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Original Article

Comprehensive evaluation of combined AngioJet and drug-coated balloon therapy for diabetic foot ulcers with lower extremity arterial occlusive disease

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Abstract: Objective: To evaluate the efficacy of AngioJet mechanical thrombectomy combined with drug-coated balloon (DCB) therapy in patients with lower extremity arterial occlusive disease (ASO) and diabetic foot ulcers (DFU), focusing on its effects on hemodynamics, glycemic control, inflammatory markers, and one-year ulcer recurrence. Methods: This retrospective study involved 198 patients with ASO and DFU treated between April 2021 and March 2024. Of these, 104 received combined AngioJet and DCB therapy (combined group), while 94 underwent mechanical thrombectomy alone (control group). Clinical outcomes, hemodynamic parameters, blood glucose levels, inflammatory markers, and functional scores were assessed before and after treatment. Ulcer recurrence was evaluated during a one-year follow-up period. Results: The combined group exhibited significantly better clinical outcomes and greater improvements in hemodynamics (pulse index and resistive index), glycemic control (fasting/postprandial glucose and HbA1c), and inflammatory markers (CRP, TNF-α, IL-6) compared to the control group. Functional indicators, including the ankle-brachial index, Rutherford and Wagner grades, and claudication distance, improved more in the combined group. The one-year recurrence rate was significantly lower in the combined group. Conclusion: The combined AngioJet-DCB approach demonstrates enhanced clinical efficacy in the management of ASO-DFU by improving hemodynamic outcomes and reducing the risk of ulcer recurrence.

Keywords: AngioJet thrombectomy, drug-coated balloon, diabetic foot ulcer, peripheral arterial occlusion, inflammatory markers, blood glucose control, functional recovery

Introduction

Diabetic patients with lower extremity arterial occlusive disease (ASO) and diabetic foot ulcers (DFU) experience one of the most severe forms of peripheral vascular disease. This combination often results in significant disability and high amputation rates [1, 2]. At the core, chronic hyperglycemia accelerates atherosclerosis, restricting blood flow to the limbs, damaging nerves, and hindering ulcer healing [3, 4]. Managing these ulcers is a challenging process, involving prolonged treatment periods, recurrent infections, and a persistent risk of limb loss [5]. As the arteries continue to narrow, revascularization remains the only viable solution; however, even the most advanced treatments often prove insufficient.

While traditional bypass surgery is effective, it is a major procedure with a lengthy recovery time, and not all patients are suitable candidates [6]. A less invasive alternative, percutaneous transluminal angioplasty, often faces challenges due to high rates of restenosis, particularly in arteries heavily clogged with blood clots [7]. Furthermore, these conventional approaches fail to address the underlying metabolic issues and chronic inflammation that hinder ulcer healing in diabetic patients [8].

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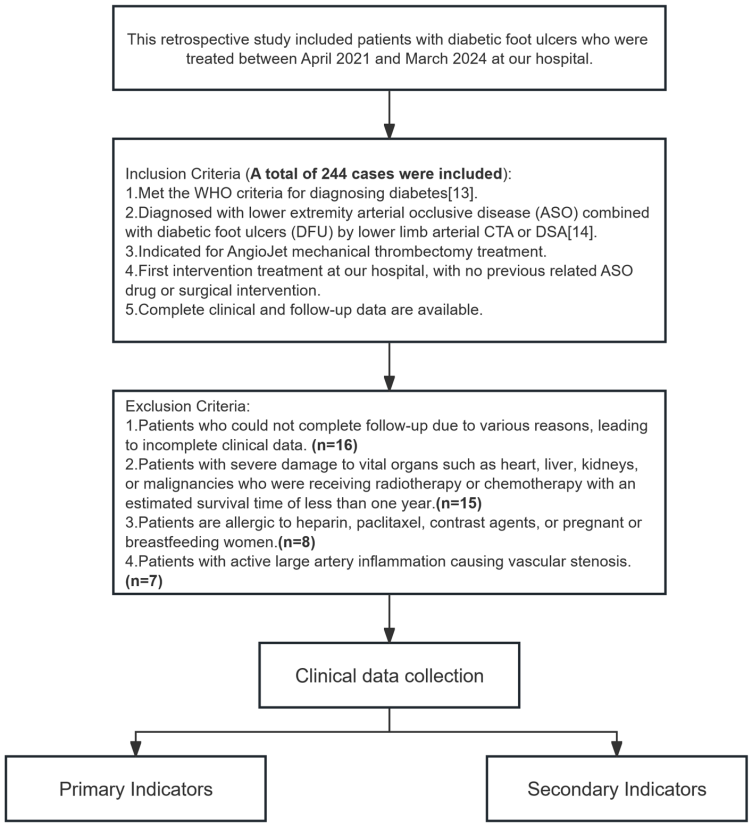

Figure 1. Study the inclusion and exclusion process diagram.

