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Anterolateral Thigh Free Flap to Coverage of Diabetic Foot Defect by Using Reverse Flow of Severely Calcified Dorsalis Pedis Artery

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Low blood flow in the distal part of the diabetic foot aggravates the wound to an ischemic state, which eventually leads to amputation. However, major advancements in microvascular surgery have shown the ability to salvage the limb even in the presence of poor perfusion. Since a foot is constituted of a complex network of angiosomes, each separate territory of the foot is supplied by interconnected vessels. We report the successful salvage of a severe diabetic foot injury of a 72-year-old male patient with a heavily calcified dorsalis pedis artery (DPA). Although the proximal end of the DPA was clogged to prevent the flow of blood and was insufficient to use as a recipient vessel, reverse flow from the distal end was restored after removing multiple calcification fragments. As a result, a large soft-tissue defect on the third and fourth toe region was successfully covered by a contralateral anterolateral thigh free flap.

Keywords: Diabetic foot, Free tissue flaps, Reconstructive surgical procedure, Foot blood supply, Limb salvage

INTRODUCTION

Diabetic foot is considered one of the most debilitating diseases due to its difficulty to treat. Although various treatment algorithms and referral pathways have been proposed for successful outcomes [1], many patients still primarily present with acute infections and tissue necrosis with poor blood perfusion [2]. Unresolved inferior blood circulation in the distal portion of the foot aggravates the wounds to an irreversible condition, leading to amputation [1]. Since an amputation is an enormous burden for diabetes patients, the optimal selection of a surgical procedure and its skillful execution are imperative for possible foot salvage [3]. Presently, with advancements in microsurgical techniques, free tissue transfer has been frequently performed to restore a severely injured diabetic foot associated with osteomyelitis [4]. This article presents the successful reconstruction of a diabetic foot using a reverse flow of the severely calcified dorsalis pedis artery (DPA) as the recipient vessel.

CASE REPORT

A 72-year-old male patient with uncontrolled diabetes was admitted to our hospital for a severe diabetic foot with necrosis of the third and fourth toes of his left foot (Fig. 1). Physical examination of the wound revealed that necrosis had progressed and wide debridement and amputation of the distal phalange were inevitable. Because the patient was determined to save his foot, we examined the

Fig. 1. Postremoval status of all vascular tissue. Bone exposure of the diabetic foot after debridement.

vascular conditions of both lower extremities by three-dimensional computed tomographic (CT) angiography and hand-held audible Doppler ultrasound before deciding on the main surgical procedure. The CT angiography revealed a multifocally calcified anterior tibial artery (ATA) and posterior tibial artery (PTA) (Fig. 2A), and an invisible DPA (Fig. 2B). Prior to the surgical attempt, endovascular intervention, balloon angioplasty was performed to restore blood flow for better wound healing. However, revascularization of the ATA and PTA failed at the level of the plantar arch of the foot due to severe calcification. We considered that all three vessels were poor candidates for reconstruction, but the strong sound of the reverse flow of the DPA was detected by hand-held audible Doppler ultrasound. Then, contralateral anterolateral thigh (ALT) free flap reconstruction of the defect was conducted. After en bloc debridement, the distal phalanges of the third and fourth toes were fixed with Kirschner wire. To examine the condition of the recipient vessel, the DPA was dissected and traced. However, the intraoperative findings showed that the DPA was rigid and thick with no elasticity (Fig. 3A). When we cut the DPA

