# Management of the Infected Total Ankle Replacement

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Christopher Bibbo and Steven J. Kovach

## Introduction

Infection of a total ankle replacement (TAR) is one of the dreaded complications that face the surgeon. Infection after TAR has been demonstrated to result in TAR failure in greater than 50 % of cases and, as such, is considered a high-grade complication [1]. Although data that estimates overall deep periprosthetic infection rates for after primary TAR is poor, the risk being as high as 14 % [2], analysis of studies reveals that superficial infections (Fig. 25.1) range from 2.5 to 9 % [2–4]. When infection after TAR is stratified, deep periprosthetic infections may be less than 2 % [3]. Thus, the authors surmises that if data were available from a national TAR registry, the incidence of deep periprosthetic infection after TAR may be lower than previously reported, perhaps even lower than hip and knee arthroplasty, with factors such as overall surgeon experience, TAR volume, patient health inventory stratification/TAR indications, and health-care facility microbiogram data correlating with all complications, including infection.

Infections after TAR are categorized as superficial (simple soft-tissue infections), which are usually associated to some degree with wound healing problems, and deep infections. Deep periprosthetic infections are the focus of this chapter. Management of any deep periprosthetic infection requires a swift and thorough protocol with the primary goal being to save the lower extremity and then, if possible, the TAR prosthesis.

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## Prevention of Infection in Total Ankle Replacement Surgery

Any treatise on deep periprosthetic joint infection would be remiss if the prevention of infection was not discussed. It may be simply stated that the standard of care is to follow preventative measures in patients undergoing TAR.

### Preoperative Work-Up

All patients undergo a preoperative screening urinalysis with microbiologic assay, especially if the patient requires frequent catheterization. Urinary tract infection (UTI) must be treated prior to TAR surgery and repeat urinalysis performed to prove eradication of the UTI. Contrarily, the elderly female patients often acquire a state of "asymptomatic bacteriuria" (ASBU), where they have persistent proximal urethral and bladder colonization but do not exhibit signs and symptoms of a UTI. Although considered a "steady-state" condition and an unproven risk for deep periprosthetic joint infections at the time of surgery, the authors have seen so numerous late total hip and knee deep periprosthetic infections under these ASBU conditions that they believe the benefits of treating ASBU on the day of surgery as a potential source for a subacute or chronic deep periprosthetic infection far exceed blind neglect [5, 6]. Furthermore, the condition of ASBU has been recently recognized to a factor of multiple molecular traits and etiologies among different patient populations and, in relatively compromised hosts (e.g., diabetes mellitus), may progress to infection [7]. Thus, the authors will treat the condition with preoperative antibiotics and postoperative antibiotics while an indwelling bladder catheter is in place or intermittent catheterization may be needed [8] but proceed with the surgery. Indwelling bladder catheters inserted at surgery should be removed on the first postoperative day or as soon as feasible [9].


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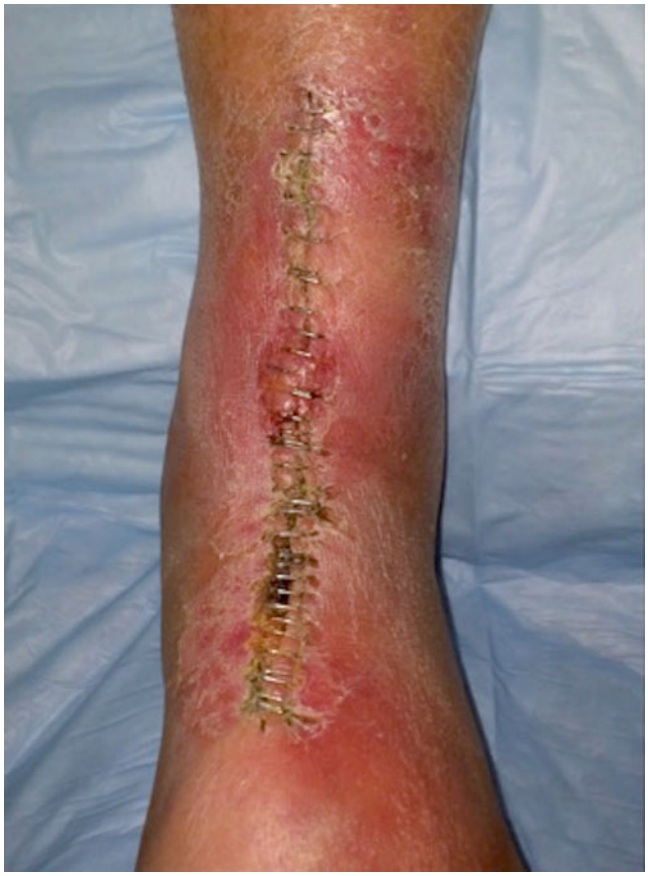

**Fig. 25.1** Cellulitis 3 weeks after primary total ankle replacement. Antibiotics should be started targeting skin flora or resistant organisms in high-risk/institutionalized patients and a work-up for deep periprosthetic infection initiated

Patients with a history of methicillin-sensitive *Staphylococcus aureus* (MRSA) are screened with swabs of the axilla, groin, and nares. Positive results are treated with topical mupirocin ointment in the nares and daily chlorhexidine washes of the axilla and groin for 2 weeks, followed by repeat swabs. Persistent positive swabs are referred to infectious disease specialists for further recommendations on systemic agents.

## The Operating Theater

Strict adherence to sterile technique is first and foremost. Common sense precautions, such as covering open instrument sets during operating room delays and following other Association of Operating Room Nurses (AORN) guidelines, are wise precautions. The use of HEPA-filtered body exhaust systems ("surgical hood and suit") to decrease infection rates as well as reduce room air contamination and therefore infection rates remains somewhat debatable [10], but it may provide a more comfortable operating attire for the surgeon. Laminar flow and ultraviolet (UV) room lights have not been consistent in hip and knee arthroplasty literature to reduce infections [11] and these have not been fully evaluated in the TAR literature. The authors does not utilize laminar flow, self-contained body exhaust suits, or UV light systems. However, the use of these techniques is still quite acceptable, and if hospital policy mandates utilization of these techniques, it is quite acceptable to implement them during TAR surgery. One item that has been recently evaluated is the amount of "traffic" in and out of the total joint operating room. Increased traffic in and out of the total joint operating room has been clearly shown to be a factor that can increase infection rates during total joint surgery and should be limited to essential personnel [12].

