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Method of Tibiocalcaneal Arthrodesis for a Total Defect of the Talus in Patients with Charcot Neuroarthropathy

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Abstract

Background. At present, treatment of patients with Charcot neuroarthropathy remains an unsolved problem. The current state of the problem motivated us to develop a new original method of hindfoot reconstruction aimed to form a tibiocalcaneal bone block with maximum possible preservation of limb length in patients with Charcot neuroarthropathy.

The aim of the paper was to demonstrate a new one-stage tibiocalcaneal arthrodesis technique aimed at preserving maximum possible limb length.

Surgical technique description. At the preoperative stage, the angle adjacent to the Gissan angle and its bisector is measured on X-rays. After performing the Kocher ankle approach with subsequent lateral malleolus resection and osteonecrectomy, the distal metaepiphysis of the tibia is cut in an oblique-horizontal plane at the bisector angle, open posteriorly and equal to the preoperatively measured value. The resulting triangular bone fragment is rotated by 180° and adapted within the external fixator.

Conclusion. The proposed method for total talar destruction in patients with Charcot neuroarthropathy is convenient and simple for adapting incongruent calcaneal and tibial surfaces and allows reducing the lower limb shortening in tibiocalcaneal arthrodesis.

Keywords: Charcot neuroarthropathy, total defect of the talus, tibiocalcaneal arthrodesis, limb length preservation.

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Способ пяточно-большеберцового артродеза при тотальном дефекте таранной кости у больных с нейроостеоартропатией Шарко

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Реферат

Введение. Лечение пациентов с нейроостеоартропатией Шарко остается в настоящее время нерешенной проблемой. Современное состояние проблемы мотивировало нас разработать новый оригинальный способ реконструкции заднего отдела стопы для формирования пяточно-большеберцового костного блока с максимально возможным сохранением длины конечности у пациентов с нейроостеоартропатией Шарко.

Цель работы — продемонстрировать новый метод одноэтапного пяточно-большеберцового артродеза с максимально возможным сохранением длины конечности.

Техника операции. На предоперационном этапе осуществляется измерение на рентгенограммах угла, смежного с углом Гиссана, и его биссектрисы. После осуществления доступа к голеностопному суставу по Кохеру с резекцией латеральной лодыжки и остеонекрэктомии производится опил дистального метаэпифиза большеберцовой кости в косо-горизонтальной плоскости под углом биссектрисы, открытым кзади и равным предоперационно измеряемому значению. Получившийся костный фрагмент треугольной формы разворачивается на 180°, и производится адаптация костных фрагментов в аппарате внешней фиксации.

Заключение. Предложенный нами метод оперативного вмешательства при тотальном разрушении таранной кости у пациентов с остеоартропатией Шарко удобен и прост для адаптации дисконгруэнтных друг к другу поверхностей пяточной и большеберцовой костей и позволяет уменьшить укорочение нижней конечности при пяточно-большеберцовом артродезе.

Ключевые слова: нейроостеоартропатия Шарко, тотальный дефект таранной кости, пяточно-большеберцовый артродез, сохранение длины конечности.

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INTRODUCTION

Charcot neuroarthropathy (Charcot foot) is a condition characterized by damage to the bones, joints, and soft tissues of the foot and ankle. Although it can develop in case of various peripheral neuropathies, diabetic neuropathy is the most common cause. Several factors contribute to its pathogenesis, including diabetic sensorimotor neuropathy, autonomic neuropathy, trauma, and metabolic disorders of bone tissue. The interaction of these factors leads to local inflammation, which subsequently causes bone destruction, subluxations, dislocations, and limb deformities [1].

A literature review reveals that the management of patients with Charcot neuroarthropathy remains an unresolved issue. Despite numerous treatment approaches, none fully satisfy the authors and other specialists. Conservative treatment is essential but does not provide lasting orthopedic correction, nor does it eliminate the risks of secondary foot deformities or trophic soft tissue lesions [2, 3, 4]. The goal of surgical treatment in patients with complicated diabetic neuroarthropathy is the radical removal of bone destruction foci, correction of deformities and removal of osteophytes that contribute to trophic ulcer formation, and the subsequent functional recovery of the foot through optimal anatomical reconstruction, rational restoration of segment length and biomechanics [5, 6, 7]. Restoring weight-bearing capacity and preserving limb length remain clinically challenging. Existing Charcot foot reconstruction techniques have high complication and recurrence rates with controversial clinical outcomes [8, 9].

