Total ankle arthroplasty with custom prosthetic fibular implantation

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When a malpositioned and painful ankle arthrodesis fails conservative treatment, conversion to a total ankle arthroplasty could be considered as a suitable surgical option. Literature provides several studies demonstrating the high risk of converting an ankle arthrodesis to a total ankle arthroplasty when the patient is lacking a distal fibula. The lack of a structurally supportive osseous and ligamentous complex laterally can lead to increased motion and aseptic loosening, thus contributing to a higher rate of failure. We present a case report in which a painful ankle arthrodesis with prior fibular resection was converted to an ankle arthroplasty utilizing a prosthetic distal fibula along with syndesmotic and lateral ankle ligament reconstruction, including a two year follow-up. To our knowledge, this is the first incidence of prosthetic fibular implantation mentioned in the literature.

Keywords: ankle arthrodesis conversion, custom fibula, fibular implant, fibular resection, prosthetic fibula

Although the ankle arthrodesis is a standard of care treatment for end-stage ankle osteoarthritis, it can still result in negative outcomes for the patient. Some of the adverse outcomes include adjacent joint arthritis, pain, and dysfunction [1]. Considerable activity limitation, foot pain, and disability have all been reported following an ankle arthrodesis [1,2]. Treatment of the painful ankle arthrodesis can create a difficult challenge. Until recently, the most common surgical options included ankle fusion revision, tibiotalocalcaneal fusion, and transtibial amputation [3].

If the painful ankle fails conservative treatment, one should consider the need for conversion of an ankle arthrodesis to a total ankle arthroplasty (TAA). Survival rates of ankle prostheses have improved over the years due to less bone resection, larger bone support, uncemented fixation, and proper ligament balance [4]. Despite these advancements, TAA complications still occur; with failure rates ranging from 0-50% [5,6]. Conversion to a total ankle arthroplasty is a more recent solution, potentially restoring pain free ankle range of motion and dissipating the increased load dispersed among adjacent joints [3].

Studies have demonstrated that there is a higher risk of complications and implant failure when converting an ankle arthrodesis to a total ankle arthroplasty if the patient has undergone previous fibular resection. The absence of a rigid bony and soft tissue structure along the lateral ankle can lead to increased motion and aseptic loosening. Therefore, when examining a

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surgical candidate for a total ankle arthroplasty conversion, stability of the ankle should be taken into consideration. In this case study we discuss the importance of adjunctive procedures that should be taken into account when converting a patient who lacks a distal fibula to a TAA. Pre-operatively, a prosthetic fibula was designed. A patient with a painful ankle arthrodesis and a previously resected fibula was converted to a TAA with additional implantation of a prosthetic fibula and reconstruction of the lateral ankle ligament complex.

Case Report

A 56-year-old female with a past medical history of hypothyroidism, vitamin D deficiency, and hypertension presented to our office in January of 2014 with a painful and malpositioned left ankle arthrodesis. She had a left ankle open reduction internal fixation in December of 2003. Secondary to degenerative disease and pain, she underwent an ankle arthrodesis with fibular resection in February of 2008 (Figure 1). She described her current pain as severe in the foot and ankle, which worsened with walking and increased activity. The pain required her to wear shoes with a higher heel or heel lift at all times. Heel elevation managed to palliate her symptoms. She had seen prior specialists and was told that she could not have a total ankle arthroplasty secondary to the absent fibula. At that time she had refused a fusion revision or bracing, so she continued her daily routine wearing an orthosis with shoe gear modification.

After 2 years of conservative treatment with minimal pain improvement, she returned to the office in the Fall of 2016. The option for a total ankle arthroplasty with a prosthetic distal fibula was discussed with her, and she was in agreement.

Clinical examination included evaluation of the foot and hindfoot while standing, sitting, and walking. Hindfoot alignment was assessed with the patient standing and noted to be neutral. Stability and mobility of the ankle and subtalar joint were assessed manually. Radiological examination included conventional weight bearing radiographs of the ankle. A CT scan of her contralateral ankle was performed in order to replicate the structure of her fibula. These CT images were mirrored to create a fibular implant designed by Additive Orthopedics (Figure 2).

Several prosthetic fibulas with varying lengths, design, and hole positions were designed.

She was taken to the operating room in February of 2017 for surgical intervention. The patient was placed on the operating room table in the supine position, utilizing general anesthesia and a thigh tourniquet.
She underwent conversion of a left ankle arthrodesis to a total ankle arthroplasty using a 3rd generation Inbone (Wright Medical) implant according to standard manufacturing protocol. A curved osteotome was employed to open the existing fusion along the anatomic contour of the previously resected tibio-talar joint. The ankle was then positioned neutrally based upon intraoperative examination and preoperative calculations.

