One-Stage Revision for Periprosthetic Hip and Knee Infections: A Multicenter Experience

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ABSTRACT

Introduction: Periprosthetic joint infection (PJI) is a devastating complication after hip or knee arthroplasty. Although two-stage revision is considered the treatment of choice for chronic infections, one-stage revision has emerged as an alternative that reduces morbidity. **Objective:** To report the results and advantages of one-stage revision for chronic PJI of the hip and knee. **Materials and Methods:** Twenty-four patients (16 knees and 8 hips) with PJI, without severe systemic or limb compromise according to McPherson's classification, were included. All underwent one-stage revision and received intravenous antibiotics for at least 10 days, followed by oral therapy for a minimum of 3 months. Comorbidities, clinical outcomes, and infection control were assessed with a minimum follow-up of 1 year. **Results:** Seventy-five percent of patients (18/24) were classified as McPherson host type A, and 91.6% (22/24) had good soft tissue conditions (type I). Infection was controlled in 22 cases (91.6%), while 2 patients had persistent infection. All patients showed improvement in mobility and satisfaction, particularly those treated for knee infections. **Conclusions:** One-stage revision achieved good outcomes in most cases of chronic PJI, with a high infection control rate (91.6%). This strategy reduces the morbidity associated with two-stage revision, provided that patients are carefully selected, the causative pathogen is identified, and antibiotic susceptibility is known.

Keywords: Periprosthetic joint infection; hip; knee; one-stage revision.
Level of Evidence: IV

Revisión en un tiempo para infecciones periprotésicas de cadera y rodilla: experiencia multicéntrica

RESUMEN

Introducción: Las infecciones periprotésicas (IPP) representan una complicación devastadora tras una artroplastia de cadera o rodilla. Aunque la revisión en 2 tiempos se considera de elección para las infecciones crónicas, la revisión en 1 tiempo surge como una alternativa que reduce la morbilidad. **Objetivo:** Comunicar los resultados y las ventajas de la revisión en 1 tiempo para IPP crónicas de cadera y rodilla. **Materiales y Métodos:** Se incluyeron 24 pacientes (16 rodillas y 8 caderas) con IPP, sin compromiso severo del estado general y del miembro inferior según la clasificación de McPherson. Todos se habían sometido a una revisión en 1 tiempo y habían recibido antibióticos intravenosos como mínimo 10 días, seguidos de terapia oral durante, al menos, 3 meses. Se analizaron las comorbilidades, los resultados clínicos y el control de la infección en un seguimiento mínimo de 1 año. **Resultados:** El 75% correspondía a la categoría A de McPherson (tipo de huésped) y el 91,6% tenía buenos tejidos blandos (tipo 1). En 22 pacientes, se controló la infección; 2 continuaron con el proceso séptico. La movilidad y la tasa de satisfacción mejoraron en todos los pacientes, especialmente los tratados de rodilla. **Conclusiones:** La revisión en 1 tiempo logró buenos resultados en la mayoría de los casos de IPP crónicas, con una alta tasa de control de la infección (91,6%). Esta estrategia reduce la morbilidad asociada a la revisión en 2 tiempos, siempre que se seleccione adecuadamente al paciente, se identifique el germen y se conozca la sensibilidad antibiótica.

Palabras clave: Infecciones periprotésicas; cadera; rodilla; revisión en un tiempo.
Nivel de Evidencia: IV

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INTRODUCTION

Periprosthetic joint infections (PJIs) are among the most feared complications following hip or knee arthroplasty due to their significant negative impact on both patient quality of life and healthcare costs.[1,2] The incidence ranges from 0.2% to 2% in primary arthroplasties but may be higher in patients with prior revisions or comorbidities.[3]

The conventional treatment for chronic PJI typically involves a two-stage revision, originally designed to eradicate infection through implant removal and placement of an antibiotic-loaded spacer, followed by a second procedure to insert a new prosthesis.[4,5] However, multiple published series have evaluated the benefits of one-stage revision, highlighting reduced morbidity associated with multiple surgeries and shorter overall treatment duration.[6,7] In this regard, Haddad and colleagues have reported encouraging results in terms of decreased patient suffering and improved short- and mid-term functionality with single-stage revision.[8]

Despite these advances, the choice between one- and two-stage revision remains a matter of debate in the orthopedic community. Several factors influence decision-making, including accurate pathogen identification, soft tissue condition, infection severity, host immunocompetence, and resource availability.[9,10]

The objective of this study was to analyze our multicenter experience with one-stage revision for chronic hip and knee PJIs, describing selection criteria, surgical technique, and infection control outcomes after a minimum follow-up of one year.

