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Hybrid Nail-Reinforced Articulating Antibiotic Spacer for Recurrent Infection After Distal Femoral Resection: A Case Report

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Abstract **Case Report**

Recurrent infection after distal femoral resection leaves a segmental defect that a conventional knee spacer cannot bridge. Intramedullary static constructs provide stability but immobilise the knee, whereas articulating spacers lack the mechanical support needed for loading. We report the case of a 51-year-old woman with chronic post-traumatic osteomyelitis of the distal femur after an open fracture-dislocation of the knee sustained in a high-energy motorcycle accident. After more than a year of polymicrobial infection and multiple debridements, she underwent extended resection of the distal femur and implantation of a fenestrated modular metallic spacer with continuous local vancomycin infusion. Seven months later she presented with acute septic arthritis of the spacer caused by *Streptococcus agalactiae*. After two weeks of intravenous ceftriaxone, the spacer was removed and a hybrid construct was built: a retrograde supracondylar intramedullary nail acting as a load-sharing scaffold, coated within the femoral canal with a resorbable calcium sulphate/hydroxyapatite biocomposite eluting vancomycin and gentamicin; reconstruction of the femoral condyles around the distal nail with gentamicin- and clindamycin-loaded cement; and a cemented articulating knee spacer providing the joint surfaces. All eight intraoperative cultures were sterile. The early postoperative course was complicated by acute anaemia requiring transfusion and a perioperative myocardial injury, both managed medically. The patient was mobilised out of bed with a knee brace on the fifth postoperative day, and C-reactive protein fell to 1.0 mg/dL by the second postoperative week. This construct combines local delivery of three antibiotics, axial stability and preserved knee motion in a single interim implant and may be an option during staged reconstruction of infected distal femoral defects with a megaprosthesis.

Keywords: Periprosthetic joint infection, articulating spacer, intramedullary nail, antibiotic-loaded bone substitute, distal femoral bone loss, megaprosthesis, open knee dislocation.

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INTRODUCTION

Open dislocation of the knee is an uncommon high-energy injury with a high incidence of deep infection and a guarded prognosis for limb survival and function [1]. When chronic infection destroys the distal femur, radical resection may be required, and the defect is usually reconstructed in stages with a distal femoral megaprosthesis. Deep infection affects about 10% of lower-limb endoprosthetic reconstructions even in tumour surgery [2].

In two-stage revision of the infected knee, articulating spacers provide greater range of motion than static spacers, with similar or lower reinfection rates [3–5]. After distal femoral resection, however, no metaphyseal bone remains to support a conventional articulating spacer. Intramedullary nail-stabilised spacers maintain leg length and stability in these defects, but most are static and immobilise the knee between stages [6–8]. Antibiotic cement-coated nails add local antibiotic delivery but may debond during removal [9].

We describe a hybrid interim construct for recurrent infection after distal femoral resection, combining an intramedullary nail as a load-sharing scaffold, a resorbable antibiotic-loaded biocomposite in the femoral canal, antibiotic cement reconstruction of the femoral condyles and an articulating knee spacer.

CASE REPORT

Initial injury and chronic infection

A 49-year-old woman, a smoker of 20 heated tobacco sticks per day without other relevant history, was the passenger on a motorcycle involved in a high-speed

collision. She sustained an open fracture-dislocation of the right knee, fractures of the right iliac wing, acetabulum and clavicle, and injuries to the left wrist and hand. Distal pulses were present, and computed tomography (CT) angiography showed no arterial injury.

Initial management included lavage and debridement of the knee, repair of the patellar tendon through three transosseous tunnels with retinacular repair, a knee-spanning external fixator (Figure 1) and external fixation of the pelvis. Over the following months she required repeated debridements for deep infection. *Enterobacter cancerogenus* was isolated from multiple samples, together with *Aeromonas hydrophila*, *E. cloacae*, *Citrobacter braakii* and *Proteus vulgaris*, and later *Staphylococcus haemolyticus*, *S. epidermidis* and *S. hominis*. Despite prolonged targeted antibiotic therapy, she developed septic arthritis with destruction of both femorotibial compartments and chronic osteomyelitis of the distal femur, with suspected bone necrosis on magnetic resonance imaging (Figure 2).