The combination of newer techniques offers a potential solution. AngioJet mechanical thrombectomy acts like a power washer for the artery, using a high-velocity saline stream to break down and aspirate blood clots. This method rapidly restores vessel patency without propelling harmful debris downstream [9, 10]. Subsequently, a drug-coated balloon (DCB) is inflated at the treatment site, releasing medication that prevents the vessel wall from overhealing and narrowing again - this is a key factor in restenosis [11]. This dual approach aims to restore blood flow effectively, reduce inflammation, and provide sufficient oxygen to the tissue, facilitating ulcer healing.

Despite some promising short-term outcomes, the long-term impact remains unclear. How does this combination affect overall metabolism and inflammation in patients? More importantly, do the ulcers stay healed? Currently, data on ASO-DFU patients treated with this combined approach are limited [12].

Our study was designed to address this gap by tracking patients treated with the AngioJet and DCB combination for one year. We closely examined their hemodynamics, blood glucose control, inflammatory markers, and ulcer recurrence. Ultimately, our goal is to determine whether this approach can be a reliable strategy, not only for healing these persistent ulcers but, more crucially, for preventing amputation.

Methods and materials

General information and grouping

This retrospective analysis included 198 patients with DFU complicated by lower extremity ASO, recruited from the Second Affiliated Hospital of Shaanxi University of Traditional Chinese Medicine between April 2021 and March 2024. The study cohort was divided into two therapeutic groups: 104 patients underwent ultrasound-guided mechanical thrombectomy combined with DCB therapy (combined group), while 94 patients received mechanical thrombectomy alone (control group). Ethical approval for this study was obtained from the Medical Ethics Committee of The Second Affiliated Hospital of Shaanxi University of Traditional Chinese Medicine, with patient allocation and treatment protocols outlined in **Figure 1**.

Inclusion and exclusion criteria

Inclusion criteria: (1) Diagnosis of diabetes according to World Health Organization criteria [13]. (2) Diagnosis of ASO with DFU confirmed by lower limb arterial computed tomography angiography (CTA) or digital subtraction angiography (DSA) [14]. (3) Indication for AngioJet mechanical thrombectomy. (4) First-time intervention at the Second Affiliated Hospital of Shaanxi University of Traditional Chinese Medicine with no prior surgical or pharmacological treatment for ASO. (5) Availability of complete clinical and follow-up data.

Exclusion criteria: (1) Patients unable to complete follow-up. (2) Patients with severe cardi-

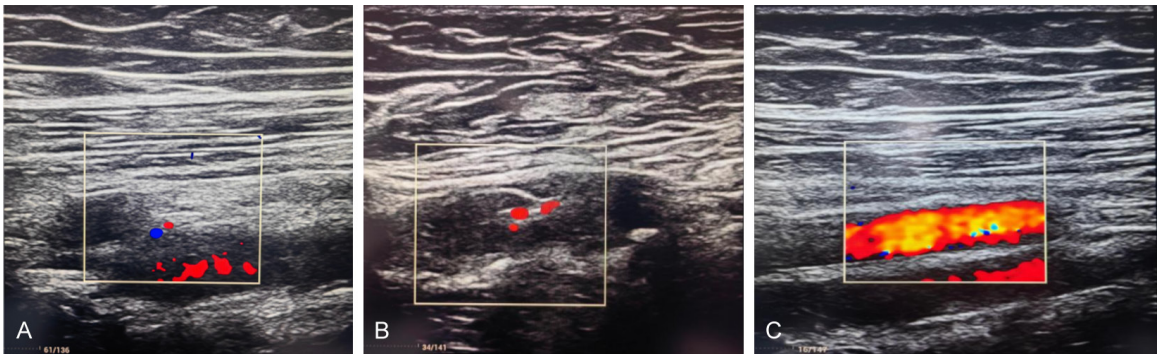

Figure 2. Color Doppler Ultrasound Images During the Treatment of Superficial Femoral Artery Occlusion in a Patient with Diabetic Foot Ulcer and Lower Extremity Arterial Occlusive Disease. A. Preoperative Color Doppler ultrasound showing the absence of blood flow in the SFA, indicating complete occlusion. B. Intraoperative Color Doppler ultrasound during DCB angioplasty at the SFA ostium, demonstrating partial restoration of blood flow with red and blue signals indicating bidirectional flow. C. Postoperative Color Doppler ultrasound after AngioJet thrombectomy and DCB therapy, revealing restored blood flow in the SFA with predominant red signals indicating improved antegrade flow. Note: SFA: superficial femoral artery, DCB: Drug-coated balloon.

ac, hepatic, or renal dysfunction, malignancy, or an expected survival of less than one year. (3) Allergy to heparin, paclitaxel, or contrast agents; pregnancy or lactation. (4) Presence of active large-vessel vasculitis.

Surgical plan

All procedures were performed by experienced interventional radiologists in a dedicated angiography suite under strict aseptic conditions. Patients received either ultrasound-guided AngioJet mechanical thrombectomy combined with DCB therapy or mechanical thrombectomy alone. Preoperative evaluation included lower limb arterial CTA or DSA, baseline hemodynamic (pulse index (PI), resistive index (RI), ankle-brachial index (ABI)), and laboratory assessments, with antiplatelet therapy (aspirin 100 mg/day or clopidogrel 75 mg/day) and anticoagulation therapy (enoxaparin 4000 IU/day) started 48 hours prior.

