Am J Transl Res 2025;17(6):4331-4340
www.ajtr.org /ISSN:1943-8141/AJTR0163815

Original Article

Therapeutic effects of transverse tibial bone transport in lower limb thromboangiitis obliterans

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Received February 9, 2025; Accepted May 6, 2025; Epub June 15, 2025; Published June 30, 2025

Abstract: Objective: To investigate the treatment efficacy of transverse tibial bone transport (TTT) technique in patients with lower-limb thromboangiitis obliterans (LLTAO). Methods: A total of 119 patients diagnosed with LLTAO were selected for this retrospective study. Among them, 55 patients treated with conventional methods were assigned into the control group, while the other 64 patients treated with TTT technique were classified into the observation group. Systematic comparative evaluations were conducted between the two patient cohorts, analyzing four key domains: clinical recovery, hemorheological profile alterations, quality of life metrics, and treatment efficacy. Furthermore, we performed an exploratory analysis to identify determinants affecting therapeutic outcome. Results: The observation group showed significantly better outcomes than the control group in terms of functional recovery, hemorheological improvement, quality of life scores, and overall treatment effectiveness following the intervention. Univariate and multivariate analyses further demonstrated that age, pretreatment HBV, and treatment approach were all independent factors influencing treatment efficacy in these patients. Conclusion: The TTT technique exhibits superior therapeutic benefits for LLTAO patients over conventional intervention, establishing it as an effective treatment for this challenging condition.

Keywords: Transverse tibial bone transport technique, lower-limb thromboangiitis obliterans, efficacy, influencing factors, functional recovery

Introduction

Thromboangiitis obliterans (TAO), also known as Buerger's disease, is a segmental, non-atherosclerotic inflammatory vascular disorder that primarily affects the extremities without posing an immediate life-threatening risk [1]. Epidemiologic data indicate a pronounced male predilection, with men accounting for a staggering 87.6% of cases. Moreover, smoking significantly elevates the risk of amputation among affected individuals, with smokers facing a 17.7% amputation risk compared to 13.0% in non-smokers [2]. This condition adversely affects medium-sized blood vessels and induces infiltration and inflammation of small-caliber blood vessels, nerves, and veins. Consequentially, segmental thrombosis and vascular occlusion occur, often leading to gangrene and, in severe cases, amputation [3]. The characteristic symptoms of TAO include paresthesia, heightened sensitivity to cold, Raynaud's syndrome, and vasospasm. The right lower limb is particularly vulnerable, being the most frequently affected appendage [4]. Despite extensive research, the exact etiology of TAO remains elusive. However, existing evidence strongly suggests associations with immune dysregulation, abnormal coagulation responses, tobacco exposure, and genetic predisposition [5, 6]. Currently, multiple treatment modalities are available, including surgical intervention, pharmacological therapies, interventional procedures, and stem-cell-based treatments. Unfortunately, no single treatment has emerged as the gold standard for managing this complex disorder [7, 8]. Given these challenges, this study aims to further explore novel treatment strategies for TAO. By focusing on patients with lower limb involvement, the study seeks to identify approaches that can enhance treatment efficacy and improve the overall prognosis for these patients.

https://doi.org/10.62347/HAAJ5979

Currently, the standard treatment for TAO predominantly relies on pharmacotherapy, incorporating multiple strategies such as vasodilation, anti-platelet aggregation, anticoagulation, and anti-inflammatory measures, to enhance blood circulation, curtail thrombus formation, mitigate symptoms, and prevent further deterioration of the disease [9]. The transverse tibial bone transport (TTT) technique is a surgical intervention that evolved from the Ilizarov technique. Based on the "tension-stress" principle, this procedure entails the transverse traction of the tibial osteotomy segment. This continuous traction of the tibial cortex stimulates cellular metabolism, accelerates tissue regeneration, restores the micro-circulatory system, and reinstates adequate blood oxygen supply to the lower extremities [10, 11]. This surgical method has demonstrated effectiveness in treating various chronic lower limb ischemic conditions, such as TAO and diabetic foot ulcers [12, 13]. However, a significant knowledge gap persists regarding the comparative clinical effectiveness of the TTT technique versus conventional treatment modalities for lower-limb TAO (LLTAO). The paucity of relevant research further complicates this issue. To address this gap, the present study aims to conduct an in-depth analyses, providing valuable insights that may alleviate the substantial treatment-related and economic burdens imposed by amputation in LLTAO patients. This research holds the potential to offer practical solutions for this patient population.

