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Case Report

Water Contamination at an Ambulatory Surgical Center Leads to Severe Mycobacterium Fortuitum Prosthetic Joint Infections: A Case Series

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ABSTRACT

Prosthetic joint infections (PJIs) following total joint arthroplasties are relatively rare but devastating complications. To date, no cases of *Mycobacterium fortuitum* PJIs associated with contaminated water supplies have been reported in the literature. Our report details 5 patients with *Mycobacterium fortuitum* PJIs related to a contaminated water supply at an ambulatory surgical center. These patients were identified by referral to our academic center. All underwent at least 1 revision surgery prior to referral and required prolonged broad-spectrum antibiotics. All had extensive wound complications, and 4 of 5 patients have received at least stage 1 of a 2-stage revision. All will require further surgery, but long-term outcomes remain relatively uncertain.

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Introduction

Prosthetic joint infection (PJI) following total hip and knee arthroplasties remains a challenging surgical complication. The incidence of PJI is relatively low, with an incidence of 1%-2% of all total hip and knee arthroplasties [1]. Nonetheless, their manifestation can lead to devastating consequences, including soft tissue and bony compromise, the need for multiple revision surgeries, and potentially chronic antibiotic suppression specifically in poor surgical candidates and those who have failed attempted surgical eradication [2]. Studies have identified the most common pathogens for these infections to be natural skin flora including *Staphylococcus aureus, Staphylococcus epidermidis*, and coagulase-negative *Staphylococcus* [3]. At 1 tertiary referral center, *Staphylococcus aureus* was the most common organism isolated, affecting 30.9% of patients with PJI, followed by coagulase-negative *Staphylococcus* and *Enterococcus* species, affecting 12.9% and 5.1%, respectively [4]. Standard microbial cultures are unable to identify the so-called "atypical" microorganisms that account for 7%-15% of PJIs [5]. Among these are nontuberculous mycobacteria (NTM), ubiquitous organisms found in environmental soil and water [6]. *Mycobacterium fortuitum* (*M fortuitum*) is a NTM subclassified as a rapidly growing mycobacteria (RGM) due to its ability to form colonies in less than 1 week and its resistance to common antibacterials due to its biofilm formation [7]. Most literature to date, mostly in the form of case studies, supports RGM as being responsible primarily for miscellaneous human infections of the skin, soft tissue, postsurgical wounds, and lungs, mostly in those with suppressed immune systems [8]. To date, sparse literature exists relating to *M fortuitum* and its implications for PJIs [9,10].

Only a handful of case reports have detailed the clinical and laboratory manifestations of *M fortuitum* PJI. *M fortuitum* infections are commonly associated with contaminated water supplies and are very rarely associated with prosthetic joints. However, our report details 5 patients who were referred to our academic medical center with *M fortuitum* PJI related to a contaminated water supply at an ambulatory surgical center. All 5 patients experienced symptoms within a similar postoperative timeframe and

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underwent repeat procedures prior to their referral. It should be stated, the repeat surgical procedures undergone by our patients varied prior to their referral to our center and their ultimate clinical course likely altered secondary to these differences. Likewise, the gold standard for PJIs remains a 2-stage replacement arthroplasty, and the often-overused course of antibiotics and wound care alone are insufficient for serious and chronic PJIs [11]. The goal of this series is to highlight this relatively uncommon yet devastating source of PJI. Detailing the clinical manifestations of these infections will help better inform and forewarn other clinicians. In addition, this index report serves to inform readers of the presentation and complexity of our current treatment strategies.

Case histories

Case 1

Patient 1 (Table 1) was a 61-year-old female with a past medical history (PMH) of gastroesophageal reflux disease, hypertension (HTN), obstructive sleep apnea, and osteoarthritis (OA). She was initially diagnosed with right knee degenerative joint disease and underwent right total knee arthroplasty (TKA). Within 2 weeks of her index surgery, she began experiencing pain, swelling, and serosanguineous/purulent drainage from her wounds. Three weeks postoperatively, she was started on oral cephalexin and trimethoprim-sulfamethoxazole. Her symptoms failed to improve with the antibiotic regimen. Two months postoperatively, she reported to her outside hospital (OSH) orthopaedic surgeon and was diagnosed with a PJI. Following her PJI diagnosis, she underwent a debridement, antibiotics, and implant retention (DAIR) procedure. In addition, her previous antibiotic regimen was discontinued, and she was started on intravenous (IV) amikacin, IV imipenem, and oral (PO) levofloxacin. Cultures taken during her DAIR procedure would eventually grow *M fortuitum*. The following month, she experienced continued surgical site drainage and wound dehiscence. Four months postoperatively, she underwent prosthetic removal and static cement block spacer implantation with continuation of her 3-drug antibiotic regimen. During this surgery, her previous implant components were found to be loose. Seven months postoperatively, an audiogram demonstrated hearing loss and resulted in the substitution of amikacin and imipenem for doxycycline and linezolid. Linezolid was subsequently discontinued secondary to nausea. She was referred to our hospital system 7 months after her index surgery for evaluation and management. Preoperative visits with our adult reconstruction orthopaedic surgeon and anesthesiologists were performed prior to her following surgery. At her initial orthopaedics office visit, her C-reactive protein (CRP) and erythrocyte sedimentation rate were noted as 0.61 mg/dL (normal < 0.5 mg/dL) and 21 mm/h (normal < 30 mm/h), respectively, and she was informed of a potential 2-stage surgical intervention. Nine months from the index surgery, she underwent irrigation and debridement with placement of a static antibiotic cement spacer using 2 grams vancomycin and 1.2 grams tobramycin per batch of cement. During this surgery, her joint was found to have extensive synovitis, purulent fluid, and extensive bone loss. Her white blood cell (WBC) count was found to be 11.6×10^3. After consulting with our infectious disease specialists, she was discharged on PO levofloxacin, PO linezolid, and IV imipenem with plans to continue this regimen for 3 months. At her postoperative clinic visit, her incision displayed a sub-centimeter region of dehiscence with underlying seroma. Given this finding, the decision was made to perform a repeat incision and drainage (I&D) with exploration of the deep fascia. Ten months from index surgery, she underwent a repeat I&D with retention of her antibiotic spacer to prevent further bone loss. During this third procedure, her joint fluid appeared noninfected with minimal synovitis which prompted the decision to retain the spacer so as not to incur any further bone loss that might complicate her ultimate reconstruction. During her most recent orthopaedics office appointment, her incision was healing with no dehiscence or drainage, and physical therapy was prescribed. During her most recent infectious disease appointment, her IV imipenem was completed, and she was continued on PO levofloxacin and linezolid.