For both groups, percutaneous femoral access was obtained using the Seldinger technique, followed by diagnostic angiography. The AngioJet system (Boston Scientific) was used for thrombectomy, employing high-velocity saline jets to fragment and aspirate thrombus over multiple passes (2-4 passes, 30-60 seconds each), with intraoperative heparin (50-100 IU/kg) to maintain an activated clotting time of 250-300 seconds. In the control group, residual stenosis (>50%) was treated with plain balloon angioplasty (4-6 mm, 6-12 atm, 60-120 seconds). In the combined group, after thrombectomy, a paclitaxel-coated DCB (e.g., IN.PACT Admiral, 3.5 μg/mm^2) was inflated (6-10 atm, 120-180 seconds) to cover the lesion, with predilation if needed. Post-procedure angiography confirmed patency (<30% stenosis), and the arteriotomy was closed using a closure device or manual compression. Real-time Doppler ultrasound guided access with monitored patency was used with distal protection devices for high thrombus burden.

Postoperatively, dual antiplatelet therapy was continued for 6 months, anticoagulation therapy for 3-7 days, and glycemic control targeted fasting plasma glucose (FPG) <7.0 mmol/L and HbA1c <7.0%. Wound care included debridement, antibiotics, and offloading, with follow-up at 1, 3, 6, and 12 months to assess patency and ulcer healing (**Figure 2**).

Data collection

Patient data were extracted from electronic records and outpatient follow-up systems, including:

Baseline data: Age, sex, BMI, smoking and alcohol history, marital status, diabetes duration, and lesion length.

Clinical indicators: Treatment efficacy (graded as cured/significantly improved/effective/ineffective), hemodynamic parameters (pulse index [PI], resistive index [RI]), and functional scores

(ABI, Rutherford grade, Wagner grade, claudication distance).

Laboratory indicators: Blood glucose metabolism (FPG, postprandial plasma glucose (PPG), glycated hemoglobin (HbA1c)) and inflammatory markers (c-reactive protein (CRP), tumor necrosis factor-alpha (TNF-α), interleukin-6 (IL-6)).

Follow-up data: Postoperative complications (hematoma, infection, thrombosis) and one-year recurrence (defined as >70% restenosis on ultrasound or CTA).

Indicator detection

FPG and PPG: Roche Cobas c702 automatic biochemical analyzer (Roche Diagnostics, Switzerland).

HbA1c: Bio-Rad D-10 Hemoglobin Analyzer (Bio-Rad, USA).

CRP: Siemens BNII protein analyzer (Siemens Healthineers, Germany).

TNF-α, IL-6: ELISA kits (Wuhan SanYing Biotechnology Co., Ltd., China).

PI and RI: Philips EPIQ 7C Doppler system (Philips Healthcare, Netherlands), measured pre- and one month post-treatment.

Functional scoring

ABI: Ratio of ankle to brachial systolic pressure. ABI ≤0.90 indicates stenosis; ≥1.30 suggests calcification [15].

Rutherford grade: Scale of ischemia from 0 (asymptomatic) to 6 (tissue loss) [16].

Wagner grade: Score for ulcer depth and infection from 0 (pre-ulcer) to 5 (extensive gangrene) [17].

Claudication distance: Measured on a treadmill (5% slope, 3 km/h) to assess painless walking distance [18].

Efficacy criteria

Cured: Pulse restoration, <30% residual stenosis, symptom resolution, and wound healing.

Significantly improved: 30-50% stenosis, improved symptoms, and good wound healing.

Effective: 50-80% stenosis, partial improvement in symptoms and wound healing.

Ineffective: ≥80% stenosis, no clinical improvement.

Total effective rate = cured + significantly improved + effective.

Recurrence definition

Recurrence was defined as ≥70% restenosis or re-occlusion based on vascular ultrasound or CTA [19].

Observation indicators

Primary indicators: Clinical efficacy at six months and recurrence rate at one year.

Secondary indicators: One-month changes in glucose and inflammatory markers; six-month changes in functional scores and hemodynamics; incidence of complications.

Statistical analysis

All statistical analyses were conducted using SPSS version 27.0. The Kolmogorov-Smirnov (K-S) test was used to assess the normality of continuous variables. Normally distributed data are presented as mean ± standard deviation (Mean ± SD), with between-group comparisons conducted using independent samples t-tests and within-group (pre- and post-treatment) comparisons using paired samples t-tests. Non-normally distributed data are presented as median and interquartile range (P50 [IQR]), and analyzed using nonparametric rank-sum tests: Mann-Whitney U test for between-group comparisons, Wilcoxon signed-rank test for within-group comparisons, and Kruskal-Wallis H test for comparisons involving more than two groups when applicable. Categorical variables were presented as counts and percentages (n, %) and analyzed using the chi-square test or Fisher's exact test when expected frequencies were small. Logistic regression analysis (Enter method) was performed to identify independent risk factors for recurrence, including variables with statistical significance in univariate analysis. Continuous variables were dichotomized based on clinical thresholds or ROC-derived cut-off values prior to model entry. A two-sided *P*-value <0.05 was considered statistically significant.

