Joint Diseases and Related Surgery

Jt Dis Relat Surg
2025;36(3):757-762

CASE REPORT

Eradication of Salmonella enteritidis periprosthetic hip infection using a custom-made articulating spacer: A case report

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ABSTRACT

Periprosthetic joint infection (PJI) remains a challenging complication following total hip arthroplasty (THA), commonly managed through a two-stage revision which can lead to significant morbidity. In this article, we present a rare case of *Salmonella enteritidis* PJI, initially presenting as prosthetic hip dislocation. Preoperative hip aspiration utilizing blood culture bottles enabled early identification of the organism and guided targeted antimicrobial therapy. The patient underwent revision THA using a well-fixed custom-made articulating spacer (CUMARS) construct, with targeted antibiotic-loaded bone cement. One-year follow-up demonstrated successful eradication of the infection, stable implant fixation, and good functional outcomes. In conclusion, this case underscores the importance of diagnostic hip aspiration and highlights the potential of the CUMARS technique as an effective and durable solution for managing rare PJIs caused by atypical organisms such as *Salmonella enteritidis*.

Keywords: Custom-made articulating spacer, periprosthetic hip infection, *Salmonella enteritidis*, staged revision.

Periprosthetic joint infection (PJI) is a serious complication following total hip arthroplasty (THA), with high patient morbidity and healthcare burden.[1] The two-stage revision procedure is a widely utilized approach for managing PJI, particularly in cases involving difficult-to-treat pathogens or compromised bone and soft tissues.[2] However, it is often poorly tolerated, with drawbacks such as higher costs, reduced quality of life, joint stiffness, and muscle wasting.[3] The custom-made articulating spacer (CUMARS) construct offers a functional interim solution in PJI management, aiming to reduce short-term complications and facilitate second-stage reconstruction.[4] In such cases, identifying the causative microorganism in PJI is essential for guiding targeted antibiotic therapy, optimizing treatment duration, and improving patient outcomes.[5]

In this article, we present a case of *Salmonella enteritidis* PJI following THA, manifesting as prosthetic hip dislocation. The CUMARS technique, also referred to as a "1.5-stage" revision, was selected over a conventional two-stage approach for several reasons. These included the absence of severe bone loss that allowed for secure component fixation,

Received: April 26, 2025
Accepted: June 19, 2025
Published online: July 21, 2025

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Doi: 10.52312/jdrs.2025.2342

Citation: Loh KW, Ayob KA, Abbas AA, Selvaratnam V. Eradication of Salmonella enteritidis periprosthetic hip infection using a custom-made articulating spacer: A case report. Jt Dis Relat Surg 2025;36(3):757-762. doi: 10.52312/jdrs.2025.2342.