Case 2

Patient 2 (Table 1) was a 55-year-old male with a PMH of HTN and chronic pain. He was initially diagnosed with OA and underwent right TKA. He noted immediate pain and swelling following his index surgery. Over the next 2 months, he complained of increasing pain, swelling, and wound dehiscence. Two months postoperatively, his OSH orthopaedic surgeon noted wound dehiscence and soft tissue necrosis. He was diagnosed with PJI and underwent I&D with hardware removal and placement of an articulating cement spacer the same month and was started on oral ceftriaxone. His antibiotic regimen was then broadened to vancomycin and cefepime after his operating room (OR) cultures were negative but gram-negative rods were found on Gram stain. Three months postoperatively, he clinically worsened, and a computed tomography scan of the right lower extremity showed loculated fluid collections with concern for abscesses and osteomyelitis. He subsequently underwent hardware and antibiotic spacer removal with articulating antibiotic spacer replacement. Operative cultures initially were negative for fungi but positive for acid-fast bacilli, prompting him to be placed on IV amikacin, IV imipenem, and PO levofloxacin. These cultures would eventually grow *M fortuitum*. Four months after his index procedure, he began to experience hearing loss, and his antibiotic regimen was changed to PO levofloxacin, doxycycline, and linezolid. He was referred to our orthopaedics and plastic surgery departments at this 4-month postoperative time point. During these initial visits, a 15-cm wound with granulation tissue, sinus tract, and purulence was noted over the anterior aspect of the right knee (Fig. 1) where a prior wound vac had been placed. He was taken to the OR 5 months after his index surgery and underwent I&D with placement of a temporary antibiotic (vancomycin/tobramycin) cement block, and wound vac due to the extent of devitalized tissue and bone loss encountered. During this procedure, extensive synovitis, purulence, soft tissue necrosis, tibial and femoral bone loss, collateral ligament loss, and sinus tracts were found. Following this surgery, he was started on IV imipenem, PO moxifloxacin, and PO linezolid after consulting with infectious disease. Three days later, he was taken to the OR for I&D and wound vac placement with plastic surgery. Four days later, he returned to OR for an additional I&D, placement of an articulating antibiotic (vancomycin/tobramycin) cement spacer, and wound vac placement. Postoperative images are shown in Figure 2. The following day, he returned to the OR with plastic surgery for a left latissimus dorsi free flap. At his most recent orthopaedics office visit, his flap was well healed (Fig. 3), and physical therapy was initiated.

Case 3

Patient 3 was a 71-year-old male with a PMH of coronary artery disease, cerebrovascular accident, prior myocardial infarction with stent placement, HTN, type 2 diabetes mellitus, and prior right total hip arthroplasty. He was diagnosed with left hip OA and underwent a direct anterior left total hip arthroplasty. Following his index surgery, he noted significant pain, wound breakdown, and loss of skin coverage of his surgical site within the first 4 weeks.

Table 1
Demographic information, clinical and labratory findings, antibiotics regimen, and surgical interventions.

Patient	Age	Sex	Comorbidities	Preoperative diagnosis	Joint	Time to PJI Dx (wk)	Culture results	Clinical findings	Operative findings	Laboratory findings	Abx regimen	Subsequent Sx intervention
1	61	F	HTN, OSA, GERD	DJD/OA	R Knee	4	*Mycobacterium fortuitum*	Pain, swelling, serosanguineous/ purulent, drainage, wound dehiscence	Purulence, synovitis, bone loss	WBC: 11.6 × 10(3)/mcL	1. Cefalexin, trimethoprim sulfamethoxazole 2. Amikacin, imipenem, levofloxacin 3. Levofloxacin, doxycycline, linezolid 4. Levofloxacin, doxycycline 5. Levofloxacin, linezolid, imipenem 6. Levofloxacin, linezolid	1. DAIR, liner exchange 2. Hardware removal, I&D,antibiotic spacer placement 3. I&D, spacer exchange 4. I&D
2	55	M	HTN, Chronic pain	DJD/OA	R Knee	8	*Mycobacterium fortuitum*	Pain, swelling, soft tissue necrosis, sinus tract, wound dehiscence	Purulence, soft tissue necrosis bone necrosis, bone loss, collateral ligament loss, sinus tract	CRP: 8.81 mg/dL	1. Ceftriaxone 2. Vancomycin, cefepime 3. Amikacin, imipenem, levofloxacin 4. Levofloxacin, doxycycline, linezolid 5. Imipenem, moxifloxacin, linezolid 6. Clofazimine, moxifloxacin, linezolid	1. I&D, hardware exchange 2. I&D, hardware removal,antibiotic spacer placement 3. I&D, wound vac placement 4. Latissimus dorsi free flap coverage
3	71	M	CAD, CVA, HTN, HLD, DM, GERD	DJD/OA	L Hip	14	*Mycobacterium fortuitum*	Pain, swelling, weakness, wound dehiscence, sinus tract, purulent drainage	Purulence, soft tissue necrosis, bone necrosis, sinus tract	CRP: 5.38 mg/dL	1. Amikacin, imipenem, levofloxacin 2. Imipenem, linezolid, levofloxacin, fluconazole	1. I&D, hardware exchange 2. I&D, hardware removal,antibiotic spacer placement, wound vac placement 4. Excisional debridement, elevation ALT myocutaneous flap placement, wound vac placement 5. Flap inset, extended trochanteric osteotomy, antibiotic spacer exchange
4	68	F	HTN, HLD,carotid stenosis, migraines	DJD/OA	R knee	4	*Mycobacterium fortuitum*	Pain, fever, erythema,swelling, malaise	Purulence, synovitis,bone loss, collateral ligament loss	WBC: 16.8 × 10(3)/mcL CRP: 31.8 mg/ dL ESR: 122 mm/h	1. Azithromycin 2. Amikacin, linezolid, levofloxacin 3. Amikacin, imipenem, levofloxacin 4. Linezolid, imipenem, ciprofloxacin 5. Imipenem, cilastatin, linezolid, doxycycline	1. I&D, hardware removal,antibiotic spacer placement 2. I&D, antibiotic spacer exchange
5	57	F	HLD	DJD/OA	R Knee	6	*Mycobacterium fortuitum*	Pain, wound dehiscence,draining fluid collections		CRP: 1.52 mg/dL ESR: 96 mm/h	1. Imipenem,doxycycline, levofloxacin, linezolid	1. I&D and liner exchange