Tibiocalcaneal arthrodesis using an intramedullary locking nail is a relatively successful surgical approach [10, 11], with a bone union rate of up to 75% in diabetic patients [12]. Two-stage arthrodesis techniques with defect reconstruction using a free autograft offer significant advantages for correcting absolute segment shortening and improving graft integration but require a second surgical procedure and prolonged fixation [13]. Some cases report foot reconstruction with a heterotopic allograft from the femoral head followed by arthrodesis with locking nail [14, 15, 16]. The use of additive manufacturing technologies to replace talar bone defects in tibiocalcaneal arthrodesis with titanium implants, supplemented with autografts or allografts, has been described in the literature [9, 17]. The advantage of this technique is the ability to create custom-made implants based on CT scans, minimizing the need for calcaneal and tibial bone resection, reducing limb shortening, and decreasing the risk of auto- or allograft collapse during implant integration [18].

Unfortunately, reconstructive operations or ankle and subtalar arthrodesis with the complete preservation of limb length are not feasible. Talectomy with tibiocalcaneal arthrodesis using an external fixator is an effective reconstruction method for restoring weight-bearing capacity, especially in patients with concomitant osteopenia and vitamin D deficiency [19]. However, limb shortening in tibiocalcaneal arthrodesis occurs not only due to the talar bone removal but also because of the resection of the tibial and, predominantly, calcaneal bone ends to achieve surface congruence. According to R. Rochman et al., the average limb shortening after tibiocalcaneal arthrodesis was 4 cm (ranging from 2.5 to 5 cm) [8].

Current challenges in treating Charcot neuroarthropathy motivated us to develop a novel reconstruction technique for the hindfoot to form a tibiocalcaneal bone block while preserving maximal limb length in patients with Charcot neuroarthropathy.

The aim of the paper was to demonstrate a new one-stage tibiocalcaneal arthrodesis technique aimed at preserving maximum possible limb length.

SURGICAL TECHNIQUE

During preoperative planning, radiographic measurements include the angle adjacent to the Gissane angle, and its bisector. Intraoperatively, with the patient in the supine position, after antiseptic preparation and placement of a pneumatic tourniquet on the lower third of the thigh, the Kocher ankle approach is performed with subsequent lateral malleolus resection. The destruction site is assessed, followed by the removal of deformed and affected talar bone fragments, scar tissue, and pathological granulations, as well as synovectomy, and articular cartilage resection.

Next, an extrafocal osteosynthesis is performed using a compression-distraction external fixator consisting of two rings fixed to the tibia and two half-rings fixed to the foot (one posteriorly and one anteriorly). Wires are placed in an oblique-frontal plane at the projection of the rings and half-rings and are fixed in the plane of the rings using wire tensioners. Half-rings are connected via threaded rods and one- or two-plane hinges. The distal metaepiphysis of the tibia is cut in an oblique-horizontal plane at the bisector angle, open posteriorly and equal to the preoperatively measured value. The resulting triangular bone fragment is rotated 180° and adapted to the surrounding bone structures within the external fixator. Fixation continues until stable tibiocalcaneal bone block is formed. The surgical stages are illustrated in Figure 1.

Using this method, 11 patients were treated at the Foot and Diabetic Foot Surgery Center of Yudin City Clinical Hospital between 2021 and 2023. Among them, 6 patients (54.5%) had type 2 diabetes, 4 patients (36.4%) had type 1 diabetes, and 1 patient (9.1%) had distal neuropathy without diabetes. The cohort included 9 women (82%) and 2 men (18%), with an average age of 53.4±3.8 years (range: 30-72). The follow-up period exceeded one year.

The average duration of external fixation was 6.4±0.2 months (5.5-7.0 months). There were no cases of infection, nonunion, or wire-associated osteomyelitis.