MATERIALS AND METHODS

Study Design and Population

A retrospective, multicenter, descriptive observational case series was conducted, including 24 patients with chronic PJI (type III according to the McPherson classification) treated between 2019 and 2022 at three specialized centers. Of the 24 cases, 16 involved the knee and 8 the hip. The minimum follow-up was 12 months to assess infection control, joint function, and patient satisfaction.

Informed consent was obtained from all participants.

Diagnosis and Classification

Diagnosis of PJI followed the criteria established by the *Second International Consensus on Musculoskeletal Infection*.[11] All patients presented with severe pain and restricted range of motion. In every case, radiographic evaluation showed prosthetic component loosening. Laboratory tests revealed C-reactive protein (CRP) levels >10 mg/L and erythrocyte sedimentation rate (ESR) >30 mm/h. Joint aspiration was performed preoperatively in all patients, showing >3000 cells/mL with >70% polymorphonuclear cells. The infecting microorganism and its antibiotic susceptibility were always identified before surgery.

Patients were also classified according to the McPherson PJI staging system (Table 1). This staging system considers the acuteness or chronicity of the infection, the patient's general medical and immunological health status, and local soft tissue status (Table 2).[12,13]

Inclusion and Exclusion Criteria

Inclusion criteria were chronic PJI (McPherson type III), good general condition (categories A and B for the host), and adequate soft tissue condition (categories 1 and 2).

Exclusion criteria included acute infections, inability to identify the causative microorganism, severe systemic illness (McPherson category C), or major soft tissue compromise (category 3 for tissues).

Data Collection Process

Data were extracted from both electronic and paper medical records using a standardized form designed specifically for this study. The information collected included demographic and clinical data, microbiological parameters and joint aspiration results, surgical details (technique, approach, use of antibiotic-loaded calcium

sulfate beads, component replacement), follow-up markers such as inflammatory indices, radiographic outcomes, range of motion, and patient-reported satisfaction.

To ensure data quality and consistency, two independent researchers entered and cross-checked the information in a centralized database, and periodic audits were conducted to resolve discrepancies and minimize errors.

Table 1. McPherson classification for periprosthetic joint infection.

Anatomical complexity	Degree of systemic involvement	Degree of local involvement
Type I: Early postoperative infection (<4 weeks postoperative)	A – No systemic involvement	1 – No local involvement
Type II – Hematogenous infection (<4 weeks duration)	B – Compromised, ≤2 compromising factors	2 – Compromised, ≤2 local compromising factors
Type III – Late chronic infection (>4 weeks duration)	C – Significant compromise, ≥3 compromising factors or one of the following: Absolute neutrophil count <1000 CD4 T cell count <100 Chronic active infection at another site Immune system dysplasia or neoplasia	3 – Significant local compromise ≥3 local compromising factors

Table 2. Systemic and local factors compromising the host according to McPherson's classification.

Systemic factors	Local factors
Immunosuppressive drugs	Multiple incisions with skin grafts
Alcoholism	Active infection >3 months
Hypoxia	Loss of soft tissue due to previous trauma
Malignancy	Subcutaneous abscess >8 cm^2
Diabetes	Synovial skin fistula
Advanced age (>80 years)	Previous periarticular fracture or trauma to a joint
Active chronic dermatitis or cellulitis	Previous local irradiation
Pulmonary insufficiency	Vascular insufficiency in the extremity
Nicotine use	
Intravenous drug abuse	
Chronic indwelling catheter	
Chronic malnutrition	
Kidney failure requiring dialysis	
Systemic inflammatory disease	
Systemic immune compromise	
Liver failure	

Bias and Variability Management

Various strategies were adopted to reduce potential biases and variability inherent in the retrospective design:

Protocol standardization: clear operational definitions and a structured data collection form were used across all centers, ensuring homogeneous data recording.

Multidisciplinary review: a committee of surgeons and internists periodically evaluated the data to identify potential selection or reporting biases.

Statistical adjustments: In the final analysis, multivariable regression models were used to control for confounding variables and assess the independent impact of each factor on outcomes.

Patient Selection Process

Beyond inclusion and exclusion criteria, a rigorous case identification process was implemented:

Systematic search: A comprehensive review of electronic records was conducted using keywords and ICD codes related to chronic hip and knee PJI.