Patients and methods

Case selection

In this retrospective study, a total of 119 patients diagnosed with LLTAO were selected based on strict inclusion and exclusion criteria. The recruitment period spanned from September 2021 to September 2024. Of these, 55 patients treated with conventional treatment were assigned to the control group, while the remaining 64 patients undergoing TTT technique constituted the observation group. This study was approved by the Ethics Committee of Tiantai County People's Hospital.

Inclusion criteria: 1) All patients were definitively diagnosed with LLTAO by arteriography, meeting the established diagnostic criteria [14]; 2) Patients were aged between 18 and 80 years, without severe coagulation dysfunction (International Normalized Ratio [INR] ≤ 1.5, platelets $\geq 100\times10^9$/L); 3) All participants were eligible candidates for TTT; 4) Patients exhibited clinical manifestations, including limb numbness, intermittent claudication, and a decline in skin temperature; 5) The affected limb was on the verge of necrosis, with some distal tissues showing necrosis or gangrene; 6) Patients demonstrated a strong preference for limb preservation and a willingness to undergo surgical procedures; 7) Patients with complete clinic records available for the study.

Exclusion criteria: 1) Patients with severe skin ulcers due to infections or osteomyelitis at the surgical site; 2) Individuals with complete occlusion of the popliteal artery and no significant collateral circulation formation; 3) Patients with comorbid conditions such as diabetes, Cushing's syndrome, or severe infectious diseases; 4) Patients unable to abstain from smoking during the treatment course, as well as individuals with mental disorders, speech impediments; 5) Patients in pregnancy or lactation; 6) Patients with surgically unfavorable vascular conditions, such as complete popliteal artery occlusion lacking sufficient collateral circulation or widespread arterial calcification; 7) Patients with severe cardiopulmonary insufficiency contraindicating surgical intervention; 8) Patients with malignancies, severe organ dysfunction, autoimmune vasculitis, or gout.

Intervention approaches

Patients in the control group were subjected to conventional treatment protocols. The detailed treatment regimen included: 10 μg of Alprostadil Injection (Penglai Nuokang Pharmaceutical Co., Ltd., H20100179, Specification: 2 ml:10 μg) diluted with 100 mL of normal saline for intravenous infusion once daily. For oral medications, 75 mg of Aspirin Enteric-coated Tablets (Henan Yonghe Pharmaceutical Co., Ltd., H41024302, Specification: 25 mg) were prescribed once daily. Beraprost Sodium Tablets (Beijing Taide Pharmaceutical Co., Ltd., H2008-3589, Specification: 40 μg) were administered orally at a dose of 40 μg, three times a day. Atorvastatin Calcium Tablets (Pfizer Pharmaceutical Co., Ltd., H20051408, Specification: 20 mg) were prescribed orally at 20 mg daily. This comprehensive treatment plan was followed for one month, after which the regimen was adjusted to long-term oral administration of only Aspirin and Atorvastatin Calcium Tablets.

Patients in the observation group underwent treatment with the TTT technique, following a meticulous procedural approach: The patient was positioned supine, and combined spinal-epidural anesthesia was initiated. Once the anesthetic effect was achieved, a 15 cm incision was made medially from the tibial crest, approximately 10 cm beneath the tibial tuberosity of the affected limb, with the incision starting around 3 cm from the baseline. Subsequently, the skin and subcutaneous tissues were incised in a sequential, layer-by-layer manner until the periosteum was exposed. On the medial aspect of the tibia, the size (approximately 10 cm × 2 cm) and the location of the tibial bone-transfer window were carefully determined. The periosteum was then incised along the boundary of the bone window. After identifying the correct location, two bone-transfer needles (3 mm in diameter) were inserted, maintaining a distance of approximately 5 cm between them. An electric drill was utilized to create intermittent drill holes along the boundary of the bone window, which were then interconnected to form a continuous line using a reciprocating saw and osteotome. The bone window was carefully dissected, leaving the medial margin intact. Subsequently, an external fixator was installed. One fixator was attached to the distal portion of the medial tibial bone window, and another was placed at the proximal end. After securing the tractor to the external fixator, the medial bone window was finally freed by completing the dissection. Thereafter, the surgical site was thoroughly irrigated to remove debris, and the incision was sutured using standard techniques and appropriately bandaged. Starting from the fifth day after the operation, the tibial osteotomy segment was gradually translated transversely outward at a rate of 0.33 mm/8 h, resulting in a daily displacement of 1 mm. X-ray examination was scheduled two weeks after initiating the displacement to assess progress. After maintaining this displacement for three days, the osteotomy segment was then moved back at the same rate, completing the reverse displacement phase after two weeks. Following a fixation period of four to six weeks, a subsequent X-ray evaluation was performed. Once radiographic evidence confirmed healing, the external fixator was removed. Throughout the treatment course, patients in both groups received comprehensive routine nursing care. They were explicitly instructed on proper limb insulation to maintain optimal blood circulation and were required to abstain from smoking, as it is a known risk factor for disease progression. Additionally, patients were guided through personalized exercise programs to enhance muscle strength and joint mobility. Comprehensive guidance was provided on medication management, dietary modifications, exercise routines, and the establishment of a regular daily schedule to promote overall well-being and recovery.

