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Troubleshooting a Difficult Trans-Tibial/Fibula Amputation: A Case Report

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Abstract

Necrotic feet secondary to vascular compromise in the diabetic patient may require an emergent guillotine amputation. Unrecognized, retained hardware in a distal ankle years after fracture repair may complicate the intraoperative guillotine amputation at the transtibial/fibula level. Troubleshooting such an unexpected surgical problem is not necessarily straightforward depending on the clinical situation. Presented is a case report where a patient with a necrotic burned foot failed to inform the burn team that he had implanted ankle hardware, prior to his surgical intervention. A successful amputation was completed after proceeding down a specific algorithm devised for such a scenario.

Keywords

Guillotine Amputation, Difficult Amputation, Amputation, Retained Hardware, Titanium Plate, Trans-Tibia Amputation

1. Introduction

Distal ankle fractures are sustained by 187 per 10^{-6} adults every year [1]. The highest incidence for the male population is between the ages of 18 to 24 years and for females between the ages of 75 to 84 years of age [2]. In one study, distal ankle and tibial fractures occurred an estimated 673,214 times within a 5-year period [3]. For those that will require operative orthopaedic repair, some might have placement of plates with screws while more proximal mid-tibial fractures could require an intramedullary nail for fracture fixation [4]. Patients and their surgeons may defer the retained hardware removal opting to leave the hardware in place [4]. Typically, there are little sequelae with retained hardware and the indications for hardware removal are not well established [4]. There is little infectious risk and hardware removal would necessitate another operation with concomitant general anesthesia [4].

Patient's memories of past injuries, medical history, and surgical procedures may remain cloudy let alone their understanding of what happened during an operation [5] [6]. A patient may or may not remember that they even had a fractured ankle with a subsequent repair in the recent or distant past. This might be especially true if they have a long past medical history including other operations [5]. Patients may come into the emergency room obtunded secondary to trauma, illicit drug or alcohol use, or from other emergency medical conditions. These medical conditions may require airway protection with intubation. Furthermore, patients may have any level of dementia precluding accuracy in their past medical history. To the provider, there may never be reason to believe that any operation has occurred, let alone a "forgotten" ankle fracture repair. Physical examination may be the only way to assess whether an operation has occurred, but the physical examination signs may be missed or misinterpreted and providing an accurate diagnosis may be low [7]. Physical examination might entail observing a surgical scar or palpating a raised excrescence under the skin representing a fixation plate and may be the only way to recognize a previous operation. With acute injuries, skin changes including edema, infection, skin sloughing/blistering, trauma (bleeding) or burns at or near the site and therefore old scarring may be overlooked or not observed. In the radiology field, there is a concept that when a radiologist reviews a radiologic examination, they are often drawn to the obvious finding and may miss a more subtle finding. Radiologists often refer to this as "satisfaction of search" where a subset of underreading errors occurs and leads to a false-negative acceptance [8]. On a busy service, the physician may not notice a small cicatrix that might otherwise denote an obscure surgical detail.

Diabetes can result in a distal foot infection that may lead to the need for a unilateral foot amputation. One recent cohort study revealed that the overall incidence of unilateral amputation in the diabetic population was 195 (95% CI 163 - 231) per 100,000 person-years while in the nondiabetic population, the overall incidence was 23 (19 - 26) per 100,000 person-years [9]. There are single-staged

and two-staged open extremity amputations that can be performed mechanically [10]. With diabetes leading to arteriosclerosis, blood flow is frequently compromised leading to poor distal pedal perfusion. Consequently, a diabetic patient may present with an edematous, malodorous, draining foot from adjacent wounds that may lead the physician to describe the obvious physical findings but miss more subtle findings such as a minor scar from a previous operation thereby missing the opportunity to question the possibility of retained hardware.

