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The Effect of Transverse Tibial Bone Transfer in the Treatment of Diabetic Foot

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Abstract

To analyse the effectiveness of performing a transverse tibial bone graft in the treatment of patients with diabetic foot. We retrospectively analysed the clinical details of 51 diabetic foot patients in our hospital from February 2023 to February 2024 and divided them into two groups according to the different treatment modalities, in which the control group received open debridement and the treatment group received transverse tibial bone transfer and compared the differences between the two groups. There were large differences in VAS score, Toronto Clinical Symptom Score, quality of life score, internal lumen diameter, blood flow velocity in the affected limb, perfusion volume, vascular endothelial growth factor, epidermal growth factor and CRP between the two groups after surgery ($P < 0.05$). Patients with diabetic foot should be treated with transverse tibial bone grafting, which is safer and more effective and can have a significant impact on improving the status of the affected limb, the inflammation and the patient's quality of life.

Keywords

Diabetic Foot, Transverse Tibial Bone Grafting, Treatment Efficacy, Prognosis

1. Introduction

The diabetic foot is a serious complication that is particularly likely to occur after the development of late-stage diabetes. The diabetic foot refers to the abnormalities of the distal nerves of the lower limbs and varying degrees of vasculopathy after diabetes, and the patient will suffer from ulcers, foot infections and destruction of deep tissues [1]. The diabetic foot has three main elements, firstly patients who have suffered from diabetes for many years, secondly lower limb

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neuropathy and vascular lesions and finally foot infections, if the patient has these three elements it means he or she is suffering from diabetes. However, diabetic patients do not always suffer from diabetic foot, the disease is only a manifestation of the development of diabetes to a more serious complication period [2]. Patients with diabetic foot suffer from dry skin, itching, low temperature, purple or pale skin colour, localised erosions, ulcers and even foul odour, pain and so on, which have a very serious impact on the patient's body and normal life [3]. The above conditions will lead to potential complications if not treated in time, including foot vascular skin lesions: diabetic foot patients who are not treated in time may develop large blisters on their feet; this is due to vascular and skin lesions on the patient's feet, which will start with itching sensations, but the condition is serious enough to cause ulceration symptoms to appear. Secondly, diabetic foot ulcers: this is the most common complication of diabetic foot, if diabetic foot patients do not have proper control of their blood sugar levels, it will lead to foot infections and ulcers; this is a more dangerous situation, if you do not get timely and effective treatment, amputation is likely to occur [4]. The former is caused by long-term damage to blood vessels, resulting in narrowing and lower limb numbness and pain. Diabetic foot patients may experience chronic peripheral vascular and neuropathic complications. The latter is a common complication that causes abnormal sensory loss. During the initial stages of the disease, patients may experience numbness and tingling in their limbs and feet. As the disease progresses, the peripheral nerves of the patients may become severely damaged, leading to peripheral nerve complications [5]. It is crucial to provide timely and effective surgical treatment for patients in the clinic. Our hospital collected and retrospectively analyzed 51 cases of diabetic foot patients. Open debridement surgery and lateral tibial bone transfer were performed to compare the effectiveness and safety of the two procedures in treating diabetic foot.

2. Information and Methodology

2.1. Clinical Information

A retrospective analysis was conducted on 51 cases of diabetic foot patients collected during the same period at our hospital for clinical observation. The patients were divided into two groups based on their means of treatment. The control group consisted of 25 cases, with 11 men and 14 women, aged between 60 - 83 years old, with an average age of (72.63 ± 3.12) years and a duration of diabetes mellitus ranging from 3 - 20 years, with an average of (9.0 ± 2.5) years. The study included 25 participants with a mean age of 63 years (±2.52). The mean ulcer duration was 11.02 days (±2.23) and ranged from 2 - 22 days. In the treatment group, there were 26 participants with a mean disease duration of 9.61 years (±2.50) and an age range of 61 - 85 years with a mean age of 72.65 years (±3.15). Of these, 15 were smokers and 10 were non-smokers. There were 13 male and 13 female participants, and the mean ulcer duration was 11.05 days

(±2.21) with a range of 3 - 21 days. Of these, 17 were smokers and 9 were non-smokers.

The statistical analysis of the data from both groups of patients with diabetic foot revealed no significant differences ($P > 0.05$), indicating that the two groups can be compared.

2.2. Methods

To implement open debridement for the control group, epidural anesthesia was chosen as the means of treatment. The necrotic tissue of the affected limb was excised with a sharp scalpel, and contaminated and infected tissues were thoroughly removed. Electrocoagulation was used for hemostasis to reduce hematomas, and hemostasis was completed after the wound was opened and sutured. If there was a large amount of traumatic tissue, it was connected to a negative pressure closure drainage device. Finally, the treatment was covered with aseptic dressings.