Data collection and outcome measurement

(1) Recovery Assessment. The ankle-brachial index (ABI), Visual Analogue Scale (VAS), and maximum walking distance were measured both before and 6 months after the intervention. The ABI is defined as the ratio of ankle arterial pressure to brachial arterial pressure. Conventionally, an ABI value between 1.0 and 1.4 is considered normal. A reading between 0.91 and 0.99 suggests mild aberration, 0.5 to 0.8 indicates moderate arterial stenosis, an ABI below 0.5 implies severe arterial stenosis, and a value exceeding 1.4 signifies possible vascular wall calcification [15]. VAS was utilized to quantify the intensity of pain, ranging from 0 to 10, with higher scores indicating greater pain severity [16]. The maximum walking distance refers to the greatest continuous walking distance achieved in a single bout.

(2) Hemorheological parameter measurement. Prior to and following the intervention, 3 mL of fasting venous blood was collected from the upper limbs of these patients. Serum was separated through centrifugation, and levels of high-shear blood viscosity (HBV), low-shear blood viscosity (LBV), fibrinogen (Fib), and plasma viscosity (PV) were determined using a hemorheometer.

(3) Quality of life evaluation. The World Health Organization Quality of Life Scale (WHOQOL-BREF) was adopted to assess the quality of life of patients in both groups before and after the intervention [17]. This scale covers four distinct domains: psychological, physical, environmental, and social, each with a maximum score of 100 points. A higher score indicates a better quality of life.

(4) Treatment efficacy evaluation. Six months after the treatment, therapeutic efficacy was evaluated according to the following criteria: Marked effectiveness: Complete relief of pain

Table 1. Comparison of baseline characteristics between two groups of patients

General characteristics	Control group (n = 55)	Observation group (n = 64)	χ^2/t	*P*
Gender			0.744	0.388
Male	45 (81.82)	56 (87.50)		
Female	10 (18.18)	8 (12.50)		
Average age (years)	47.53±7.94	49.34±7.36	1.290	0.200
Daily cigarette consumption (cigarettes/day)	27.98±7.25	28.28±6.85	0.232	0.817
Body mass index (kg/m^2)	23.64±2.64	24.02±3.19	0.701	0.485
Disease course (years)	5.09±1.84	4.53±1.57	1.792	0.076
Lesion site			0.310	0.578
Left	29 (52.73)	37 (57.81)		
Right	26 (47.27)	27 (42.19)		

in the affected limb, normalization of skin color and temperature, and the patient regaining full walking mobility. Effectiveness: Significant alleviation of pain, gradual improvement in skin color and temperature, but with continued limitations in sustained walking. Ineffectiveness: No discernible improvement in pain, skin color, or other symptoms, rendering the patient significantly impaired in walking ability. The overall treatment efficacy was calculated as the proportion of patients achieving marked or effective outcomes relative to the total number of patients.

Primary outcome measures included ABI, VAS score, maximum walking distance, WHOQOL-BREF quality-of-life assessment, and therapeutic efficacy. Secondary outcome measures included HBV, LBV, Fib levels, and PV.

Statistical methods

Statistical analysis was performed using SPSS 22.0 software. Measured data were presented as mean ± SEM for statistical description. For the comparison of measured data between two groups, an independent samples t-test was employed. When comparing data within a group before and after treatment, a paired t-test was used. Enumerated data were expressed as rates (percentages) and compared between two groups using a chi-square (χ^2) test. Univariate analysis of variance was first employed to identify factors influencing the treatment efficacy in LLTAO patients. Subsequently, binary Logistic regression analysis was employed to explore these factors at the multivariate level. A *P*-value less than 0.05 was considered significant.

Results

Comparison of baseline characteristics between the two groups

No significant differences were observed in terms of gender, age, daily cigarette consumption, body mass index (BMI), disease duration, or lesion site between the two groups ($P > 0.05$, **Table 1**), indicating comparability between the groups.