Trans-tibial/fibular amputation is a quick operation to remove the diseased septic or necrotic foot [11]. Removal of a foot via a transtibial amputation may become challenging as the Gigli saw, hand saw, or electric saw cannot cut through the retained titanium hardware to separate the infected foot from the more proximal limb. Since source control will only be achieved after removing the necrotic foot from the rest of the body, what should the surgeon do in the operating room if the Gigli saw keeps breaking or the surgeon and his assistant repeatedly fatigue as they cannot cut through the tibia or fibula? What if the electric saw makes a stuttering sound or motion that is clearly abnormal based on experience? What if the saw will not stay centered against the distal bone or cannot push through the bone(s) to complete the amputation?

Presented is a case where a plated ankle completed in the patient's distant past for fracture repair remained undetected and the bones could not be transected by surgical means. An algorithm is established as well as suggestions on how to manage this unfortunate situation where a saw cannot amputate the diseased foot secondary to undisclosed/retained hardware. Alternative operations are suggested. The institutional review board (IRB) at Valleywise Health Medical Center (formerly known as Maricopa Integrated Health System) has determined that this case report (CR2021-018) is exempt from IRB review based on code or Federal Regulations (CFRs) Title 45, Part 46—Protection of Human Subjects. The human data presented is in accordance with the Declaration of Helsinki. There was no funding provided or obtained in the writing and development of this scientific paper.

2. Case Report

A 49-year-old male developed blistering, redness and swelling after errantly soaking his insensate, left foot in scalding hot water. As stated to the admitting medical team his past medical history only included hypertension, poorly controlled insulin dependent diabetes mellitus, peripheral neuropathy of his bilateral feet, significant alcohol use and abdominal/thoracic exploration after multiple stab wounds. Physical examination revealed a blood pressure of 155/107mmHg, heart rate of 85 beats/minute, a temperature of 36.1˚ Celsius, and a respiratory rate of 16 breaths per minute. He had a two percent total body surface area, deep partial and full-thickness scald burns to his left foot and toes with edema, cellulitis, and blistering (**Figure 1(a)** and **Figure 1(b)**). On palpation his left foot and left leg compartments were soft with a normal motor examination to his bilateral feet. His bilateral dorsalis pedal artery pulses were diminished but equal capillary

refill (less than 3 seconds). He had diminished pedal light touch sensation distal from his toes to his proximal ankles.

The patient was initially debrided in the emergency department with water and Hibiclens (Monlycke, Norcross, GA) soaked wash cloths followed by Silvadene (Pfizer, New York, NY) application to his left foot burn wounds. On hospital day two he was taken to the operating theater where he underwent a left foot tangential excision of full thickness burns down to fat for a total of 230 square cm. This was followed by application of allografts secured with staples and covered with hypochlorous acid (Vashe Wound Solution, Urgo Medical North America, Fort Worth, TX). The left foot wounds developed deeper necrosis despite repeated debridements (**Figure 2(a)** and **Figure 2(b)**). A vascular ultrasound revealed compromised blood flow in two major arterial vessels to the left foot. The patient required amputations of the left third through fifth toes, but despite the aggressive care to salvage this patient's left foot, it was deemed non-salvageable after two weeks and required a left foot amputation (**Figures 3(a)-(c)**).

(a) (b)

Figure 1. (a) and (b): Photograph of left foot, partial thickness, burn injuries from scalding water at presentation.

(a) (b)

Figure 2. (a) and (b) Photographs of injured left foot with continued necrosis despite repeated debridements because of non-reconstructible arterial atherosclerotic disease.

(a) (b) (c)

Figure 3. (a)-(c): Photographs of necrotic and ischemic foot after multiple debridements including amputations of toes three through five that require trans-tibia/fibula amputation.

