

Intraosseous Vancomycin for Acute Periprosthetic Knee Infection: A Retrospective Study

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ABSTRACT

Introduction: Periprosthetic joint infection (PJI) is an uncommon but serious complication after total knee arthroplasty (TKA), with significant clinical and healthcare implications. This study evaluated the effectiveness of the debridement, antibiotics, and implant retention (DAIR) protocol combined with intraosseous vancomycin administration and modular component exchange in controlling acute infection and improving functional outcomes. **Materials and Methods:** We conducted a retrospective study across three institutions, including 12 patients (7 women, 5 men; mean age, 72.4 ± 6.3 years) with acute PJI treated with DAIR between February 2022 and June 2023. The mean interval between primary TKA and the DAIR procedure was 12.3 days. A standardized protocol was applied, consisting of intraosseous vancomycin delivery, modular component exchange, and pathogen-directed antibiotic therapy. **Results:** The mean surgical time was 95 ± 10 minutes. Infection control was achieved in 11 of 12 cases (91.6%), with one reinfection requiring two-stage revision. The Knee Society Score improved significantly from 42.5 ± 5.8 preoperatively to 88.6 ± 6.3 at 1 year ($p < 0.001$). **Conclusion:** The DAIR protocol with intraosseous vancomycin and modular component exchange appears to be a promising strategy for managing acute periprosthetic knee infection. Larger studies are needed to confirm these preliminary results.

Keywords: Periprosthetic joint infection; knee; intraosseous vancomycin; debridement; implant retention.

Level of Evidence: IV

Vancomicina intraósea para la infección periprotésica aguda de rodilla. Estudio retrospectivo

RESUMEN

Introducción: La infección periprotésica es una complicación poco frecuente, pero grave, tras la artroplastia total de rodilla, tiene un alto impacto clínico y sanitario. Este estudio evalúa la eficacia del protocolo de desbridamiento, antibióticos y retención del implante (*debridement, antibiotics, and implant retention*, DAIR), combinado con la administración intraósea de vancomicina y el recambio de componentes modulares, para controlar la infección aguda y mejorar los resultados funcionales. **Materiales y Métodos:** Estudio retrospectivo en 3 instituciones, que incluyó a 12 pacientes (7 mujeres, 5 hombres; edad media 72.4 ± 6.3 años) con infección periprotésica aguda tratados con DAIR entre febrero de 2022 y junio de 2023. El tiempo promedio desde la artroplastia total de rodilla hasta la cirugía DAIR fue de 12.3 días. Se aplicó un protocolo uniforme con administración intraósea de vancomicina, recambio de componentes modulares y antibioterapia dirigida. **Resultados:** El tiempo quirúrgico medio fue de 95 ± 10 minutos. Se logró el control de la infección en el 91,6%, hubo una reinfección que requirió revisión en dos tiempos. El *Knee Society Score* mejoró de $42,5 \pm 5,8$ a $88,6 \pm 6,3$ al año ($p < 0,001$). **Conclusión:** El protocolo DAIR con vancomicina intraósea y recambio modular es prometedor en el manejo de la infección periprotésica aguda de rodilla. Se requieren estudios más amplios. **Palabras clave:** Infección periprotésica de rodilla; vancomicina intraósea; desbridamiento; retención de implantes.

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INTRODUCTION

Total knee arthroplasty (TKA) is a proven and increasingly common procedure. According to the 2023 *American Joint Replacement Registry* report, 194,695 TKAs were performed in the United States.¹ Periprosthetic joint infection (PJI) is the leading cause of knee revision, accounting for 29.5% of all revisions and 50.3% of early revisions.¹

The use of debridement, antibiotics, and implant retention (DAIR) to treat acute PJI after TKA remains a matter of debate.^{2,3} Variable definitions and diagnostic criteria for PJI, pathogen heterogeneity, differences in host immunocompetence, and evolving success criteria partly explain the inconsistent outcomes reported.⁴ Strategies such as modular component exchange⁵ and intraosseous antibiotic administration⁶ have been proposed to improve the effectiveness of DAIR by targeting bacterial biofilms at concentrations unattainable with systemic intravenous therapy.