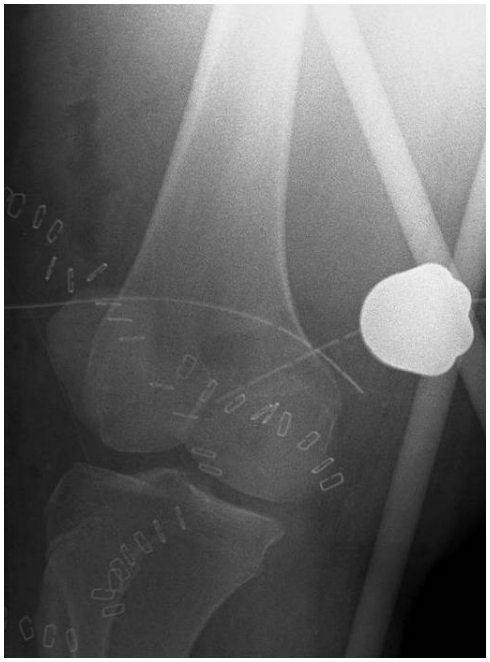


Figure 1: Lateral radiograph of the right knee after initial management, with patellar tendon repair and knee-spanning external fixator

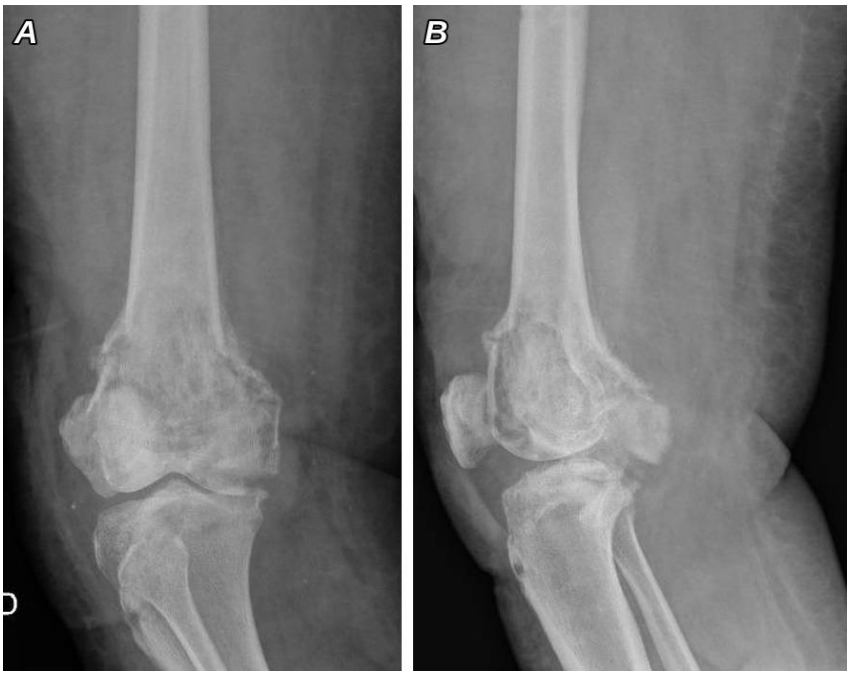


Figure 2: Anteroposterior (A) and lateral (B) radiographs eight months after the injury, showing destruction of the femorotibial joint and osteomyelitis of the distal femur

Fifteen months after the injury she underwent extended resection of the distal femur and implantation of a fenestrated modular metallic spacer of an older design, which allowed continuous local infusion of vancomycin (2 g in 1,000 mL of saline every 24 hours) through catheters (Figure 3). Intraoperative cultures isolated ampicillin-susceptible *Enterococcus faecium* and *E. faecalis*, and she completed 18 days of intravenous ampicillin followed by oral amoxicillin.

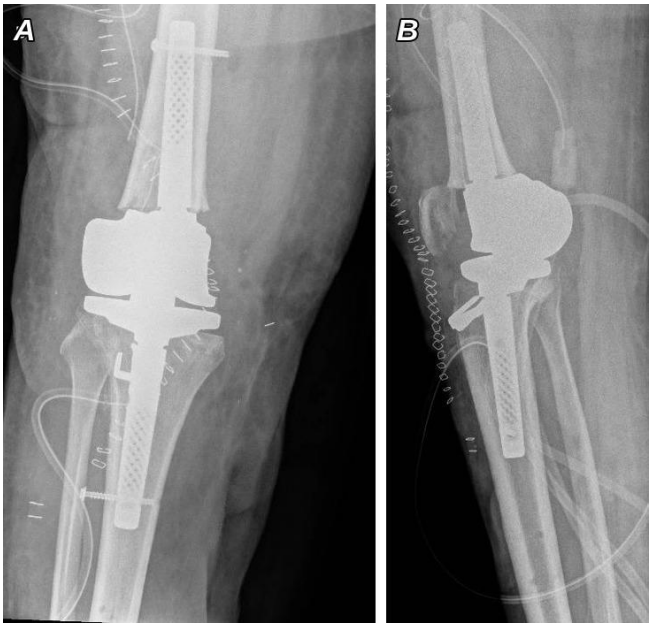


Figure 3: Anteroposterior (A) and lateral (B) radiographs after extended resection of the distal femur and implantation of a fenestrated modular metallic spacer, with catheters for continuous local vancomycin infusion