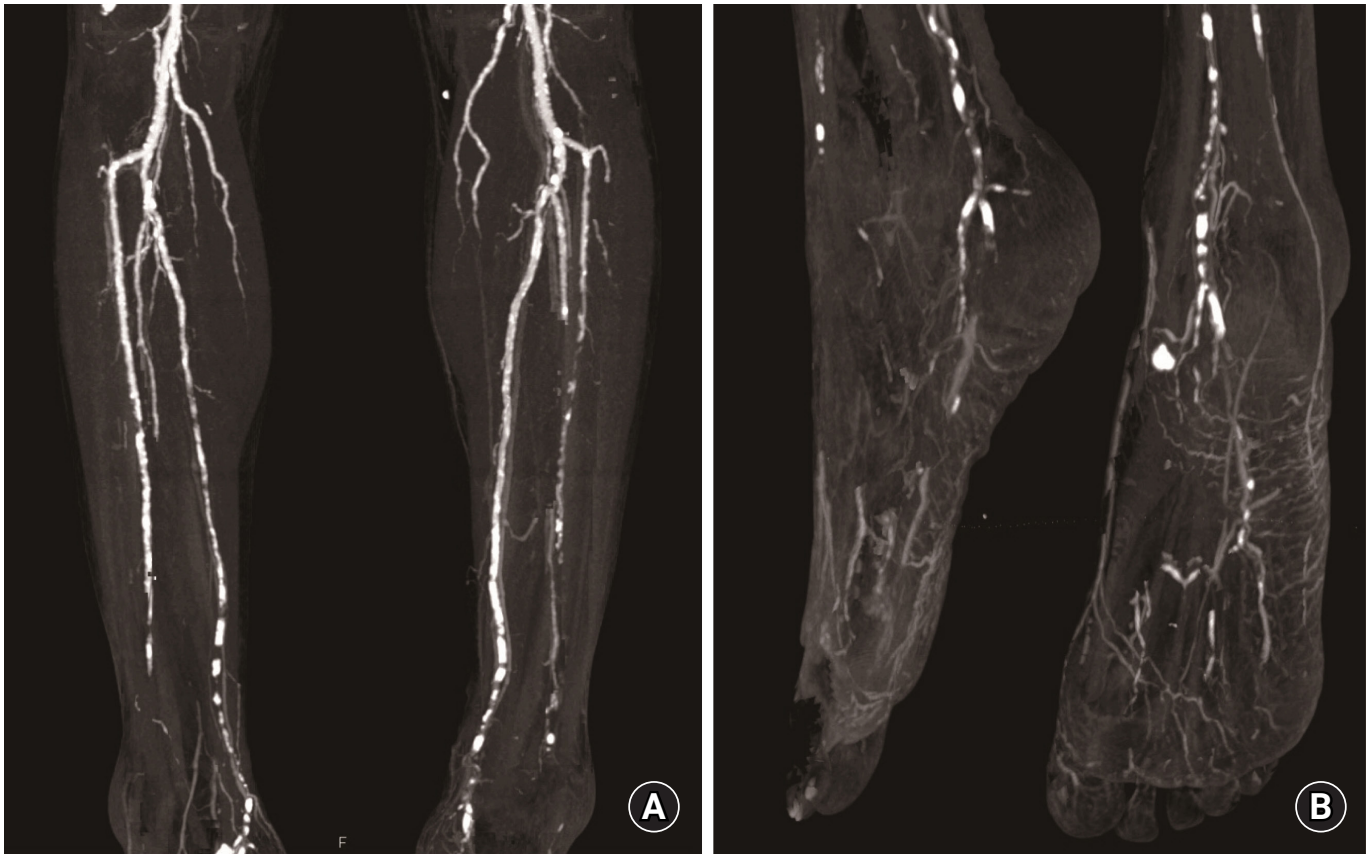

Fig. 2. Preoperative computed tomography angiography. (A) Multifocal calcified anterior tibial artery, posterior tibial artery, and peroneal artery. (B) Invisible dorsalis pedis artery.

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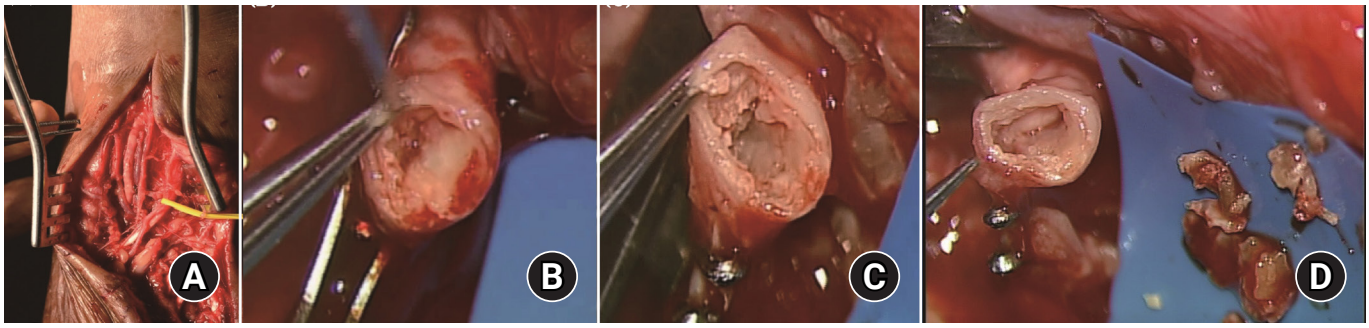

Fig. 3. (A) Revealing the calcified dorsalis pedis on the recipient site. (B, C) Severe atherosclerosis of the distal end of the dorsalis pedis artery. (D) Calcification removal under a surgical microscope (ZEISS S88; Carl Zeiss AG, Oberkochen, Germany).

into sections, we observed complete obstructions with severe calcifications at each end (Fig. 3B). We could not observe any blood flow through the lumen of the proximal end, but very weak blood flow was detected at the distal end of the DPA. The proximal end was additionally resected in a cephalic direction to find adequate blood flow, but flow was not observed. Since the pulsatile sound of reverse flow was heard at the distal end of the DPA, we attempted to carefully remove the calcified fragments with jeweler forceps to restore blood flow (Fig. 3C). After several attempts to remove the calcifications and additional irrigation with urokinase and heparin solution (Fig. 3D), limited reverse blood flow through the distal end was restored. Thus, end-to-end anastomosis of the ALT flap pedicle to the distal end of the DPA was done with Ethilon 10-0 (Ethicon, Somerville, NJ, USA) (Supplementary Video 1). A venous anastomosis was also performed with the vena comitans using Ethilon 10-0. However, because the occlusion was observed 3 cm proximal to the anastomotic region, we re-anastomosed a tributary vein of the great saphenous vein at this site. The ALT flap was then folded to the toe level and inset appropriately (Fig. 4). Although the color was pale immediately postoperatively, pulsation was audible with a hand-held Doppler. The flap was well-perfused with no major complications (Fig 5A). However, partial necrosis followed by venous congestion occurred 7 days postoperatively in the distal third of the flap, which was folded to cover the sole and several toes (Fig. 5B). A total of 10 medical leeches were applied for 3 days to reduce the necrosis. The donor defect healed completely without any complications.