The aim of this study was to evaluate the efficacy and safety of DAIR supplemented with intraosseous vancomycin and modular component exchange in patients with acute knee PJI, compared with conventional infection-management methods.

MATERIALS AND METHODS

Study Design

We conducted a retrospective, multicenter, observational study at three institutions in Argentina, including patients with acute knee PJI who underwent a DAIR protocol between February 2022 and June 2023. Clinical, radiological, and functional follow-ups lasted at least 12 months. Intraoperative and postoperative adverse events related to intraosseous vancomycin were recorded.

Patient Selection and Inclusion Process

To mitigate selection bias, we systematically searched electronic and paper medical records at each institution to identify all patients presenting with symptoms or signs suggestive of acute PJI (severe pain, erythema, edema, persistent drainage, limited mobility) during the study period. An orthopedic surgeon, an infectious disease specialist, and a radiologist jointly reviewed the cases and confirmed PJI based on the following clinical and laboratory criteria: (1) severe or persistent knee pain; (2) erythema, edema, or wound drainage for at least 7 days; (3) C-reactive protein >100 mg/L; and (4) arthrocentesis with >10,000 cells/mL and >90% polymorphonuclear cells, or two positive cultures with phenotypically identical organisms.

Patients with chronic infection (>6 weeks after primary TKA), an unstable implant, or serious medical conditions contraindicating surgery were excluded.

Fifteen potential cases were identified; three were excluded (two chronic infections >6 weeks and one unstable prosthesis). Thus, 12 patients (7 women, 5 men; mean age 72.4 ± 6.3 years) were included. The mean interval between the index TKA and DAIR was 12.3 days (range, 8–31).

The study adhered to the principles of the Declaration of Helsinki. Informed consent was obtained from all participants.

Data Collection and Bias Management

Data were extracted and coded by an independent investigator not involved in the surgery or postoperative care. A unified database captured demographics, comorbidities, culture results, operative time, blood loss, complications, follow-up duration, and joint function scores.

Reducing Measurement Variability

Knee Society Score (KSS) assessment was standardized across institutions by training evaluators on the same scale. Uniform protocols were followed for sampling and for the DAIR surgical technique to minimize method-related variability.

Interpretation Bias Control

Antibiotic regimens were determined by the Infectious Diseases Service according to pathogen susceptibility and local guidelines.

We recognize the inherent limitations of retrospective designs; documentation is not always standardized. However, all data were double-checked (medical records, operative notes, laboratory reports) to limit omissions of relevant information.

Surgical procedure: standardized DAIR protocol

Intraosseous vancomycin was administered per the protocol of Young et al.⁶ Five hundred milligrams of vancomycin were dissolved in 10 mL of normal saline, then diluted in 140 mL of saline (total 150 mL). An incision was made in the adhesive field and skin (Figure 1), cancellous bone was accessed medial to the tibial tubercle using a Jamshidi needle (Figure 2), and the 150 mL preparation was injected (Figure 3). A tourniquet was used in all cases.



Figure 1. Incision in the adhesive field and in the skin medial to the tibial tubercle.



Figure 2. Perforation of the proximal metaphyseal tibial bone, medial to the tibial tubercle, with a Jamshidi needle.



Figure 3. Infusion of 150 mL of the diluted vancomycin preparation.

The knee was approached through a standard medial parapatellar incision. Five representative periprosthetic tissue samples were obtained for culture in enriched media. Extensive debridement of infected tissue and removal of the tibial polyethylene were performed. Exposed metal components were scrubbed with a sterile brush soaked in 0.36% povidone-iodine.