For the treatment group, transverse tibial bone transfer was performed. Basic interventions, such as glucose lowering, infection prevention, trauma clearance, correction of electrolyte imbalances, and negative pressure drainage, were carried out before surgery to help patients adopt the supine position. An incision was made in the middle and lower part of the medial tibia in the tibial area of the affected side as the bone transfer area (curved), and the periosteum was cut longitudinally after separating the subcutaneous tissues. To clarify the osteotomy length, a traction pin (2 mm) was placed in the pre-transferred bone window. The osteotomy bone window was then drilled for 2 cm to minimize artificial lifting and prying of the bone block. Two 3.5 mm external fixation half-pins were drilled into the upper and lower ends, and the external fixation device was installed and sutured, followed by a sterile dressing. After the surgery, the patient will undergo regular medication changes and receive antibiotics to prevent infection. Starting one week after surgery, begin moving the bone by 1 mm per day, three times a day, continuously moving outward for three weeks towards the tibia bone. The bone block should protrude to the subcutaneous area. Check the imaging to assess the effect of moving the bone back to its original position on the tibia bone. After completing the movement, review the X-ray to confirm the reset situation. The external fixation bracket will be removed one month after the procedure. After treatment, both groups should be monitored. Diabetic foot patients should engage in appropriate exercises based on their physical condition, such as walking, brisk walking, marching in place, lifting the heel, bending over, and flinging the legs. Each exercise should last about 30 minutes. It is important to avoid subjective evaluations and biased language. Diabetic foot patients should ensure appropriate elevation of the affected limbs, especially at night. It is recommended to use a pillow to elevate the foot, positioning it higher than the heart. This helps to ensure smooth blood flow in the lower extremities. Patients with diabetic foot should take care to keep their feet warm. Even in

hot weather, they should avoid going barefoot and spending prolonged periods in air-conditioned rooms or humid environments. In cold weather, it is important to wear cotton shoes. Shoes and socks should be loose, breathable, and soft. Pointed shoes and leather shoes should be avoided as they can compress the toes. Before putting on your shoes, check for any small sand particles or foreign objects inside to prevent skin injuries. When trying on new shoes, gradually increase the amount of time you wear them. Additionally, those with diabetic feet should be mindful of various precautions in their daily lives. It is important to pay attention to the aspects mentioned above. At the same time, it is recommended to maintain a light diet, avoiding sugary foods, and developing regular habits. It is also important to maintain a relaxed and positive state of mind.

2.3. Observation Indicators

There were differences observed in quality of life scores, VAS scores, Toronto Clinical Symptom Score, perfusion volume (as measured by lower extremity venous ultrasound), lumen internal diameter (as measured by lower extremity venous ultrasound), and blood flow velocity of the affected limb (as measured by lower extremity venous ultrasound). CRP (particle-enhanced immunoturbidimetric assay), vascular endothelial growth factor (VEGF) (chemiluminescent immunoassay), and epidermal growth factor (EGF) (chemiluminescent immunoassay) were compared between the two groups.

2.4. Statistical Analysis

The data was analysed using SPSS 21.0 software. The measurements were presented as mean standard deviation ($\overline{x} \pm s$) and the counts were expressed as x^2. Statistical significance was indicated by $P < 0.05$.

3. Results

3.1. VAS Scores, Quality of Life Scores, Toronto Clinical Symptom Score in Both Groups

There was no significant difference between the two groups before treatment ($P > 0.05$). However, after the intervention, the treatment group had higher quality of life scores and lower Toronto Clinical Symptom Score and VAS scores compared to the control group ($P < 0.05$), as presented in Table 1.

3.2. Lumen Internal Diameter, Perfusion Volume, and Blood Flow Velocity in the Affected Limb in Both Groups

Preoperatively, there was no significant difference between the two groups ($P > 0.05$). Postoperatively, the treatment group showed higher perfusion volume and lumen internal diameter compared to the control group. However, the blood flow velocity in the affected limb was lower in the treatment group ($P < 0.05$), as presented in Table 2.

Table 1. Toronto clinical symptom score, VAS score, quality of life score (points) in both groups.

Groups	VAS score		Toronto Clinical Symptom Score		Quality of life score	
	preoperative	postoperative	preoperative	postoperative	preoperative	postoperative
Control group (25)	5.52 ± 1.12	4.01 ± 1.00	8.79 ± 2.12	5.62 ± 1.38	57.10 ± 3.62	63.96 ± 5.10
Treatment group (26)	5.50 ± 1.15	2.99 ± 0.78	8.80 ± 2.10	4.50 ± 1.12	57.12 ± 3.65	70.11 ± 5.45
t-value	0.452	5.632	0.525	5.639	0.002	4.150
P-value	1.126	<0.001	1.120	<0.001	1.001	<0.001

Table 2. Perfusion volume, lumen internal diameter, blood flow velocity in the affected limb in both groups.

