Clinical case
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Management of a total defect of the talus with a customized 3D-implant made of porous titanium for Charcot neuroosteoarthropathy in a patient with neurosyphilis: a case report

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Abstract

Introduction Neuropathic arthropathy, or Charcot arthropathy, is characterized by rapid progressive bone destruction due to impaired nociceptive and proprioceptive innervation of the affected limb. In recent years, there have been publications on the use of 3D modeling and 3D printing of porous titanium implants for filling large bone defects in the foot, but we found only two descriptions of clinical cases of 3D porous titanium implants in patients with Charcot arthropathy.

The **aim** of the work is to demonstrate and analyze the results of performing resection calcaneotibial arthrodesis with defect plasty using a customized 3D implant made of porous titanium in a patient with manifestation of Charcot arthropathy as a complication of tertiary syphilis.

Materials and methods A 50-year-old woman, with a history of syphilis for 26 years, noted the signs of inflammation in the ankle joint during increased loading two months after total knee arthroplasty on the left joint. The examination revealed total destruction of the talus. The diagnosis was Charcot neuroosteoarthropathy of the foot, active stage. After 2.5 months of unloading, based on the results of a CT study of the left ankle joint and 3D modeling, a 3D porous titanium customized implant was fabricated; resection calcaneotibial arthrodesis with autograft harvesting from the tibial canal and plastic surgery of the defect with a 3D implant and fixation with the Ilizarov apparatus were performed. Five months after the operation, consolidation was determined based on the results of control radiographs, and the Ilizarov apparatus was dismantled.

Discussion The proposed method of surgical treatment for total destruction of the talus and the resulting defect-diastasis allows for reconstructive intervention with immediate compensation of shortening, regardless of the shape and size of the defect, to avoid secondary shortening of the limb while maintaining its ability to support, thereby preventing the occurrence of secondary overload changes in the adjacent joints.

Conclusion The initial results in this clinical case seem encouraging, but additional research is required to clarify the indications and patient selection criteria for this treatment method.

Keywords: Charcot arthropathy, total defect of the talus, 3D porous titanium customized implant, resection calcaneotibial arthrodesis

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INTRODUCTION

Neuropathic arthropathy, or Charcot arthropathy, is characterized by rapid progression of bone destruction due to severe impairment of nociceptive and proprioceptive innervation of the affected limb. In 1868, Jean-Martin Charcot identified the relationship between spinal cord damage (tabes dorsalis), a form of tertiary neurosyphilis that may develop months to decades after the initial infection of the patient, and a specific foot deformity based on aseptic destruction of its osseo-articular apparatus and/or ankle joint [1]. Currently, Charcot arthropathy is most often found in patients with diabetes mellitus [2]. There are known cases of Charcot arthropathy developing with other lesions of the peripheral and central nervous system, while in the contemporary society and current healthcare, syphilitic etiology of arthropathy is quite rare [3].

Charcot's neuroosteoarthropathy results in necrosis and pathological destruction of the ankle joint bone tissue, including the talus, and therefore ankle joint arthroplasty is unacceptable in this case [4]. Moreover, movements and loads in the affected area is a trigger that exacerbates the pathological process. Therefore, one of the main components of management is the exclusion of the load on the affected segment and immobilization, achieved with conservative treatment using polymer customized unloading TCC (Total Contact Cast) or various orthoses. Surgical treatment uses various options of joint arthrodesis [5, 6].

The issue of total defects of the talus in reconstructive surgery has always been challenging. The search for materials for filling extensive defects led to its plastic surgery with implants made of porous titanium or nickel-titanium [7–10], implants of various shapes were used, both with cavities for integrating a heterotopic autograft and without them.

Since 2015, due to the development of 3D modeling and 3D printing from porous titanium, publications have appeared on the implementation of this technology in the field of foot surgery. The use of customized dodecahedral implants marked a new direction in the management of defects of the hind foot [11, 12]. However, despite the growing number of publications on this topic, we found only two descriptions of clinical cases in the literature on the use of 3D porous titanium implants in patients with Charcot arthropathy [13, 14]. A search in the electronic platform PubMed (with keywords: neuropathic arthropathy; syphilis) showed that over the past 15 years, only 10 cases were published on the Charcot arthropathy of various joints developed as a complication of tertiary syphilis. However, based on the analysis of published clinical cases and literature reviews, it can be assumed that the most common localization of arthropathy in tertiary syphilis is the knee joint [3, 15].