The patient was taken to the operating theater for a left trans-tibial/fibular guillotine amputation. During that operation multiple attempts were made using the Gigli saw to transect tibial and fibular bones above the level of the medial and lateral malleolus to remove the necrotic foot from the distal left leg. Despite maximal physical sawing force from multiple surgical personnel, three Gigli saws failed to transect the bone. After the failed third attempt an electric saw was brought to the OR but also failed with an unusual stuttering sound, akin to metal rubbing upon metal. The electric saw continued to hesitate, stutter and "slip off" the lateral fibular bone. It was recognized that these failed attempts could be the result of retained hardware from either ankle fixation plate(s) or an intramedullary tibial nail. Intraoperative radiographs were ordered and reviewed. A retained plate with multiple screws from a previously undisclosed distant ankle fracture repair (subsequently remembered by the patient and his family but forgotten pre-operatively) was identified over the lateral aspect of the fibula (**Figure 4**).

With the left lateral plate identified in the wound bed (**Figure 5**), soft tissue debridement using periosteal elevators and scalpels over the left lateral fibula revealed the retained hardware (**Figure 6**). The plate and screws were removed by the surgical team with a combination of an electric drill and a manual screwdriver (**Figure 7(a)** and **Figure 7(b)**) with a grasper (**Figure 8**). The fourth attempt at guillotine trans-tibia and fibula amputation using the Gigli saw was successful. The five major vascular vessels were identified and ligated (**Figure 9**), the amputated left foot was passed off the field (**Figure 10**) and a hypochlorous acid cleanser dressing placed over the distal open stump. The pathology report revealed "… two types of hardware. Type 1 hardware consists of a metallic plate measuring 8.5 × 0.9 × 0.1 cm. There is presence of seven holes, each measuring 0.6 × 0.5 cm. Type 2 hardware consists of five metallic screws measuring from 1.0 to 1.4 cm in length and up to 0.5 cm in diameter" (**Figure 11(a)** and **Figure 11(b)**).

Figure 4. Plain radiograph of the left foot (medial view) with retained left fibular plates with screws in place.

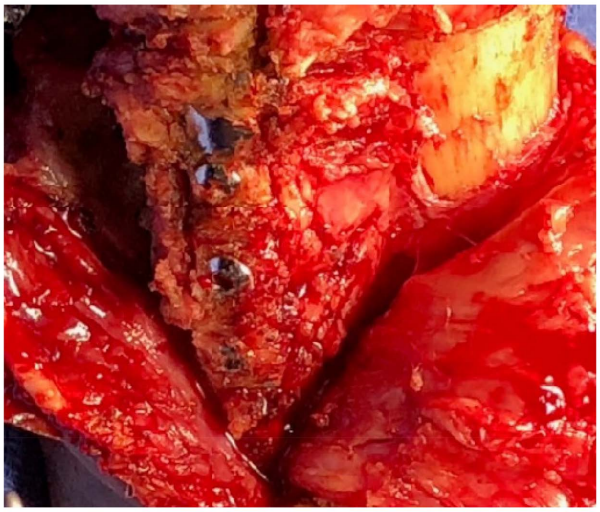
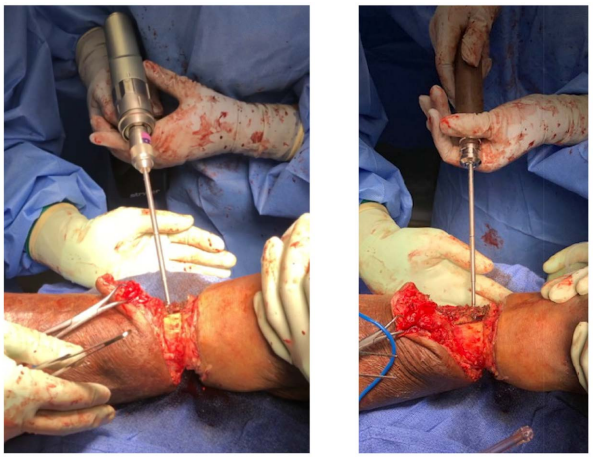


Figure 5. Photograph of retained hardware over the left fibula placed years before and well incorporated by the soft tissue.

