)	5.8 ± 1.3 (n = 4)	0.001

Values are presented as mean ± standard deviation (n). Range-of-motion outcomes are reported in degrees. NPRS denotes Numeric Pain Rating Scale, ranging from 0 to 10, with higher scores indicating greater pain intensity. Baseline outcomes correspond to the preoperative assessment before spacer placement, and final follow-up outcomes correspond to the last available clinical assessment. P values compare articulating and static spacer groups within each time point and were calculated using independent-samples Student’s t-test with Welch correction for unequal variances when appropriate.

Final extension was strongly associated with final pain, and changes in extension and adduction were also associated with final pain. These analyses are exploratory and should be interpreted with caution because of the small reimplantation subset. Exploratory Spearman correlations between ROM and final pain are shown in Table 8.

Table 8
Association between hip range of motion and pain at final follow-up.

ROM outcome	Final ROM vs NPRS	Change in ROM vs NPRS
Flexion (degrees)	rho = 0.046 (p = 0.865)	rho=-0.344 (p = 0.192)
Extension (degrees)	rho = 0.793 (p < 0.001)	rho = 0.559 (p = 0.024)
Abduction (degrees)	rho=-0.275 (p = 0.303)	rho=-0.043 (p = 0.873)
Adduction (degrees)	rho=-0.346 (p = 0.189)	rho=-0.545 (p = 0.029)
Internal rotation (degrees)	rho=-0.092 (p = 0.736)	rho = 0.171 (p = 0.527)
External rotation (degrees)	rho=-0.118 (p = 0.663)	rho = 0.100 (p = 0.713)
Spearman rho is reported with two-tailed p values. These correlations are exploratory and may be influenced by small sample size and group differences.		

Microbiological cultures in the hip PJI cohort showed a predominance of Staphylococcus aureus, followed by Pseudomonas spp. Less frequent isolates included Escherichia coli, Staphylococcus epidermidis, Candida spp., Klebsiella pneumoniae, and Mycobacterium porcinum (Fig. 3).

The frequency distribution of microorganisms cultured from hip periprosthetic infections showed a predominance of Staphylococcus aureus, followed by Pseudomonas spp.

Discussion

This retrospective cohort study found that chronic hip PJI requiring spacer-based two-stage revision represented 6.1% of hip arthroplasty procedures recorded in a tertiary referral institutional registry over 16 years. Within the comparative outcome cohort, articulating antibiotic-loaded hip spacers were associated with greater functional recovery and pain improvement than static hip spacers in selected patients undergoing staged management for chronic hip PJI. Importantly, the cohort comprised complex, multimorbid hosts with overlapping rheumatic diagnoses, systemic comorbidities, immunosuppressive exposure, and demanding local reconstructive problems. In the articulating spacer group, all patients had low-to-moderate bone loss compatible with Paprosky femoral type I–II and acetabular type I–II defects. Advanced Paprosky type III–IV acetabular or femoral defects were not represented among patients managed with articulating spacers, limiting extrapolation of these findings to cases with massive bone loss.

The observed frequency should be interpreted in the context of the study definition. The numerator was limited to chronic hip PJI cases requiring implant removal, antibiotic-loaded spacer placement, and planned two-stage revision; therefore, this measure does not represent all infections after total hip arthroplasty, nor should it be interpreted as a population incidence rate. Instead, it describes the institutional burden of complex chronic hip PJI requiring spacer-based staged reconstruction in a tertiary referral setting. This distinction is important because referral patterns, case complexity, rheumatic

disease prevalence, systemic comorbidity burden, material availability, and institutional treatment pathways can influence the observed proportion.