## Preoperative and Postoperative Antibiotic Prophylaxis

In general, patients should receive a first-generation cephalosporin within 1 h of skin incision (1 g cefazolin for adults up to 70–90 kg, 2 g for patients >90 kg, and 3 g for patients >120-kg). Antibiotics are re-dosed every 4–6 h. In patients who are penicillin/cephalosporin allergic, either clindamycin 900 mg or vancomycin 1 g is used prophylactically. In patients who have had a history of MRSA infection and colonization or are at high risk for developing MRSA, cefazolin and vancomycin are administered with the dosing noted above. Postoperatively, with exception of ASBU and MRSA history, antibiotics are discontinued after 36 h. ABSU and MRSA patients will continue their antibiotics for a full 10-day course if needed; oral agents such as tetracycline 200 mg twice daily may be used as an outpatient. When patients are on immune suppression agents for disorders such as rheumatoid arthritis, the lead authors has not found it necessary to hold disease-modifying agents or immune suppression agents in the perioperative period, unless the patient has a history of prior poor wound healing or infection after surgery [13].

## The Preoperative Skin Prep

Povidone-iodine 10 % is a popular skin prep but has come under scrutiny. Several randomized studies have demonstrated the superiority of chlorhexidine as a preoperative skin prep agent [14, 15]. The authors prefer a single-step chlorhexidine skin prep (Chloraprep, CareFusion, San Diego, CA) for patients who exhibit overall good foot and ankle hygiene. However, for those who have skin crusts, dry scaled skin, or suboptimal hygiene, the authors use a 4 % chlorhexidine 10-min scrub followed by an isopropyl alcohol 70 % rinse/pat-down. The toes are generally covered with sterile Coban (3M, St. Paul, MN) or Ioban (3M, St. Paul, MN).

In patients who have severe onychomycosis and large amounts of subungual debris, they undergo informed consent that all toenails will be removed as part of the prep process once they are under anesthesia. New skin cuts and scratches are prepped within the operative field and may be covered with Ioban dressing.

### Surgical Incision Care

The postoperative dressing may be simply a petrolatum/antibiotic ointment covered with sterile gauze and sterile cast padding and then plaster of Paris splinting. For "tight" or tenuous closures, an incisional negative pressure wound therapy dressing is applied and set at 50–100 mmHg for 1–3 days. Indwelling drains are used on all cases, and a multilayered closure is performed. New dressings are applied at the first postoperative office visit at 10–14 days, and from then, based on the wound condition (i.e., swelling, edema seepage, etc.), judicious ankle range of motion is initiated. When the incision is "sealed over" between 2 and 4 weeks, the patient is allowed to shower with a neutral-pH soap, followed by an antibiotic dressing and edema wrap. Any signs of redness are immediately reported to the surgeon office for evaluation.

## Deep Periprosthetic Infection of the Total Ankle Replacement

Deep periprosthetic infections are generally classified as "early" and "late." Indeed these are vague terms; thus, it has become commonplace to use 4 weeks as the cutoff for "early" or "acute" versus "late" infections. These numbers are not as arbitrary as previously thought. In general, 4–6 weeks postoperatively corresponds to the development of biofilms on the implants that are difficult to eradicate. Prior to this, the bacterial burden is in a more planktonic form, which is easier to eradicate and may allow for the retention of well-fixed prosthetic components, and the infection has not progressed to periprosthetic osteomyelitis. An infected TAR implies not only an infection of the fluids bathing the prosthetic components but also surface infection of the implant, as well as infection of intracapsular soft tissues and potentially infection of peri-implant bone (osteomyelitis). Management of the infected TAR is a combined medical and surgical venture. The diagnosis is not one of exclusion; rather, it should be sought in any patients with obvious clinical signs such as redness, fever, and pain, but patients with subclinical infection may present with night pain, low-grade fever, and malaise [16].

### Clinical Evaluation for an Infected Total Ankle Replacement

When a deep periprosthetic infection is suspected, joint aspiration utilizing sterile technique is the first step. Joint fluid is sent for gram stain and cultures: aerobe, anaerobe, acid-fast, and fungal cultures. If available, specimens that are negative on final cultures are held and 16-Svedberg-unit bacterial polymerase chain reaction (16s PCR) is performed. Fluid cell counts are included in the specimen and are a helpful guide to the clinician, but ultimately culture data is what clinicians should consider as the pivotal data to determine frank TAR sepsis. On occasion, joint aspiration may be scant or technically difficult. The instillation of sterile saline with in situ aspiration may assist to yield adequate fluid for gram stain and cultures. When a joint is difficult to enter, aspiration may be performed with fluoroscopic guidance. Empiric antibiotics may be initiated if symptomatology escalates during the interval between clinical evaluation and definitive treatment. This empiric outpatient therapy should be geared toward coverage of skin flora and common gram-negative organisms; patients with a history of MRSA colonization or infection should be treated with antibiotics to cover MRSA (e.g., doxycycline).

The authors typically admits the febrile patient with an obvious diagnosis of infected TAR and starts parenteral antibiotics to cover gram-positive and gram-negative organisms. Patients who are more prone to resistant organisms, such as a history of MRSA or previous resistant gram-negative infections, are started on vancomycin and levofloxacin. An infectious disease consult is a vital part of the management plan. Surgical irrigation and debridement is performed in the obvious infection and is performed emergently when the patient exhibits early signs of systemic inflammatory response or frank sepsis.

### Imaging of the Infected Total Ankle Replacement

Radiographs may demonstrate periprosthetic lucencies, but are not diagnostic of infection (Fig. 25.2a, b). Air fluid levels or gases in the soft tissues suggest the formation of gas by bacteria and, when accompanied with systemic signs of infection, is a surgical emergency. Otherwise, radiographs in subtle infections may be indeterminate.