The residual distal fibular stump was cut to appropriate length using a sagittal saw. The stem of the prosthetic fibula was then inserted into the medullary canal of the proximal fibula. It was fixated to the proximal fibula using three 3.5mm bicortical screws. A fourth screw was inserted through the prosthetic into the tibia for syndesmotic fixation (Figure 3). Lastly, a gracilis tendon allograft was inserted through a pre-designed hole within the distal prosthetic fibula and fixated to the talus and calcaneous using biotenodesis anchors (Figure 4). The positioning of the hole for the tendon graft in the distal prosthetic was designed and based off of the origin points for the ATFL and CFL.

Post-operatively, the patient maintained strict non-weight bearing to the surgical limb. After four weeks she was allowed to begin 50% weight bearing. She was then transitioned from her boot as guided by physical therapy. She began passive range of motion at week two and formal physical therapy at week six.

At approximately three months postoperatively, radiographs revealed disruption of the syndesmotic fixation screw.

At that time the patient revealed that she had returned to unrestrained high demand activity prematurely (including hiking and bowling).

Five months postoperatively the clinical position was well maintained; she continued normal activity without restriction, and was pleased with her newly reestablished anatomic gait. At one year follow-up the patient exhibited some intermittent discomfort with prolonged demand and weather pattern changes. She was able to participate in both daily and moderate demand exercise activity without limitation. She had near gained anatomically normal ankle range of motion, while maintaining overall stability and functionality (Figure 5). She did have fractured syndesmotic fixation, but demonstrated no clinical findings of concern.
At 14 months postoperatively the patient began to not increased gutter pain, both medially and laterally. She admitted that she had withheld some information at previous visits, hoping that symptoms would improve.

It was thought that these symptoms were secondary to progressive syndesmotic widening. A CT scan did confirm widening, but the implants within both the fibula and ankle remained stable. An attempt was made at ASO type bracing and physical therapy. Her pain persisted. At that time, the determination was made to revise the syndesmosis.

In July of 2018, the patient underwent syndesmotic revision. A linear incision was made along the existing surgical scar. Dissection was carried down to the underlying implant. The previously inserted syndesmotic screw was removed. The syndesmosis was debrided and the distal fibula was mobilized. The syndesmosis was at this time reduced with a large tenaculum. Positioning was assessed fluoroscopically. A tightrope was passed through the inferior syndesmotic hole. The tightrope was secured and the reduction clamp was withdrawn.

To further augment the stabilization, 4.5mm corkscrew anchors were placed within the distal tibia at both the proximal and distal fibular syndesmotic holes. These were stabilized to the implant with endo-buttons. The proximal corkscrew anchor was a 4.5 mm implant while the distal was a 3.5 mm implant. For added security and stabilization, screw was removed from the proximal stem of the implant and replaced with a new transsyndesmotic screw.

Under live fluoroscopy, the ankle was challenged with internal and external rotation views as well as inversion-eversion. The stability of the syndesmosis and the ankle was maintained. There was no apparent shift in the implants (Figure 6).

Postoperatively, the patient was kept non-weight bearing for 2 weeks. She was then allowed to weight bear as tolerated on the surgical limb in a boot. At 6 weeks she resumed home physical therapy and was transitioned to normal activity.

At present, she has resumed normal function. She does have some intermittent mid-foot and subtalar joint symptoms, for which an orthotic was prescribed. However, given the rarity of her symptoms, she elected to forgo orthosis support. She has had some persistent valgus rotation to the implant; however, this has remained stable (Figure 7).
Discussion

The presence of ankle instability and pathologic motion will often contribute to implant failure. Aseptic loosening is known to be the most common cause of failure of a total ankle arthroplasty [5]. According to Sadoghi et al, 38% of failures were caused by aseptic loosening [7]. Aseptic loosening refers to the failure of fixation at the bone implant interface, caused by micro or macromotion [8]. Some authors refer to aseptic loosening and subsidence as separate outcomes. However, subsidence has been referred to as macroscopic motion of the implant, while aseptic loosening implies non macroscopic loosening [8]. A systematic review by Glazebrook demonstrated that when a TAA went on to failure it was caused by aseptic loosening 70% of the time [5]. Aseptic loosening was therefore considered a high-grade complication. Another study by Brunner et al, showed that aseptic loosening and subsidence required a revision in 32% of the patients who received a 3 component mobile bearing TAA [9].

