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# Treatment of Diabetic Foot Ulcer with Tibial Transverse Transport Combined with Antibiotic Bone Cement, a Case Report

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**Abstract:** Diabetic foot is one of the most difficult complications of diabetes and the main cause of non-traumatic amputation, accounting for 85% of all non-traumatic amputations. [1-2], We report a case of diabetic foot ulcer treated with transverse tibial transport combined with bone cement implantation. The ulcer healed and the effect was good. Case presentation: A 65-year-old man has been diagnosed with Type 2 diabetes for more than 20 years, combined with Type 2 diabetic neurological complications and type 2 diabetic eye complications. Two years ago, his right thumb was removed due to foot ulcers. 20 days ago, The second toe of the right foot was removed due to an ulcer. When he entered our hospital for treatment, the back of the right foot and the sole of the foot had large ruptures. After thorough debridement and transverse tibial transport combined with bone cement placement, the wound healed well. Conclusion: In the treatment of diabetic foot ulcers, it is very important to restore the blood supply of the affected limb. Tibial transverse transport promotes the reconstruction of anastomotic branches below the knee joint, and the induced membrane technology can improve local blood supply. The combination of the two can provide an economical and effective way for the treatment of diabetic foot, which is worthy of our continued exploration.

**Keywords:** Diabetic Foot Ulcer, Tibial Transverse Transport, Induced Membranes

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## 1. Background

Diabetic foot is the most expensive and one of the most difficult complications of diabetes. It is also the main cause of non-traumatic amputation. Although many treatment methods have been proposed, the effect is still not very satisfactory. The tibial transverse transport based on the gravity-stress law is a new method developed in recent years to treat diabetic foot. [3-6]

At present, its specific mechanism of action still needs to be further explored. Preliminary animal experiments believe that stretch-stress mechanical stimulation can promote capillary regeneration and tissue regeneration, and stretch tissue regeneration technology can stimulate the formation of "vascular network". [7-9] Clinical retrospective studies have shown that this technique is used to treat Wagner grade 3 diabetic foot, and its wound healing rate and limb salvage rate are both over 95%, and the 1-year recurrence rate is less than

10%. Compared with traditional treatment methods, the ulcer cure rate, amputation rate, vascular recanalization rate, blood flow and other indicators have been significantly improved after the treatment of diabetic foot by tibial transverse transport. The wounds healed gradually and normal life was restored. [7-9] Therefore, the tibial transverse transport has shown a broad prospect in the treatment of diabetic foot. As a new bone defect technique, bone cement implantation was proposed by Masquelet. [10] In the first stage, antibiotic bone cement is placed to control infection after thorough debridement, and in the second stage, bone grafting in the biofilm formed around the bone cement is used to reconstruct the bone defect. In the treatment of diabetic foot, bone cement loaded with antibiotics can continue to exert antibacterial effects. The induction membrane not only plays a mechanical barrier, but also loads a large amount of growth factors to promote wound healing.

## 2. Case Presentation

The patient is a 66-year-old male. He has been diagnosed with "Type 2 diabetes" for more than ten years, and has multiple diabetic complications such as diabetic nerves and diabetic eye disease. The patient usually took hypoglycemic drugs to control blood sugar, and his fasting blood glucose was maintained at 11-13mmol/L. In 2018, he underwent "right thumb resection" in another hospital because of foot ulcers. More than 20 days ago, due to an ulcer of the second toe of his right foot, he received a "second toe resection of the right foot" in another hospital. When admitted to our hospital, the right foot was obviously red and swollen, and there were two ulcers in the back of the right foot, which were 3×2.2cm and 7×4cm. The size of the wound on the right toe was 2×1.5cm. The wound on the sole of the right foot is 10×6cm. (Figure 1). Probe test: negative. Fasting venous blood glucose: 7.2mmol/L, postprandial blood glucose: 11.9mmol/L, urine creatinine: 3154μmol/L, urine glucose: 2.8mmol/L, WBC:  $15.25 \times 10^9/L$ , color Doppler ultrasound and three-dimensional CT reconstruction of the right lower limb arteries were not found blocked blood vessels. There was no obvious abnormality in cardiovascular color Doppler ultrasound. The insulin treatment plan after admission is: basic dose 12u, 5u before breakfast, 5u before lunch, and 5u before dinner.