Table 1. Baseline data assessment of patients

Variable	Total (n=198)	Control group (n=94)	Combined group (n=104)	t/χ^2 Value	*P* Value
Age					
≥65 years	119 (60.10)	58 (61.70)	61 (58.65)	0.191	0.662
<65 years	79 (39.90)	36 (38.30)	43 (41.35)		
Sex					
Male	106 (53.54)	49 (52.13)	57 (54.81)	0.143	0.706
Female	92 (46.46)	45 (47.87)	47 (45.19)		
BMI					
≥25 kg/m^2	83 (41.92)	36 (38.30)	47 (45.19)	0.964	0.326
<25 kg/m^2	115 (58.08)	58 (61.70)	57 (54.81)		
Duration of Diabetes					
≥10 years	132 (66.67)	61 (64.89)	71 (68.27)	0.253	0.615
<10 years	66 (33.33)	33 (35.11)	33 (31.73)		
Smoking History					
Yes	124 (62.63)	55 (58.51)	69 (66.35)	1.295	0.255
No	74 (37.37)	39 (41.49)	35 (33.65)		
Drinking History					
Yes	24 (12.12)	8 (8.51)	16 (15.38)	-	0.191
No	174 (87.88)	86 (91.49)	88 (84.62)		
Marital Status					
Married	181 (91.41)	85 (90.43)	96 (92.31)	-	0.8
Other	17 (8.59)	9 (9.57)	8 (7.69)		
Length of Affected Vessels (mm)	156.70±51.36	153.52±53.06	159.58±49.87	0.828	0.409

Table 2. Comparison of clinical efficacy post-treatment

Group	Cure	Marked improvement	Effective	Ineffective	Total
Control group (n=94)	18 (19.15%)	24 (25.53%)	30 (31.91%)	22 (23.40%)	72 (76.60%)
Combined group (n=104)	29 (27.88%)	38 (36.54%)	27 (25.96%)	10 (9.62%)	94 (90.38%)
χ^2/Z		5.094			6.928
P Value		<0.001			0.009

Results

Comparison of baseline data

Comparison of baseline characteristics between the two groups revealed no statistically significant differences in age (P=0.662), sex (P=0.706), BMI (P=0.326), duration of diabetes (P=0.615), smoking history (P=0.255), alcohol history (P=0.191), marital status (P=0.800), or length of the affected vessels (P=0.409), indicating good baseline comparability between the groups (**Table 1**).

Comparison of clinical efficacy

Analysis of clinical efficacy showed that the combined group demonstrated significantly better overall treatment improvement compared to the control group (P<0.001). Additionally, the total effective rate was significantly higher in the combined group (P=0.009) (**Table 2**).

Comparison of hemodynamic indicators before and after treatment

There were no significant differences in PI and RI between the two groups before treatment (PI: t=0.178, P=0.859; RI: Z=0.697, P=0.486). However, one month after treatment, both groups exhibited significant reductions in PI and RI (PI: t=23.481, P<0.001; RI: t=27.732, P<0.001). Moreover, reductions in the combined group were significantly greater than in the control group (PI: t=8.763, P<0.001; RI: t=9.452, P<0.001), suggesting superior hemodynamic improvement (**Table 3**).

Table 3. Comparison of hemodynamic indicators before and after treatment

Variable	Control group (n=94)	Combined group (n=104)	Statistical Value	*P* Value
Pre-Treatment PI	7.86±0.79	7.88±0.76	0.178	0.859
Post-Treatment 6-Month PI	5.26±0.70	4.41±0.66	8.763	<0.001
Statistical Value	23.481	33.920		
P Value	<0.001	<0.001		
Pre-Treatment RI	1.12 (0.15)	1.12 (0.18)	0.697	0.486
Post-Treatment 6-Month RI	0.70±0.07	0.60±0.08	9.452	<0.001
Statistical Value	27.732	31.064		
P Value	<0.001	<0.001		

Note: PI: Pulse Index, RI: Resistive Index.

Table 4. Comparison of blood glucose indicators before and after treatment

Variable	Control group (n=94)	Combined group (n=104)	Statistical Value	*P* Value
Pre-Treatment FPG (mmol/L)	8.58±0.47	8.64±0.45	0.965	0.336
Post-Treatment 1-Month FPG (mmol/L)	8.23±0.34	8.09±0.39	2.575	0.011
Statistical Value	5.887	9.573		
P Value	<0.001	<0.001		
Pre-Treatment PPG (mmol/L)	15.09±1.27	15.30±1.18	1.213	0.226
Post-Treatment 1-Month PPG (mmol/L)	13.96±1.00	13.62±1.03	2.411	0.017
Statistical Value	6.481	11.392		
P Value	<0.001	<0.001		
Pre-Treatment HbA1c (%)	8.93 (1.50)	8.82 (1.78)	0.091	0.928
Post-Treatment 1-Month HbA1c (%)	8.13±1.02	7.69±0.98	3.078	0.002
Statistical Value	5.258	10.754		
P Value	<0.001	<0.001		

Note: FPG: Fasting Plasma Glucose, PPG: Postprandial Plasma Glucose, HbA1c: Glycated Hemoglobin.