ESR, erythrocyte sedimentation rate; OSA, obstructive sleep apnea; DM, diabetes mellitus; GERD, gastroesophageal reflux disease; CAD, coronary artery disease; CVA, cerebrovascular accident; HLD, hyperlipidemia; DJD/OA, degenerative joint disease/osteoarthritis.

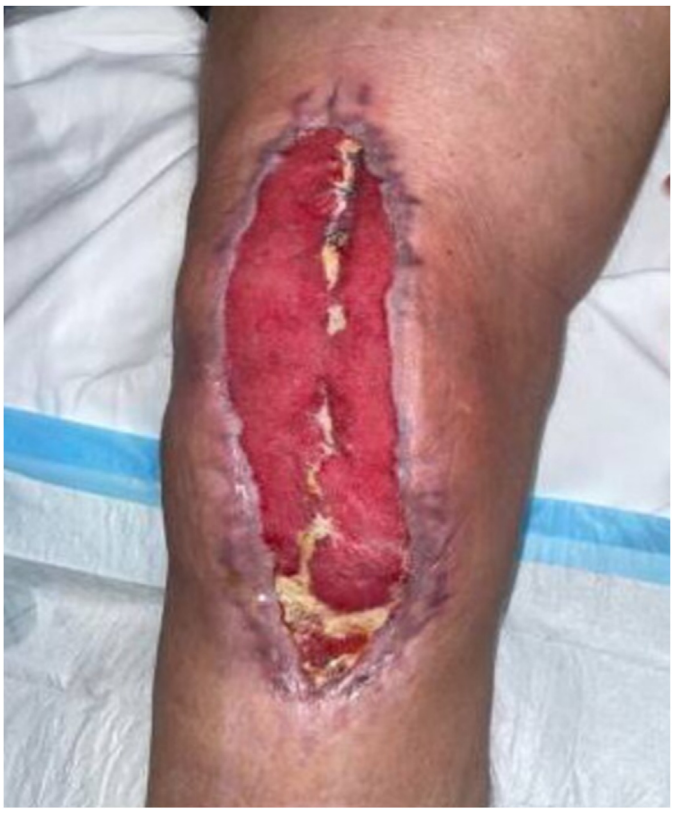

Figure 1. 15 cm wound over patient 2's right knee at the time of referral.

Approximately 3 months postoperatively, he was diagnosed with a left hip PJI and underwent an I&D with liner exchange. Cultures taken at this time were initially negative but eventually grew *M fortuitum*. Approximately 2 weeks later, he was found to have open draining wounds and taken for an I&D, hardware removal, antibiotic spacer placement, and wound vac placement. Following this procedure and the results of previous cultures, he was started on IV amikacin, IV imipenem, and PO levofloxacin. He was referred to our institutions' orthopaedic surgery and plastic surgery clinics 6 months after his index surgery. During his initial office visits, he was found to have a 15-cm dehisced wound with purulent drainage (Fig. 4), a CRP of 5.38 mg/dL, and X-rays indicative of a left hip periprosthetic fracture (Fig. 5). Seven months from index surgery, he was taken to the OR with plastic surgery and underwent excisional wound debridement of approximately 30 × 8 cm, elevation of an anterolateral thigh myocutaneous flap, and wound vac placement. During this procedure, caseous necrotic material was noted in the vastus lateralis muscle, a sinus tract extending into the hip joint, and infectious material surrounding the prosthesis were noted. One week later, he returned to the OR with the orthopaedic and plastic surgery teams for an I&D, extended trochanteric osteotomy, antibiotic (vancomycin/tobramycin) spacer exchange, and flap inset (Fig. 6). Cultures from this surgery grew *Staphylococcus epidermidis* and *Candida lusitaniae*. After infectious disease consultation, he was started on IV imipenem, PO linezolid, PO levofloxacin, and PO fluconazole. At the time of this report, 11 months after index surgery, his surgical site remained swollen with Jackson-Pratt drain containing serosanguineous fluid.

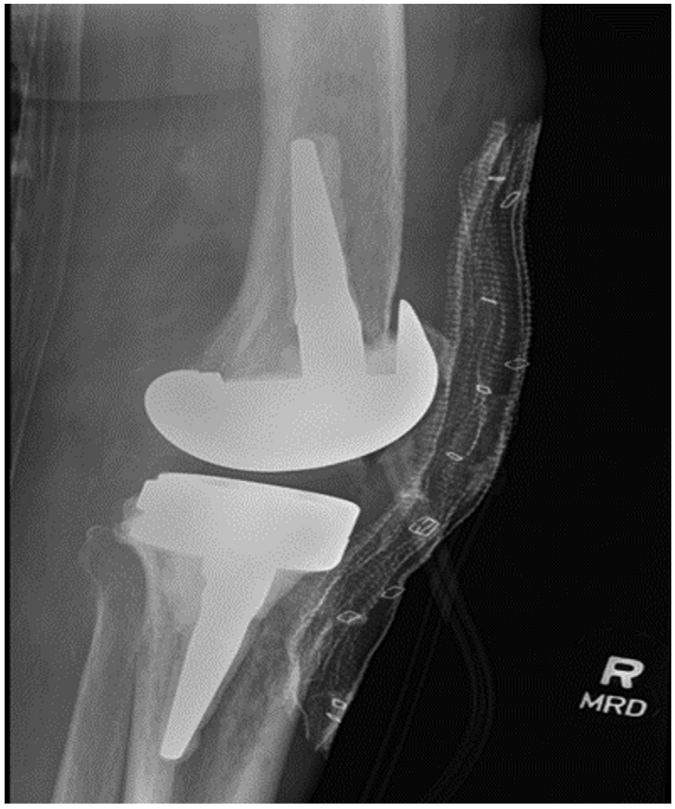

Figure 2. Right knee lateral X-ray of patient 2's most recent postoperative implants including a replacement antibiotic spacer.