For transparency and comparability, our cohort was anchored in widely used diagnostic and management frameworks, including IDSA guidance for the diagnosis and management of PJI, the 2018 MSIS/ICM definition, and the EBJIS definition [35–37]. These frameworks are particularly important in inflammatory rheumatic disease because clinical signs, inflammatory markers, and pain may overlap with disease flares, complicating diagnostic interpretation [12, 15, 20]. The small sample size should therefore be interpreted within the context of strict case definition and host complexity. This was not a broad cohort of all primary hip arthroplasties or all postoperative infections; rather, it was a selected group of chronic hip PJI cases requiring implant removal, antibiotic-loaded spacer placement, and planned staged reconstruction. Most identified cases had rheumatic disease, systemic comorbidities, immunosuppressive exposure, or overlapping complexity factors. These features limit statistical power but increase the clinical relevance of the cohort for tertiary referral centers managing high-risk hosts.

Although the hip differs from the knee in biomechanics and instability risk, previous spacer literature helps contextualize the functional rationale for maintaining joint motion across stages. Studies of articulating knee spacers and hip spacer constructs suggest that a motion-preserving interim construct can facilitate rehabilitation and may simplify reimplantation. However, the benefit depends on spacer design, host factors, and local mechanical stability [2–10, 19, 24, 25, 27–34, 38]. Our findings are consistent with the concept that spacer choice may affect more than infection eradication alone, but they do not eliminate the need for individualized selection.

In the reimplantation subset, patient-centered outcomes remained generally consistent with the overall pattern favoring articulating spacers. Patients managed with articulating spacers had lower residual pain at final follow-up, whereas the static subgroup reported persistent symptoms despite reimplantation. Residual pain after two-stage treatment is clinically important because it strongly influences perceived recovery, rehabilitation tolerance, and quality of life. In patients with inflammatory rheumatic disease, prolonged disability and deconditioning may further magnify this effect.

The perioperative findings highlight a practical trade-off. During first-stage surgery, placement of an articulating spacer required a longer operative time, likely reflecting additional technical steps such as trialing, templating, soft-tissue balancing, and construction of a stable articulating construct. Conversely, static spacers were associated with greater blood loss at first stage and more demanding reimplantation metrics. A plausible explanation is confounding by indication: static spacers may have been used in more complex local environments with greater bone loss, soft-tissue compromise, instability, limited rehabilitation potential, or when the materials required for a stable articulating construct were not available at the time of surgery. Therefore, the observed differences should not be interpreted as causal effects of spacer type alone, but rather as outcomes of pragmatic real-world decision-making in a resource-variable tertiary referral setting.

The microbiological distribution, dominated by Staphylococcus aureus with a relevant Gram-negative component, is clinically important. Pathogen profile may influence recurrence risk, antimicrobial strategy, timing of reimplantation, and overall treatment success. This is particularly relevant in immunosuppressed hosts, in whom atypical presentations and delayed recognition may occur [13, 21, 22, 30, 32].

Rheumatic disease adds complexity beyond the risk of infection. Differentiating PJI from inflammatory flares can require tailored diagnostic reasoning, and perioperative management of antirheumatic medications must balance infection control, wound healing, and flare prevention [12, 15, 20, 23]. Prior reports in rheumatoid arthritis patients treated surgically for PJI have described high complication and mortality rates, reinforcing the vulnerability of this population [41]. In our cohort, rheumatic diagnoses were not mutually exclusive, and the source-case registry also showed frequent diabetes, hypertension, hypothyroidism, neoplasia, steroid exposure, and other systemic factors. This multimorbidity helps explain why the final analytical cohort was small despite a long study period: the study captured a strict, high-complexity phenotype rather than all hip arthroplasty infections or all spacer procedures.

The main strengths of this study include consecutive case screening across a long study period, explicit definition of the source population, standardized functional and pain outcomes, long follow-up, complete-case denominators, and a clinically relevant high-risk host population. The main limitation is the small, imbalanced cohort, which makes the analysis underpowered to detect modest clinical differences and prevents robust adjusted or matched comparisons. The limited sample size should be interpreted in light of the strict case definition, the rarity of chronic hip PJI requiring spacer-based staged revision in this referral population, and the high multimorbidity burden of eligible patients. Spacer selection was not randomized and may reflect surgeon preference, bone loss, soft-tissue quality, instability risk, host complexity, rehabilitation potential, and construct/material availability, introducing selection bias, confounding by indication, and material-availability bias. Some outcomes, particularly ROM and second-stage variables, were available only in the reimplantation subset, which may overrepresent patients who progressed to reimplantation and may underestimate attrition in two-stage exchange, a limitation previously emphasized in the two-stage revision literature [8, 39]. Missing documentation for selected variables is possible despite systematic chart review.