Figure 6. Photograph of periosteal elevator removing scar tissue and subcutaneous tissue from the retained plates and screws over the left lateral fibula.



(a) (b)

Figure 7. (a) and (b) Photograph of hand-held drill followed by a screwdriver to explant screws from left fibular plate.

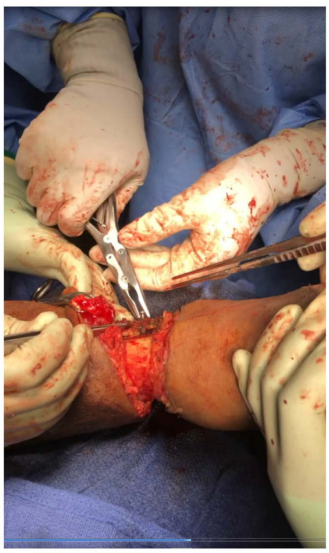


Figure 8. Photograph of hand-held grasper to assist grasping and then explanting the screws.

Figure 9. Photograph of completed left guillotine amputation of the foot with ligated arteries and veins.

Eventually, the patient had formalization to a left below knee amputation using an inferior-posterior Burgess lower leg flap. He was discharged on HD 28 after achieving pain, blood glucose and hypertension control. The patient was seen in the wound clinic for wound and below knee amputation management and had an uneventful recovery (Figure 12).

Figure 10. Photograph of the necrotic left foot amputated from the left leg.

(a) (b)

Figure 11. (a) and (b): Photographs of explanted screws (left) in a sterile specimen cup followed by the plate (right) in the surgeon's hand from the left lateral fibula.

Figure 12. Photograph of the left anterior below knee amputation stump revealing a healing wound stump in wound clinic post-operative day #10.

3. Discussion

Accurate history taking and physical examination are critically important in the clinical care of every patient [7] [11] [12]. Nonetheless, there may be a few instances that make this process difficult rendering a history and physical incomplete especially with obtunded, intoxicated, demented, or intubated patients. Surgical scars (**Figure 13**) may be a clue on physical examination of prior interventions especially if patients cannot accurately recall what transpired at their previous operation or that hardware was left in place from many years previously. Furthermore, patients may no longer recall what transpired at a previous operation decades before [5]. Therefore, intraoperative contingency plans need to be devised to assist the unsuspecting surgeon (**Annex**).

First, any patient that requires an amputation of the distal extremity for a chronic condition should have pre-operative imaging and possibly a preoperative vascular evaluation [13] [14]. This could have immediately alleviated the issues discovered in this case. While not necessarily required to make a medical diagnosis, if a foot amputation through the tibia or fibula is required, simple A/P and lateral radiographs help in pre-operative planning if nothing more than to assess for retained hardware (**Figure 14**). While a duplex Doppler examination was obtained for assessment of arterial flow in this case, there was no static plain imaging that was completed. Second, during a trans-tibia/fibula amputation, if the surgeon, finds that 1) the Gigli saw or potentially the handheld saw cannot transect the bone easily, 2) an electric saw is making odd/stuttering sounds while attempting to transect the bone 3) the electric saw keeps slipping off "the bone"

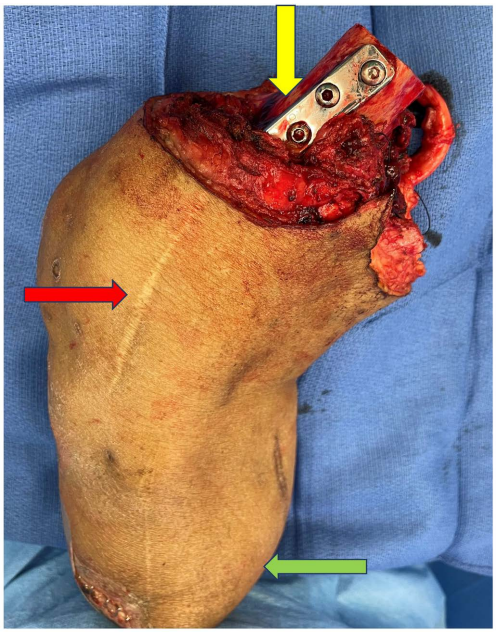


Figure 13. Photograph of an unrelated patient status post right above knee amputation with retained hardware of the transfected femur (yellow arrow). Notice a well-healed cutaneous epidermal scar on the medial aspect of the right knee from a previous operation (red arrow). Also notice the previous right below knee amputation (green arrow).