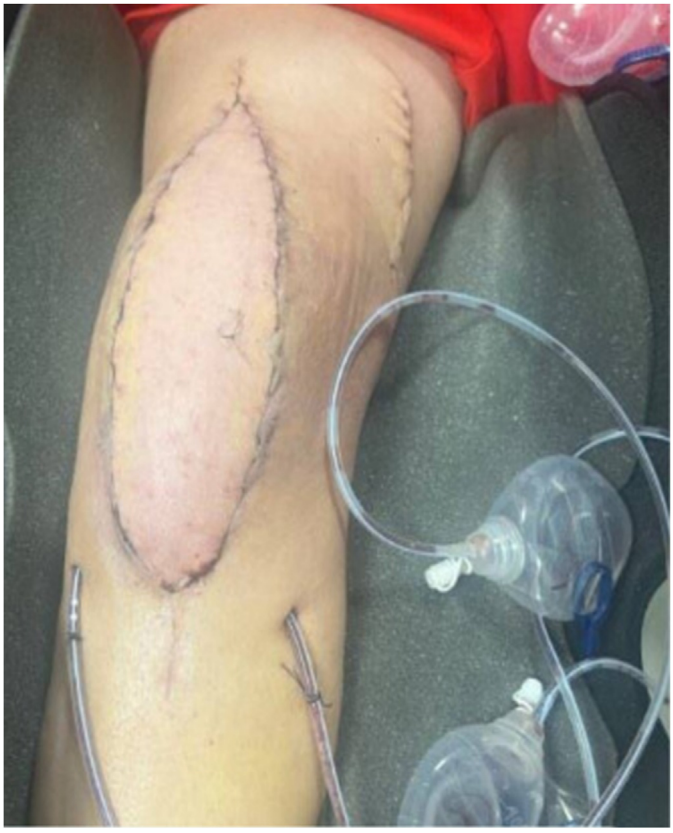

Figure 3. Patient 2's postoperative wound following flap coverage and drain placement.

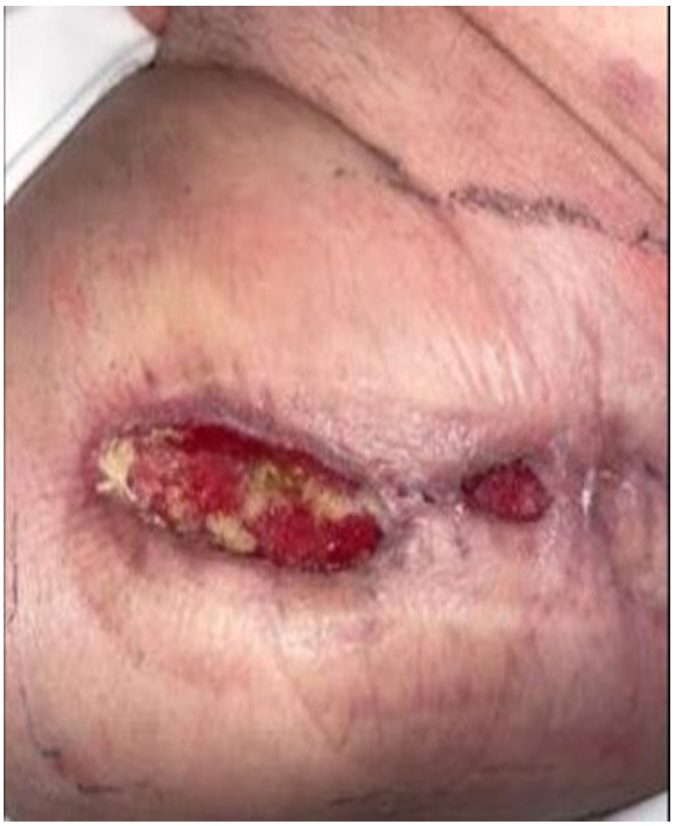

Figure 4. Patient 3's 15 cm wound dehiscence over left thigh.

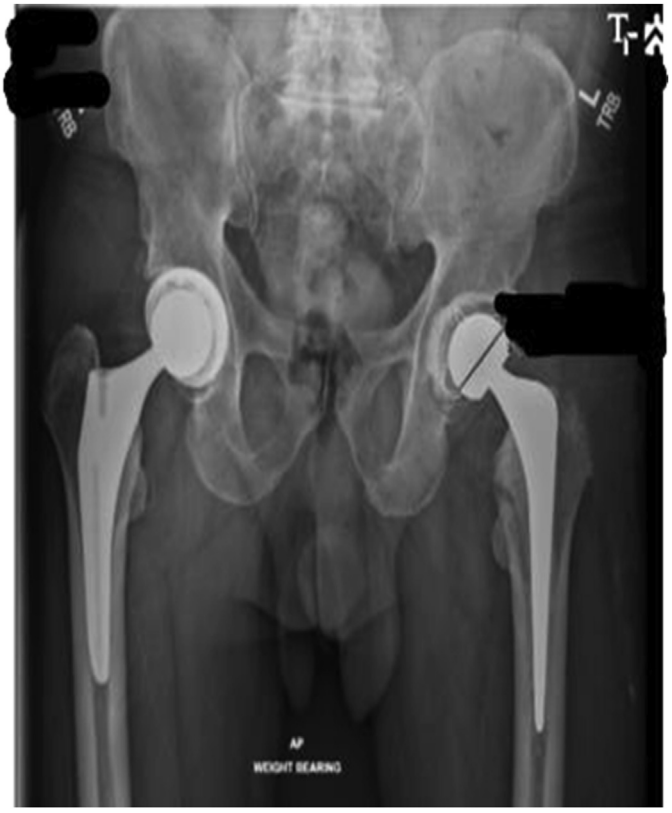

Figure 5. Anterior-posterior X-ray of the pelvis of patient 5 during their initial office visit. Note the left hip periprosthetic femur fracture.