Detailed clinical evaluation: each identified case was assessed by a multidisciplinary team applying McPherson criteria (type III chronic infection, host categories A–B, soft tissue categories 1–2), and exclusion criteria (acute infections, inability to identify the microorganism, patients with severely compromised systemic status or significant skin alterations), along with review of surgical history, comorbidities, and prior treatment response.

Diagnostic confirmation: the diagnosis of chronic PJI was corroborated by microbiological (at least two positive cultures of the same microorganism) and radiological criteria, which allowed only those cases with a confirmed and homogeneous diagnosis to be included.

Surgical Procedure

Antibiotic prophylaxis was tailored to the organism identified in the preoperative aspiration culture. A posterolateral approach was used for hips and an extended medial parapatellar approach with quadriceps snip for knees. The surgical protocol comprised two stages. The first phase, the dirty phase (Figure 1), involved removal of the implant, cement, and all foreign or devitalized tissue. Five samples (bone, interfacial membrane, and joint fluid) were collected for culture; infection was confirmed with ≥2 positive cultures for the same microorganism.

A five-step irrigation and chemical debridement protocol was performed following Kildow et al.:

1. Low-pressure lavage with 3 L of saline solution.
2. Lavage with 100 mL of 3% hydrogen peroxide (H_2O_2) and 100 mL of sterile water for 2 minutes.
3. Lavage with 3 L of saline solution.
4. Lavage with 1 L of diluted 0.36% povidone-iodine, left in the wound for 3 minutes.
5. Low-pressure lavage with 3 L of saline solution.

The bone surfaces were covered with gauze soaked in diluted povidone-iodine, and the skin was closed with simple sutures (end of dirty phase).

For the clean phase (Figure 2), instruments, gowns, and drapes were replaced. The skin was disinfected again with povidone-iodine, sutures were removed, and the joint was washed once more with diluted povidone-iodine and 1 L of saline solution. Finally, new components were implanted.

For knee revisions, cemented prostheses were used, adding antibiotics to the cement (a combination of glycopeptides and aminoglycosides, 2 g per 40 g of polymethylmethacrylate). For hips, four implants were uncemented and three cemented using the same antibiotic formulation.

All patients received intravenous antibiotic therapy for at least 10 days according to sensitivity testing, followed by oral antibiotics for a minimum of 3 months.