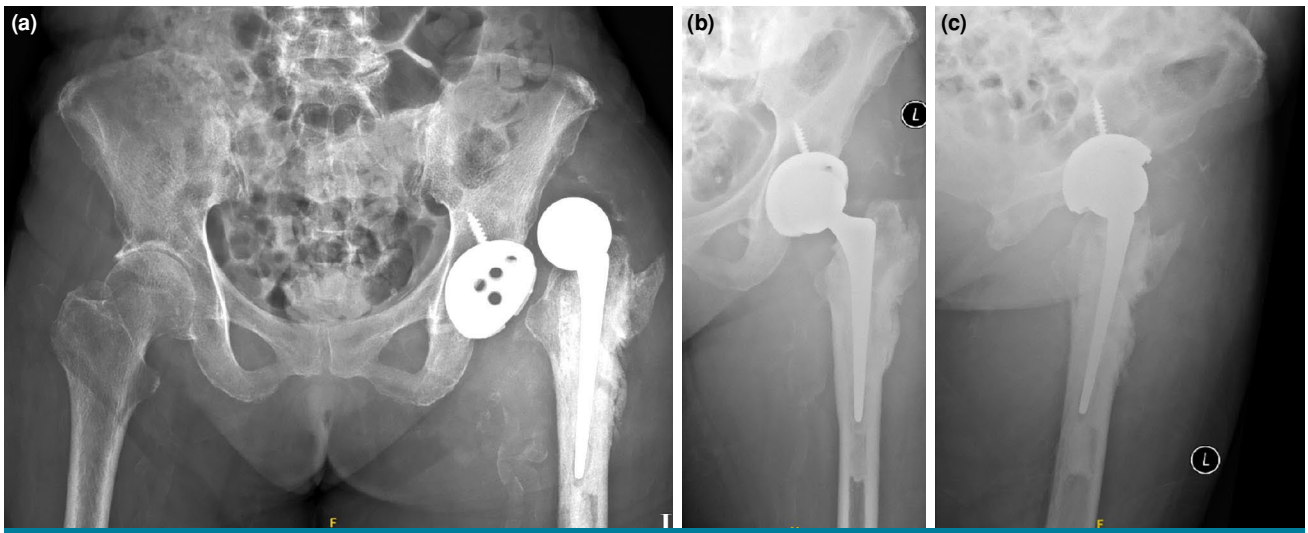

FIGURE 1. (a) Plain radiographs of the left hip before and **(b, c)** after reduction of the dislocation.

and the opportunity to preserve joint mobility and function. More importantly, preoperative aspiration yielded a known organism *(Salmonella enteritidis)* with a clear antibiotic sensitivity profile, allowing for targeted antimicrobial therapy. This made the CUMARS construct a suitable and durable solution in this clinical scenario, with favorable outcomes observed at one-year follow-up.

CASE REPORT

A 69-year-old woman presented with an inability to ambulate following a posterior dislocation of her prosthetic left hip. While seated on a low chair at home, she experienced a sudden onset of left hip pain accompanied by an audible pop as she attempted to stand. There was no preceding history of trauma or fall. She exhibited no local or systemic signs of infection. The dislocation was successfully reduced using the Bigelow maneuver (Figure 1), and the telescoping test demonstrated stability at 90° of hip flexion.

The patient underwent a left hybrid THA, consisting of an uncemented acetabular component and a cemented femoral stem, four years earlier for a femoral neck fracture. Following the index procedure, she regained independent ambulation without walking aids and remained functionally active. Two years later, she was diagnosed with right breast infiltrating ductal carcinoma, for which she underwent breast-conserving surgery with sentinel lymph node biopsy and immediate Grisotti flap reconstruction. She completed adjuvant chemotherapy comprising six cycles of FEC-TH (5-fluorouracil, epirubicin, and cyclophosphamide followed by docetaxel and trastuzumab), received radiotherapy (26 Gy in 5 fractions over one week), and continued trastuzumab for a total of nine cycles. She is currently on long-term letrozole therapy. During the course of her cancer treatment, she developed an episode of infective diarrhea requiring hospitalization, which was successfully treated with a short course of antibiotics.

C-reactive protein and white cell count were elevated, measuring 260.6 mg/L and 20×10^9/L, respectively (Table I). Serial plain radiographs of the left hip (Figure 2) revealed peri-implant lucency at the proximal femur on the radiograph taken two years prior, while periosteal

TABLE I
Postoperative trend of inflammatory markers showing progressive normalization

Week since operation	0	1	2	4	6	12	16	24
CRP (mg/L)	260.6	22.7	16	9.6	2.21	0.8	0.63	<0.5
WBC ($\times10^9$/L)	20	10	6.2	6.9	5.7	6.0	7.6	6.5

CRP: C-reactive protein; WBC: White blood cell; Normal limit for CRP in our laboratory is <5 mg/L, and the WBC reference range is 4-10$\times10^9$/L