Irrigation followed a five-step protocol based on Kildow et al.:

1. Low-pressure irrigation with 3 L of saline.
2. Irrigation with 100 mL of 3% hydrogen peroxide (H₂O₂) plus 100 mL of sterile water for 2 minutes.
3. Irrigation with 2 L of saline.
4. Irrigation with 1 L of sterile diluted 0.36% povidone-iodine, left in the wound for 3 minutes.
5. Low-pressure irrigation with 3 L of normal saline.

Gauze soaked in diluted povidone-iodine was placed between prosthetic components, the skin was closed, and instruments, gowns, and drapes were changed. The skin was re-prepped with povidone-iodine, the sutures were removed, and the joint was re-irrigated with diluted povidone-iodine and 1 L of saline. Finally, a new tibial polyethylene insert was implanted.

Microorganisms and Antibiotic Regimens

Isolates among the 12 infections were: methicillin-resistant *Staphylococcus aureus* (MRSA, n=3), methicillin-resistant coagulase-negative *Staphylococcus* (n=1), methicillin-susceptible *S. aureus* (MSSA, n=2), methicillin-susceptible coagulase-negative *Staphylococcus* (n=2), *Streptococcus agalactiae* (n=1), Enterobacterales (n=2), and culture-negative (n=1).

All patients received intravenous antibiotics for at least one week after surgery, followed by oral antibiotics for at least three months, provided clinical status was stable and infection markers improved (decreasing/normalized ESR and CRP, satisfactory wound appearance, and appropriate clinical course).

Study Variables

Variables included demographics (age, sex); surgical data (operative time, intraoperative blood loss); intra- and perioperative complications; time to ambulation; knee function (e.g., KSS); and infection control (resolution of clinical signs and normalization of CRP and ESR).

Treatment success was defined by the criteria of Diaz-Ledezma et al.,⁷ which were developed through a consensus reached using the Delphi method. These criteria are based on the eradication of infection, the absence of subsequent surgical interventions, and the absence of deaths associated with prosthesis infection.

Statistical Analysis

Descriptive statistics characterized the cohort (means $\pm$ SD or median and interquartile range, as appropriate). Categorical variables are reported as frequencies and percentages. Paired t-tests compared pre- and postoperative KSS values. Significance was set at $p < 0.05$.

RESULTS

Population Characteristics

Twelve patients (7 women, 5 men; mean age 72.4 ± 6.3 years) were included. Six had at least one comorbidity (Table 1).

Table 1. Patient comorbidities.

Comorbidities	Number of patients
Hypertension	6 (75%)
Chronic renal failure	1 (12.5%)
Collagenopathies	1 (12.5%)
Diabetes	2 (25%)

Intraoperative and Postoperative Data

Mean operative time was 95 ± 10 min (range, 80-110). Mean intraoperative blood loss was 180 ± 30 mL (range, 140-220).

No cases of hypotension or bradycardia were observed during intraosseous vancomycin infusion or upon tourniquet release. No histamine-related cutaneous events were recorded.

Perioperative Complications

One patient (8.3%) had wound drainage during the first 72 hours, which resolved with conservative management. Two patients with type 2 diabetes had hyperglycemic events managed by Endocrinology. No other major immediate postoperative complications were observed.

Control of the Infectious Process

Infection control was achieved in 11 of 12 patients (91.6%). There was one recurrence (reinfection). In that case, pre- and intraoperative cultures (arthrocentesis fluid and tissue) were negative; the patient underwent two-stage revision, and intraoperative cultures grew *Pseudomonas aeruginosa*. Imipenem 2 g/day plus ciprofloxacin 1 g/day were given intravenously for 7 days, followed by oral ciprofloxacin 1 g/day during the spacer phase (12 weeks).

Clinical and Functional Outcomes

Patients began weight-bearing on the operated limb at 24 hours postoperatively with a walker. KSS improved significantly in all cases (Table 2).

Table 2. Preoperative *Knee Society Score*, at 6 months, and at one year.