Comparison of blood glucose indicators before and after treatment

No significant differences in FPG, PPG, and HbA1c were observed before treatment (FPG: t=0.965, P=0.336; PPG: t=1.213, P=0.226; HbA1c: t=0.091, P=0.928). After one month of treatment, all three indicators showed significant decreases in both groups (FPG: t=5.887, P<0.001; PPG: t=6.481, P<0.001; HbA1c: t=5.258, P<0.001), with the combined group demonstrating significantly greater reductions (FPG: t=2.575, P=0.011; PPG: t=2.411, P=0.017; HbA1c: t=3.078, P=0.002) (**Table 4**).

Comparison of inflammatory markers before and after treatment

Before treatment, no significant differences in CRP, TNF-α, or IL-6 levels were observed between the two groups (CRP: t=1.205, P=0.230; TNF-α: t=2.111, P=0.036; IL-6: t=0.196, P=0.845). After one month, levels of all three markers significantly decreased in both groups (CRP: t=16.123, P<0.001; TNF-α: t=35.485, P<0.001; IL-6: t=20.370, P<0.001). The combined group exhibited significantly greater reductions in CRP, TNF-α, and IL-6 compared to the control group (CRP: t=11.314, P<0.001; TNF-α: t=7.387, P<0.001; IL-6: t=7.049, P<0.001) (**Table 5**).

Comparison of functional scores before and after treatment

No significant differences were observed in ABI, Rutherford grade, Wagner grade, or claudication distance before treatment (ABI: t=0.288, P=0.773; Rutherford: t=0.360, P=0.718; Wagner: t=0.701, P=0.483; claudication distance: t=1.467, P=0.144). At six months post-treatment, all functional indicators showed significant improvements in both groups (ABI: t=14.159, P<0.001; Rutherford: t=19.387,

Table 5. Comparison of inflammatory markers before and after treatment

Variable	Control group (n=94)	Combined group (n=104)	Statistical Value	*P* Value
Pre-Treatment CRP (mg/L)	25.77±6.80	26.86±6.00	1.205	0.230
Post-Treatment 1-Month CRP (mg/L)	12.94±2.22	8.68±2.98	11.314	<0.001
Statistical Value	16.123	26.991		
P Value	<0.001	<0.001		
Pre-Treatment TNF-α (ng/L)	49.66±7.62	47.15±8.99	2.111	0.036
Post-Treatment 1-Month TNF-α (ng/L)	14.68±5.09	10.21±3.32	7.387	<0.001
Statistical Value	35.485	37.067		
P Value	<0.001	<0.001		
Pre-Treatment IL-6 (ng/L)	2.92±0.55	2.90±0.46	0.196	0.845
Post-Treatment 1-Month IL-6 (ng/L)	1.55±0.29	1.26±0.29	7.049	<0.001
Statistical Value	20.370	31.39		
P Value	<0.001	<0.001		

Note: CRP: C-reactive Protein, TNF-α: Tumor Necrosis Factor-alpha, IL-6: Interleukin-6.

Table 6. Comparison of functional scores before and after treatment

Variable	Control group (n=94)	Combined group (n=104)	Statistical Value	*P* Value
Pre-Treatment ABI	0.23±0.11	0.23±0.11	0.288	0.773
Post-Treatment 6-Month ABI	0.56±0.20	0.63±0.17	2.644	0.009
Statistical Value	14.159	18.772		
P Value	<0.001	<0.001		
Pre-Treatment Rutherford Grading	5.00 (1.00)	5.00 (1.00)	0.360	0.718
Post-Treatment 6-Month Rutherford Grading	3.00 (1.00)	1.00 (1.00)	11.832	<0.001
Statistical Value	19.387	47.91		
P Value	<0.001	<0.001		
Pre-Treatment Wagner Grading	3.00 (0.00)	3.00 (0.00)	0.701	0.483
Post-Treatment 6-Month Wagner Grading	2.00 (1.00)	1.00 (1.00)	4.630	<0.001
Statistical Value	10.018	16.36		
P Value	<0.001	<0.001		
Pre-Treatment Claudication Distance	217.44±32.86	210.24±35.87	1.467	0.144
Post-Treatment 6-Month Claudication Distance	824.50 (124.75)	900.50 (63.25)	6.777	<0.001
Statistical Value	8.417	8.851		
P Value	<0.001	<0.001		

Note: ABI: Ankle-Brachial Index.

P<0.001; Wagner: t=10.018, P<0.001; claudication distance: t=8.417, P<0.001). The combined group showed significantly greater improvements compared to the control group (ABI: t=2.644, P=0.009; Rutherford: t=11.832, P<0.001; Wagner: t=4.630, P<0.001; claudication distance: t=6.777, P<0.001) (**Table 6**).