Written informed consent was obtained for publication of this case report and accompanying images.

Fig. 4. Left 3rd and 4th phalanxes are fixed with Kirschner wire and the extended soft-tissue defect was covered by a free anterolateral thigh flap.

DISCUSSION

Peripheral arterial disease is one of the serious complications of diabetes. Chronic hyperglycemia with oxidative stress causes atherosclerosis and vascular calcification, especially in the infragenicular arteries of the lower extremity [2]. With the development of diffuse arterial occlusion of the tibial arteries, the distal part of the limb is prone to intractable limb ischemia due to unreliable blood supply and the propensity for soft tissue and bone infections [2,4].

Because diabetes patients with chronic complex lower ex-

Fig. 5. (A) The appearance 14 days after anterolateral thigh free flap reconstruction. (B) Partial necrosis followed by venous congestion on the sole portion was noted.

tremity wounds have poor vascular perfusion and multiple comorbidities, limb salvage has been reluctantly performed. Approximately 55% of diabetes patients with a large defect at the distal end of the lower extremity, exposing tendons and bone, eventually opt for amputation [5]. The potential benefits of amputation are early return to ambulation and independent daily living by shortening the hospital stay [6]. However, the recovery of functional motor skills after amputation requires high energy expenditure, which increases morbidity and mortality rates in comorbid patients over the age of 60 years [3,6]. In fact, 30% of patients older than 60 years are more prone to developing severe contralateral limb-threatening disease requiring further amputation within 2 years [4]. Therefore, with the significant advances in microsurgical techniques, it has recently been recommended to preserve the maximum length of the lower limbs to prolong life expectancy by reducing energy consumption [3,6]. The combination of preoperative revascularization techniques and innovative limb salvage procedures has also demonstrated high mobility rates and low mortality rates in patients with compromised perfusion [6].

As a result of the long-term effects of diabetes on the vascular structure of major blood vessels, the condition of the main pedicle may be insufficient to use for microsurgical anastomoses of a free tissue transferred flap [2-4]. However, vascular reconstruction with a free flap with adequate blood flow is possible based on the angiosome concept [7]. The foot consists of five angiosome territories fed by collateral arteries and branches of the major arteries [7,8]. Each angiosome is connected at a different level to the leg arteries called "choke vessels" that supply the damaged angiosome territory with sufficient blood

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[7,9]. In addition, a free flap can be placed to maintain blood flow by reversing the distal outflow [10]. Specifically, the deep plantar branch of the DPA from the ATA and the lateral plantar artery of the PTA are connected to form an arch at the subdermal level [9]. A free transferred flap supplied by reverse flow from the PTA can cover a large defect on both the dorsal and distal aspects of the foot without the use of end-to-side anastomosis to other intact major arteries or a venous graft from the patent proximal end of the ATA [7,8].

Recently, successful vascular bypass, graft, or supermicrosurgery have been performed when the condition of the recipient vessel was not suitable for free tissue transfer [9]. Moreover, to improve wound healing by restoring blood flow, revascularization has been performed preoperatively by direct or indirect endovascular intervention based on angiosome concepts [7]. In our case, the vascular status of the affected foot seemed to make it unavailable to use as a recipient vessel due to severe calcification. Preoperatively, only the strong audible Doppler sound of the reverse flow of the distal end of the DPA was detectable. When fragments of calcification were removed from the thick intima of the arterial wall by jeweler forceps during the microsurgical procedure, significant intimal damage was also observed. However, reverse arterial blood flow was sufficiently restored, which could be used in anastomosis. Since several successful cases of foot intrinsic fasciocutaneous island flap using a reverse flow pattern were performed prior to this case [10], we were able to reconstruct the large defect of the injured foot using limited reverse flow from the PTA to the ATA. There are no clear contraindications for limb salvage in ischemic foot injuries, and plastic surgeons can achieve successful results in active reconstruction even in severely occluded vessels with calcifications after mechanical interventions.

SUPPLEMENTARY MATERIALS

Supplementary Video can be found via https://doi.org/10.12790/ahm.21.0122.

Supplementary Video 1. This video demonstrates the entire process of end-to-end arterial anastomosis of the anterolateral thigh flap pedicle to the distal end of the dorsalis pedis artery. After several attempts to remove the calcifications and additional irrigation with urokinase and heparin solution, limited reverse blood flow through the distal end was restored.

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CONFLICTS OF INTEREST

The authors have nothing to disclose.

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