DOI: https://doi.org/10.30795/jfootankle.2024.v18.1831

Case Report

Total ankle arthroplasty with total talus implant printed by 3D printer

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Abstract

Describe a case of an aggressive talus tumor treated with total ankle arthroplasty with a patient-specific total talus implant printed on a three-dimensional (3D) printer. A 46-year-old female patient with a history of giant cell tumor treated in the past with partial resection of the talus and replacement with cement, evolving with progressive functional limitation eight years after the initial procedure. In the preoperative, the range of motion was 15° of flexion and 0° of extension, Visual analog scale (VAS) of 8, The American Orthopaedic Foot & Ankle Society (AOFAS) of 45, and the data compiled from the 36-Item Short Form Survey (SF-36) of 50%. The patient was submitted to total ankle arthroplasty with a patient-specific total talus implant printed on a 3D printer. The evaluation six months after the procedure showed a range of motion of 30° of flexion, 8° of extension, VAS of 2, AOFAS of 75, and the data compiled from the SF-36 were 75%. Weight-bearing anteroposterior and profile radiographs indicated that the alignment of the implants was maintained. Our study is the first patient-specific total ankle arthroplasty procedure with total talus implant described in the Brazilian literature. Patient-specific total ankle arthroplasty with total talus implantation is a technique that can provide pain relief, maintain movement, and improve patients' quality of life.

Level of evidence IV; Therapeutic study; Case report.

Keywords: Arthrosis; Bone avascular necrosis; Arthroplasty, Replacement, Ankle; Printing, three-dimensional.

Introduction

Several conditions can cause massive bone loss of the talus, such as avascular necrosis, comminuted fracture, infection, tumors, and failures related to a total ankle prosthesis. Avascular necrosis is the most common reason a talus cannot be reconstructed. Traditionally, pantalar arthrodesis with a structural bone graft has been the go-to salvage procedure for addressing irreparable talus lesions. However, functional limitations, non-consolidation, and patient dissatisfaction have led to the search for alternative treatments[1,2].

Patient-specific three-dimensional (3D) printing technology has recently created digitally engineered implants from a computed tomography (CT) scan. These titanium or chromium-cobalt implants expand the range so that surgeons can plan better, choose alternatives, and improve efficiency and results for several complex foot and ankle pathologies[1,3,4].

The purpose of this study is to describe a case of an aggressive talus tumor treated with total ankle arthroplasty with a patient-specific total talus implant printed on a 3D printer.

Study performed at the Hospital Felício Rocho, Belo Horizonte, MG, Brazil.

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Conflict of Interest: Daniel Baumfeld is Consultant/Speaker for Arthrex and Stryker. Caio Nery is Consultant/Speaker for Arthrex and Stryker. Tiago Baumfeld is Speaker for Medartis. **Source of funding:** None. **Date received:** September 15, 2024. **Date accepted:** October 25, 2024. **Online:** December 30, 2024.

How to cite this article: Baumfeld DM, Macedo BD, Sanhudo JAV, Machado PC, Macedo BMG, Baumfeld TS, et al. Total ankle arthroplasty with total talus implant printed by 3D printer. J Foot Ankle. 2024;18(3):406-10.

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Case report

A case of a 46-year-old female patient with a history of pain and edema around the left ankle started eight years ago. At the time, radiographs of the ankle showed an expansive lytic lesion involving more than half of the talar body. The diagnosis after an incisional biopsy was a giant cell tumor[5]. A resection of the tumor by anterior access followed by partial replacement of the talus with bone cement was then performed. Histopathology confirmed the diagnosis of a giant cell tumor. There was no radiological evidence of recurrence, and the patient could perform her daily activities partially, with progressive limitations during this period.

Recent imaging tests (radiographs and CT) showed severe tibiotalar arthrosis, with talar erosions at the site where the orthopedic cement was implanted and irreparable pantalar degeneration (Figure 1). The patient had disabling pain in the ankle when walking, limitation of daily life, and claudication.