Comparison of post-operative complications

There were no significant differences in the incidence of post-operative complications between the two groups (P>0.999). Both groups had 3 cases of puncture site hematoma and 2 cases of secondary thrombosis. The combined group had 1 case of infection, while the control group had 2 cases. The overall incidence was 6 cases in the combined group and 7 in the control group (**Table 7**).

Recurrence and risk factors within one year post-surgery

A total of 62 patients experienced recurrence within one year postoperatively, defined as >80% stenosis or occlusion confirmed by vascular ultrasound or CTA. These patients were categorized into the recurrence group (n=62) and non-recurrence group (n=136), and related clinical variables were analyzed (Table S1).

Table 7. Comparison of complications between the two groups

Group	Puncture site hematoma	Infection	Secondary thrombosis formation	Overall incidence rate
Control group (n=94)	3	1	2	6
Combined group (n=104)	3	2	2	7
χ^2	-	-	-	-
P Value	<0.999	<0.999	<0.999	<0.999

Note: Fisher test was used.

Table 8. Variable assignment table

Variable	Variable Type	Assigned Value
Length of Affected Vessels (mm)	Continuous	Raw data for analysis
Pre-Treatment PI	Continuous	Raw data for analysis
Pre-Treatment RI	Continuous	Raw data for analysis
Pre-Treatment FPG	Continuous	Raw data for analysis
Pre-Treatment PPG	Continuous	Raw data for analysis
Pre-Treatment HbA1c	Continuous	Raw data for analysis
Pre-Treatment CRP	Continuous	Raw data for analysis
Pre-Treatment TNF-α	Continuous	Raw data for analysis
Pre-Treatment IL-6	Continuous	Raw data for analysis
Pre-Treatment ABI	Continuous	Raw data for analysis
Pre-Treatment Rutherford Grading	Continuous	Raw data for analysis
Pre-Treatment Wagner Grading	Continuous	Raw data for analysis
Pre-Treatment Claudication Distance	Continuous	Raw data for analysis
Age	Categorical	≥65 years =1, <65 years =0
Sex	Categorical	Male =1, Female =0
BMI	Categorical	≥25 kg/m^2 =1, <25 kg/m^2 =0
Duration of Diabetes	Categorical	≥10 years =1, <10 years =0
Smoking History	Categorical	Yes =1, No =0
Drinking History	Categorical	Yes =1, No =0
Marital Status	Categorical	Married =1, Other =0
Treatment Modality	Categorical	Control =1, Combined =0
Recurrence	Categorical	Yes =1, No =0

Note: PI: Pulse Index, RI: Resistive Index, FPG: Fasting Plasma Glucose, PPG: Postprandial Plasma Glucose, HbA1c: Glycated Hemoglobin, CRP: C-reactive Protein, TNF-α: Tumor Necrosis Factor-alpha, IL-6: Interleukin-6, ABI: Ankle-Brachial Index.

After variable assignment (**Table 8**), univariate logistic regression identified the following as significant risk factors: pre-treatment ABI (OR=0.001, P<0.001), TNF-α (OR=1.041, P=0.035), age (OR=0.503, P=0.037), BMI (OR=0.381, P=0.002), diabetes duration (OR=0.415, P=0.014), and treatment modality (combined vs. control, OR=0.362, P=0.001) (**Table 9**). Multivariate logistic regression further confirmed pre-treatment ABI (OR=3.954, P<0.001), BMI (OR=0.370, P=0.006), diabetes duration (OR=0.435, P=0.037), and treatment modality (OR=0.327, P=0.002) as independent predictors of recurrence (**Table 10**).

Predictive value of recurrence-related variables

ROC analysis revealed that pre-treatment ABI had the highest predictive value for recurrence (AUC=0.695, 95% CI: 0.615-0.775), with high specificity (79.41%) and moderate sensitivity (53.23%). Treatment modality followed (AUC=0.624, 95% CI: 0.551-0.697; sensitivity: 64.52%, specificity: 60.29%). TNF-α (AUC=0.589) and BMI (AUC=0.618) had moderate predictive power. Age (AUC=0.421) and diabetes duration (AUC=0.410) showed poor predictive value, with perfect sensitivity but zero