Period	<i>Knee Society Score</i> (mean score $\pm$ SD)	Score range
Preoperative	42.5 ± 5.8	35-50
Postoperative (at 6 months)	85.3 ± 7.1	75-95
Postoperative (at 12 months)	88.6 ± 6.3	80-98

SD = standard deviation.

Statistical analysis showed a significant improvement in the KSS ($p < 0.001$) between the preoperative period and the 6- and 12-month follow-ups.

Paired Student's t-tests were used to compare preoperative and postoperative KSS scores, with a significance level set at $p < 0.05$. Improvements in KSS scores were statistically significant, indicating significant functional improvement in all patients treated with the DAIR protocol, intraosseous vancomycin, and modular component exchange.

DISCUSSION

Our findings suggest that DAIR supplemented with intraosseous vancomycin, chemical debridement, and modular component exchange is effective and safe for managing acute knee PJI.

DAIR is commonly used in the early postoperative period for acute postoperative or hematogenous infections. While early intervention is generally assumed to improve control, reported success rates for open irrigation and debridement with component retention in acute infection vary widely from 16% to 100% (mean ~50%).^{8,9}

Recent studies indicate that host factors, causative microorganism, the timing of intervention, modular component exchange, and symptom duration can influence the outcomes of the DAIR protocol. Duque et al. reported an 80% failure rate in methicillin-resistant *Staphylococcus aureus* infections treated with debridement,¹⁰ while Bradbury et al. reported an 84% failure rate in patients with acute MRSA knee PJI treated with DAIR.¹¹

To address the modest outcomes of DAIR in acute PJI, several adjunctive strategies have been proposed. Riesgo et al. combined vancomycin powder and diluted povidone-iodine lavage with DAIR and modular exchange for *Staphylococcus* infections, achieving an 83% eradication rate versus 63% in controls at ≥1-year follow-up.¹² McQuivey et al. described a two-stage debridement using high-dose antibiotic-loaded cement microspheres between stages plus modular exchange for acute PJI, with 87% eradication in both primary and revision TKA.¹³

Another strategy to improve the results of the DAIR protocol is prolonged oral antibiotic therapy. Siqueira et al. reported higher 5-year survival with suppressive therapy after *S. aureus* infection versus no suppression (57.4% and 40.1%, respectively, $p = 0.047$).¹⁴ A recent systematic review concluded suppressive therapy after DAIR may benefit *S. aureus* PJI.¹⁵

Methods to achieve higher tissue antibiotic concentrations via intraosseous administration have also been described.¹⁶ Such levels are otherwise unattainable without systemic toxicity. Low-dose intraosseous delivery has achieved 10–20-fold higher tissue concentrations compared with systemic intravenous administration.^{6,17} Despite these elevated concentrations, we observed no significant complications with intraosseous vancomycin, consistent with prior reports.¹⁸ Kildow et al. reported a 92.3% control rate in acute knee PJI treated with DAIR, modular exchange, and intraosseous vancomycin at a mean 16.5-month follow-up.¹⁹

In our study, we expanded the series to 12 cases, including the successful management of infections caused by methicillin-resistant *Staphylococcus aureus*, methicillin-sensitive *Staphylococcus aureus*, coagulase-negative *Staphylococcus*, *Streptococcus*, and even two cases of enterobacterales, under appropriate antibiotic regimens. Nevertheless, small sample size, retrospective design, and lack of a control group limit generalizability. Prospective studies with larger cohorts are needed to confirm and refine these findings.

CONCLUSIONS

Intraosseous vancomycin, combined with modular component exchange and aggressive debridement (DAIR), appears to be an effective strategy for improving control of acute knee PJI without increasing vancomycin-related adverse events. Although our results are encouraging, prospective, larger studies are required to confirm these observations and to better define selection criteria, optimal timing, and long-term follow-up protocols.

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

During manuscript preparation, 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 publication's content.

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