Comparison of patient recovery between the two groups

Prior to treatment, no significant differences were found between the two groups in terms of ABI, VAS, or maximum walking distance ($P > 0.05$). After the intervention, both groups demonstrated substantial improvements in ABI and maximum walking distance, while VAS scores decreased markedly ($P < 0.05$). Notably, the observation group showed significantly higher ABI and maximum walking distance and significantly lower VAS scores compared to the control group ($P < 0.05$). Details are presented in **Figure 1**.

Comparison of hemorheological parameters between the two groups

The hemorheological parameters, including HBV, LBV, Fib, and PV, were measured in both groups. Prior to the intervention, no significant differences were observed between the two groups ($P > 0.05$). Post-intervention, a significant decline was noted in all these parameters for both groups ($P < 0.05$). Moreover, the observation group exhibited significantly lower values

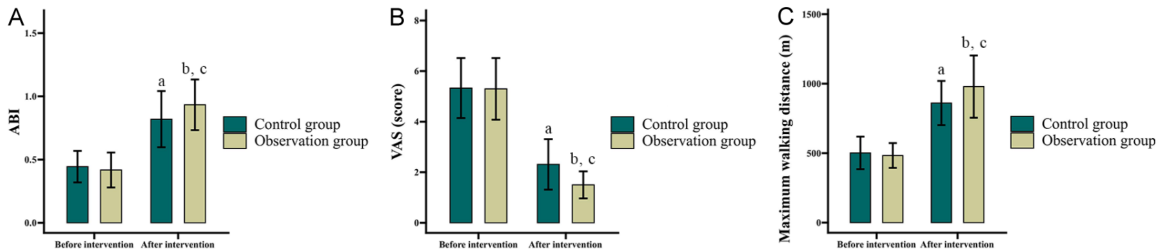

Figure 1. Comparison of patient recovery between the two groups of patients. A. Pre- and post-interventional ABI in two groups. B. Pre- and post-interventional VAS scores in two groups. C. Pre- and post-interventional maximum walking distance in two groups. Note: ABI, Ankle-Brachial Index; VAS, Visual Analogue Scale; $^{a}P < 0.05$, $^{b}P < 0.01$, when compared to the pre-intervention state; $^{c}P < 0.05$, when compared to the control group.

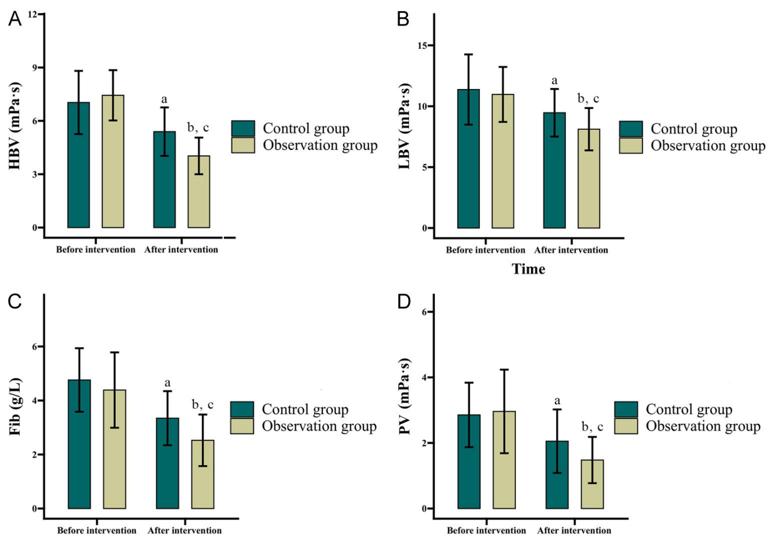

Figure 2. Comparison of hemorheological parameters between the two groups before and after treatment. A. Pre- and post-interventional HBV level in two groups. B. Pre- and post-interventional LBV level in two groups. C. Pre- and post-interventional Fib level in two groups. D. Pre- and post-interventional PV level in two groups. Note: HBV, high-shear whole blood viscosity; LBV, low-shear whole blood viscosity; Fib, fibrinogen; PV, plasma viscosity; $^{a}P < 0.05$, $^{b}P < 0.01$, when compared to the pre-intervention state; $^{c}P < 0.05$, when compared to the control group.

for all parameters compared to the control group ($P < 0.05$). Detailed information is available in **Figure 2**.