Recurrence

Seven months later, at the age of 51, she presented with a three-day history of fever up to 39 °C and a swollen, warm and painful right knee. C-reactive protein (CRP) was 40.1 mg/dL and the leucocyte count 11,600/µL with 84% neutrophils. CT showed a large heterogeneous effusion, periosteal reaction along the femur and gas bubbles. Aspiration of the knee yielded 80 mL of pus, from which penicillin-susceptible *Streptococcus agalactiae* was isolated; blood cultures were sterile. Empirical vancomycin and piperacillin-tazobactam were switched to ceftriaxone 2 g every 12 hours after identification, and CRP fell to 6 mg/dL within one week. Because acute haematogenous infection superimposed on persistent chronic infection could not be excluded, exchange of the implant was preferred to debridement with implant retention. Surgery was performed after 14 days of ceftriaxone.

Surgical technique

Under general anaesthesia with femoral and sciatic nerve blocks and 1 g of intravenous tranexamic acid, the previous incision was reopened; the skin was scarred and showed a draining sinus (Figure 4A). The fenestrated spacer was removed, and a radical debridement of the soft tissues and remaining bone was performed, followed by copious lavage. Eight deep tissue samples were sent for culture (Figure 4B).

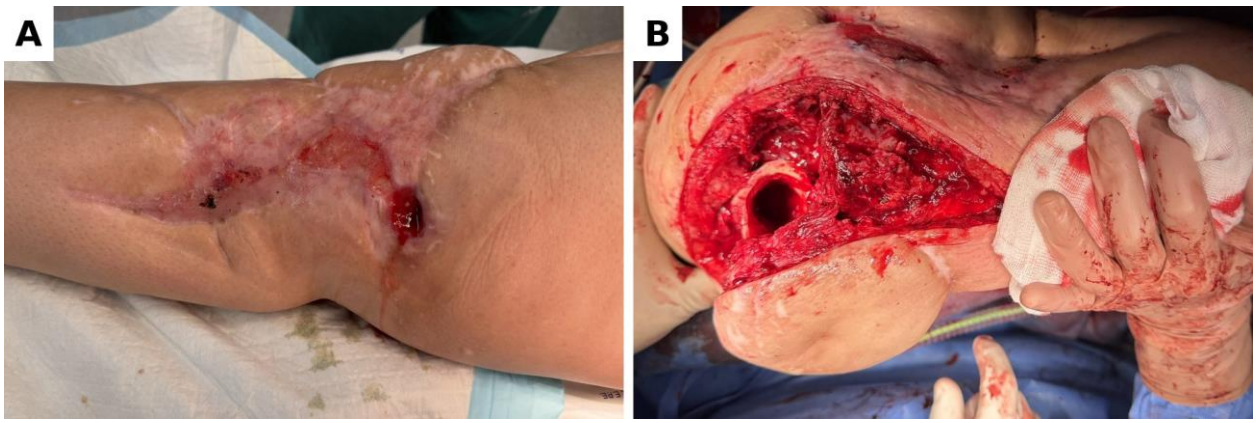


Figure 4: (A) Knee immediately before surgery, with a draining sinus in scarred skin. (B) Intraoperative view after removal of the spacer and debridement, showing the open femoral canal

The femoral canal was reamed to 13 mm. One 10-mL syringe each of CERAMENT V and CERAMENT G (BONESUPPORT AB, Lund, Sweden) was applied alternately to a 300-mm retrograde supracondylar intramedullary nail (T2 SCN, Stryker; 11 mm) while it was still mounted on its insertion guide (Figure 5A), and to the femoral canal (Figure 5B). The nail was then inserted and locked proximally, leaving its distal end and locking screws within the resection gap as an internal scaffold (Figure 5C). The biocomposite forms a resorbable coating that elutes vancomycin and gentamicin.