Magnetic resonance imaging (MRI) may be useful in late infections that have collected copious fluid volumes and progressed to osteomyelitis, but one needs to keep in mind that bone changes on MRI may persist after surgery for up to 6 months; thus, if MRI is utilized, gadolinium enhancement

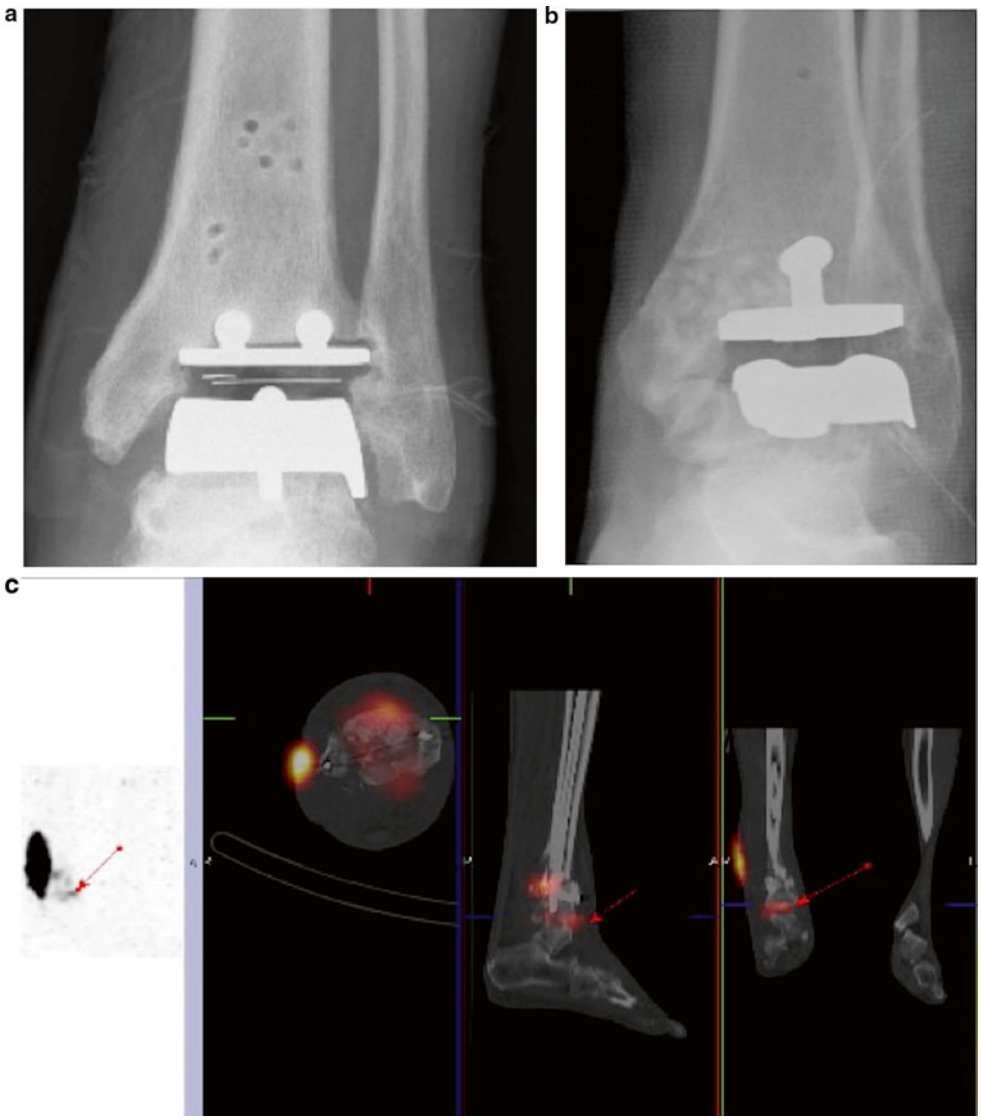


**Fig. 25.2** Radiograph of infected total ankle replacement with minimal changes on radiographs (**a**). Radiograph of total ankle replacement with changes within the medial malleolus suspicious for infection or avascular osteonecrosis. Indium-111 scan can assist in differentiating an infectious etiology (**b**). Indium-111 WBC scan complimented by color-enhanced spot computed tomography scan. In the depicted patient, bone infection is detected in the ankle and distal tibia away from the lateral soft tissues (**c**)

is mandatory. MRI is an excellent modality to search for abscess and phlegmon. Bone scintigraphy has limited predictability alone for detecting septic joint prosthesis, and (99m)Tc-ciprofloxacin imaging also does not differentiate well infection from aseptic inflammation [17]. Due to subtle differences between infection and white blood cell phagocytic activity related to polyethylene debris wear (a.k.a. aseptic inflammation), in order to maximize imaging accuracy and specificity, the authors always utilizes an indium-111 radionuclide scan in combination with a technetium scan (I-111/Tc99m dual window scan) [18]. Color-enhanced spot computed tomography imagery is helpful in chronic infection (Fig. 25.2c), as the uptake patterns of low-grade osteomyelitis may mimic periprosthetic lucency by phagocytic osteolysis due to polyethylene wear. Laboratory markers are ordered to follow trends in response to therapy. These include erythrocyte sedimentation rate (ESR), complete white blood cell count (WBC) with differential, and C-reactive protein (CRP). The use of procalcitonin has become common in medical patients but has still proven only to be useful in patients in the intensive care unit setting with occult sepsis.

## Surgical and Medical Management of the Infected Total Ankle Replacement

Operative irrigation and debridement must be thorough. The polyethylene insert is exchanged in acute infections with susceptible organisms; well-seated implants in acute infections may be retained, unless there is overwhelming joint sepsis. In this setting, as well as infections that are detected beyond 6 weeks, all prosthetic components are removed and antibiotic-loaded polymethylmethacrylate (PMMA) cement spacers or beads are utilized (Fig. 25.3a). After prosthetic