Purpose The aim of the work is to demonstrate and analyze the results of performing resection calcaneotibial arthrodesis with defect plastic surgery using a customized 3D implant made of porous titanium in a patient with manifestation of Charcot arthropathy as a complication of tertiary syphilis.

MATERIALS AND METHODS

This is a case of a 50-year-old woman without diabetes mellitus, with BMI of 22 kg/m2, history of syphilis diagnosed for the first time in 1997 that was treated with a course of penicillin and a repeated course of antibiotic therapy in 2008. She did not receive specific therapy lately. The tests findings: from 03/31/2016: RMP 4+, RPGA 4+, ELISA + 10.9; from 08/11/2016: RMP 2+, RPGA 4+, ELISA 10.9; from 03/23/2020: RMP +1, RPGA 4+, ELISA 13.3. She was registered with the dermatovenereology dispensary at her place of residence. Control analysis from 09/21/2023: Syphilis RPR (+) in titer 1:2.

Two months before the admission, total arthroplasty of the left knee joint was performed due to grade 3 arthrosis. During rehabilitation when she increased the duration of walking with crutches and load on the left lower limb, she noted the appearance of edema, minor local hyperthermia and hyperemia in the area of the left ankle joint and foot. There was no pain during passive and active movements. She denied injuries. A CT scan of the left ankle joint was performed on an outpatient basis and revealed a pathological fracture and destruction of the talus with its fragmentation and displacement of fragments.

Based on the examination results, the patient was consulted at the Center for Foot and Diabetic Foot Surgery of the Yudin City Clinical Hospital and hospitalized. At admission, the foot and lower leg were swollen, there was moderate hyperemia in the area of the left ankle joint (Fig. 1). According to laboratory tests, the erythrocyte sedimentation rate (ESR according to Panchenkov) was elevated (42 mm/h); the number of leukocytes in the general blood test was 7.6 × 109/l; the level of C-reactive protein was 6.52 mg/l. Radiography revealed destruction of the subtalar joint corresponding to Eichenholtz stage 2 [16–18]. Magnetic resonance imaging confirmed the extent of the lesion, and also revealed edema of the bone marrow of the navicular bone and tibia and signs of synovitis of the associated joints (Fig. 2).

Fig. 1 Appearance of the limb at first examination; tight edema and foot hyperemia of the foot, ankle and tibia

Fig. 2 Radiograph and MRI of the ankle joint and foot upon admission: *a* the radiograph shows unclear edges of osteodestruction and cloud-like foci of osteoproliferation; *b* MRI in fat-suppression mode shows pronounced bone marrow edema of the talus, navicular, tibial head and calcaneus, destruction of the talus, calcaneus and, to a lesser extent, navicular bone

The diagnosis was established: Charcot's neuroosteoarthropathy of the left foot with damage to the ankle and subtalar joints, Eichenholtz stage 2, varus deformity [19].

After examination, a posterior plaster immobilizing cast was applied from the toes to the upper third of the shin, and walking without weight-bearing on the left leg with crutches was allowed. The patient was followed up on an outpatient basis at the Yudin City Clinical Hospital.

After 2.5 months of limb immobilization with a plaster cast and unloading with additional support means, the patient was hospitalized at the Yudin City Clinical Hospital. Based on the results of a CT scan of the left ankle joint, 3D model of a customized implant was done to fill in the bone defect. A patient-specific 3D implant made of porous titanium was manufactured based on the 3D model (Fig. 3).

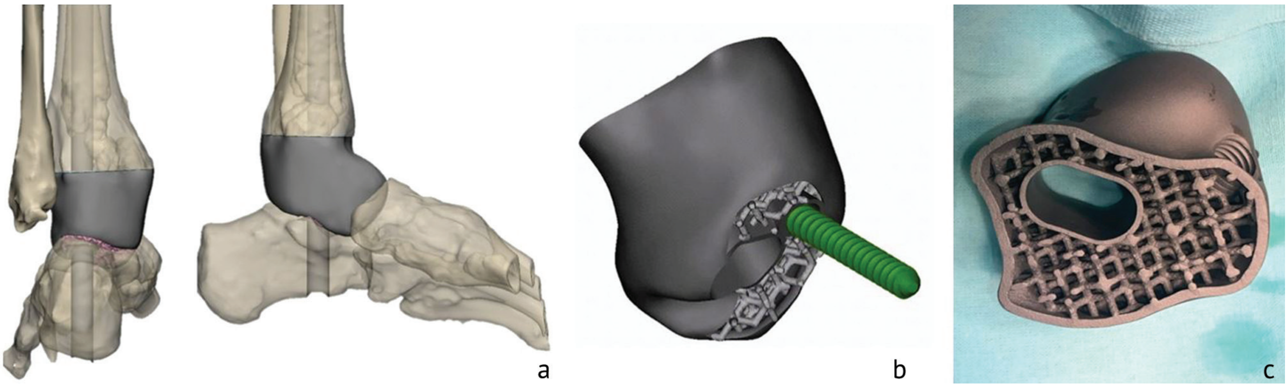

Fig. 3 Diagram of implant position in the ankle joint (*a*); 3D-model (*b*) and view of the fabricated implant (*c*)