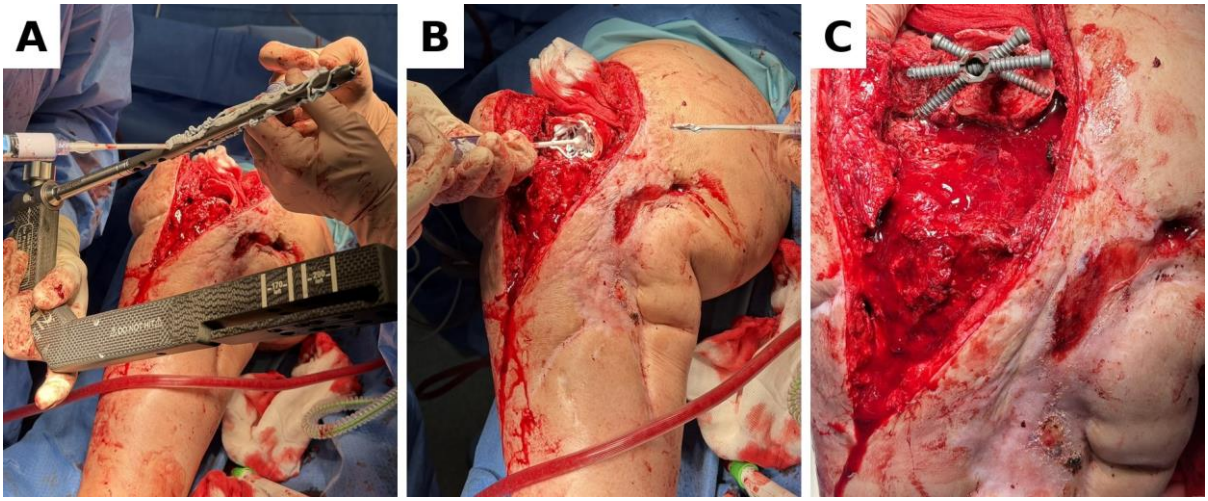


Figure 5: (A) Retrograde nail on its insertion guide, coated with CERAMENT. (B) CERAMENT injected into the femoral canal. (C) Nail in place, with its distal end and locking screws in the resection gap

The articulating spacer was then built with gentamicin- and clindamycin-loaded cement (COPAL G+C, Heraeus Medical), using one pack for the tibial component and then two packs to reconstruct the femoral condyles. These were moulded around the distal end of the nail and its locking screws, which anchor the cement block, restoring the joint line (Figure 6A, B). The femoral and tibial components provided the articular surfaces (Figure 6C). Operating time was approximately four hours and estimated blood loss 1,200 mL.

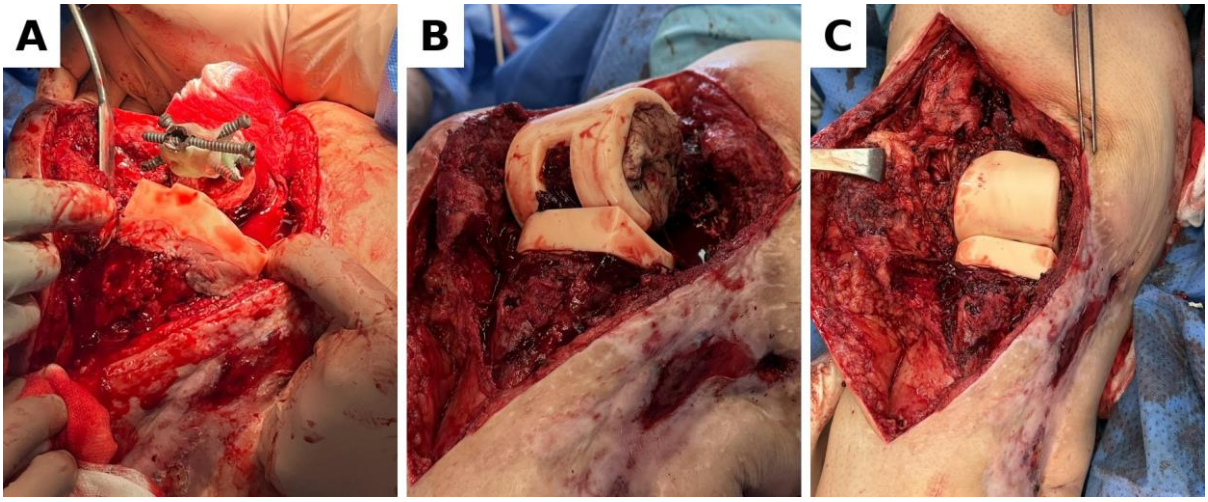


Figure 6: (A) Antibiotic cement moulded around the distal end of the nail and its locking screws. (B) Femoral condyles reconstructed with gentamicin- and clindamycin-loaded cement. (C) Femoral and tibial components of the articulating spacer in situ

Postoperative course

The patient was admitted to a level 2 care unit and required low-dose norepinephrine for hypotension. On the first postoperative night she had an episode of atypical retrosternal pain with a normal electrocardiogram; troponin I peaked at 1,102.8 pg/mL and decreased over the following days, in the setting of acute postoperative anaemia with a haemoglobin nadir of 6.5 g/dL. This was managed medically with red blood cell transfusion and intravenous iron, without further cardiac events.