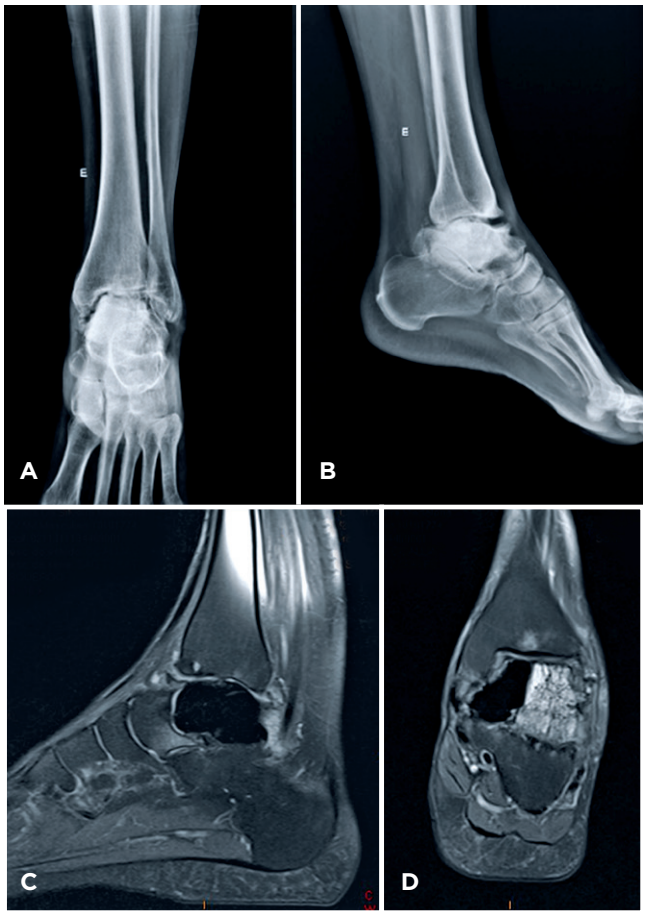

Figure 1. Recent images (radiographs and computed tomography) show severe tibiotalar arthrosis. A) Anteroposterior radiography of the ankle. B) Profile radiography. C) Coronal section computed tomography. D) Sagittal section computed tomography.

Ankle movement was limited, with 15° of flexion and 0° of extension. The visual analog scale (VAS) was 8, the American Orthopaedic Foot and Ankle Score (AOFAS) was 45, and the data compiled from the 36-Item Short Form Survey (SF-36) of 50% with functional data of 40%, energy of 65%, emotional of 72%, social of 62.5%, pain of 10%, overall health of 55%.

Preoperative planning

Comparative weight-bearing anteroposterior and profile radiographs, panoramic radiographs of the lower limbs, long posterior axial radiographs of the calcaneus and CT with bilateral 3D reconstruction of the ankles were performed. The DICOM file images were used to make the 3D implant. The contralateral CT was used as a reference for drawing the talus.

For 3D manufacturing and printing, DICOM file images allowed the design engineers to import CT scan data, segment the anatomy, and create volume reconstructions for 3D printing of the metallic implant (Figure 2). The metal chosen for printing was polished titanium with nitride coating. The model of the tibial implant and polyethylene that will be used must also be available so that the engineers and the manufacturer can adapt the printed talus to the proposed tibial component. The model Infinity prosthesis (Stryker Corporation, Michigan, USA) was used in our patient. The surgery team should be closely involved in the design process so that the implant's size follows the surgical planning. It is recommended that the supplying company send the surgeon an acrylic model of the printed talus to familiarize themselves with the size and approve the final print (Figure 3). Test implants of the same size as the definitive talus implant for the surgical procedure are also recommended to test the ligament balance before the definitive implantation.

Surgical technique

The patient was submitted to spinal anesthesia and venous sedation by the anesthesia team. A non-sterile thigh tourniquet was placed on the left side. Anterior ankle access of 8 cm was

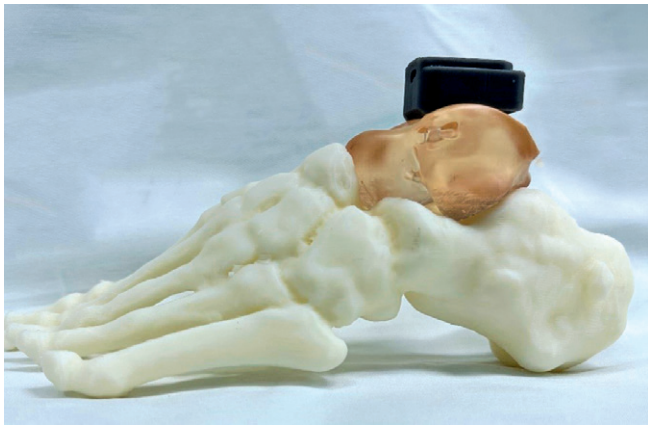

Figure 2. Printed talus acrylic template.

performed. Once the tibiotalar and talonavicular joints were exposed, the osteophytes were removed from the distal tibia and the medial and lateral gutter. The tibia was prepped before talus removal to create a larger working area. The technical guide for the tibial portion of the Infinity ankle arthroplasty was followed, and the standard tibial size number 3 was selected. The tibial plafond cut was made 3 mm more proximal than a normal cut to accommodate the full talus.