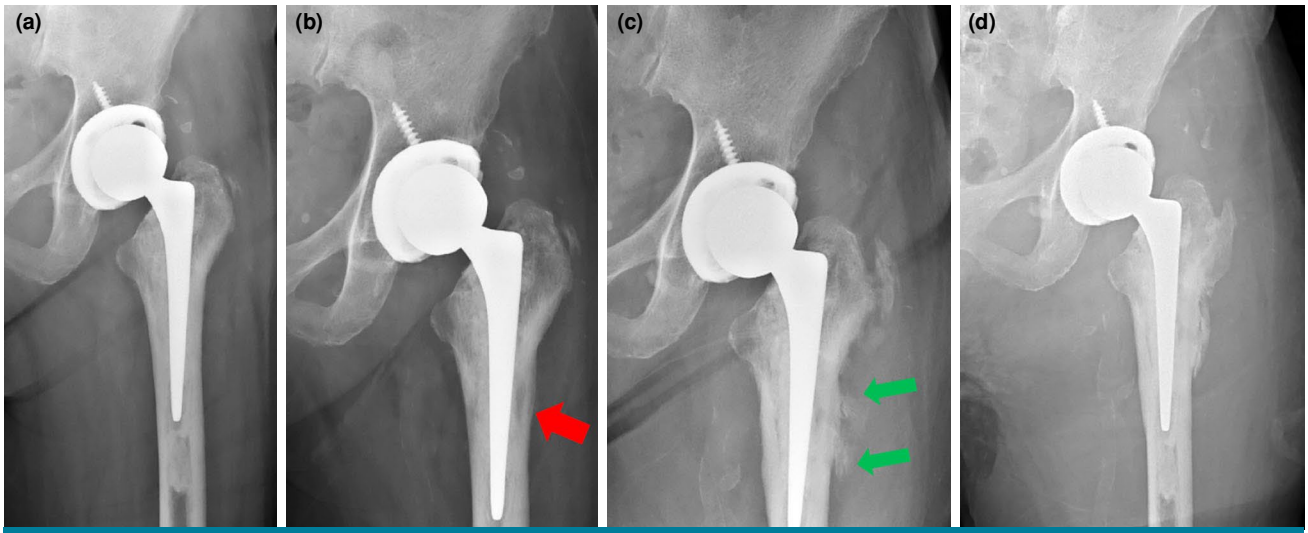

FIGURE 2. Serial plain radiographs of the left hip. **(a)** Taken three years prior to the dislocation event, with no obvious abnormality. **(b)** Taken two years prior to dislocation, showing peri-implant lucency (red arrow). **(c)** Taken one year prior to dislocation, showing periosteal reaction (green arrows). **(d)** Taken following closed reduction of the dislocated prosthetic hip.

reaction was noted on the radiograph obtained one year ago. Contrast-enhanced computed tomography (CT) scan of the pelvis and femurs showed rim-enhancing hypodense collection at left hip involving the left gluteus medius and piriformis muscles, measuring approximately 3.3×8.6×6.7 cm (Figure 3). Aspiration of the left hip joint was performed under image intensification guidance, and the aspirate was inoculated into blood culture bottles. *Salmonella enteritidis* was identified via culture, with growth observed after 48 h of incubation. Antimicrobial susceptibility testing revealed sensitivity to ampicillin, ceftriaxone, ciprofloxacin, and trimethoprim-sulfamethoxazole.

She underwent a revision left THA using the CUMARS construct. Intraoperatively, inflamed tissue was observed surrounding the left hip joint, with thickening of the proximal femur consistent with a periosteal reaction. No sinus tract was identified at the proximal femur. Slough was present within the acetabulum, and biofilm was noted on the femoral stem upon explantation. Although the posterior acetabular wall appeared thin, it remained structurally intact. The prosthesis was completely removed, and a thorough synovectomy was performed. Multiple tissue samples were collected for microbiological culture and antimicrobial susceptibility testing.

Targeted antibiotics ceftazidime and meropenem, 2 g each, were incorporated into every 40 g pack of bone cement powder. Although the isolated *Salmonella enteritidis* strain was susceptible to several antibiotics, meropenem was selected to ensure coverage against the full spectrum of Salmonella spp., including potential extensively drug-resistant (XDR) variants. This approach was taken as a precautionary measure to minimize the risk of treatment failure in the event of undetected or emerging resistance. Additionally, four vials of liquid gentamicin (80 mg each) were added to each pack of cement to enhance the antibiotic load, increase the liquid content for improved mixability, and promote greater cement porosity, thereby facilitating antibiotic elution.

A total of three cement packs were used during implantation: one for the acetabular component and two for the femoral component. On the acetabular side, a Trident® All Poly Constrained Acetabular Liner (Stryker, Mahwah, NJ, USA) was cemented in place, while on the femoral side, a 37.5-mm offset Exeter V40 cemented hip stem (150 mm stem length) (Stryker, Mahwah, NJ, USA) was implanted.

Postoperatively, she received intravenous meropenem 1 g three times daily for a total of six weeks. Intraoperative cultures confirmed the presence of *Salmonella enteritidis*, consistent with preoperative hip aspiration findings, and demonstrated sensitivity to meropenem. She was subsequently switched to oral ciprofloxacin and completed a total of 12 weeks of antibiotic

FIGURE 3. Axial view of contrast-enhanced computed tomography scan showing a rim-enhancing hypodense collection at the left hip, involving the left gluteus medius and piriformis muscles (red arrows).

therapy. Her blood inflammatory markers showed a progressive decline and eventually normalized (Table I). Serial postoperative radiographs showed a stable, well-fixed revision implant (Figure 4). The patient regained the ability to mobilize with a walking frame within the first week postoperatively and progressed to walking independently without support by four weeks. At one-year follow-up, the patient remained infection-free and was ambulating unaided for community distances. She was able to perform activities of daily living independently, reported no hip pain at rest or during ambulation, and did not require further surgical intervention. Written informed consent was obtained from the patient.