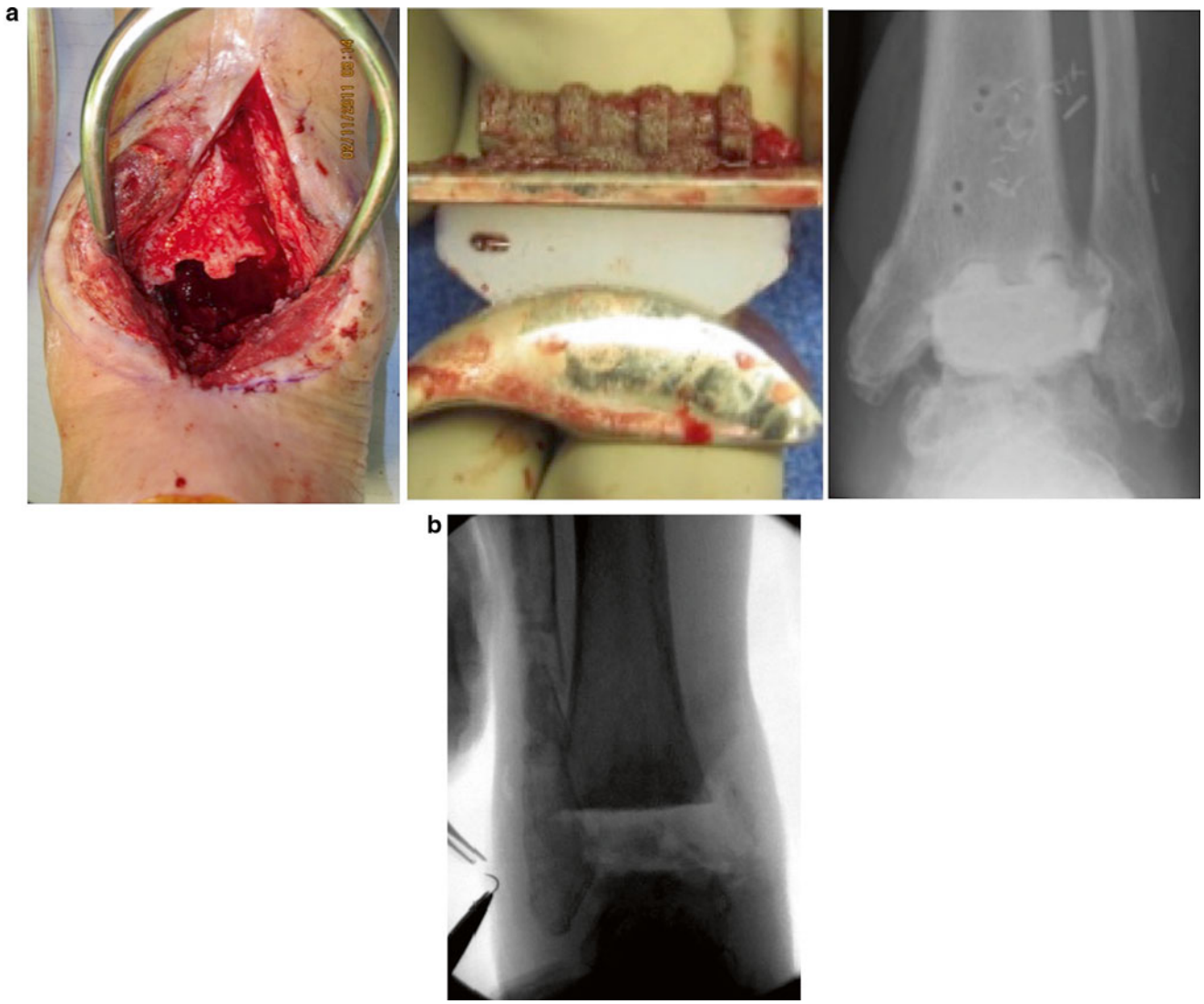


**Fig. 25.3** Infected total ankle replacement (*left panel*) that is easily explanted (*center panel*) and the residual osseous defect is filled with antibiotic-loaded polymethylmethacrylate cement spacer (*right panel*) (**a**). Bone resection should be kept to the minimum needed if replantation is planned. Explant of total ankle replacement and resection to clean bone margins after deep periprosthetic infection (**b**). Loss of the medial malleolus wound mandates its reconstruction prior to total ankle replacement replantation

component removal, bone is debrided judiciously. It is a fine line between retaining infected bone versus performing an overzealous resection of bone (Figs. 25.3b and 25.4); all devitalized soft tissue needs resection as well. Antibiotics used in PMMA cement must be heat stable [16, 19] and available in a lyophilized form. A complete list of antibiotics for PMMA- and calcium-based delivery forms is presented in Tables 25.1 and 25.2.

Since 2005, the primary authors has utilized negative pressure wound therapy treatments with direct instillation of antiseptics, such as sodium hypochlorite (Dakin's solution), in the setting of massive purulent and necrotizing infections. After being performed three to four times per day for 3–5 days, the instillation fluid may be then switched to a triple antibiotic solution, normal saline, various antibiotic solutions, or commercially available products that contain surfactants plus bactericidal preservatives, such as Prontosan (B. Braun Medical Inc., Bethlehem, PA) (Table 25.3). The authors has found that with negative pressure wound therapy installation regimens, the number of repeat debridements can be reduced.

In patients with suspected infection or suspected occult infection, the work-up may proceed with labs and imaging, as mentioned above. In suspected occult infections, antibiotics may be held until deep intraoperative cultures are taken. Prosthetic components that are removed may be sent for

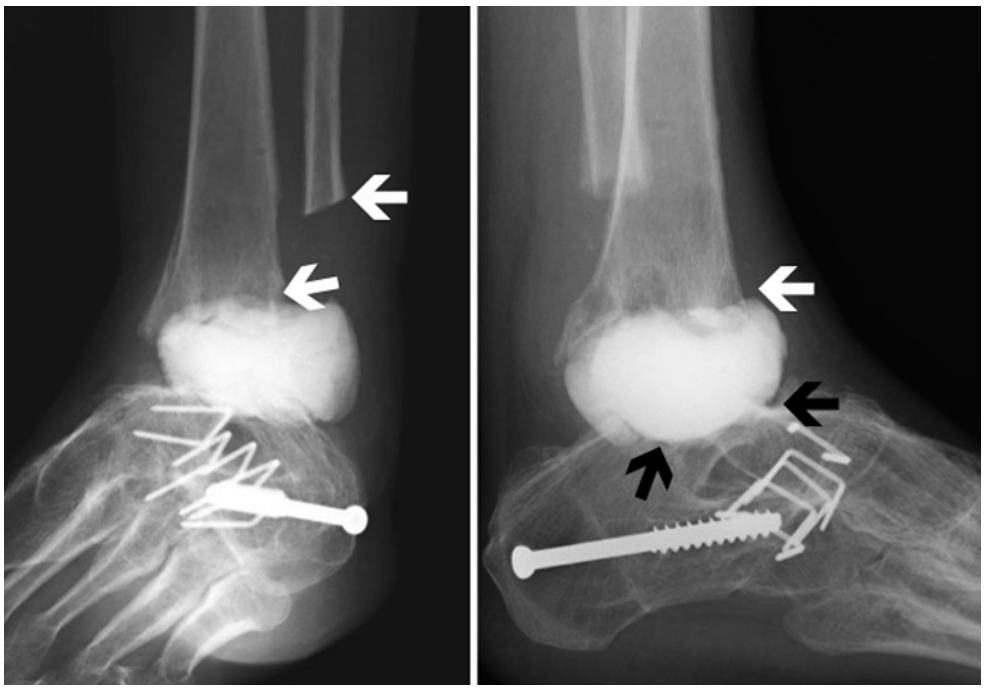

**Fig. 25.4** Antibiotic-loaded polymethylmethacrylate cement spacer after explant of infected total ankle replacement. Note the bone loss on both the tibia and fibula (*white arrows*) and the near total loss on the talar side (*black arrows*). This setting mandates a fusion with reconstitution of the bone that has been resected to maintain functional limb length