Table 9. Univariate logistic regression analysis of recurrence factors

Variable	Estimate	Std Error	*P* Value	OR	Lower	Upper
Lesion Vessel Length	-0.001	0.003	0.721	0.999	0.993	1.005
Pre-Treatment PI	-0.328	0.201	0.104	0.721	0.482	1.066
Pre-Treatment RI	-0.402	1.166	0.730	0.669	0.066	6.500
Pre-Treatment FPG	-0.060	0.335	0.857	0.941	0.486	1.821
Pre-Treatment PPG	-0.226	0.127	0.076	0.797	0.618	1.021
Pre-Treatment HbA1c	-0.095	0.137	0.486	0.909	0.693	1.188
Pre-Treatment CRP	-0.029	0.024	0.229	0.971	0.926	1.018
Pre-Treatment TNF-α	0.040	0.019	0.035	1.041	1.003	1.081
Pre-Treatment IL-6	0.221	0.309	0.473	1.248	0.684	2.306
Pre-Treatment ABI	-7.237	1.735	<0.001	0.001	<0.001	0.019
Pre-Treatment Rutherford Grading	0.570	0.307	0.063	1.769	0.977	3.272
Pre-Treatment Wagner Grading	0.103	0.266	0.698	1.109	0.658	1.876
Pre-Treatment Claudication Distance	-0.003	0.004	0.481	0.997	0.988	1.006
Age	-0.687	0.329	0.037	0.503	0.260	0.946
Sex	-0.171	0.308	0.579	0.843	0.458	1.539
BMI	-0.964	0.314	0.002	0.381	0.204	0.703
Duration of Diabetes	-0.878	0.358	0.014	0.415	0.200	0.820
Smoking History	-0.118	0.319	0.711	0.888	0.471	1.650
Drinking History	-0.105	0.463	0.820	0.900	0.372	2.336
Marital Status	0.472	0.519	0.362	1.604	0.557	4.395
Treatment Modality	-1.016	0.318	0.001	0.362	0.192	0.670

Note: PI: Pulse Index, RI: Resistive Index, FPG: Fasting Plasma Glucose, PPG: Postprandial Plasma Glucose, HbA1c: Glycated Hemoglobin, CRP: C-reactive Protein, TNF-α: Tumor Necrosis Factor-alpha, IL-6: Interleukin-6, ABI: Ankle-Brachial Index.

Table 10. Multivariate logistic regression analysis of recurrence factors

Variable	Estimate	Std Error	*P* Value	OR	Lower	Upper
Pre-Treatment TNF-α (<49.43 vs. ≥49.43)	-0.636	0.359	0.076	0.529	0.259	1.066
Pre-Treatment ABI (<0.175 vs. ≥0.175)	1.375	0.369	<0.001	3.954	1.933	8.269
Age (≥65 years vs. <65 years)	-0.369	0.371	0.320	0.692	0.331	1.426
BMI (≥25 kg/m^2 vs. <25 kg/m^2)	-0.993	0.361	0.006	0.370	0.180	0.746
Duration of Diabetes (≥10 years vs. <10 years)	-0.833	0.400	0.037	0.435	0.193	0.933
Treatment Modality (Control vs. Combined)	-1.116	0.364	0.002	0.327	0.157	0.660

Note: TNF-α: Tumor Necrosis Factor-alpha, ABI: Ankle-Brachial Index. Pre-treatment TNF-α and ABI are categorized based on the cut-off values.

specificity, limiting their practical utility (**Figure 3**).

Discussion

ASO combined with DFU is a common and severe complication in diabetic patients [20]. Metabolic disorders caused by diabetes, particularly persistent hyperglycemia, accelerate the progression of atherosclerosis, leading to insufficient blood supply to the lower limbs, which in turn causes neuropathy and the formation of foot ulcers [21]. This study aimed to evaluate the efficacy of the Rotarex mechanical thrombectomy system combined with DCB in treating ASO with DFU and to analyze its impact on postoperative recurrence and related risk factors.

The results demonstrated that Rotarex mechanical thrombectomy combined with DCB significantly improved lower extremity hemodynamics and clinical outcomes. This combination therapy effectively cleared thrombus, restored vascular patency, and enhanced blood supply, creating favorable conditions for lower