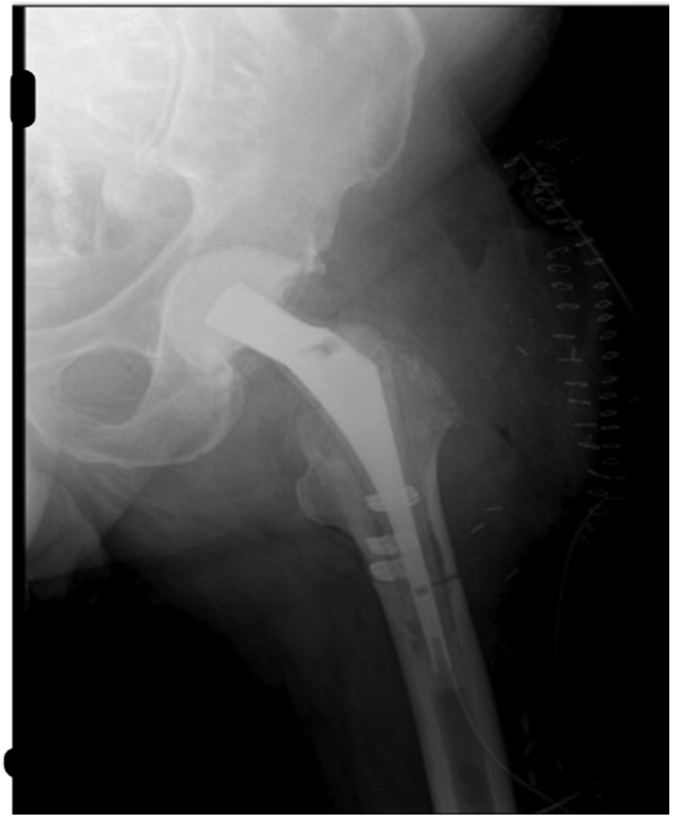

Figure 6. AP X-ray of the left hip showing patient 3's extended trochanteric osteotomy and antibiotic spacer exchange.

Case 4

Patient 4 was a 68-year-old female with a PMH of HTN, hyperlipidemia, carotid stenosis, and migraines. She was diagnosed with right knee OA and subsequently underwent right TKA. Two weeks following her index procedure, she was progressing well and had her staples removed at a clinic visit. One week later, she developed fevers, increasing knee pain, and erythema around her incision site. Her right knee was aspirated, and blood cultures were taken at an OSH. She was discharged in stable condition on PO azithromycin after her initial culture results showed no bacterial growth. One month postoperatively, she received a phone call stating her aspirate cultures had grown *M fortuitum*. She reported back to the OSH orthopaedic surgeon who performed her initial surgery where she was informed of plans for a 2-stage procedure beginning with an antibiotic spacer. The following week, she presented to our hospital's emergency department for a second opinion. The on-call orthopaedic resident documented reports of subjective fevers and general malaise. On examination, there was minimal incisional erythema (Fig. 7), and her right lower extremity was neurovascularly intact. Laboratory findings were significant for elevated CRP and WBC (Table 1). The patient declined repeat knee aspiration and ultimately returned to her OSH physician for a resection arthroplasty and antibiotic spacer placement 6 weeks after her index surgery. During this admission, she started on amikacin, linezolid, and levofloxacin. She was seen by her OSH infectious disease team who ordered a magnetic resonance imaging following her revision surgery due to a lack of clinical improvement, diffuse abscesses in the surrounding postsurgical site, and concern for osteomyelitis. These findings prompted transition to a regimen of amikacin, imipenem, and levofloxacin. Two months after her index surgery, she was admitted to

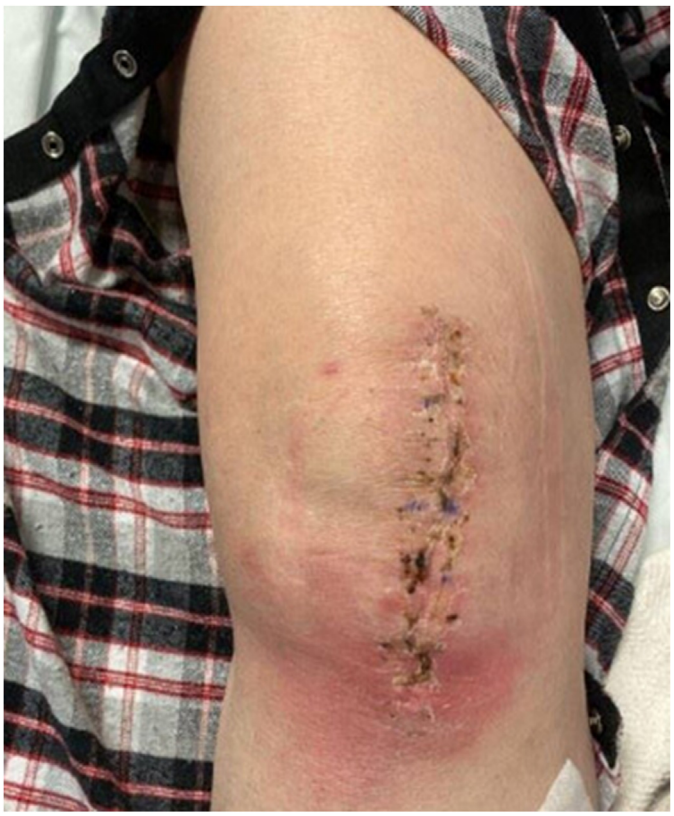

Figure 7. Patient 4's right knee at the time of initial consultation postoperatively.