**Table 25.1** Antibiotics (Abx) compatibility with polymethylmethacrylate (PMMA)

| Abx mixable w/PMMA (heat stable) | Decreased activity (heat unstable) | Curing decreases activity | Tips |
|---|---|---|---|
| Amikacin | Chloramphenicol; colistimethate; tetracyclines; quinupristin/dalfopristin | Liquid gentamicin and clindamycin; Rifampicin | ABX elute better from spacers, beads, rods with micro-imperfections: |
| Amoxicilli | | | 1. Hand mix |
| Ampicillin | | | 2. No vacuum |
| Amphoteracin-B | | | 3. need an extra bottle of PMMA monomer for beads, spacers, rods |
| Bacitracin | | | 4. ABX elute better when combinations of different ABX are used |
| Cefamandole cefazolin | | | |
| Cefuroxime, cefuzonam | | | |
| Cephalothin | | | |
| Ciprofloxacin | | | |
| Clindamycin (power) colistin | | | |
| Daptomycin | | | |
| Erythromycin | | | |
| Gentamicin (powder) lincomycin | | | |
| Methicillin | | | |
| Novobiocin | | | |
| Oxacillin, penicillin | | | |
| Polymyxin B | | | |
| Streptomycin | | | |
| Ticarcillin | | | |
| Tobramycin, vancomycin | | | |

**Table 25.2** Suggested antibiotic delivery ratio developed by the authors for use in PMMA

| Antibiotic | Dose for prosthesis fixation | Dose for spacers, beads, rods |
|---|---|---|
| Amikacin | 1 g | 2 g |
| Amoxicillin | NR | Quadruple standard dose† |
| Amphotericin-B (1-2× total QD IV dose [0.5–1.5 mg/kg]) (j.) | 0.5–1.5 mg/kg (?) | 0.5–1.5 mg/kg |
| Bacitracin | NR | Quadruple standard dose† |
| Cefamandole (Mandol®) | NR | Quadruple standard dose† |
| Cefazolin (Ancef®) | NR | 4–8 g |
| Cefotaxime (Claforan®) | 3 g | 4–6 g |
| Ceftazidime (Fortaz®) | NR | 10–16 g [3 g in 20 g Palacos] |
| Cefuroxime (Ceftin®) | 1.5–3 g | 6–9 g |
| Cephalothin | NR | Quadruple standard dose† |
| Ciprofloxacin (powder for oral suspension) | NR | 1 g |
| Clindamycin | NR | 4–8 g |
| Colistin (polymyxin E) (comes in 150-mg vial) | NR (NL dose =2.5–5 mg/kg/day) | Quadruple standard dose† |
| *Potentially heat unstable! | MDR *Acinetobacter* two million units/day (k.) | MDR *Acinetobacter*: add rifampin (Osteoset) and doxycycline (Osteoset) |
| Daptomycin | NR | Quadruple standard dose† |
| Erythromycin | 0.5–1 g | 2–4 g |
| Fluconazole | 400–800 mg | 400–800 mg |
| Gentamicin | 1 g | 2–5 g |
| Linezolid (Zyvox®) | NR | 2.4 g |
| Lincomycin | NR | Quadruple standard dose† |
| Methicillin | NR | Quadruple standard dose† |
| Novobiocin | NR | Quadruple standard dose† |
| Oxacillin | NR | Quadruple standard dose† |
| Polymyxin B | NR | Quadruple standard dose† |
| Quinupristin-dalfopristin (Synercid®) | Unstable in PMMA: use Osteoset® | 2 g in 50 $cm^3$ D5 into Osteoset®‡ |
| Rifampin | Unstable in PMMA, use Osteoset® | 2.4–3 g into Osteoset® ‡ |
| Streptomycin | NR | 7 g |
| Ticarcillin (Timentin®) | Not appropriate | 5–13 g |
| Tobramycin (Nebcin®) | 1.2 g | 2.4–9.6 g |
| Vancomycin | 1 g (powdered vancomycin) | 3–9 g (powdered or lyophilized) |

† Osteoset and is Wright Medical Technologies, Inc., Arlington, TN

direct cultures. If all fluid and tissue is negative, 16s bacterial PCR is performed and the prosthetic components are sonicated. The sonicant fluid is centrifuged and cultured and 16s PCR performed. Sonication is a method to remove biofilms and "uncover" hidden pathogens embedded in complex bacterially protective biofilms [20].

Parenteral antibiotics are the author's preference, as monitoring of dosing (i.e., patient compliance) is easier and a broader range of options exists. Oral antibiotics are acceptable in low-virulence infections. All antibiotic therapy is guided by the results of deep intraoperative cultures. Therapy should last 6–8 weeks and the ESR and CRP followed biweekly. All antibiotics have serious, even life-threatening side effects that may affect nearly every organ system. Thus, patients need routine clinical follow-up to assess for antibiotic-related side effects. Signs of systemic antibiotic toxicity are monitored clinically and with laboratory data (i.e., basic metabolic panel for creatinine and liver enzymes for antibiotics cleared by the liver). Diarrhea is worked up with *C. difficile* toxin assays. Lethargy and nausea should prompt an evaluation for antibiotic-induced neutropenia or even potentially fatal neutropenic enterocolitis [21]. All these parameters are coordinated with the infectious disease team.

## Replantation of the Total Ankle Replacement after Infection: When Is It Possible?

Timing of TAR reimplantation after infection is critical, with a need for maximum antimicrobial treatment and resumption of patient function. In general, prosthetic joint replantation should not be performed until after a 6–8-week course of antibiotics is completed and subsequent operative cultures are negative and laboratory data normalized. Revision TAR after infection requires that the benefits outweigh any further risks.