Intraoperatively, destruction of the talus in the left foot was detected, its fragments, articular surfaces of the calcaneus and tibia were removed. Then, using the RIA (Reamer Irrigator Aspirator) system, an autograft was taken from the tibial canal using a retrograde approach (Fig. 4). After bringing the foot into normocorrection, plastic surgery of the defect thus formed after removal of the talus was performed using a custom-made 3D implant made of porous titanium with preliminary integration of the bone autograft into the intertrabecular space and fixation with the Ilizarov apparatus [7, 19].

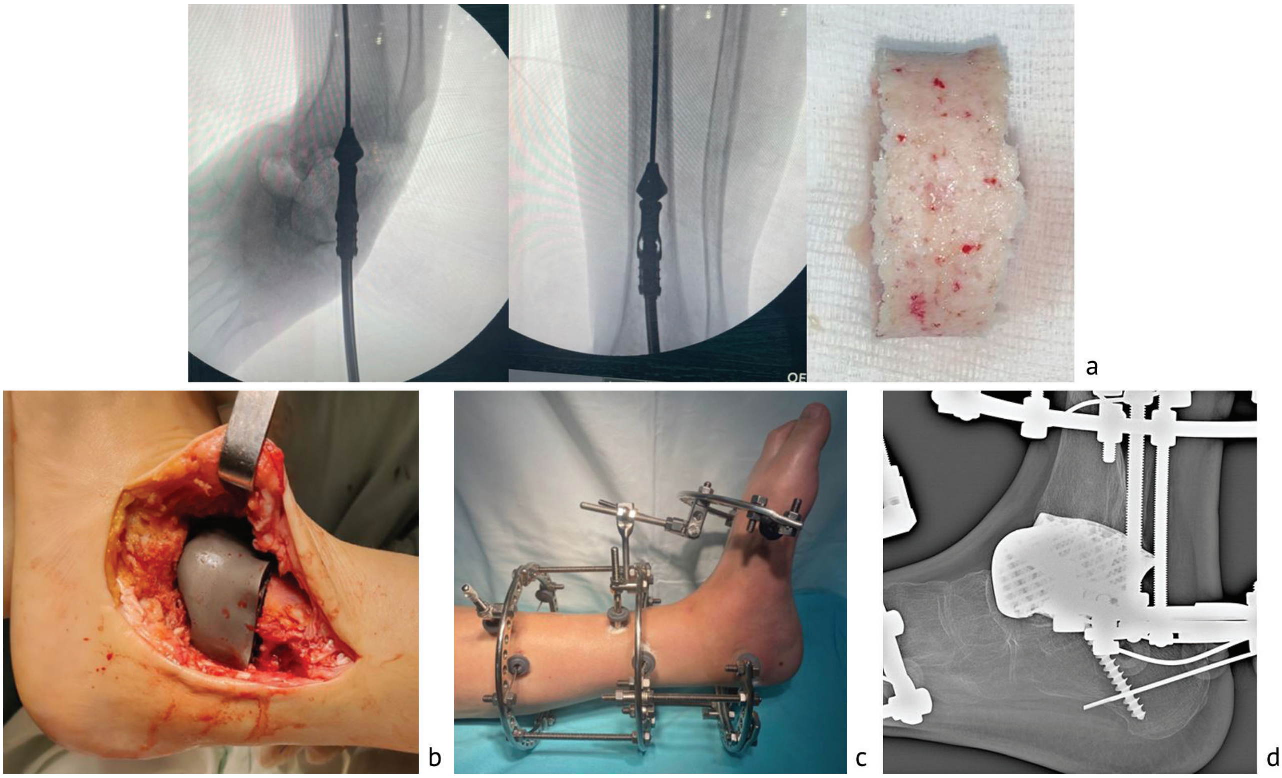

Fig. 4 Stages of surgical intervention: using the RIA system, an autograft was taken from the tibial canal (*a*); placement of the 3D porous titanium customized implant (*b*); fixation with the Ilizarov apparatus, the final appearance of the foot and ankle joint after surgery (*c*); X-ray of the foot and ankle joint after surgery (*d*)

She was discharged on the 12th day and was followed on an outpatient basis; the sutures were removed after 6 weeks. Staged supporting 1-mm compression in the Ilizarov fixator was performed monthly. Five months after the operation, the results of checking radiographs and computed tomography revealed restructuring of the bone graft in the intertrabecular spaces of the implant; lysis phenomena and instability of the implant were not detected.