Comparison of quality-of-life scores between the two groups

The WHOQOL-BREF scale was used to evaluate the quality of life in both groups. Prior to the intervention, no significant differences were observed in the WHOQOL-BREF scores across the physical, psychological, social, and environmental domains between the two groups ($P > 0.05$). After the intervention, significant improvements were observed in all domains for both groups ($P < 0.05$), with the observation group showing higher scores ($P < 0.05$). See **Table 2** for details.

Comparison of treatment efficacy between the two groups

In the control group, the overall treatment effectiveness rate was 70.91%, whereas in the observation group, it reached 89.06%. The treatment effectiveness rate of the observation group was significantly higher than that of the control group ($P < 0.05$, **Table 3**).

Univariate analysis of factors affecting treatment efficacy in patients with LLTAO

Univariate analysis revealed that gender, average age, daily cigarette consumption, pretreatment HBV, pretreatment Fib, and treatment approach were significantly associated with treatment efficacy in patients with LLTAO ($P < 0.05$). Factors such as BMI, disease duration, lesion site, pretreatment LBV, and pretreatment PV did not show a significant association with treatment efficacy ($P > 0.05$). Details are presented in **Table 4**.

Multivariate analysis of factors affecting treatment efficacy in patients with LLTAO

In the multivariate analysis, factors identified as significant in the univariate analysis (gender, age, daily cigarette consumption, pretreatment HBV, pretreatment Fib, and treatment approach) were entered into a binary Logistic regres-

Table 2. Comparison of quality of life between the two groups of patients

WHOOOL-BREF	Control group (n = 55)	Observation group (n = 64)	t	*P*
Physical				
Before intervention	61.87±7.00	63.47±7.41	1.205	0.231
After intervention	80.24±6.87[a]	84.70±7.38[b]	3.393	< 0.001
Psychological				
Before intervention	60.84±6.08	58.80±5.20	1.973	0.051
After intervention	76.85±6.52[a]	83.25±8.55[b]	4.532	< 0.001
Social				
Before intervention	65.31±6.61	67.62±6.82	1.868	0.064
After intervention	81.07±7.03[a]	87.64±7.22[b]	5.010	< 0.001
Environmental				
Before intervention	65.07±6.79	65.23±6.67	0.129	0.897
After intervention	81.78±6.43[a]	87.70±6.69[b]	4.900	< 0.001

Note: WHOQOL-BREF, World Health Organization Quality of Life Scale; [a]$P < 0.05$, [b]$P < 0.01$, when compared to the pre-intervention state.

Table 3. Comparison of treatment efficacy between the two groups of patients

Therapeutic effectiveness	Control group (n = 55)	Observation group (n = 64)	χ^2	*P*
Marked effectiveness	19 (34.55)	30 (46.88)		
Effectiveness	20 (36.36)	27 (42.19)		
Ineffectiveness	16 (29.09)	7 (10.94)		
Overall effectiveness	39 (70.91)	57 (89.06)	6.252	0.012

Table 4. Univariate analysis of factors affecting treatment efficacy in LLTAO patients

General data	Ineffective (n = 23)	Effective (n = 96)	χ^2	*P*
Gender			5.205	0.023
Male	16 (69.57)	85 (88.54)		
Female	7 (30.43)	11 (11.46)		
Average age (years)			4.354	0.037
< 48	6 (26.09)	49 (51.04)		
≥ 48	17 (73.91)	47 (48.96)		
Daily cigarette consumption (cigarettes/day)			6.295	0.012
< 28	6 (26.09)	53 (55.21)		
≥ 28	17 (73.91)	43 (44.79)		
Body mass index (kg/m^2)			0.691	0.406
< 24	10 (43.48)	51 (53.13)		
≥ 24	13 (56.52)	45 (46.88)		
Disease course (years)			0.395	0.530
< 5	11 (47.83)	39 (40.63)		
≥ 5	12 (52.17)	57 (59.38)		
Lesion site			0.125	0.724
Left	12 (52.17)	54 (56.25)		
Right	11 (47.83)	42 (43.75)		
Pretreatment HBV (mPa·s)			5.829	0.016
< 7	4 (17.39)	43 (44.79)		
≥ 7	19 (82.61)	53 (55.21)		

Pretreatment LBV (mPa·s)			2.772	0.096
< 11	13 (56.52)	36 (37.50)		
≥ 11	10 (43.48)	60 (62.50)		
Pretreatment Fib (g/L)			5.135	0.023
< 5	10 (43.48)	66 (68.75)		
≥ 5	13 (56.52)	30 (31.25)		
Pretreatment PV (mPa·s)			1.725	0.189
< 3	15 (65.22)	48 (50.00)		
≥ 3	8 (34.78)	48 (50.00)		
Treatment approach			6.252	0.012
Conventional therapy	16 (69.57)	39 (40.63)		
Lateral tibial bone transport technique	7 (30.43)	57 (59.38)		

Note: LLTAO: lower-limb thromboangiitis obliterans; HBV, high-shear whole blood viscosity; LBV, low-shear whole blood viscosity; Fib, fibrinogen; PV, plasma viscosity.