DISCUSSION

In this case, the patient sustained a posterior dislocation of her prosthetic hip four years after her index THA, in the absence of any traumatic event. This atypical presentation prompted further evaluation for underlying causes. Serial radiographs revealed peri-implant lucency and periosteal reaction in the proximal femur, which developed following an episode of infective diarrhea which required hospitalization during her adjuvant breast cancer therapy.

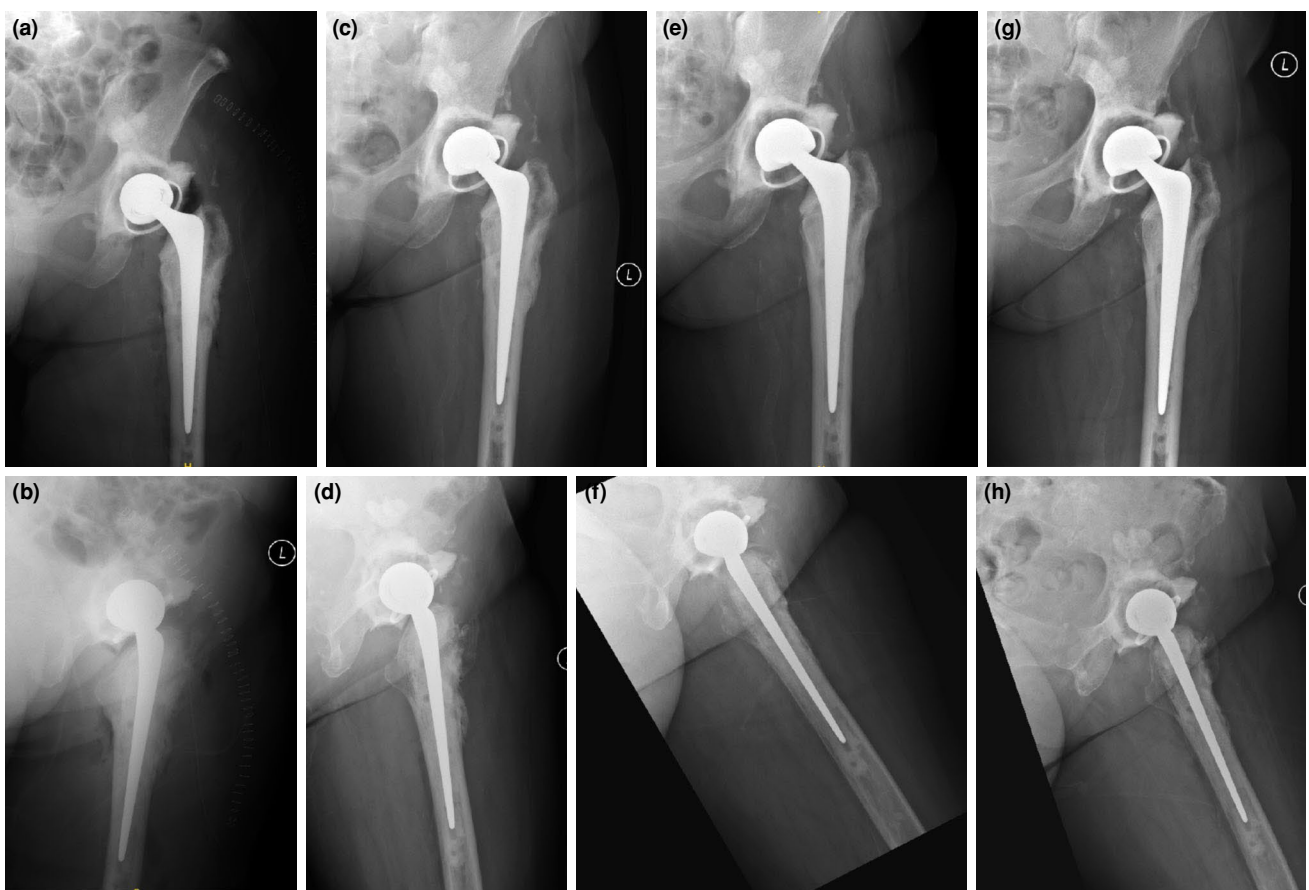

FIGURE 4. Serial plain radiographs of the left hip following the CUMARS procedure: **(a, b)** immediate postoperative period, **(c, d)** at one month, **(e, f)** at six months, and **(g, h)** at one year postoperatively.