**Table 25.3** Antibacterial solutions that are effective agents with negative pressure wound therapy installation

| Solution | Active ingredients | Notes | Uses |
|---|---|---|---|
| Marshfield | 0.1 % clindamycin (200 mg per 1.33 mL) | Refrigerate up to 90 days | Acute and chronic infections |
| Clinic triple-antibiotic solution[a] | 0.1 % gentamicin 200 mg per 5 mL | | |
| | 0.005 % polymyxin B (2×500,000 unit vial); sterile $H_2O$ to expand to 200 mL | | |
| Dakin's solution | Buffered sodium hypochlorite (NaClO) | Use 25 % or 50 % strength | Acute purulent infections, necrotizing fasciitis, MRSA; Use for only 3–5 days |
| Vancomycin 1 % | Vancomycin | | Methicillin resistant |
| | | | *Staphylococcus* species |
| Dilute acetic acid (5 %) | Acetic acid (CH3 COOH) | | Good for *Pseudomonas* contaminations and reduce surface bioburden |
| Prontosan®[b] | Polyhexanide (PHMB) and betaine (surfactant) | FDA approved with VAC® | Noninfected wounds with high bioburden/surface biofilms, prevent wound desiccation |
| Normal sterile saline | Normal sterile physiologic saline solution | | Prevent wound desiccation; minor bioburden reduction |

Most are used every 6–8 h with a dwell time of 30 min
[a]Developed by Michael Caldwell, M.D., Ph.D., F.A.C.S., Marshfield Clinic, Marshfield, WI
[b]R. Braun Medical, Bethlehem, PA; FDA approved with Veraflow® VAC® (KCI, San Antonio, TX)

Requisites to be fulfilled include eradication of the infection from soft tissues and bone, adequate residual bone stock of good quality, and the other surgical site characteristics that are required for a primary TAR.

The question arises at replantation whether antibiotic-loaded PMMA should be used to secure the prosthetic components especially if there is a need for implant support and to provide a local repository for antibiotics. From a microbiologic standpoint, the authors believes that some benefit may be derived from antibiotic-loaded PMMA cement. However, the antibiotic must be more than one, have broad coverage including the previous offending organisms, and be prepared in a manner to achieve very high minimal inhibitory concentration (MIC). The downside of antibiotic-loaded PMMA is that the strength characteristics of PMMA are lowered with the addition of high levels of antibiotics. Further TAR failure, be it from infection or component-related failure, creates a scene of difficult extraction, with the usual result of bone being removed along with the PMMA cement. Techniques to avoid excessive bone removal, such as ultrasonic bone cement removal systems (Oscar, Orthosonics, Edinburgh, UK), are best suited to a cortical bone/PMMA cement interface. Thus, antibiotic-loaded PMMA cement is best used judiciously. Temporary "biologic" cements may be used with clinician-determined amounts of antibiotic to allow the fill of voids [22].

Replantation of a TAR after infection may be embarked upon if after 6–8 weeks of culture-specific antibiotics, serum markers (i.e., ESR and CRP) have normalized and residual infection has been effectively ruled out by indium-111/Tc-99 m dual window scans (Fig. 25.2) and surgical biopsy of bone and soft tissue with cultures and 16s PCR. The soft-tissue envelope must be cared for or reconstructed as described elsewhere in this textbook. Custom TAR components vary by manufacturer so the authors considers the INBONE and INBONE II total ankle replacement system (Wright Medical Technologies, Inc., Arlington, TN) to be a satisfactory revision choice with bone loss. Other qualifications for replantation include a stable soft-tissue envelope and a thorough assessment of the value of TAR replantation over ankle or tibio-talo-calcaneal arthrodeses.

At times, a compromised host, highly virulent multidrug-resistant organisms, massive bone loss, or an unstable soft-tissue envelope prohibits the replantation of a TAR. In this setting, complex fusion procedures may be performed, a variety of which exist. A common choice is retrograde intramedullary fixation. Placing such a device is feasible after infection, but to avoid secondary infection of the intramedullary device (Fig. 25.5), the protocol described by Bibbo et al. [23] should be followed.

When bone loss is present and structural bone is required for a late reconstruction, several options exist. The authors prefers to utilize fine-wire circular external fixation and autologous bone grafting (Fig. 25.6). Fine-wire circular external fixation with bifocal compression/distraction osteogenesis avoids permanent metallic implants in the previously infected field and can assist with compensating for bone loss up to 5 cm (Fig. 25.7). Patients at extreme high risk for nonunion may require vascularized bone graft procedures, such as vascularized free fibula or free iliac crest (Fig. 25.8) or free fibula (Fig. 25.9) [24]. The authors' preferred fixation technique in conjunction with free

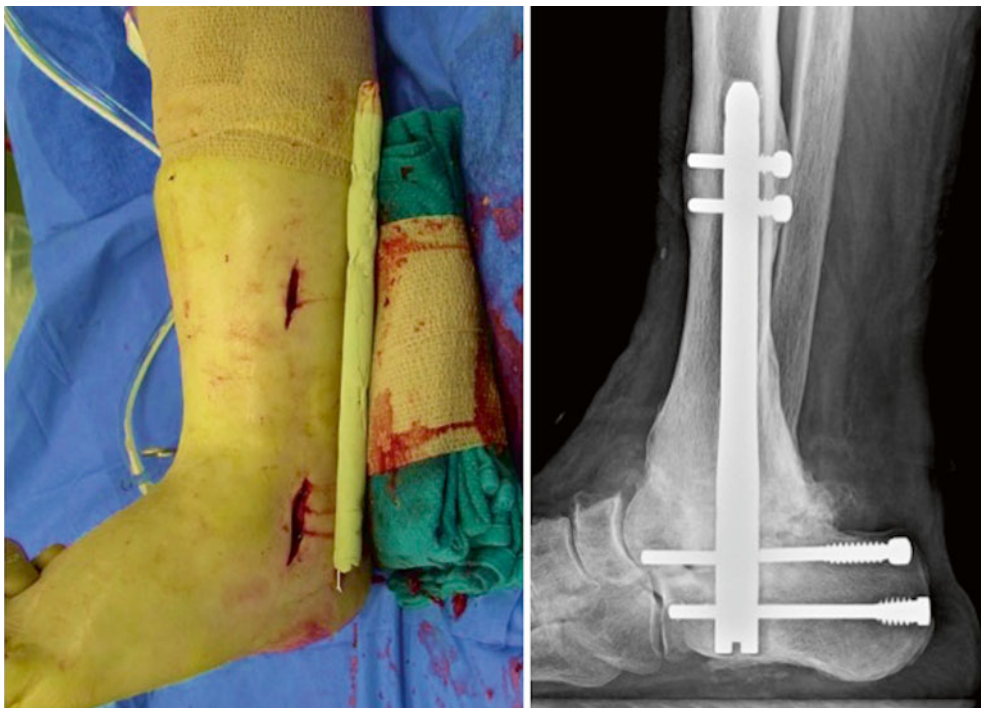

**Fig. 25.5** Extended ankle fusion with retrograde intramedullary nail (*right panel*) after surgical cultures was negative following serial debridements, culture-specific systemic antibiotics, and exchanges of the antibiotic-loaded polymethylmethacrylate cement impregnated nail (*left panel*)