Groups	Blood flow velocity in the affected limb (cm/s)		Tube lumen inner diameter (cm)		Blood perfusion (pu)	
	preoperative	postoperative	preoperative	postoperative	preoperative	postoperative
Control group (25)	36.56 ± 4.55	27.11 ± 3.20	0.15 ± 0.06	0.20 ± 0.10	520.12 ± 20.25	611.01 ± 32.26
Treatment group (26)	36.55 ± 4.50	25.01 ± 2.12	0.17 ± 0.05	0.25 ± 0.12	520.10 ± 20.30	645.50 ± 35.10
t-value	0.785	6.932	0.127	5.127	0.220	4.450
P-value	1.125	<0.001	1.520	<0.001	2.012	<0.001

3.3. Vascular Endothelial Growth Factor, CRP, Epidermal Growth Factor in Both Groups

There were no significant differences between the two groups prior to the intervention ($P > 0.05$). Following treatment, the levels of vascular endothelial growth factor and epidermal growth factor were higher in the treatment group compared to the control group, while CRP levels were lower ($P < 0.05$), as presented in Table 3.

4. Discussion

Some articles suggest that as the prevalence of diabetes increases, so does the incidence of diabetic foot at this stage. This can cause significant harm to the patient's physical, psychological, and overall well-being [5] [6]. Diabetic foot can be classified into three types: neurological, ischaemic, and neurological ischaemic, with the latter also known as mixed type. Each type has distinct characteristics. Neurological diabetic foot is primarily caused by neuropathy in the foot, resulting in better blood circulation. Patients may experience warmth, numbness, and dryness in the foot, but pain is not a prominent symptom [7]. Ischemic diabetic foot patients mainly present with vascular lesions of the foot. The nerve function is relatively intact, resulting in symptoms of cold feet and pale or cyanotic skin. Intermittent claudication may also be present, and foot arterial pulsation is significantly weakened. Treatment is challenging, and the risk of amputation is high. Patients with nerve ischemia type experience foot neuropathy and vascular lesions, resulting in reduced arterial pulsation and foot sensation. When the skin breaks, it can easily lead to the occurrence of diabetic foot, which is difficult to heal and has a high risk of amputation if not treated promptly due to the

Table 3. Epidermal growth factor, CRP, vascular endothelial growth factor in both groups.

Groups	CRP (mg/L)		Vascular endothelial growth factor (ng/L)		Epidermal growth factor (ng/L)	
	preoperative	postoperative	preoperative	postoperative	preoperative	postoperative
Control group (25)	9.25 ± 2.02	6.25 ± 0.85	75.45 ± 8.23	115.45 ± 7.63	395.10 ± 45.46	633.20 ± 50.17
Treatment group (26)	9.23 ± 2.10	4.78 ± 0.80	75.50 ± 8.22	129.63 ± 7.50	396.02 ± 45.49	685.49 ± 52.63
t-value	0.865	5.632	0.952	4.552	1.010	3.996
P-value	1.122	<0.001	0.552	<0.001	0.089	<0.001

increased risk of infection. Therefore, it is crucial to seek medical attention as soon as possible [8].

Therefore, it is crucial to implement effective and timely treatment for patients with diabetic foot in the clinic. The traditional open debridement surgery, although capable of removing the ulcerated parts of the affected limbs, causes significant trauma to the patient and fails to address the root cause. Consequently, many patients still require amputation surgery at a later stage of treatment, which is a significant limitation. Therefore, in clinical practice, tibial transverse bone transfer intervention is generally performed on patients. This procedure involves continuous, slow, and stable pulling of blood vessels, nerves, and bone to actively regenerate the microvascular network in the affected area [9]. This helps to rebuild the haematology of the diabetic foot, accelerate wound healing, and promote better reconstruction of collateral circulation in the affected limb [9]. During surgical operations, slow tugging on active tissue prompts capillary regeneration and the construction of a denser meshwork. This results in increased activity of capillaries in newborns, allowing for continuous and lateral skin growth, as well as an increase in the number of blood vessels in skin tissues. This decreases the likelihood of recurrence and amputation, ultimately improving the patient's quality of life [10]. This result demonstrates that the Toronto Clinical Symptom Score and VAS score of the treatment group were lower compared to the control group. This suggests that tibial transverse bone transfer may effectively reduce the pain and symptoms caused by diabetic foot. In the treatment group, the blood perfusion volume, lumen internal diameter, vascular endothelial growth factor, and epidermal growth factor were higher than those of the control group. However, the blood velocity of the affected limb was lower, suggesting that tibial transverse bone transfer may be more efficient than in the control group. The study found that the blood flow velocity, vascular endothelial growth factor, and epidermal growth factor in the affected limb were lower than those in the control group. This suggests that tibial transverse bone transfer can improve blood flow velocity in the affected limb more quickly and effectively, expand the inner diameter of the canal, and accelerate rehabilitation.

In conclusion, the transverse tibial bone transfer procedure can provide excellent surgical results for treating patients with diabetic foot.

Conflicts of Interest

The authors declare no conflicts of interest regarding the publication of this paper.

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