**Figure 1.** The pictures ABC show the condition of the patient's leg when he was first admitted.



**Figure 2.** Wound condition of affected limb after operation.

After perfecting the routine preoperative examination and eliminating the contraindications of the operation, surgical treatment is given. During the operation, an assembled unilateral external fixation stent (Shanghai Kaiwei Pharmaceutical Co., Ltd.) was used. Bone cement filled with gentamicin is placed in the defect to eliminate the dead space, and vancomycin is added according to the preoperative drug sensitivity results. The surrounding soft tissues were sutured and fixed without tension, and washed with ice salt water until the bone cement was completely shaped. (Figure 2)

On the 7th day after the operation, the front and side X-rays of the tibia and fibula of the affected limb were re-examined, and the tibial window was moved laterally according to the healing of the incision at the osteotomy. On the 10th day after operation, the tibia block was stretched. According to the accordion technique, 1mm per day, divided into 4 times. Clockwise 7d, counterclockwise 7d, two back and forth. After the operation, use 75% ethanol to clean the needle passage of the external fixator 2 to 3 times a day to prevent needle tract infection. At the same time, clean and change dressing regularly, and observe the wound condition.

He returned to the hospital for the second stage of debridement one month after the operation. Before the operation, the wound dressing of the right foot and right calf was dry and clean, and there was no bleeding or exudation. The upper and middle tibia of the right calf was fixed with an external fixator. The random blood glucose on admission was 7.2mmol/L, WBC:  $10.02 \times 10^9$ , A/G: 0.75, GLB: 47.9g/L, and hypersensitive C-reactive protein: 24.09mg/L. Disinfect before surgery, then remove the bone cement, the granulation tissues of the right sole and the second toe were seen to grow well, and the surface induced membrane formation was visible.



**Figure 3.** Returning to the hospital one month after surgery to clean the wound. (A) The granulation growth at the bottom of the right foot is bright red, and the surface induced membrane formation is visible. (B) The granulation of the second toe amputation wound grows well and the surface induces membrane formation.

The granulation growth at the distal end of the right lateral malleolus wound, and part of the tendon necrotic tissue in the posterior wound. (Figure 3) The wound was washed with hydrogen peroxide and normal saline, the skin flap was trimmed, the first toe wound was sutured in full thickness, the necrotic tissue of the lateral malleolus wound was debrided. After washing, fill with bone cement containing gentamicin to eliminate dead space. Suture and fix the bone cement and rinse to cool down to complete shape.



**Figure 4.** (A) Three weeks after the second debridement, the wound was checked. It can be seen that the wound on the back of the foot was covered by the induction membrane. Check the wound condition three months after bone removal. (B) The wound on the back of the foot has been filled with induction membrane and granulation, and no exudate and blood have been seen. (C) The wound on the right toe has completely healed.



**Figure 5.** Seven months after the bone removal, except for the plantar wounds that have not healed completely, the toes and dorsal wounds have healed completely.

Three weeks after the second debridement, return to the hospital to review the wound. There was no swelling on the right foot and sole. The wound dressing was dry and clean. Remove the bone cement after disinfection and spreading sterile towels. the granulation of each wound was bright red and the induced membrane grew well, especially the back of the right foot. The necrosis of the dorsal tissue was also

covered by the induction membrane. After the bone cement was removed, the wound was flushed and sutured throughout the process. (Figure 4) Three months after the bone removal, he returned to the hospital to remove the external fixation bracket. It was seen that the wound on the toe of the right foot had completely healed, and the back of the right foot and the sole of the right foot had been filled with the induction membrane and granulation, and there was no exudation and blood. (Figure 4)

Seven months after the bone removal, except for the plantar wounds that have not healed completely, the toes and dorsal wounds have healed completely. (Figure 5)