Due to the high incidence of implant loosening, one could perceive how lacking a distal fibula could negatively impact the outcome of the ankle arthroplasty conversion. A study by Greisberg et al looked at 19 ankles which were converted from an ankle fusion to a total ankle replacement. Five of the ankles had extensive thinning or resection of the distal fibula at the original time of fusion. All five of these patients had a complicated course after being converted to arthroplasty. Complications included severe valgus tilting of the talus in the mortise with subsidence, and continued postoperative pain. Greisberg et al. describes the biomechanics of failure by stating that the mortise is narrowed with resection of the lateral malleolus. Considering this, the implant is positioned relatively medially to maintain proper apposition of the tibial component. This shifts the weight bearing axis lateral to the center of the implant, thus creating a valgus force that eventually overcomes the deltoids, causing talar tilting and bony impingement along the lateral ankle. For this reason, they considered fibular resection to be a relative contraindication [10].

Pelligrini et al converted 23 ankle fusions to ankle arthroplasties. Two of those patients had a distal fibulectomy during their original arthrodesis, and both of these conversions failed. Therefore these authors state that “their experience with conversion of a total ankle arthroplasty in patients whom the ankle arthrodesis had been performed with complete distal fibular resection reflects prior studies”, referring to studies by Greisberg et al and Hintermann et al [10-12]. They concluded that lack of a distal fibula is a contraindication to arthroplasty conversion. Both of their patients went on to demonstrate progressive valgus talus tilt and lateral talar translation [12].

The etiology of aseptic loosening can be linked to macromotion as discussed previously in this paper. Soft tissue instability of the ankle is a characteristic which can contribute to increased macromotion. Significant ligament instability has been one of many contraindications discussed when considering an ankle arthroplasty [13]. It was important that we provide the patient with a reconstructed lateral ankle ligament complex in order to reduce macromotion and increase the odds of implant survival. By passing tendon allograft through the prosthesis and anchoring it into the talus and calcaneus we were able to recreate this lateral soft tissue support.

Another factor, which can contribute to aseptic loosening or subsidence, includes implant design [8]. There must be strong bony ingrowth at the bone-implant interface in order to bypass or avoid loosening. Therefore the addition of implant stems can provide a larger fixation surface, increasing implant stability, reducing micromotion and mechanical stresses [14]. The INBONE total ankle system is a third-generation, fixed bearing implant, which utilizes stem fixation for the tibial and talus components to better distribute stresses [3,5]. The talus component, which has a central sulcus, provides additional coronal stability [14]. Two major indications for INBONE include patients with moderate to severe ligamentous instability of the ankle and incongruent talar coronal plane deformities. Stresses transferred from the prosthesis to the bone implant are mitigated by the increased surface area achieved with the stemmed component of the tibia and talus [15,16]. The INBONE system is known for being used in revisions of previously failed ankle replacements, given its inherent tibial stability. For the aforementioned reasons, the 3rd generation INBONE total ankle system was utilized for our case. Inherent tibial component stability is crucial when
considering a surgical candidate who has a surgically absent fibula and soft tissue insufficiency.

Overall, several tactics were employed in order to construct a pre-operative plan before proceeding with this TAA conversion. The first crucial factor considered was the inherent design and stability of the implant, hence the use of the 3rd generation INBONE. The second factor taken into consideration was the lateral bony and soft tissue support structures. The fibula was recreated using a 3D scanned prosthesis, while the soft tissue ATFL and CFL ligamentous support was reconstructed out of tendon allograft. By doing so, the stability of the ankle complex was improved, thus resulting in less micro/macro motion and enhancing the odds of implant survival. With the advancements in prosthetic design, along with a better understanding of ligamentous balancing and component alignment, we believe that the surgical outcomes of converting an ankle arthrodesis with distal fibular resection to a total ankle arthroplasty have the potential to improve.

To the best of our knowledge, we present the first report of a postoperative prosthetic fibula in order to provide stability for a total ankle arthroplasty. In conclusion, conversion of an ankle arthrodesis to a total ankle arthroplasty with a prosthetic fibula is a worthwhile limb and function preserving technique. Although complex in nature, this case study shows that the outcome can be advantageous.

In reflection of this first case, small adjustments could be made to the design of the implant—though, the long term success remains to be understood. Elongation of the fibular component could be considered. This would include an extended intramedullary stem, and proximally translated syndesmotic holes. The use of tight rope like syndesmotic fixation could also be considered. Otherwise, we believe that the anatomy of the implant was sound.

References


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