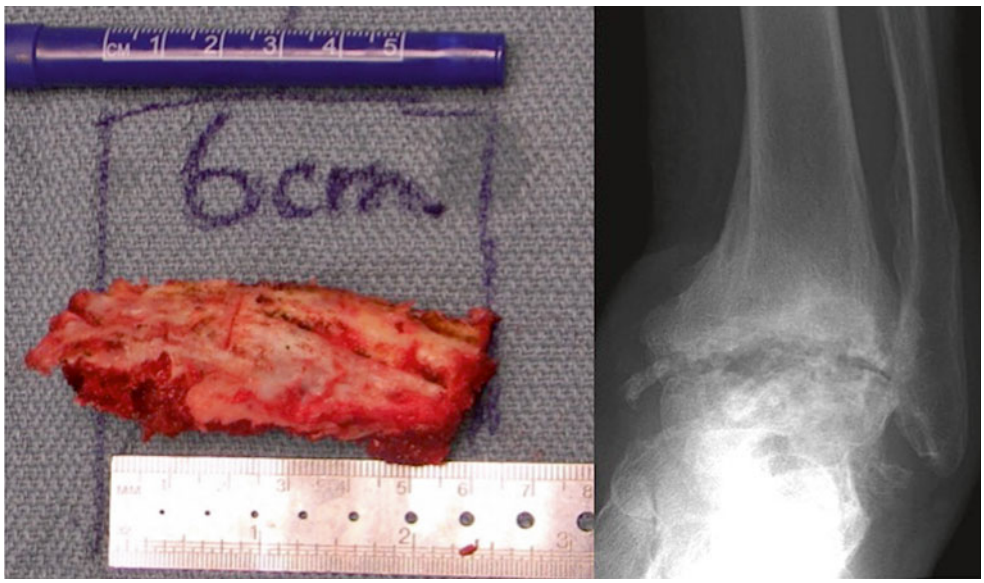


**Fig. 25.6** Intraoperative photograph of a 6-cm autologous iliac crest bone graft. Typically, a single 6-cm graft combined with banked bone and rhBMP-2 will suffice for the ankle radiograph shown on the *right* that demonstrates both talar and tibial plafond bone loss. For massive local bone loss, the authors has used non-vascularized grafts as large as 9 cm from each iliac crest to salvage to the ankle after deep periprosthetic infection

vascularized bone graft remains fine-wire circular external fixation; internal fixation may be used but not in the face of residual infection.

## Conclusions

Infections following total ankle replacement are a serious complication, about which there is little information in the current literature to guide diagnosis and treatment. Infections are classified as acute postoperative, late chronic, or remote hematogenous. Prosthesis removal for infection following primary or revision total ankle replacement along with a thorough debridement and parenteral culture-driven antibiotic therapy are the mainstay of treatment. Only a limited number of patients who develop a deep periprosthetic infection following primary or revision total ankle replacement can expect to undergo successful joint-preserving revision total ankle replacement. Instead, ankle or tibio-talo-calcaneal arthrodesis usually with significant volumes of bone graft is

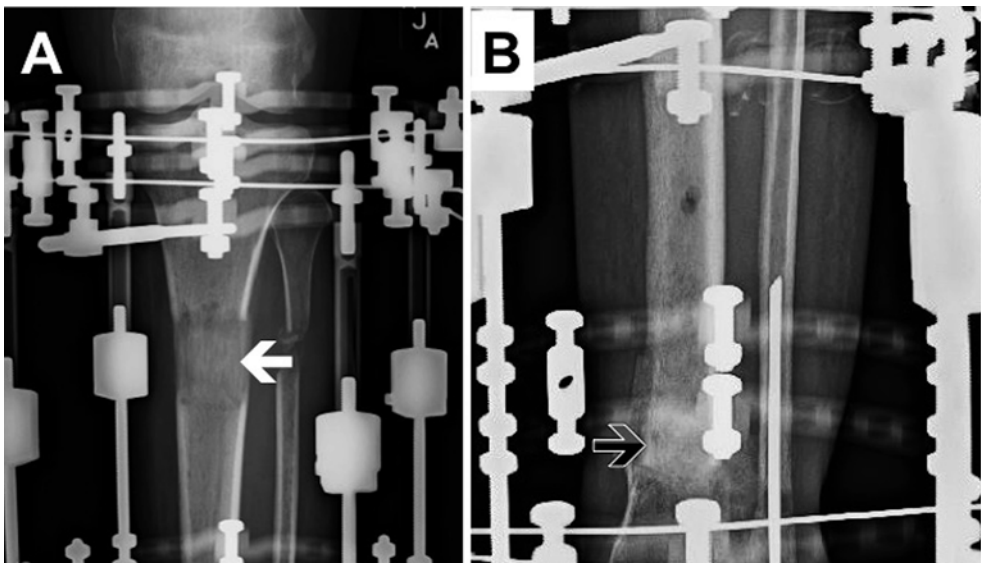


**Fig. 25.7** Radiograph of bifocal Ilizarov technique (*white arrow*) for 4-cm bone loss. Proximal distraction osteogenesis is carried out (**a**, *white arrow*) at the same time as distal compression osteogenesis (**b**, *black arrow*)