Physiotherapy started on the first postoperative day with active ankle exercises, quadriceps isometrics and gentle mobilisation of the knee, and the patient was mobilised out of bed with a knee brace on the fifth day. Weight-bearing was limited to proprioceptive loading. All eight intraoperative cultures were sterile.

Postoperative radiographs showed an aligned construct with the spacer in slight hyperextension (Figure 7). By the 12th postoperative day CRP had fallen to 1.0 mg/dL without leucocytosis, and at day 18 she was afebrile and pain-free (CRP 1.0 mg/dL, leucocytes 7,800/µL, haemoglobin 11.8 g/dL). At the time of writing the patient reaches 90° of knee flexion (Figure 8), as obtained intraoperatively, and physiotherapy does not force it further because of ligamentous insufficiency after the knee dislocation. Persistent serosanguinous wound drainage without inflammatory signs required continued wound care. Oral amoxicillin 1 g every 8 hours was prescribed for six weeks after surgery. If the wound and laboratory tests remain unremarkable, new samples will be taken for culture and, if sterile, the second stage with a distal femoral tumour megaprosthesis will follow.



Figure 7: Postoperative anteroposterior radiograph showing the hybrid construct: retrograde intramedullary nail with antibiotic-loaded biocomposite in the femoral canal, condylar block of antibiotic cement anchored by screws through the nail, and articulating spacer



Figure 8: Clinical photograph of the operated right knee in the seated position at the time of writing, showing approximately 90° of flexion

DISCUSSION

Large segmental defects after resection of an infected distal femur leave few interim options: traction, external fixation, static intramedullary spacers or amputation. Static constructs built on intramedullary nails embedded in antibiotic cement maintain length and stability and allow conversion to a megaprosthesis, with

86% infection eradication in one series at the knee [8], but spacer fracture has been reported and the knee remains immobilised [6,7]. Because articulating spacers preserve motion without compromising infection control [3–5], nails have been combined with articulating components for massive, mainly total femoral, defects [10]. Our construct applies this principle to a distal femoral defect.

Each component had a specific purpose. The locked nail transfers load from the femoral diaphysis to the condylar cement block, prevents its rotation and dislocation and allowed early mobilisation. Instead of a polymethylmethacrylate coating, the canal was filled with a calcium sulphate/hydroxyapatite biocomposite, which has been used safely as a coating of revision stems [11], achieves high local and low systemic antibiotic concentrations, with 17.5 mg/mL of gentamicin or 66 mg/mL of vancomycin [12], and has given durable results in chronic osteomyelitis [13]. Being resorbable, it should avoid the debonding described with cement-coated nails [9] and may ease nail removal at the second stage, although this remains to be confirmed. Vancomycin and gentamicin covered both the Gram-positive organisms isolated recently (staphylococci, enterococci and streptococci) and the Gram-negative bacteria isolated earlier. Gentamicin- and clindamycin-loaded cement releases more antibiotic and inhibits biofilm formation better than gentamicin-only cement [14]. Finally, the articulating spacer preserves soft-tissue tension and knee motion, which should facilitate the second stage.

This report has limitations. It describes a single patient with short follow-up, so infection eradication and the durability of the construct cannot yet be confirmed. Weight-bearing was limited to proprioceptive loading, so the behaviour of the construct under full load is unknown. The procedure was long, with substantial blood loss, and was followed by a perioperative myocardial injury in the context of acute anaemia. The persistent wound drainage may reflect dissolution of calcium sulphate, which is usually self-limiting and not associated with recurrent infection [15], but requires surveillance. Longer follow-up and the result of the second stage are needed.

Conclusion

A hybrid spacer combining a locked intramedullary nail, a resorbable antibiotic-loaded biocomposite, antibiotic cement condylar reconstruction and an articulating spacer delivered three local antibiotics while providing axial stability and knee motion after resection of an infected distal femur. In this patient it allowed early mobilisation, with sterile cultures and normalising inflammatory markers. It may be considered as an interim implant before definitive reconstruction with a distal femoral megaprosthesis.

Declarations

Consent: Written informed consent was obtained from the patient for publication of this case report and the accompanying images.

Conflicts of interest: The authors declare no conflicts of interest.

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