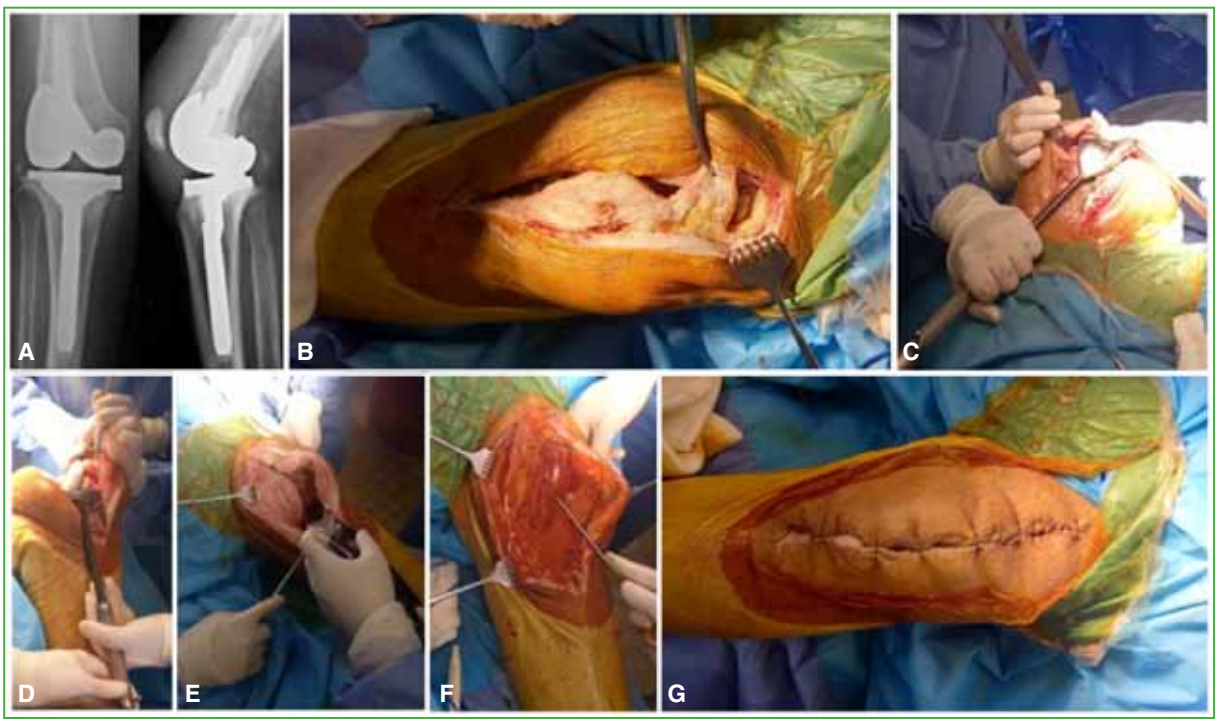

Figure 1. Dirty phase of one-stage revision. **A.** Preoperative radiograph of a knee prosthesis infected with methicillin-resistant *Staphylococcus aureus*. **B.** Extended medial parapatellar incision (quadriceps snip). **C–D.** Removal of prosthetic components. **E–F.** Chemical debridement with hydrogen peroxide and povidone-iodine. **G.** Dermal suture.

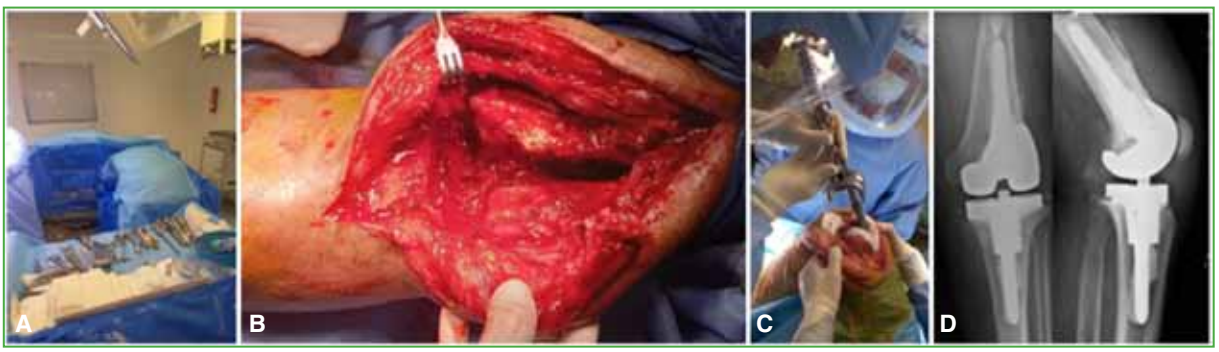

Figure 2. **A.** Complete instrument replacement. **B–C**. Placement of new implants after lavage. **D.** Postoperative radiograph.

Follow-up and Success Definition

Clinical and radiological follow-up was conducted for at least 12 months. Therapeutic success was defined as absence of clinical signs of infection, normalization or reduction of inflammatory markers, and no recurrence during follow-up. Joint mobility (degrees of knee flexion per standardized scales) and patient satisfaction were also assessed.

RESULTS

General Characteristics

The series included 24 patients with PJI: 16 knees and 8 hips. Mean age was 67 years (range 59-82), with a mean follow-up of 14 months (range 12-23). Among knee infections, 9 were women, 2 had diabetes, 1 was a smoker, and 1 had acute renal failure. Among hip infections, 5 were men, 1 had diabetes, and 1 had rheumatoid arthritis. All modifiable risk factors were optimized before surgery.

All infections were chronic (McPherson type III).

Host and Soft Tissue Classification

Eighteen patients were category A and six category B. Regarding soft tissue, 22 were type 1 and two were type 2 (Table 3).

Methicillin-sensitive *Staphylococcus aureus* and *Staphylococcus epidermidis* were the microorganisms with the highest rate of positive cultures in the infected patient population (20.8% and 20.7%, respectively). Table 4 details the incidence rates by type of microorganism.

Table 3. Host and soft tissue category in the McPherson classification. Infection control in the different categories

Degree of systemic/local compromise	Total	Control of PJI	%
A1	17	16	94.1
A2	1	0	0
B1	5	4	80
B2	1	1	100

PJI = periprosthetic joint infection.

Table 4. Microorganisms isolated in 24 periprosthetic joint infections.