Figure 14. Photograph of a retained right tibial nail with a distal interlocking screw requiring orthopaedic removal prior to a right above knee amputation.

or, 4) the surgeons are physically fatiguing with the Gigli or handheld bone saw, retained titanium hardware is possibly present. Intraoperative radiographic imaging of the tibia/fibula or ankle must be obtained looking for an ankle plate or intramedullary nail. These radiographs should include the joint above and below the proposed ankle transection site as there may be the presence of a tibial nail identified below the knee and within the tibia medullary cavity. If a major artery has been transected and there is ongoing hemorrhage, a proximal tourniquet may be quickly applied and inflated to 250 mmHg minimizing any further blood loss if not already applied.

Once hardware is identified radiographically such as plate with screws, the plate should be cleaned off with scalpels and periosteal elevators, removing any scar and subcutaneous tissue adherent to the plate. Next, a screw removal set including a screwdriver or drill can be used to remove the screws and adjacent fixation plate. If the patient has an intramedullary nail in place, an immediate intraoperative consultation must be made with the on-call orthopaedic surgeon so that the metallic device can be removed. The tensile strength of the Gigli saw is around 250 pounds per square inch (psi) [15] and will not be able to cut through a titanium plate or an intramedullary nail with a tensile strength ranging from 240 to greater than 1700 psi [16].

Today, most of the orthopaedic hardware can be easily removed, however, decades ago, when there were numerous manufactures of orthopaedic hardware, extraction kits were not as easily found for all those random companies to remove their particular hardware. The Midas Rex (Medtronic, Minneapolis, MN)

device, which takes specialized instruction for its operation can be utilized to extract unusual or rare manufactured devices retained in the patient. Today's devices come from only a few companies and removal is simpler but can also be challenging. Once the orthopaedic device is removed, the amputation may commence.

Another clinical situation might arise where a septic foot needs to be removed from a sick patient and there is no on-call orthopaedic surgeon at a medical facility to remove an intramedullary nail or no orthopaedic screwdriver or drill to remove the screws holding the plate in place. Such an occurrence may happen in medical centers in rural facilities or austere environments. Patient transfer becomes necessary to a facility with orthopaedic coverage. Nonetheless, infectious source control in a diabetic patient is paramount and if the surgeon performing a transtibial/fibular amputation intraoperatively identifies a plate or intramedullary nail that cannot be readily removed, a plan to remove the infected foot must still be strongly considered. Halting the operation and sending the patient may not be necessary. Moving the amputation incision site more distally to include a through-ankle joint disarticulation remains a reasonable and viable option. This provides for immediate infectious source control. The amputation incision is moved distally several centimeters below the more standard trans-tibial/fibular level approach. If the through ankle disarticulation pathway is chosen, it should be paired with medial and lateral incisions coupled with soft tissue leg debridement with a washout allowing for adequate source control. This provides time for the operative surgeon and hospital to transfer the patient to a facility that has orthopaedic capabilities to remove the retained hardware thereby allowing for a higher-level amputation if source control is not obtained. It should next be considered and asked, "why not just transect the leg bones above the ankle plate?" This is a reasonable question, however, maintaining maximal length of tibia and fibular bones for a formal below knee amputation is important for subsequent amputation formalization and prosthesis application. Amputation at a higher level above the level of a retained plate may be problematic for a subsequent formalization of a below knee amputation if the plate is long necessitating a higher level of amputation. However, if the ankle plate is short and the surgeon can perform a tibia/fibular transection just above that shorter plate without transecting too much bone, this may be a viable option.