Given the eventual isolation of *Salmonella enteritidis* from diagnostic hip aspiration, we suspect that hematogenous spread from a gastrointestinal source during this episode may have seeded the prosthetic joint. The patient's immunocompromised state during chemotherapy likely facilitated this dissemination. The subsequent chronic low-grade infection may have progressed silently, leading to gradual osteolysis and soft tissue compromise. These changes ultimately resulted in biomechanical instability and culminated in a posterior dislocation of the prosthetic hip.

Salmonella, a Gram-negative enteroinvasive bacterium is a rare cause for PJI, and is most commonly disseminated via the hematogenous route.[6] A 44-year retrospective study of PJI cases at the Mayo Clinic identified only six cases of Salmonella PJI, of which five had a THA infection.[7] This case emphasizes the need to recognize Salmonella spp. as potential causative agent of PJI, even in the absence of preceding gastrointestinal symptoms. Reports in the literature remain limited. Most authors advocate for a two-stage revision procedure combined with appropriate antimicrobial therapy as the optimal approach for effective eradication of Salmonella PJI.[7-9]

The CUMARS technique, introduced in 2001, employs a standard cemented hip system, fixed using targeted antibiotic-loaded acrylic cement, as a functional long-term spacer in the management of PJI.[10] This procedure allows for indefinite postponement of a second-stage operation, provided that the patient remains infection-free and experiences no implant-related issues. As an alternative to conventional two-stage revision, the CUMARS construct is well-tolerated, enables weight-bearing, and preserves joint mobility, while reducing the risk of periarticular fibrosis and limb shortening, which can complicate subsequent surgical intervention.[11]

A critical factor influencing the success of the CUMARS procedure is the preoperative identification of the causative pathogen, which can be reliably achieved via hip aspiration and culture using blood culture bottles.[12] This allows for precise antimicrobial susceptibility profiling and facilitates targeted antibiotic therapy. Intraoperative assessment of bone stock is critical to ensure adequate support for proper implantation of components using antibiotic-loaded cement. In cases where bone stock is insufficient to achieve stable fixation, a conventional two-stage revision remains the recommended approach.[10] A femoral cement in cement revision using antibiotic loaded cement may be performed when the femoral bone-cement interface is intact.[13]

To preserve the mechanical integrity of polymethylmethacrylate bone cement, previous study has suggested limiting the addition of heat-stable powdered antibiotics to no more than 10% of the total cement powder weight (i.e., 4 g per 40 g pack).[14] Exceeding this threshold may significantly reduce the compressive strength of the cement, thereby increasing the risk of implant loosening and ultimately failure.[14,15] In this case, 2 g of ceftazidime and 2 g of meropenem (both in powder form) were added per pack, complying with this limit. An additional four vials of liquid gentamicin (320 mg) were added to improve mixability and enhance elution; this was not included in the weight-based limit applied to powdered antibiotics. We prefer the use of well-fixed CUMARS constructs in the management of THA-related PJI. This approach offers the advantage of allowing the implants to remain indefinitely, while also reducing the risk of early implant loosening and periprosthetic fractures commonly associated with loosely fixed femoral components.[10]

This case report describes a rare presentation of *Salmonella enteritidis* PJI presenting with a dislocated prosthetic hip following THA. Preoperative hip aspiration, enabling identification of the causative organism and antibiotic susceptibility profiling, alongside targeted antimicrobial therapy, was critical to successful management. The use of a CUMARS construct facilitated effective local antibiotic delivery while preserving joint mobility during the interim period. This construct provides a versatile solution, functioning as a long-term spacer that maintains patient ambulation while preserving the option for a second-stage revision if clinically necessary.

In conclusion, although the current literature offers limited support for alternatives to the conventional two-stage revision in Salmonella PJIs, this case demonstrates that the CUMARS technique can be a safe and effective treatment strategy when combined with targeted intraoperative antibiotic-loaded cement and appropriate postoperative antibiotic therapy.

Data Sharing Statement: The data that support the findings of this study are available from the corresponding author upon reasonable request.

Author Contributions: Conceptualization: V.S.; Managed patient care: L.K.W., A.A.A., K.A.A., V.S.; Data collection: A.A.A, V.S.; Writing draft: L.K.W., V.S.; Review & editing: A.A.A., K.A.A.

Conflict of Interest: The authors declared no conflicts of interest with respect to the authorship and/or publication of this article.

Funding: The authors received no financial support for the research and/or authorship of this article.

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