Microorganism	n	%
Methicillin-sensitive *Staphylococcus aureus*	5	20.8
Staphylococcus epidermidis	4	16.6
Methicillin-resistant *Staphylococcus epidermidis*	1	4.16
Staphylococcus lugdunensis	1	4.16
Escherichia coli	2	8.3
Enterococcus faecalis	2	8.3
Methicillin-resistant *Staphylococcus aureus*	2	8.3
Streptococcus mitis	1	4.16
Serratia marcescens	1	4.16
Pseudomonas aeruginosa	1	4.16
Proteus mirabilis	1	4.16
Finegoldia magna	1	4.16
Cutibacterium acnes	2	8.3
Total	24	100%

Relevant Statistical Analysis of the Results

Overall infection control

Infection control was achieved in 91.6% of the 24 patients included, at 12 months of follow-up.

Influence of host classification (McPherson)

Patients in category A (without significant comorbidities) represented 75% (18/24) of the sample and achieved an infection control rate of 94.4% (17/18).

In contrast, in patients in category B (with systemic involvement), the control rate was 83.3% (5/6). Although no inferential analysis was performed due to the small sample size, results suggest better outcomes in patients with fewer systemic comorbidities.

Impact of soft tissue status

In subcategory A1 (healthy systemic status and type 1 soft tissue), success reached 94.1%. In contrast, infection control dropped to 50% in patients with compromised soft tissue (type 2). These findings emphasize the importance of local tissue quality in procedural success.

Microorganisms and their influence on outcomes

The most commonly isolated microorganisms were methicillin-sensitive *S. aureus* (20.8%) and *Staphylococcus epidermidis* (16.6%).

It should be noted that the two patients in whom infection control was not achieved were infected with *Pseudomonas aeruginosa* and *Serratia marcescens*, both resistant Gram-negative pathogens with limited antibiotic options, which likely contributed to treatment failure, a relevant finding for future research.

Functional improvement

Average knee flexion improved by 15°, and hip patients achieved earlier gait recovery, corresponding with high satisfaction rates.

Complications

Persistent wound drainage was detected in 2 patients undergoing knee revision, which was resolved after anticoagulation adjustment and rest.

DISCUSSION

One-stage revision has gained growing acceptance for chronic PJI management, especially when patients are carefully selected, pathogens and sensitivities are clearly identified, and aggressive debridement is combined with prolonged antibiotic therapy.[9,14]

Several renowned authors have endorsed the effectiveness of this strategy. Gehrke et al. emphasized the importance of thorough debridement and antibiotic-loaded cement or coated implants to achieve infection control rates of 80-100%.[6,7] Similarly, Haddad and colleagues have emphasized that the main benefit lies in avoiding multiple surgeries, thereby reducing surgical stress and overall recovery time.[8,14]

Our infection control rate of 91.6% aligns with previous reports,[14,15] supporting one-stage revision as a valid option when selection criteria are met: confirmed pathogen, known resistance profile, healthy host with adequate immune response, and preserved soft tissue envelope. Success was highest in McPherson stage A1 patients, consistent with other series.[16] We excluded cases with major systemic compromise (category C) or severe soft tissue defects (category 3), given their high failure rates in single-stage revision.[16,17]

The emergence of quinolone-resistant Gram-negative organisms remains a major challenge, requiring prolonged antibiotic regimens and often leading to reoperation.[18,19] Microbiologic profiling and sensitivity testing are therefore critical in surgical planning.[19,20]

Optimization of systemic factors, such as glycemic control, smoking cessation, and nutritional correction, has also been shown to improve cure rates.[21] Thus, multidisciplinary collaboration among infectious disease specialists, orthopedic surgeons, and microbiologists is essential for success.[22,23]

Despite encouraging results, our sample size is small, and prospective randomized trials are needed to confirm the superiority or equivalence of the one-stage approach compared with two-stage revision.

CONCLUSIONS

One-stage revision for chronic hip and knee PJIs is associated with high infection control rates and substantial improvements in joint function and patient satisfaction. This approach reduces morbidity and expedites recovery by avoiding multiple surgeries. However, success depends on appropriate patient selection, meticulous surgical technique, and comprehensive understanding of pathogen profiles. Larger, prospective studies with robust design are warranted to refine indications and define the limits of this technique.

Statement on generative AI and AI-assisted technologies in the writing process

During the preparation of this manuscript, the authors used ChatGPT (OpenAI) to improve readability and language. After using this tool, the authors reviewed and edited the content as necessary and assume full responsibility for the content of the publication.

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