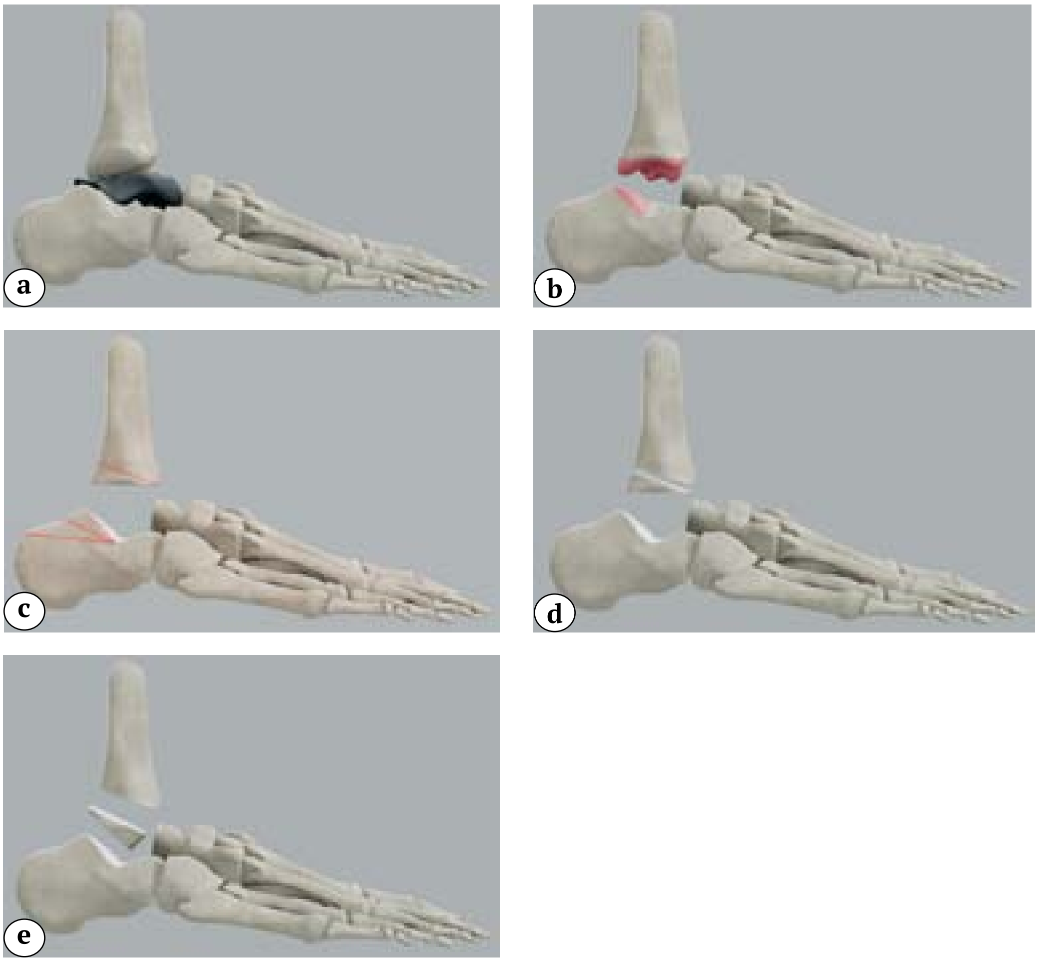

Figure 1. Schematic representation of the surgery stages:
a — destruction of the talus;
b — resection of the articular surfaces of both the distal tibial and calcaneal metaepiphysis;
c — markings performed;
d — sawing of the posterior edge of the tibia with the isolation of a wedge-shaped graft;
e — turning the graft by 180º for better adaptation of the fragments

We present the use of this technique in a clinical case of a 72-year-old female patient with distal neuropathy without diabetes. A year before seeking treatment, she noticed progressive left foot deformity, was observed on an outpatient basis. Conservative treatment and orthotic use for one year yielded no improvement (Figure 2).

The patient underwent the described resectional tibiocalcaneal arthrodesis at the Foot Surgery Center of Yudin Hospital, with subsequent external fixation for seven months (Figure 3). After Ex-Fix removal, rehabilitation involved gradual weight-bearing in an immobilizing ankle brace with an air chamber for 10 months, followed by a transition to custom-made orthopedic footwear with a rocker bottom sole. The treatment outcome at 1.5 years is shown in Figure 4.

Figure 2. Photograph and X-ray of the foot and ankle joint before inpatient treatment