In addition, spacer selection was influenced not only by local anatomy and surgical judgment but also by construct availability in a resource-variable setting. Therefore, the observed differences should not be interpreted as causal effects of spacer type alone. The findings are most applicable to chronic hip PJI cases with low-to-moderate bone loss and should not be extrapolated to advanced Paprosky type III–IV defects.

Because of these limitations, the present study should be viewed as a hypothesis-generating description of a high-risk tertiary referral cohort rather than as definitive comparative-effectiveness evidence. The findings are most applicable to centers treating complex, multimorbid, inflammatory rheumatic hosts with similar spacer constructs, antimicrobial protocols, resource constraints, and reimplantation

thresholds. Larger multicenter studies using matched cohorts or prospective designs are needed to determine whether the observed functional differences persist after accounting for baseline disease severity, systemic comorbidity burden, bone loss, soft-tissue compromise, microbiology, rehabilitation potential, and spacer material availability.

Conclusions

In this tertiary referral registry, chronic hip PJI requiring implant removal, antibiotic-loaded spacer placement, and planned two-stage revision represented 6.1% of hip arthroplasty procedures recorded between 2008 and 2023. Among patients included in comparative outcome analyses, articulating antibiotic-loaded hip spacers were associated with greater improvements in WOMAC, HHS, and pain than static spacers. However, the cohort was small, imbalanced, multimorbid, and non-randomized; therefore, the results should be interpreted as exploratory and hypothesis-generating. Spacer selection in inflammatory rheumatic disease should remain individualized, integrating host factors, systemic comorbidity burden, microbiology, bone and soft-tissue status, mechanical stability, rehabilitation potential, and the availability of safe spacer constructs. Larger matched or prospective studies are required to refine hip spacer selection in high-risk immunosuppressed populations.

Abbreviations

AAHKS
American Association of Hip and Knee Surgeons
ACR
American College of Rheumatology
BMI
body mass index
CI
confidence interval
CUMARS
custom-made articulating spacer
DMARDs
disease-modifying antirheumatic drugs
EBJIS
European Bone and Joint Infection Society
HHS
Harris Hip Score
ICM
International Consensus Meeting
IDSA
Infectious Diseases Society of America
IQR

interquartile range
JAK
Janus kinase
MSIS
Musculoskeletal Infection Society
NPRS
Numeric Pain Rating Scale
PJI
periprosthetic joint infection
ROM
range of motion
SD
standard deviation
SPSS
Statistical Package for the Social Sciences
STROBE
Strengthening the Reporting of Observational Studies in Epidemiology
THA
total hip arthroplasty
WOMAC
Western Ontario and McMaster Universities Osteoarthritis Index.

Declarations

Ethics approval and consent to participate

This retrospective study involving human data was reviewed and approved by the Comité de Bioseguridad (Biosecurity Committee) of the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán on May 23, 2025 (reference SEN-5628-25-26-1). The study was conducted in accordance with the Declaration of Helsinki and applicable institutional regulations. The requirement for written informed consent was waived by the Comité de Bioseguridad (Biosecurity Committee) of the Instituto Nacional de Ciencias Médicas y Nutrición Salvador Zubirán because the study used retrospective, de-identified clinical data.

Consent for publication

Not applicable. The manuscript does not contain identifiable individual patient data, images, or videos.

Availability of data and materials

The datasets generated and/or analyzed during the current study are not publicly available because they contain institutional clinical data and potentially identifiable patient information. De-identified data

supporting the findings may be available from the corresponding author on reasonable request and subject to institutional approval and applicable privacy regulations.

Competing interests

All authors declare that they have no competing interests.