After the tibial cut, the talar remnants and the talus cement were removed. During this part of the procedure, care was taken to perform all dissection of the capsule and ligaments inserted into the navicular and calcaneal tibia, preserving the soft tissue shell. The articular cartilage of the navicular and calcaneus were preserved. A fluoroscopic image was obtained to confirm that the talus had been removed completely.

After tibia implantation, the 3D total talus test was inserted for stability, movement, and alignment testing (Figure 4). The test polyethylene was inserted, and fluoroscopic images were obtained to evaluate the component size adequacy. Once the proper stability and alignment were confirmed, the test components were removed, and the final talus component size 3 was placed, followed by the polyethylene size 3/6 mm. It was followed by flat closure, dressing, and positioning of a splint in neutral.

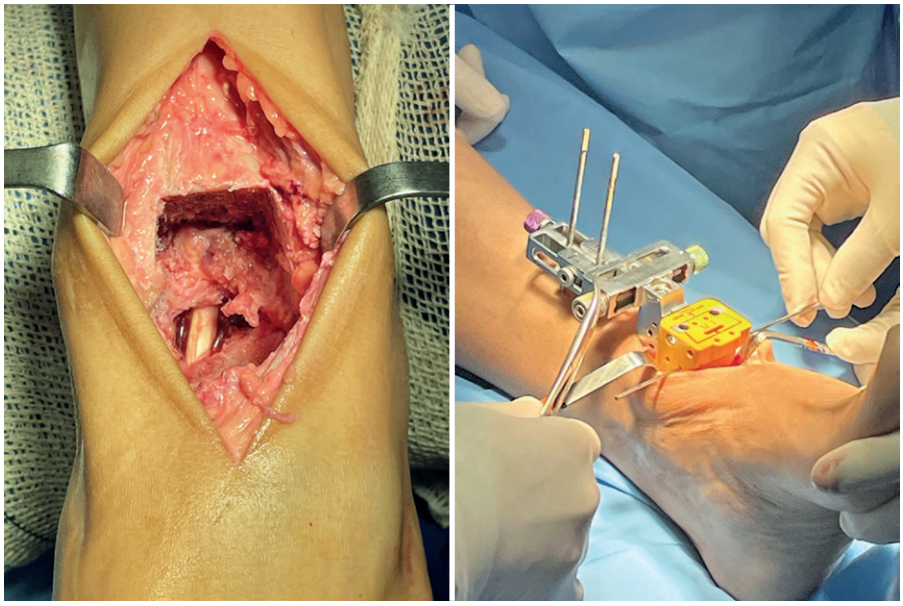

Figure 3. Ankle cuts already made and the process of the cuts.

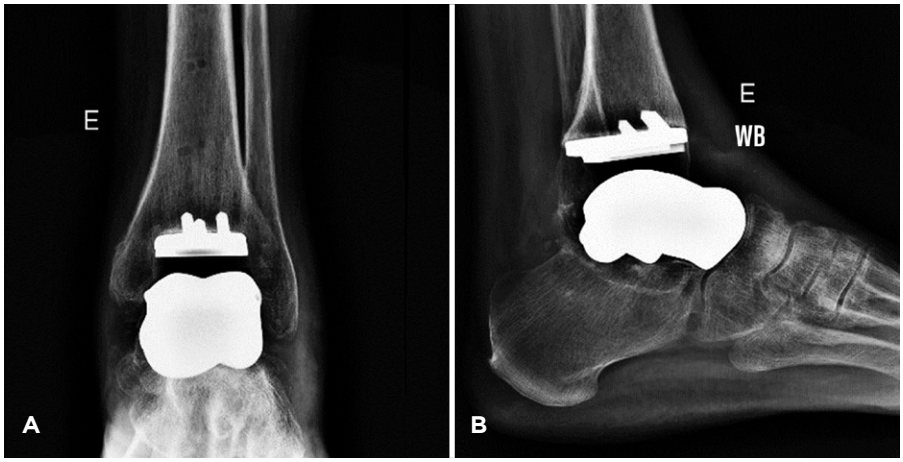

Figure 4. Radiographs showing the alignment of the implants were maintained. A) Anteroposterior radiography of the ankle. B) Profile radiography.