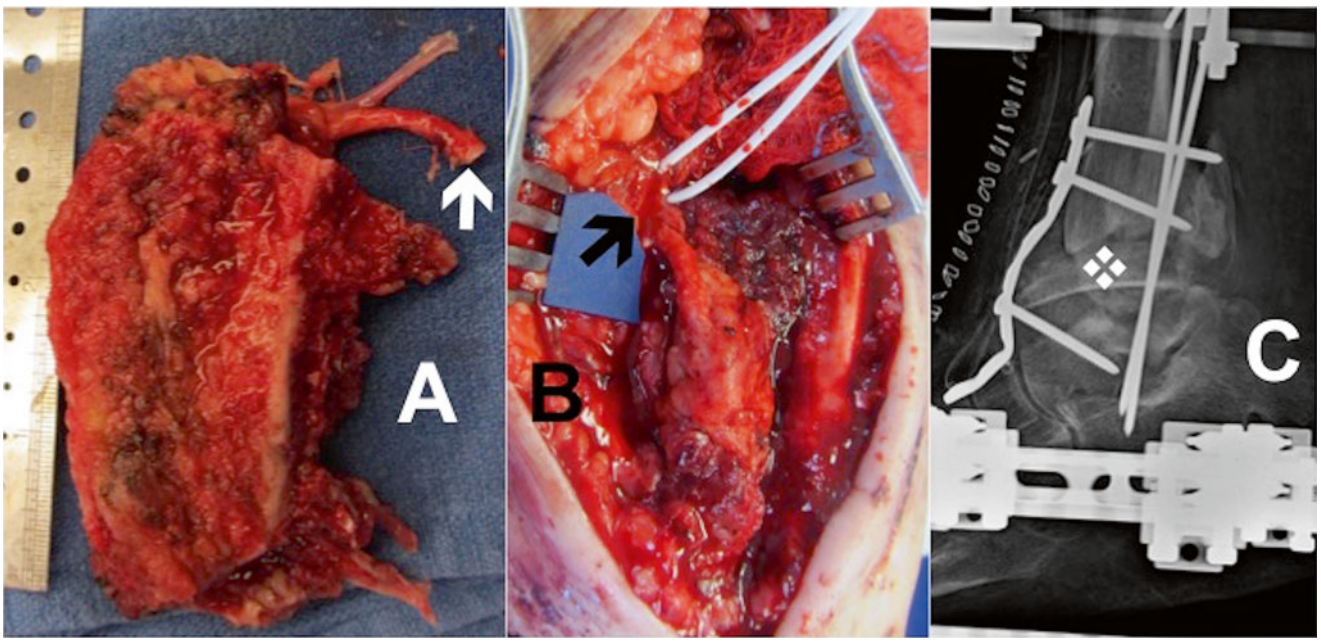


**Fig. 25.8** Free vascularized iliac crest bone flap to treat a recalcitrant nonunion for limb salvage after explanted total ankle replacement. Free flap with pedicle (**a**, *arrow*); inset of bone free flap with anastomosis to tibialis anterior vessels (**b**, *arrow*); radiograph of free bone flap (**c**)

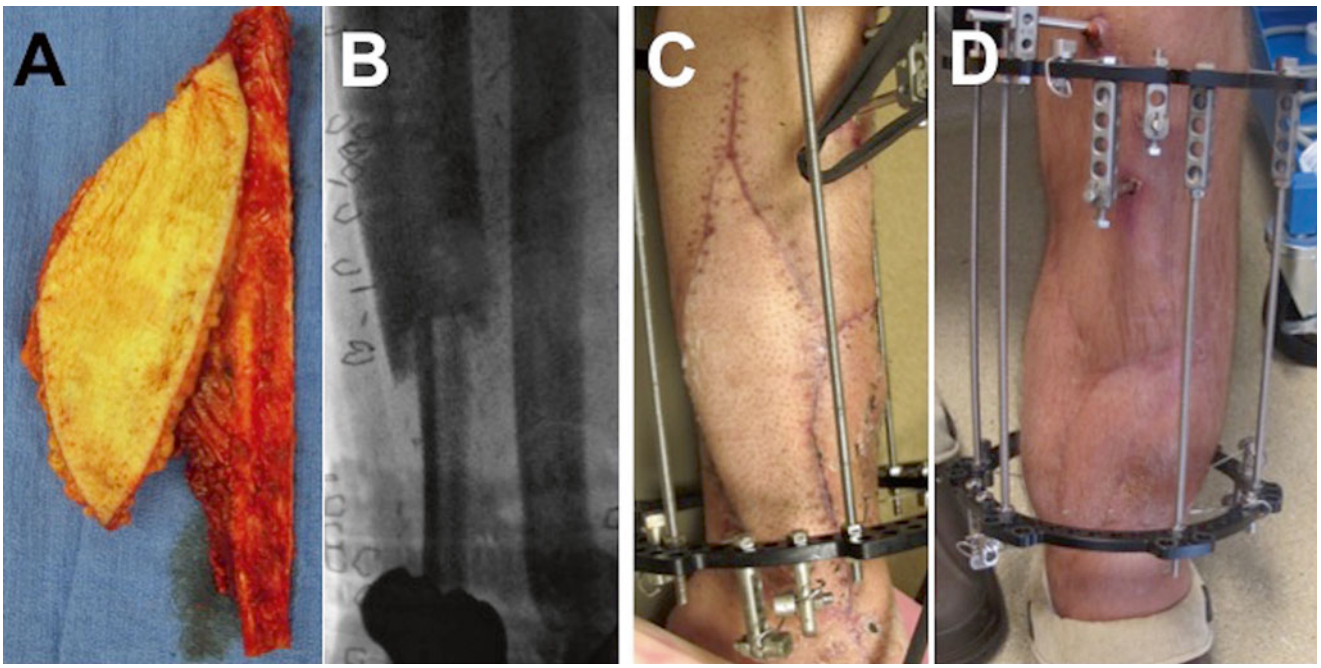


**Fig. 25.9** Free fibula osteocutaneous flap for limb salvage after severe distal tibial bone loss and anterior/medial soft-tissue loss after an infected total ankle replacement with massive wound complications. Intraoperative photograph of the harvested fibula osteocutaneous flap (**a**). Intraoperative image intensification view of free osteocutaneous flap in place (**b**). Lateral (**c**) and anterior (**d**) clinical photographs at 6 months postoperatively with external fixation system in place

required to obtain a functional limb. Given the morbidity of infected total ankle replacement, careful consideration should be made about performing these procedures in patients with multiple prior surgeries and comorbidities that predispose to wound healing difficulties. Prompt diagnosis and involvement of a multidisciplinary care team is essential to a successful outcome.

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