Unidentified retained hardware may also be found in patients requiring a below knee amputation or an above knee amputation. If the patient has plates and screws for reconstruction (**Figure 13**), the hardware may be removed with screwdrivers or drill once the soft tissue/scar elements are removed with scalpels and periosteal elevators (**Figure 6**). However, if there are tibial, femoral nails or a hip prothesis present with or without interlocking screws (**Figure 14**), the orthopaedic surgeon will need to be called for removal prior to the planned amputation. It would, therefore, behoove the operating surgeon that needs to remove the diseased limb at which ever level to obtain simple A/P and lateral radiographs of the bone to assess for prior retained nail or hardware. This may also be done uti-

lizing a computerized axial tomography (CAT) scan. A CAT scan can also assess the presence and the level of ascending gas pockets or purulence created by invasive microorganisms.

4. Conclusion

Surgeons must always expect the unexpected. A review of all the clinical notes, laboratory values and radiographs is essential, but every surgeon must have contingency plans. Even with routine, urgent, or emergent procedures adaptability, flexibility and being able to think "outside of the box" is important. A clinical algorithm (Annex) is included for surgeons who during a transtibial/fibular amputation encounter such difficulties as found in this case.

Conflicts of Interest

Dr. Matthews is a surgical consultant and on the speaker's bureau for 3 M/KCI, MIMEDX, Urgo Medical North America.

Dr. Amy C. Ross, Alejandra Navarro, Jared Stucki, Marisse A. Lardizabal, Bryan Roth, and Ms. Katie A. Dishner have no conflicts of interest.

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Annex: Algorithm for Retained Hardware during a Trans-Tibial/Fibular Amputation

1) Whenever an amputation of the upper or lower extremity, including digits, is planned, pre-operative A/P and lateral radiographs at the site of the proposed amputation should be obtained. Preferably, these radiographs should include the joint above and below the proposed amputation site.

2) The performing surgeon and team should review these A/P and lateral radiographs pre-operatively.

3) If any intramedullary nails, plate with screws or surgical pins are identified, the primary surgical team should consult orthopaedic surgery to discuss the timeliness of removal pre-operatively. If no on-call orthopaedic surgeon is available, transfer to a medical facility with an on-call orthopaedic surgeon is advised.

4) Once in the operating room, if the Gigli, handheld or electric saws are unable to transect the bone, recognize that this may be secondary to retained hardware if no pre-operative radiographs had been obtained.

a) If using an electric saw, listen for a "metal on metal" sound and/or the repeated slipping of the saw off the metal hardware implant.

b) If using a Gigli or handheld saw and the surgical team keeps fatiguing or the Gigli saw keeps breaking, consider retained hardware.

5) If not previously obtained, it is essential to obtain A/P and lateral radiographs intra-operatively during this scenario to accurately identify the presence and type of hardware.

6) Identified hardware such as plates and screws should then be cleaned off with periosteal elevators and scalpels.

7) The retained screws can be removed with a screwdriver or drill by the primary team or orthopaedic surgeon.

8) If an intramedullary nail is present, an orthopaedic surgeon should be consulted for removal.

9) Once the hardware is removed the primary operating team may then complete the amputation as planned.

10) If transfer is not an option secondary to inclement weather, an austere environment or other factors and the septic/necrotic foot must be removed secondary to sepsis, move the level of amputation to the through ankle level separating the foot from the leg or consider amputating above the level of the ankle plate. Wide local debridement of all pedal or crural tissue is encouraged in such cases, especially if the patient cannot be immediately transferred or the foot cannot be removed secondary to retained intramedullary nail with no orthopaedic surgeon available to remove it.

11) If hemorrhage develops during an amputation where the limb or foot cannot be removed because of retained hardware, place a tourniquet proximal to the initial incision and inflate the cuff to above 250 mmHg.