The Ilizarov apparatus was dismantled as planned (Fig. 5). Subsequently, the left ankle joint was unloaded for 6 months using an individual polymer unloading bandage. The patient was activated using additional support means with a dosed load on the operated lower limb up to 20 % of the weight, followed by a gradual increase to full weight-bearing.

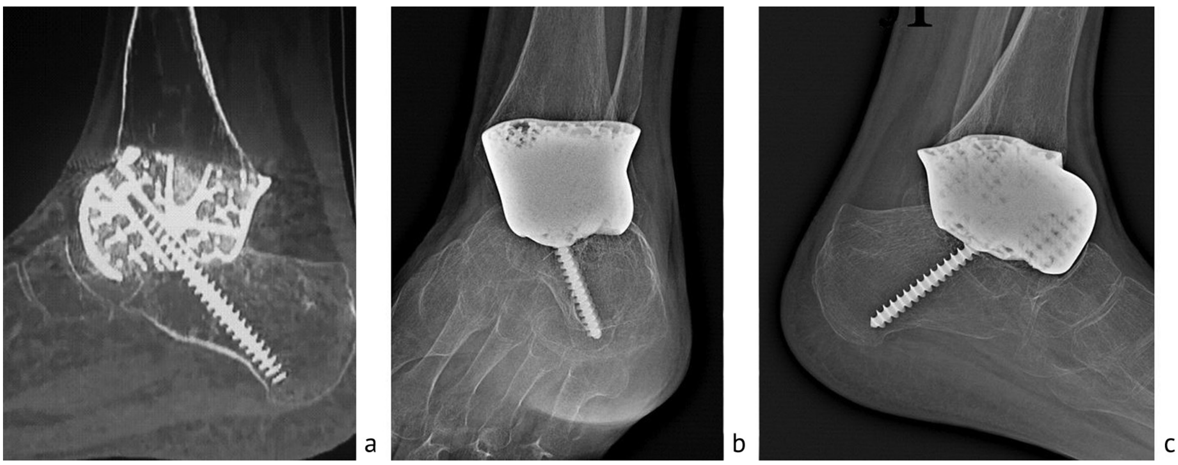

Fig. 5 Treatment results: CT image after dismantling the Ilizarov fixator shows signs of bone remodeling (*a*); X-rays of the ankle joint (*b*) and foot (*c*) six months after surgery

RESULTS

At the follow-up after 10 months, no clinical or radiographic signs of early instability of the endoprosthesis components and 3D porous titanium implant were observed (Fig. 6). The patient walked without the use of additional support means in orthopaedic diabetic shoes with individual orthopaedic insoles.