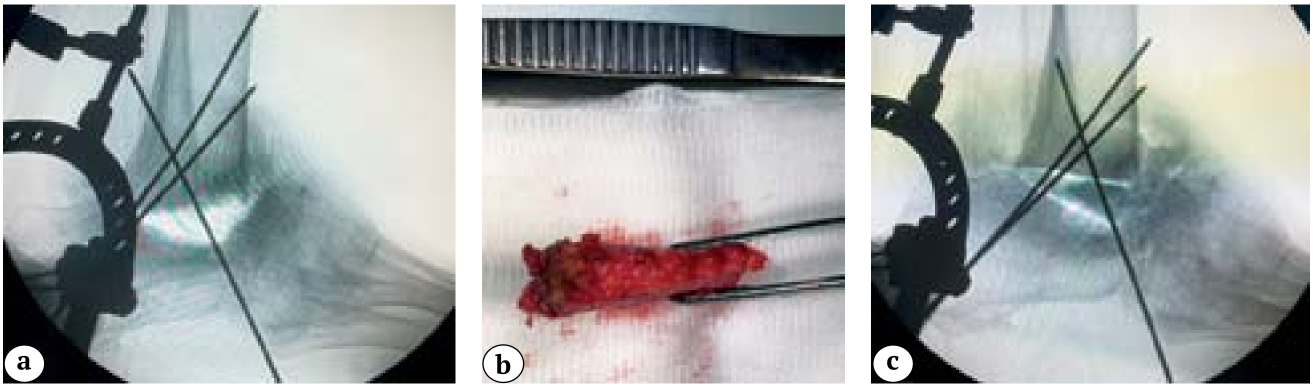

Figure 3. Stages of surgical intervention:
a — intraoperative X-ray — fragments adaptation;
b — photograph of the wedge-shaped bone graft;
c — X-ray after installation of the wedge-shaped autograft

Figure 4. X-ray and photograph of the patient's feet and ankle joints 1.5 years after dismantling the external fixation device

DISCUSSION

According to L.I. Sanders and R.G. Frykberg, Charcot neuroarthropathy affects the ankle and subtalar joints (Sanders types 4 and 5) in up to 10% of cases [20]. This region is particularly important due to the unique vascular supply of the talus, increased risk of avascular necrosis, and critical functional role in weight-bearing. Although talus involvement in Charcot neuroarthropathy is less common than that of Lisfranc and Chopart joints (27.60% and 30.35%, respectively), the pathologic process in the ankle joint is more severe [21]. Patients with distal neuropathy continue full weight-bearing on the compromised limb, which leads to pathologic fractures, particularly of the talus. In diabetic neuroarthropathy, dysregulation of the RANKL-RANK-OPG system contributes to osteoclast hyperactivity and subsequent bone resorption. Additionally, increased inflammatory cytokine levels exacerbate RANKL activation, reducing bone repair capacity and accelerating bone destruction [22, 23]. This results in total or subtotal talar defects, multiplanar deformities, and ankle instability [24], leading to non-weight-bearing and necessitating surgical intervention.

Despite numerous fixation techniques, single-stage reconstructions remain relevant for patients unwilling to undergo prolonged multi-stage procedures for limb length restoration.

Our technique for total talar destruction in Charcot neuroarthropathy is more convenient, facilitating better adaptation of incongruent calcaneal and tibial surfaces in tibiocalcaneal arthrodesis. This method is patented (RF Patent No 2782784, 02.11.22, “The method of tibiocalcaneal arthrodesis for Charcot neuroarthropathy”).

We consider this technique the method of choice for Sanders types 4 and 5 Charcot neuroarthropathy, allowing single-stage surgical correction while maximizing calcaneal bone preservation without additional bone grafting or extended duration of fixation.

Currently, when analyzing the outcomes of using external fixators to achieve stable arthrodesis, it is not possible to formulate an evidence-based standard protocol that reliably determines the duration of external fixation, functional weight-bearing regimens and terms, or the specifics of orthotic support.

The introduction of the hindfoot reconstruction technique in clinical practice to form a tibiocalcaneal bone block is one of the effective and technically simple options for restoring limb weight-bearing capacity in patients with Charcot neuroarthropathy.

CONCLUSION

The proposed method of tibiocalcaneal arthrodesis for severe hindfoot bone defects represents a simple and practical surgical solution. We hope our experience will be of interest to specialists in foot reconstruction, including those performing transosseous osteosynthesis. In our opinion, this approach has strong potential for clinical implementation as an alternative to existing techniques for treating Charcot neuroarthropathy.

DISCLAIMERS

Author contribution

All authors made equal contributions to the study and the publication.

All authors have read and approved the final version of the manuscript of the article. All authors agree to bear responsibility for all aspects of the study to ensure proper consideration and resolution of all possible issues related to the correctness and reliability of any part of the work.

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Disclosure competing interests. The authors declare that they have no competing interests.

Ethics approval. The study was performed on the basis of ethical principles of the World Medical Association’s Declaration of Helsinki (2013), “Good Clinical Practice in the Russian Federation” approved by the order of the Ministry of Health of the Russian Federation from 19.06.2003 No 266.

Consent for publication. Written consent was obtained from the patient for publication of relevant medical information and all of accompanying images within the manuscript.

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