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Authors' contributions

GAAP contributed to data curation. JMV contributed to writing - review and editing. GJMS contributed to writing - original draft. EDB contributed to conceptualization, clinical supervision, and critical revision of the manuscript. CHHR contributed to methodology, study conception and design, data acquisition, data interpretation, and manuscript drafting. LDMB contributed to supervision, surgical management, interpretation of the results, and critical revision of the manuscript. All authors read and approved the final manuscript.

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Authors' information

Not applicable.

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Figures

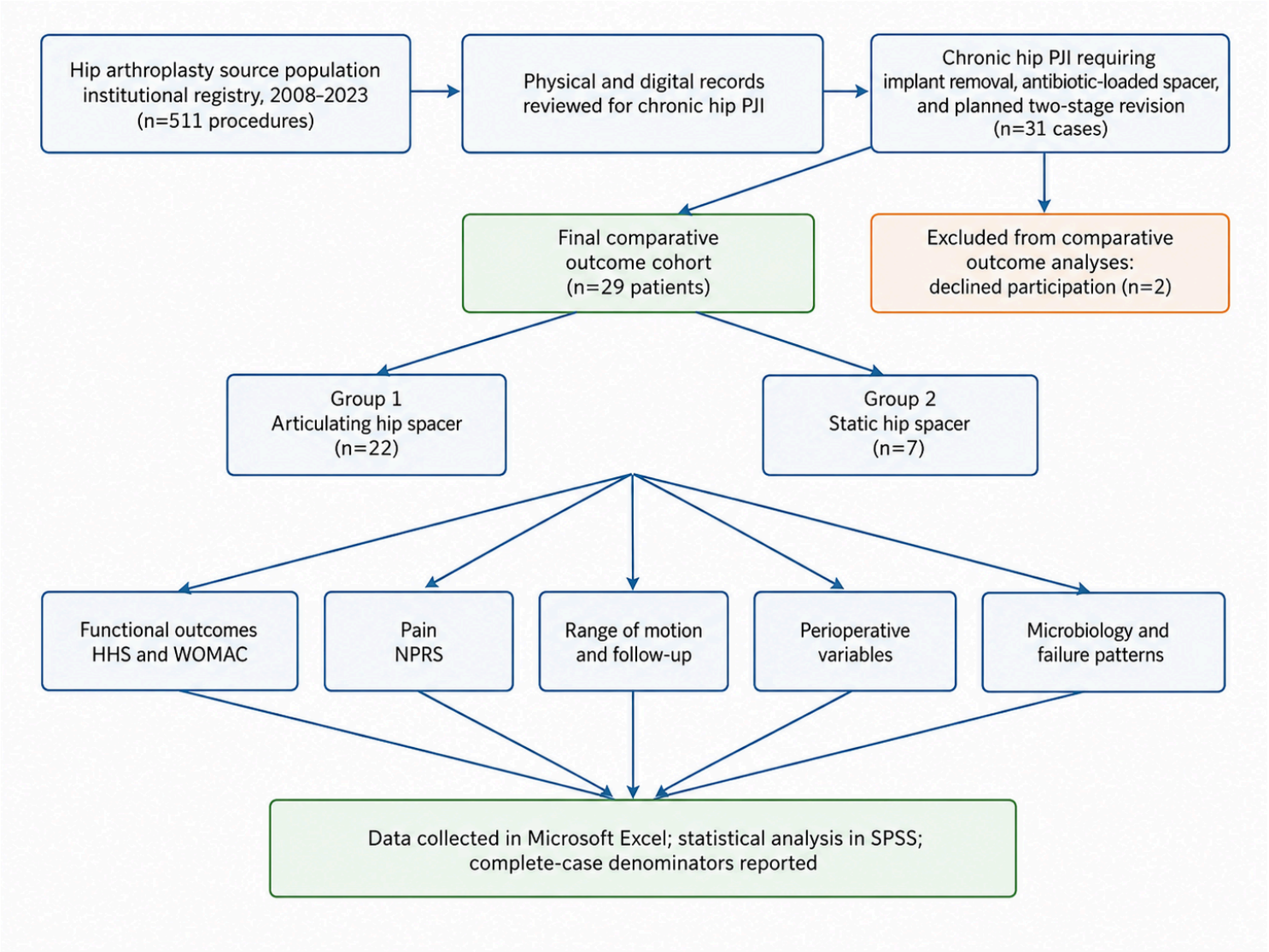


Figure 1

Study workflow, source population, and comparative outcome analyses.