Table 5. Assignments

Variable	Variable	Assignment
Gender	X1	Male = 0, female = 1
Average age (years)	X2	< 48 = 0, ≥ 48 = 1
Daily cigarette consumption (cigarettes/day)	X3	< 28 = 0, ≥ 28 = 1
Pretreatment HBV (mPa·s)	X4	< 7 = 0, ≥ 7 = 1
Pretreatment Fib (g/L)	X5	< 5 = 0, ≥ 5 = 1
Treatment approach	X6	Conventional treatment = 0, lateral tibial bone transport technique = 1

Note: HBV, high-shear whole blood viscosity; Fib, fibrinogen; PV, plasma viscosity.

Table 6. Multivariate analysis of factors affecting treatment efficacy in LLTAO patients

Variable	β	SE	Wald	*P*	OR	95% CI
Gender	1.076	0.643	2.798	0.094	2.933	0.831-10.349
Average age (years)	1.254	0.617	4.132	0.042	3.505	1.046-11.745
Daily cigarette consumption (cigarettes/day)	1.097	0.570	3.696	0.055	2.994	0.979-9.157
Pretreatment HBV (mPa·s)	1.642	0.657	6.238	0.013	5.164	1.424-18.730
Pretreatment Fib (g/L)	0.630	0.544	1.342	0.247	1.877	0.647-5.449
Treatment approach	-1.263	0.570	4.908	0.027	0.283	0.093-0.864

Note: LLTAO: lower-limb thromboangiitis obliterans; HBV, high-shear whole blood viscosity; LBV, low-shear whole blood viscosity; Fib, fibrinogen; PV, plasma viscosity.

sion model. The results indicated that age ≥ 48 years (OR = 3.505, 95% CI: 1.046-11.745), and pretreatment HBV ≥ 7 mPa·s (OR = 5.164, 95% CI: 1.424-18.730) were independent risk factors for poor therapeutic outcome in patients with LLTAO ($P < 0.05$). Conversely, TTT (OR = 0.283, 95% CI: 0.093-0.864) emerged as a significant protective factor ($P < 0.05$). Specific details can be found in **Tables 5**, **6**.

Discussion

The results of this study suggest that the TTT technique provides significant advantageous for the recovery of LLTAO patients. Specifically, after the intervention, patients in the observation group demonstrated higher ABI values, greater maximum walking distances, and lower VAS scores compared to the control group. These findings are consistent with those from a preliminary study by Wen et al. [18], which demonstrated that the TTT technique not only elevated ABI but also reduced VAS scores and facilitated wound recovery in patients with diabetic foot ulcers. In support of our findings, Mo et al. [19] reported that using ulnar cortex transverse transport in LLTAO patients remarkably improved upper limb blood circulation, reconstructed microcirculation, reduced inflammation, and alleviated ulcer pain, all of which align with the benefits observed in our study. Additionally, a meta-analysis by Guo et al. [20] highlighted that TTT therapy was more effective than conventional treatments in terms of wound healing, improving quality of life, relieving pain, reducing complications, and lowering amputation rate, which further corroborates our observations. Besides, the TTT technique resulted in a more pronounced improvement in the hemorheological parameters, with significant reductions in HBV, LBV, Fib, and PV levels. This indicates that the TTT technique effectively enhances blood flow characteristics, further supporting its role in improving microcirculation and reducing blood viscosity in LLTAO patients. In terms of quality of life, patients in the observation group experienced substantial improvements across all dimensions - physical, psychological, social, and environmental, which is consistent with the findings by Chen et al. [21], who observed similar outcomes in patients with refractory diabetic foot ulcers. Notably, our research revealed that TTT technique demonstrated a significant increase in the overall treatment effectiveness rate (89.06% versus 70.91% in the control group). This enhancement can likely be attributed to the TTT technique's ability to induce tissue traction, stimulating and promoting tissue regeneration [22]. This technique also performs local fracture intervention before applying traction to achieve transverse displacement of the tibia. This process stimulates bone tissues, neurovascular structures, and other relevant biological tissues, effectively improving microcirculation, enhancing blood flow, and preventing the complications that arise from increased blood viscosity, ultimately ameliorating clinical symptoms and limb motor function [23, 24].