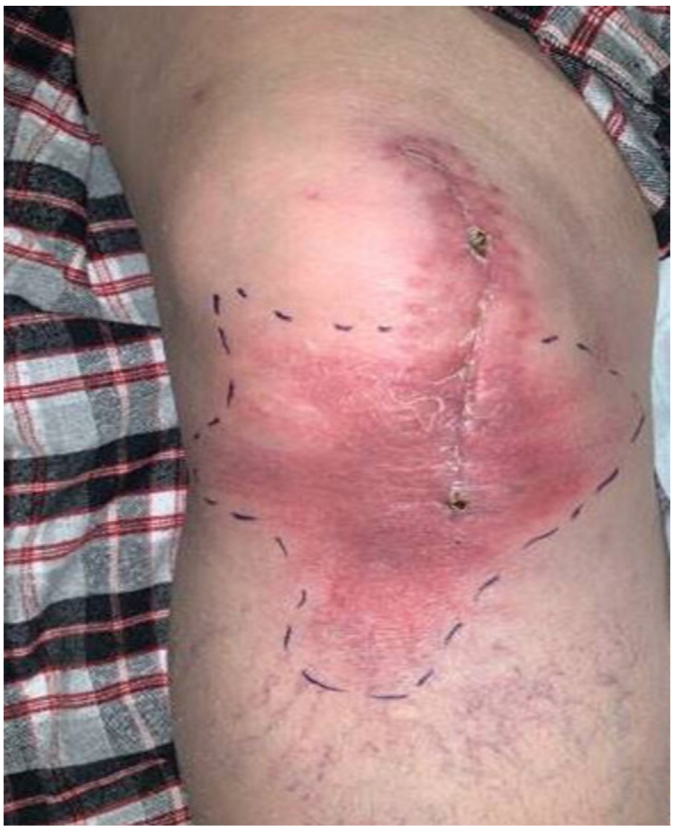

Figure 8. Patient 4's right knee showing worsening skin changes after their second consultation and admission.

our hospital with a sinus tract and worsened erythema (Fig. 8), and benign laboratory values. The following week, she underwent I&D with vancomycin and gentamycin antibiotic spacer exchange. Her intraoperative findings included extensive synovitis, purulent joint fluid, femoral and tibial bone loss, and incompetence of the medial collateral ligament. At the time of this article, the patient had been recently discharged from our hospital in stable condition to an inpatient rehabilitation facility with plans to continue imipenem, linezolid, and ciprofloxacin.

Case 5

Patient 5 was a 57-year-old female with a PMH of hyperlipidemia and right knee OA, for which she underwent right TKA. She was subsequently diagnosed with a culture-positive *M fortuitum* PJI and underwent I&D with liner exchange 2 months after her index surgery. She remained on long-term suppressive antibiotics following her revision surgery. She developed a purulent fluid collection near her right gastrocnemius muscle following her revision surgery. At the time of this article, limited medical history was available aside from a single office visit with our hospital's orthopaedics and infectious disease departments. On this visit, she reported receiving wound care and multiple unsuccessful hyperbaric oxygen treatments for her nonhealing wounds. She continued to receive IV imipenem and PO doxycycline and levofloxacin. Her examination was notable for 5 draining wound sites, poor soft tissue coverage over her surgical site, and a right Jackson-Pratt drain filled with serosanguineous fluid (Fig. 9).

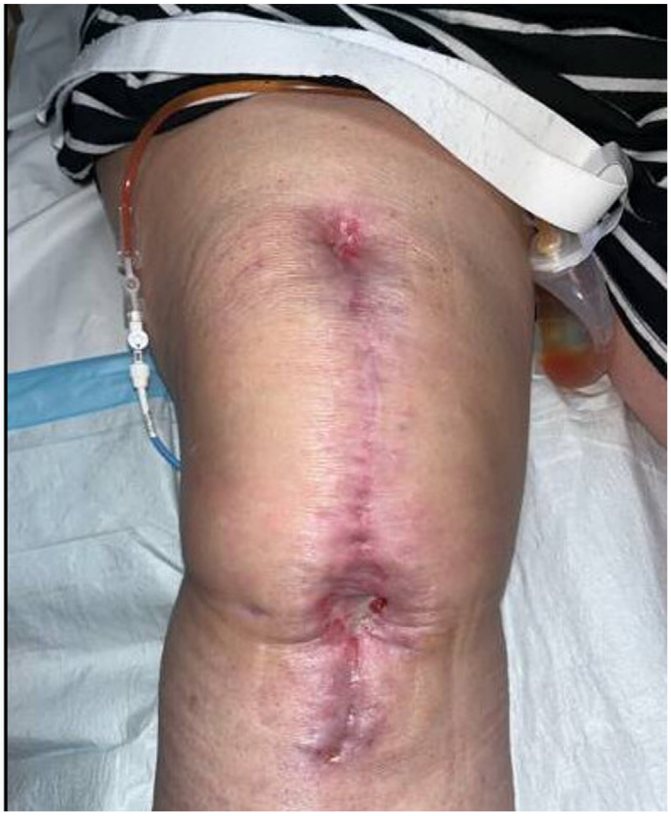

Figure 9. Patient 5's right knee during initial referral to our department.

Discussion

These cases highlight the devastating effects this rare infectious etiology of PJI can cause including significant bone and soft tissue

compromise. The degree of skin threatening in our population is striking. Four of 5 patients had evidence of wound dehiscence. Two of these patients had more than 15 cm of skin breakdown surrounding their surgical site. In addition, 4 had either active drainage from their wounds or a sinus tract communicating from their surgical site to the external environment. Even more alarming, 1 patient had obvious soft tissue necrosis at the time of consultation. In addition, our cohort suffered bony and ligamentous compromise including bone necrosis, femoral erosion, and collateral ligament destruction. The degree of soft tissue compromise in our cohort may be due in part to the multiple procedures undertaken on these patients prior to referral. However, all patients suffered draining wounds, severe erythema, purulence, overt wound dehiscence, or all the above before a second surgery was performed. This leads us to believe *M fortuitum*—associated PJIs have a predilection for soft tissue damage that, if not addressed quickly, can lead to devastating results. We believe a timely initial 2-stage revision provides the best opportunity for infectious process eradication, may minimize soft tissue sequelae, and potentially may have altered these patients' course. Unfortunately, due to the rarity of this specific pathology, its ultimate clinical course is still unknown. Even advanced, multistage interventions with medical and surgical co-management thus far have an unknown long-term trajectory.