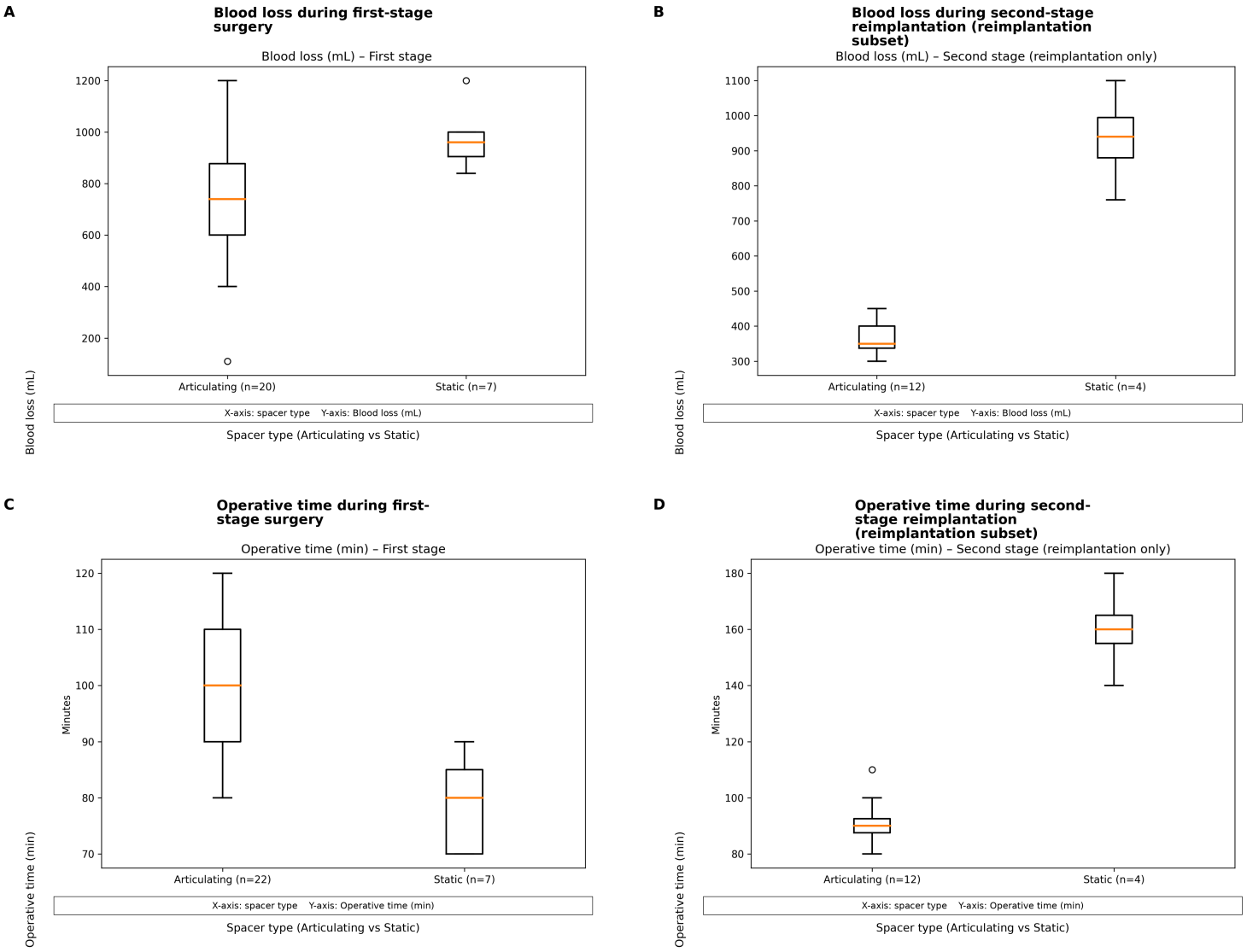


Figure 2

Perioperative blood loss and operative time by spacer type.