Univariate analysis identified gender, age, daily cigarette consumption, pretreatment HBV, pretreatment Fib, and treatment approach as significant factors associated with treatment efficacy in patients with LLTAO. Further multivariate analysis identified age, pretreatment HBV, and treatment approach as independent factors for treatment failure in these patients. This finding underscores the necessity of closely monitoring patients who are aged 48 years or older, have pretreatment HBV levels ≥ 7 mPa·s, or are receiving conventional treatment. Providing tailored nursing care to these patients could help optimize therapeutic outcomes. Jiang et al. [25] proposed a collaborative nursing model for diabetic foot patients undergoing TTT treatment, who was shown to shorten hospital stays and reduce postoperative pain and anxiety. This observation implies the importance of comprehensive nursing interventions in enhancing treatment efficacy for LLTAO patients undergoing the TTT procedure. Collectively, TTT technique demonstrates clinically significant benefits in the management of LLTAO.

Several limitations should be acknowledged in the current study. First, the relatively small sample size may have limited the statistical power of our findings, making it difficult to generalize the results to a broader population. Second, the short follow-up period restricted our ability to assess long-term outcomes. Third, potential selection bias exists, which may have influenced the representativeness of our results. To enhance the validity and applicability of these findings, future research should incorporate multicenter collaborations with larger sample sizes and extended follow-up durations. Furthermore, additional investigations are needed to elucidate the precise mechanism of action underlying TTT's therapeutic effects. Particular attention should be paid to determining the optimal timing for initiating treatment, as well as the ideal transport rate and frequency of bone transport procedures in clinical practice. Addressing these knowledge gaps will be a key focus of our subsequent research efforts.

Despite these limitations, the data presented herein suggest that, compared with conventional treatment, the TTT technique provides more favorable outcomes for patients with LLTAO. This technique demonstrates superior efficacy in accelerating recovery, reducing pain, enhancing ambulatory capacity, improving hemorheological indices, and boosting both the quality of life and treatment effectiveness. In addition, particular attention and comprehensive nursing care should be given to patients exhibiting specific characteristics, such as an age of 48 years or older, a pretreatment HBV of 7 mPa·s or higher, and the use of conventional treatment. Moreover, it is imperative to expeditiously modify the treatment regimen to optimize the therapeutic effect to the greatest extent possible. Based on the available evidence, we conclude that TTT represents a clinically valuable treatment modality for LLTAO and warrants broader adoption in clinical practice.

Disclosure of conflict of interest

None.

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References

[1] Liu Z, Zhou C, Guo H, Wang M, Liang J and Zhang Y. Knowledge mapping of global status and trends for thromboangiitis obliterans: a bibliometrics and visual analysis. J Pain Res 2023; 16: 4071-4087.

[2] Watanabe Y, Shimizu Y, Hashimoto T, Iwahashi T, Shigematsu K, Nakaoka Y and Harigai M; Japan Research Committee of the Ministry of Health, Labour, and Welfare for Intractable Vasculitis (JPVAS). Demographic traits, clinical status, and comorbidities of patients with thromboangiitis obliterans in Japan. Circ J 2024; 88: 319-328.

[3] Kidron A and Daahir C. Clinical presentation and treatment of thromboangiitis obliterans with superimposed osteomyelitis. Cureus 2022; 14: e21423.

[4] Modaghegh MHS, Kamyar MM, Shafiei A, Shariatmaghani SS, Saremi E and Sadeghipour Kermani F. A comprehensive review of the epidemiology and clinical features of 91 cases with Buerger's disease. Vascular 2023; 1708-5381231175257.

[5] Cacione DG, Macedo CR, do Carmo Novaes F and Baptista-Silva JC. Pharmacological treatment for Buerger's disease. Cochrane Database Syst Rev 2020; 5: CD011033.

[6] Awara MA, Downing LM and Elnenaei MO. Psychiatric sequelae of thromboangiitis obliterans: a case report and review of the literature. J Med Case Rep 2023; 17: 40.

[7] Zheng G, Xie H, Lai M and Liu X. Short-term efficacy of endovascular procedures for lower extremity thromboangiitis obliterans (Buerger's disease). Postgrad Med 2024; 136: 577-583.

[8] Jiang X, Ju S, Chen B, Jiang J, Shi Y, Ma T, Lin C, Xu X, Fu W and Dong Z. Safety and effectiveness of excimer laser ablation combined with drug-coated balloon for atherosclerotic obliterans in the lower extremity. J Endovasc Ther 2023; 30: 721-729.