Literature relating to *M fortuitum* PJI is sparse, consisting of mostly case reports and case series. Existing literature detailing *M fortuitum* and other NTM PJIs supports our findings with more than half occurring within 1 year of the index surgery, wound complications and drainage predominating the clinical findings, initially negative cultures, and relatively benign laboratory results [7,12,13]. Most telling is the degree to which an *M fortuitum* PJI results in soft tissue compromise. Similarly to our findings, the limited reports detailing *M fortuitum* PJIs focus on their persistent wound drainage, abscess formation, dehiscence/necrosis, and sinus tract formation [9,10]. Our findings are in line with that of current literature in that the clinical, mostly soft tissue, manifestations of *M fortuitum* are devastating and disproportionate to laboratory or radiologic findings. Regarding the cause of *M fortuitum* PJIs, water contamination at a surgery center has not previously been reported. However, water contamination of hospital water supplies has been linked to other *M fortuitum* infections such as dialysis peritonitis as well as contaminated surgical instruments [8].

The exact cause and ultimate resolution of the contaminated water supply at the ambulatory surgical center was not disclosed to the authors. Furthermore, we have not been made aware of any nonorthopaedic-related or nonarthroplasty-related *M fortuitum* infections from the center. In addition, how the surgical center identified their water supply as the source was not divulged. Speculation alone would be unfit to detail in this report. The information we have access to denotes that all 5 patients were operated on at the same ambulatory surgical center (ASC), over a 9-month period from February to November of 2023, and that the source was a water supply used for sterilizing surgical equipment. Although further detail is lacking, lessons can be learned from this report. The devastating complications seen in our patients highlight the need for proper quality control, sterile processing, and environmental precautions. State and federal agencies regulate ASCs, and the Centers for Medicare and Medicaid Services highlight the need for ASCs to implement water supply quality control measures in their state operations manual [14,15]. We recommend not only adherence to state and federal ASC regulations but also routine internal review of potential supply chain, employee, and local environmental factors that can lead to poor patient outcomes and their expeditious resolution prior to coming to fruition.

RGM species present similarly to typical PJIs in terms of pain and swelling near infection site and WBC elevation being nonspecific and nonsensitive [1,6,7]. However, they differ in important ways including RGM's predilection for early and prolonged PJI complication, poor sensitivity for erythrocyte sedimentation rate/CRP elevations, and lack of routine culture growth [1,7,12]. Importantly, reported culture results of all 5 of our cases were initially negative but later identified the presence of *M fortuitum* in multiple cultures, thus meeting Musculoskeletal Infection Society criteria for PJI [16]. This delay in diagnosis is likely related to the fact that RGM require specific culture mediums and an incubation period of up to 7 days, which is after most PJI specimens are discarded [17]. This begs the question: Should all suspected PJI cultures undergo a prolonged incubation with mediums capable of growing atypical organisms? In addition, as previously discussed, *M fortuitum* appears to have a predilection for clinical rather than laboratory or radiographic manifestations. Indolent and unyielding PJIs should alert the treating physician they may be dealing with an atypical, potentially highly resistant infectious etiology. Given our findings and those of other authors, *M fortuitum* should be considered if an early and prolonged PJI is suspected, there is a disproportionate degree of skin and soft tissue compromise, and routine culture mediums have failed to show growth of standard pathogens.

A limitation of our study is the nonuniform-based, and for some potentially nonevidence-based, treatment of our patients' PJIs prior to their referral to our center. The gold standard for an infected joint > 3-4 weeks after arthroplasty remains a 2-stage replacement arthroplasty [11,18-20]. A DAIR procedure remains a viable option during the acute (<3-4 weeks) postoperative period [18,19]. However, there is no role for antibiotics and wound care alone in PJI patients unless they are unfit for surgery. In patient 1, they likely had an acute PJI within the first 3 weeks postoperatively but only received oral antibiotics. In addition, 2 months postoperatively, they underwent a DAIR procedure rather than hardware explantation. Patient 3 had a chronic PJI with significant soft tissue compromise, yet only underwent I&D with liner exchange at 3 months postoperatively rather than complete hardware removal. Similarly, patient 5 was diagnosed with a PJI 2 months postoperatively but only underwent I&D with liner exchange. Patients 2 and 4 underwent complete hardware removal and antibiotic spacer placement when their PJIs were diagnosed and treated. It is unclear at this time whether these treatment differences will alter our patients' final clinical outcome. However, the differences will make drawing standardized conclusions on the correct *M fortuitum* treatment course difficult to define. In addition, the lack of following evidence-based treatment guidelines for hardware removal vs DAIR and the over-reliance on antibiotics and wound care alone brings into question how much the severity of the postoperative complications was related to the actual infection vs the treatment course.

The standard I&D does not appear adequate in a patient with an *M fortuitum* PJI. In our series, all patients had at least one irrigation and debridement surgery prior to referral. At the time of this report, our patients required an average of 3 additional surgeries related to complications following their index procedure. In a report by Fix et al., their patient had also undergone 2 additional surgeries including I&D and liner exchange followed by antibiotic spacer placement prior to referral to their center [9]. Our patients and those described by Fix et al. continued to have clinical and diagnostic findings consistent with a severe PJI after their I&Ds. Moreover, each of our patients was either followed by an infectious disease specialist prior to coming under our care or was referred to our infectious disease team upon arrival. In addition, 4 of the 5 patients in our series required co-management with our plastic surgery department. Therefore, when treating *M fortuitum* PJIs, I&D alone is insufficient, early plastic surgery and infectious disease co-management may be necessary, and to date, long-term outcomes

remain uncertain. If *M fortuitum* is grown on cultures, we recommend hardware removal regardless of time from index procedure. At this time, long-term outcomes for these patients are not available. However, we believe it is important to publish this rare discovery to increase awareness now. Long-term follow-up will be necessary to document outcomes and counsel future patients.