Boxes show interquartile ranges with median lines; whiskers show dispersion; points indicate outliers. (A) Blood loss during first-stage surgery. (B) Blood loss during second-stage reimplantation. (C) Operative time during first-stage surgery. (D) Operative time during second-stage reimplantation.

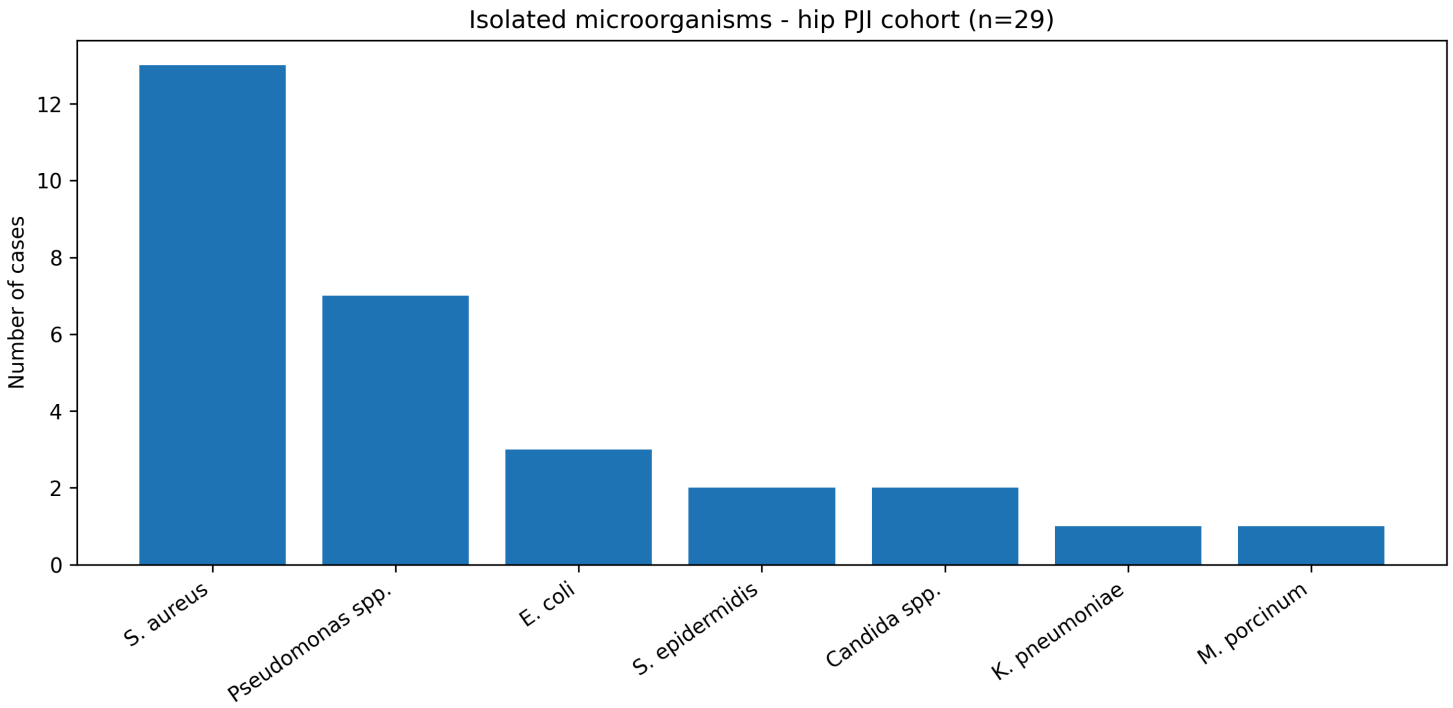


Figure 3

Distribution of microorganisms isolated in hip chronic PJI

Supplementary Files

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