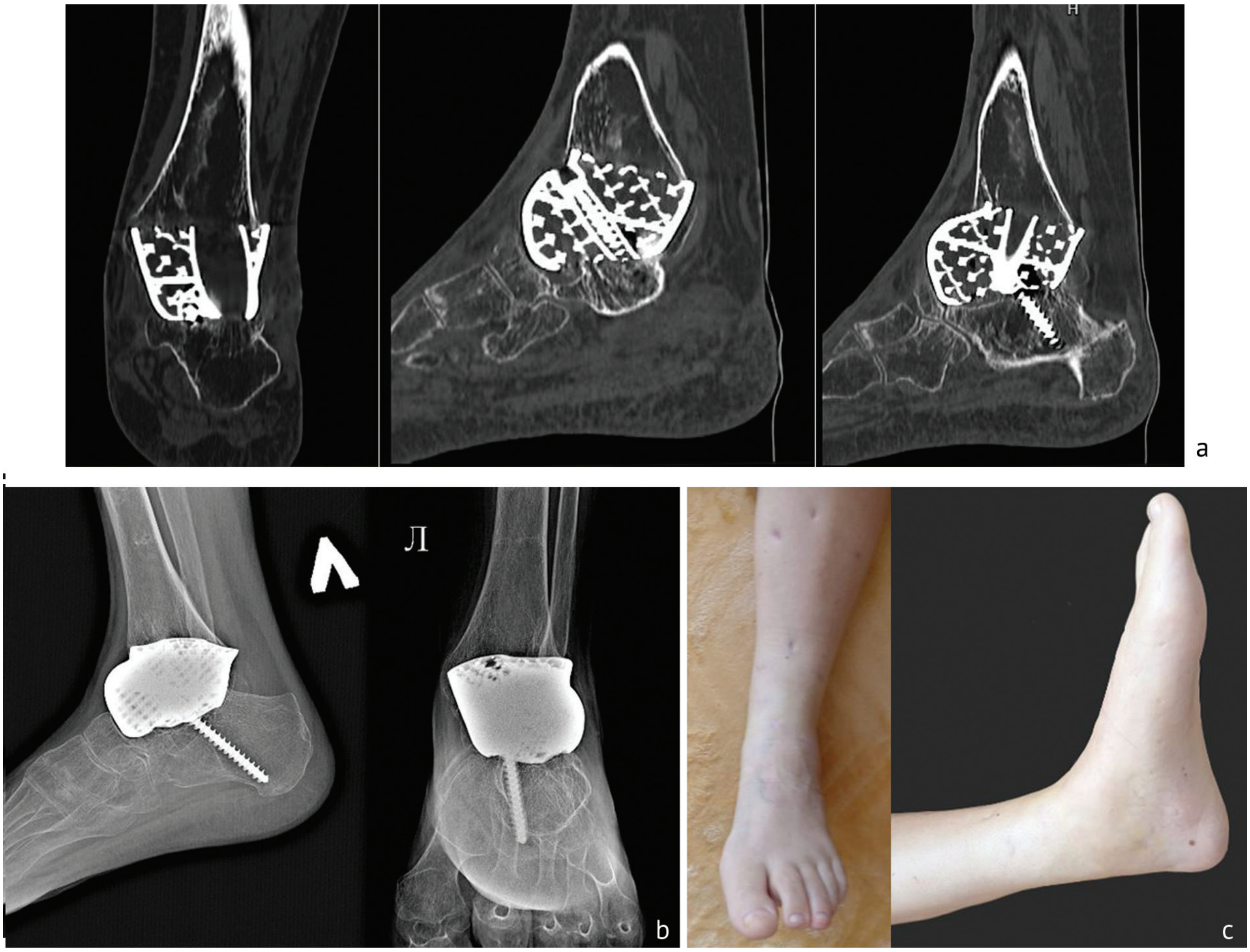

Fig. 6 CT-scans (a); radiographs (b) and photos of the foot (c) at 10-month follow-up after Ilizarov fixator removal

DISCUSSION

This clinical case demonstrates the need for a thorough anamnesis and preoperative examination to verify concomitant diseases and associated possible complications.

Conservative methods still prevail in the treatment of diabetic neuroosteoarthropathy, but cannot be applied to patients with complete or partial disorder of the supporting function of the foot, which, in turn, significantly increases the urgency of orthopedic reconstruction [20].

This method of surgical treatment is used in total destruction of the talus and the resulting defect-diastasis due to resection for calcaneotibial arthrodesis. The method allows for one-stage reconstructive intervention and precise compensation of shortening, regardless of the shape and size of the defect, avoiding secondary shortening of the limb while maintaining its support ability, thereby preventing the occurrence of secondary overload changes in the adjacent joints. However, one of the key tasks of orthopaedic treatment of patients with Charcot's neuroosteoarthropathy is to reduce the risk of high amputation and maintain the patient's motor activity. Stabilization of the foot with an external fixator is a factor that contributes to subsidence of the process and, as a result, has a positive effect on the completeness of the arthrodesis performed. It should also be noted that the treatment result largely depends on the patient's compliance and adherence to treatment, as well as his/her adherence to prescriptions and recommendations [21].

To clarify the indications for this treatment method and patient selection criteria, it is necessary to have a group of patients and conduct additional studies.

CONCLUSION

The results of performing resection calcaneotibial arthrodesis associated with defect plasty using a 3D porous titanium customized implant, presented in a patient with manifestation of Charcot arthropathy as a complication of tertiary syphilis, are encouraging. Given the person-specific approach, this method appears to be a promising treatment concept that allows restoring the weight-bearing capacity of the lower limb without shortening.

Conflict of interests *None declared.*

Source of funding *None declared.*

Informed consent *The patient gave written informed consent for the study to be conducted and for the results to be published.*

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