Summary

Identification of *M fortuitum* PJIs requires a high index of suspicion. Nontuberculous mycobacterial infections should be included in the treating physician's differential diagnosis when evaluating patients with indolent infections necessitating multiple revision surgeries, who have failed medical management, or whose initial cultures are negative. This report serves as a warning for the importance of quality control when placing hardware and the need for an outside-the-box approach when looking at atypical periprosthetic joint infection presentations.

Conflicts of interest

J. Ryan Martin received royalties from Enovis and restor3d; is a paid consultant for Enovis, restor3d, and DePuy. Stephen M. Engstrom received royalties from Enovis; is a paid consultant for Enovis and LinkBio; is in the advocacy committee of AAHKS and in the Coding Coverage and Reimbursement Committee of AAOS. Christina Fiske was a speaker for Insmed from July-October 2023; is no longer on speaker's bureau. All other authors declare no potential conflicts of interest.

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Informed patient consent

The author(s) confirm that written informed consent has been obtained from the involved patient(s) or if appropriate from the parent, guardian, power of attorney of the involved patient(s); and, they have given approval for this information to be published in this case report (series).

CRediT authorship contribution statement

Reece Vesperman: Writing – review & editing, Writing – original draft, Validation, Supervision, Project administration, Investigation, Conceptualization. **J. Ryan Martin:** Writing – review & editing, Validation, Supervision, Project administration, Methodology, Investigation, Formal analysis, Data curation, Conceptualization. **Logan Locascio:** Writing – review & editing, Investigation, Formal analysis, Conceptualization. **Christina T. Fiske:** Resources, Investigation, Formal analysis. **Jessica Rice:** Investigation. **Stephen Engstrom:** Writing – review & editing, Formal analysis, Data curation, Conceptualization.

References

[1] Ayoade F, Li DD, Mabrouk A, Todd JR. Prosthetic joint infection. Treasure Island, FL: StatPearls Publishing; 2021.
[2] Burr RG, Eikani CK, Adams WH, Hopkinson WJ, Brown NM. Predictors of success with chronic antibiotic suppression for prosthetic joint infections. J Arthroplasty 2022;37:S983–8.
[3] Geno Tai DB, Patel R, Abdel MP, Berbari EF, Tande AJ. Microbiology of hip and knee periprosthetic joint infections: a database study. Clin Microbiol Infect 2021;28:255–9.
[4] Wang FD, Wang YP, Chen CF, Chen HP. The incidence rate, trend and microbiological aetiology of prosthetic joint infection after total knee arthroplasty: a 13 years' experience from a tertiary medical center in Taiwan. J Microbiol Immunol Infect 2018;51:717–22.
[5] Parvizi J, Erkocak OF, Della Valle CJ. Culture-negative periprosthetic joint infection. J Bone Joint Surg Am 2014;96:430–6.
[6] Cheung I, Wilson A. Mycobacterium fortuitum infection following total knee arthroplasty: a case report and literature review. Knee 2008;15:61–3.
[7] Zulipikaer M, Li Z, Xu C, Fu J, Hao L, Chen J, et al. Non-tuberculosis Mycobacterium periprosthetic joint infections following total hip and knee arthroplasty: case series and review of the literature. Orthop Surg 2023;15:1488–97.
[8] Kothavade RJ, Dhurat RS, Mishra SN, Kothavade UR. Clinical and laboratory aspects of the diagnosis and management of cutaneous and subcutaneous infections caused by rapidly growing mycobacteria. Eur J Clin Microbiol Infect Dis 2012;32:161–88.
[9] Fix WC, Sheth NP, Braffman MN. Mycobacterium fortuitum prosthetic joint infection after total hip arthroplasty. JBJS Case Connect 2020;10:e0343.
[10] Herold RC, Lotke PA, MacGregor RR. Prosthetic joint infections secondary to rapidly growing Mycobacterium fortuitum. Clin Orthop Relat Res 1987:183–6.
[11] Saad T, Chen AF, Higuera CA, Parvizi J, Polkowski GG. 2022 American association of hip and knee surgeons symposium: periprosthetic joint infection. J Arthroplasty 2023;38:S45–9.
[12] Parvizi J, Tan TL, Goswami K, Higuera C, Della Valle C, Chen AF, et al. The 2018 definition of periprosthetic hip and knee infection: an evidence-based and validated criteria. J Arthroplasty 2018;33:1309–1314.e2.
[13] Tille PM. Bailey & Scott's diagnostic microbiology-E-book. Amsterdam, Netherlands: Elsevier Health Sciences; 2015.
[14] State operations manual appendix L -guidance for surveyors: ambulatory surgical centers transmittals for appendix L Part I -ambulatory surgical center survey protocol. https://www.cms.gov/Regulations-and-Guidance/Guidance/Manuals/Downloads/som107ap_l_ambulatory.pdf. [Accessed 20 May 2024].
[15] Ambulatory Surgery Centers | CMS [Internet]. www.cms.gov. https://www.cms.gov/medicare/health-safety-standards/guidance-for-laws-regulations/ambulatory-surgery-centers/ambulatory-surgery-centers. [Accessed 20 May 2024].
[16] Osmon DR, Berbari EF, Berendt AR, Lew D, Zimmerli W, Steckelberg JM, et al. Diagnosis and management of prosthetic joint infection: clinical practice guidelines by the infectious diseases society of America. Clin Infect Dis 2012;56:e1–25.
[17] Zmistowski B, Parvizi J. Identification and treatment of infected total hip arthroplasty. Expert Rev Anti infect Ther 2012;10:509–18.
[18] Trampuz A, Zimmerli W. Prosthetic joint infections: update in diagnosis and treatment. Swiss Med Wkly 2005;135:243–51.
[19] Qasim SN, Swann A, Ashford R. The DAIR (debridement, antibiotics and implant retention) procedure for infected total knee replacement – a literature review. SICOT J 2017;3:2.
[20] Mortazavi SMJ, Vegari D, Ho A, Zmistowski B, Parvizi J. Two-stage exchange arthroplasty for infected total knee arthroplasty: predictors of failure. Clin Orthop Relat Res 2011;469:3049–54.