Postoperative period

The patient was kept for four weeks with a splint, which was changed weekly for inspection and wound care. The splint and dressings were removed at four weeks, and the patient was placed in an orthopedic boot with progressive weight-bearing for the subsequent four weeks. During this period, the patient was allowed to remove the boot to perform ankle range of motion exercises. The boot was discontinued at eight weeks, and formal physiotherapy was started. In her most recent follow-up, with six months of evolution, the patient walked without gait support. Clinically, it had 30° of flexion and 8° of extension. She presented VAS of 2, AOFAS of 73, and SF-36 of 75% with compiled and descriptive data with functional data of 70%, energy of 85%, emotional of 76%, social of 75%, pain of 67.5%, overall health of 65%.

Weight-bearing anteroposterior and profile radiographs indicated that the alignment of the implants was maintained (Figure 4).

Discussion

The first patient-specific talus implants were reported in the literature in the 1990s as an alternative to arthrodesis procedures[2,6,7]. This first-generation implant replaced only the talar body made with ceramic or stainless steel, with pins cemented to the talus neck to provide initial fixation. Despite some initial success, there were concerns regarding the loosening and sinking of the prosthesis as well as subtalar erosion[8]. As a result, in the early 2000s, second-generation ceramic and metal talar body prostheses were developed without pins and with more anatomical subtalar curvature. However, the loosening of the prosthesis and the collapse of the talus head continued to affect the survival of these implants[3,6].

In irreparable talar losses and tibial arthrosis cases, total ankle arthroplasty with total talus implantation is needed. Few cases like this have been published in the literature, but it is suggested that total arthroplasty results in better clinical outcomes than isolated talus replacement[2-4,6,8].

Kanzaki et al.[9] performed 22 procedures with talus made of ceramic, where they demonstrated an improvement in range of motion from 26.6° to 46.5°. Complications reported included one intraoperative fracture of the medial malleolus, two postoperative fractures of the medial malleolus, and three cases of delayed wound healing. Some authors report that metal talus printing is more beneficial and has a lower complication rate than ceramic due to the greater ease in performing metal 3D printing, lower component fracture rate, and greater assertiveness in performing specific implants for the patient[9].

Kurokawa et al.[10] published a retrospective comparative analysis of ten patients submitted to total talus replacement alone compared to total talus replacement combined with total arthroplasty. At a median follow-up of 58 months, the Japanese Society for Surgery of the Foot (JSSF) functional score for the hindfoot was better for the group in which surgery was combined (44-89) compared to replacement alone (49-72). The authors concluded that combined surgery resulted in better short-term clinical outcomes[10].

Conclusion

Our study is the first patient-specific total ankle arthroplasty procedure with total talus implant to be described in the Brazilian literature. It is hoped that with the popularization of ankle arthroplasty and its range of implants, more surgeons can be trained to perform the procedure, and more patients can benefit from it.

Patient-specific total ankle arthroplasty with total talus implantation is a technique that can provide pain relief, maintain movement, and improve patients' quality of life.

Authors' contributions: Each author contributed individually and significantly to the development of this article: DSB *(https://orcid.org/0000-0001-5404-2132) Performed the surgeries, data collection and approved the final version; BDM *(https://orcid.org/0000-0003-2178-5671) Performed the surgeries, data collection and approved the final version; JAVS *(https://orcid.org/0000-0002-6321-9566) Conceived and planned the activities that led to the study and approved the final version; CASN *(https://orcid.org/0000-0002-9286-1750) Conceived and planned the activities that led to the study and approved the final version; PCM *(https://orcid.org/0009-0008-0505-1145) Interpreted the results of the study, participated in the review process and approved the final version; BMGM *(https://orcid.org/0009-0002-4821-1061) Interpreted the results of the study, participated in the review process and approved the final version; TSB *(https://orcid.org/0000-0001-9244-5194) Performed the surgeries, data collection and approved the final version; HMMR *(https://orcid.org/0009-0002-0738-9103) Wrote the article, interpreted the results of the study, data collection and statistical analysis.

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