### 3. Discussion

Diabetic foot is one of the most serious complications of diabetes, and its pathophysiological key factors are peripheral neuropathy and peripheral vascular disease. Changes in the patient's gait and biomechanics promote the occurrence of ulcers. Relevant literature points out that the continuous increase in blood sugar leads to a series of complex biochemical reactions between the glucose carbonyl group entering the body and the protein amino group in the body to produce excessive advanced glycation end products (AGEs). Excessive AGEs can directly inhibit nerve conduction, damage nerve cells and vascular endothelial cells. Or by binding to receptors on the cell surface to activate related signal pathways, and ultimately damage nerve cells and vascular endothelial cells. Although the pathogenesis of diabetic foot is closely related to AGEs, other complicated mechanisms are still involved. Drugs that inhibit the formation of AGEs, such as amino guanidine, are still unsatisfactory. [11, 12] Other treatment options have many limitations and deficiencies. For example, debridement alone cannot rebuild blood supply. The vascular reconstruction technique not only has the risk of re-blocking but also is expensive. The bioengineered skin and various growth factor treatment techniques are not yet fully mature.

Current studies believe that the tibial transverse transport can stimulate the formation of the body's "vascular network", including 1. After the tibia is opened, it can effectively reduce intramedullary pressure and relieve the pressure of intramedullary edema. 2. Stress and tension can promote the regeneration of capillaries and improve the distal circulation. 3. Bone traction can promote the recruitment of stem cells to the injured site, reduce local inflammation, and improve the local microenvironment. Animal experiments have proved that tibial transverse transport promotes the establishment of the body's collateral circulation. [13, 14] Studies have also pointed out that when the body is traumatized, stromal cell-derived factor 1 (SDF-1) is released at the wound site, which activates the body's SDF-1/chemokine receptor 4 (CXCR4) pathway, thereby mediating the arrival of BMSCs. The injured site promotes regeneration and repair of wound tissue. However, due to the diabetic foot, the blood supply of the lower limbs is poor, resulting in low SDF-1 concentration, which is not conducive to wound repair.

After the tibia is transported, it can be found that the concentration of SDF-1 in the peripheral blood of the body increases, which activates the corresponding pathway and repairs the wound. [15, 16] Therefore, the tibial transverse transport can promote the recovery of blood supply to the end of the limbs by continuously giving stable tension to the tissues and provide a suitable environment for wound repair. Chronic ulcers of diabetic feet are often accompanied by infections, but because the blood supply of the lower limbs is poor and the necrotic bone is often surrounded by scar tissue, the effect of direct application of antibiotics is not good. In this case, we used a bone cement containing gentamicin to eliminate the dead space after thorough debridement. At the same time, vancomycin is added according to the results of the drug sensitivity test to maintain a sufficient antibiotic concentration in the infected area to achieve the purpose of continuous anti-infection. There is evidence that the resistance to gentamicin in bone cement may be low, and low concentrations of drugs can also maintain effective antibacterial effects. [17-18] The added vancomycin has the characteristics of high temperature resistance and can continue to play a role after the bone cement sets and heats up. [19-20] More importantly, the placement of bone cement promotes the formation of induced membranes on the wound surface. The induced membranes not only form a rich vascular system, improve local blood supply and facilitate wound healing, but also induce a variety of factors secreted by the membrane such as TGF- $\beta$ 1 and angiogenesis Factors, vascular endothelial factor and other biologically active substances, these active substances are beneficial to wound healing. [21]

#### 4. Conclusion

The treatment of diabetic foot ulcer is a difficult clinical problem, and there is no economical and effective treatment method. Tibial transverse transport can promote the reconstruction of anastomotic branches below the knee joint, and the induced membrane technology can improve local blood supply. The combination of the two can promote the healing of local wounds, improve the blood supply of the entire lower limbs, and avoid the recurrence of ulcers. It is a therapeutic approach worth continuing to study for the treatment of diabetic foot ulcers.

#### Availability of Data and Materials

The datasets used and/or analyzed during the current study are available from the corresponding author on reasonable request.

#### Consent for Publication

Written informed consent was obtained from the patient for publication of this case report and any accompanying images. A copy of the written consent is available for review by the Editor-in-Chief of this journal.

#### Competing Interests

The authors declare that they have no competing interests.

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