[9] Fazeli B, Dadgar Moghadam M and Niroumand S. How to treat a patient with thromboangiitis obliterans: a systematic review. Ann Vasc Surg 2018; 49: 219-228.

[10] Liu Z, Xu C, Yu YK, Tu DP, Peng Y and Zhang B. Twenty years development of tibial cortex transverse transport surgery in PR China. Orthop Surg 2022; 14: 1034-1048.

[11] Nickinson ATO, Houghton JSM, Bridgwood B, Essop-Adam A, Nduwayo S, Payne T, Sayers RD and Davies RSM. The utilisation of vascular limb salvage services in the assessment and management of chronic limb-threatening ischaemia and diabetic foot ulceration: a systematic review. Diabetes Metab Res Rev 2020; 36: e3326.

[12] Liu Z, Xu C, Yu Y and Tu D. Research progress of tibial transverse transport in treatment of chronic ischemic diseases of the lower extremities. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2020; 34: 994-999.

[13] Ou S, Xu C, Yang Y, Chen Y, Li W, Lu H, Li G, Sun H and Qi Y. Transverse tibial bone transport enhances distraction osteogenesis and vascularization in the treatment of diabetic foot. Orthop Surg 2022; 14: 2170-2179.

[14] Bae M, Chung SW, Lee J, Kim E, Kang G and Jin M. Early diagnosis and intervention are needed for a reasonable prognosis of thromboangiitis obliterans. J Chest Surg 2023; 56: 328-335.

[15] Peltonen E, Laivuori M, Vakhitov D, Korhonen P, Venermo M and Hakovirta H. The cardiovascular-mortality-based estimate for normal range of the ankle-brachial index (ABI). J Cardiovasc Dev Dis 2022; 9: 147.

[16] Astrom M, Thet Lwin ZM, Teni FS, Burstrom K and Berg J. Use of the visual analogue scale for health state valuation: a scoping review. Qual Life Res 2023; 32: 2719-2729.

[17] Vu LG, Nguyen LH, Nguyen CT, Vu GT, Latkin CA, Ho RCM and Ho CSH. Quality of life in vietnamese young adults: a validation analysis of the world health organization's quality of life (WHOQOL-BREF) instrument. Front Psychiatry 2022; 13: 968771.

[18] Wen R, Cheng X, Cao H, Zhang L, Luo F and Shang W. Transverse tibial bone transfer in the treatment of diabetes foot ulcer: a pilot study. Diabetes Metab Syndr Obes 2023; 16: 2005-2012.

[19] Mo X, He C, Zhou J, Chen W, Nie K, Wei Z and Chang S. Preliminary application of ulnar cortex transverse transport technique in treatment of upper extremity thromboangiitis obliterans. Zhongguo Xiu Fu Chong Jian Wai Ke Za Zhi 2024; 38: 1242-1248.

[20] Guo J, Bao H, Hu H, Lideer, Ni X, Zhao Y and Sun G. Effect of tibial transverse transport on

chronic lower extremity angiopathy: a protocol for a systematic review and meta-analysis. BMJ Open 2022; 12: e060249.

[21] Chen Y, Ding X, Zhu Y, Jia Z, Qi Y, Chen M, Lu J, Kuang X, Zhou J, Su Y, Zhao Y, Lu W, Zhao J and Hua Q. Effect of tibial cortex transverse transport in patients with recalcitrant diabetic foot ulcers: a prospective multicenter cohort study. J Orthop Translat 2022; 36: 194-204.

[22] Cao XJ, Jia ZW, Guo XS, Wang XD, Yu JP, Niu JW, Liu JY and Wei J. Experimental study on the improvement of Ilizarov transverse tibial bone transport and microcirculation reconstruction technique. Zhonghua Yi Xue Za Zhi 2019; 99: 3592-3596.

[23] Zhang X, Dong T, Yao S, Lu S and Li W. Application of transverse tibial bone transport and microcirculation reconstruction in the treatment of diabetic foot ulcer: a case report. Ann Palliat Med 2021; 10: 8358-8364.

[24] Yang Y, Li Y, Pan Q, Bai S, Wang H, Pan XH, Ling KK and Li G. Tibial cortex transverse transport accelerates wound healing via enhanced angiogenesis and immunomodulation. Bone Joint Res 2022; 11: 189-199.

[25] Jiang L and Mendame Ehya RE. Effectiveness of a collaborative nursing care model for the treatment of patients with diabetic foot disease by transverse tibial bone transport technique: a pilot study. J Perianesth Nurs 2020; 35: 60-66.