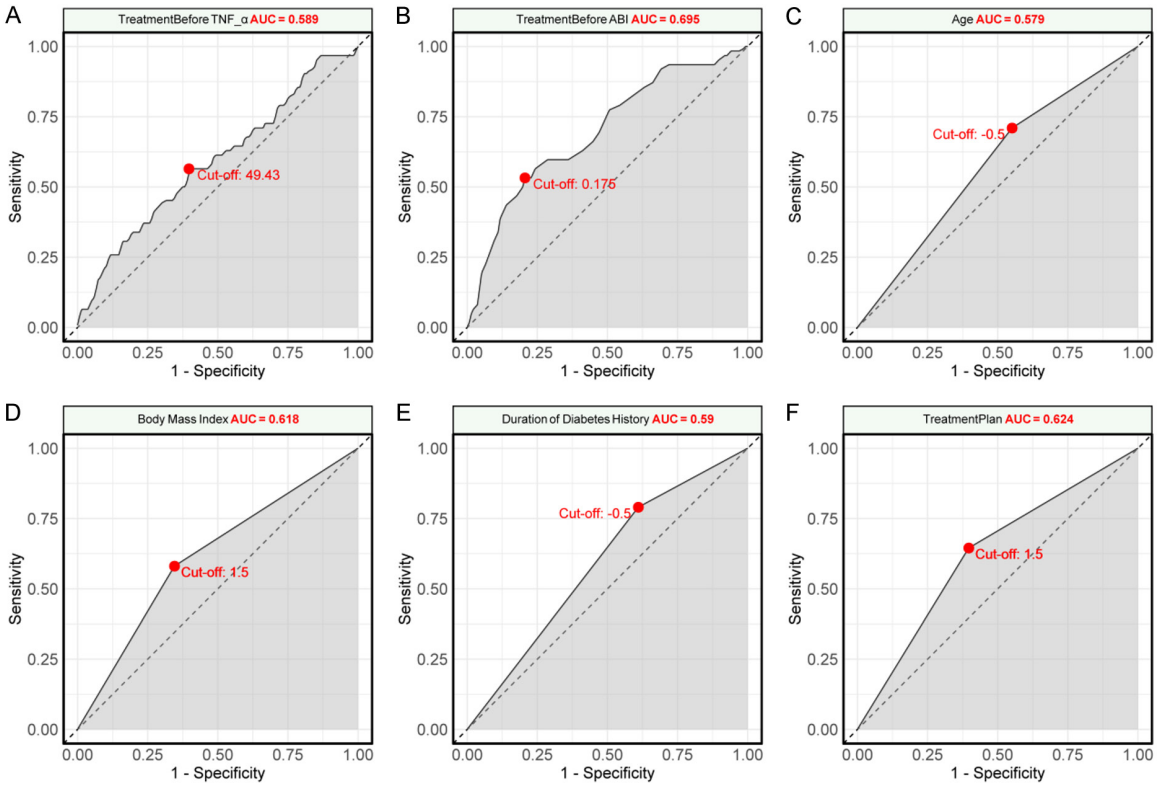

Figure 3. ROC curve of recurrence characteristic factors. A. Pre-treatment TNF-α in predicting patient recurrence ROC curve. B. Pre-treatment ABI in predicting patient recurrence ROC curve. C. Pre-treatment Age in predicting patient recurrence ROC curve. D. Pre-treatment BMI in predicting patient recurrence ROC curve. E. Pre-treatment Duration of Diabetes History in predicting patient recurrence ROC curve. F. Pre-treatment Treatment Plan in predicting patient recurrence ROC curve. Note: TNF-α: Tumor Necrosis Factor Alpha, ABI: Ankle-Brachial Index, ROC: Receiver Operating Characteristic, BMI: Body Mass Index.

limb functional recovery and ulcer healing. Similarly, studies on periosteal distraction in diabetic foot treatment have shown that this approach can promote wound healing and relieve pain [22]. Although the mechanisms of action differ, both treatments improve local blood supply and microcirculation, thus providing better conditions for wound repair. These findings suggest that restoring blood flow is likely a key factor in improving the healing rate of diabetic foot ulcers.

Another major challenge in diabetic foot treatment is maintaining long-term vascular patency and functional recovery. The Rotarex mechanical thrombectomy combined with DCB not only improves hemodynamics in the short term but also demonstrates stable efficacy during the follow-up period. Literature reports indicate that diabetic patients often exhibit lower long-term clinical success rates after treatment for lower extremity arterial occlusion, with limited improvements in quality of life [23]. The difference observed in this study may be due to the combined treatment reducing the risk of local restenosis and extending vascular patency, thereby promoting long-term vascular repair and functional recovery, leading to better clinical outcomes.

Notably, the Rotarex mechanical thrombectomy combined with DCB also appears to positively impact metabolic control. The observed improvement in blood glucose control suggests that this therapy not only restores blood supply to the lower limbs but may also improve the metabolic condition of diabetic patients by alleviating tissue ischemia and enhancing microcirculation. Previous studies have shown that tibial transverse transport combined with antibiotic bone cement can reduce inflammatory responses and promote wound healing in patients with chronic foot infections [24]. These findings indicate that improving blood flow may

influence wound repair through multiple mechanisms, including reducing local inflammation, optimizing the cellular metabolic environment, and enhancing tissue repair capacity, which is especially crucial for patients with diabetic foot.

The underlying pathology of both diabetic foot ulceration and lower extremity ischemia centers on inflammatory processes that drive disease progression and therapeutic resistance. Our study shows that the combined therapeutic approach significantly reduced key inflammatory biomarkers - CRP, TNF-α, and IL-6 - confirming its potent anti-inflammatory properties and clinical relevance.

Chronic low-grade inflammation perpetuates a cascade of vascular dysfunction, simultaneously accelerating atherosclerotic progression. This highlights inflammation control as a critical determinant for achieving sustained vascular patency [25]. This therapeutic principle is supported by previous research showing that tibial transverse transport, when combined with antibiotic bone cement, effectively reduces inflammation and mitigates vascular damage in diabetic foot populations [24]. These findings underscore the importance of incorporating inflammation management strategies in comprehensive treatment protocols for this vulnerable patient group.

From a safety perspective, our analysis revealed that Rotarex mechanical thrombectomy combined with DCB intervention did not significantly elevate complication rates, suggesting that the therapy preserves a favorable safety profile while simultaneously enhancing therapeutic efficacy. These findings align with contemporary literature, which indicates that innovative treatment modalities, including LTPD approaches, maintain acceptable risk profiles when implemented under appropriate clinical management protocols, despite inherent procedural complexities [22].

The clinical feasibility and practical implementation of Rotarex mechanical thrombectomy combined with DCB technology demonstrates clear advantages in enhanced hemodynamic optimization, metabolic function regulation, and inflammatory response modulation. This integrated therapeutic strategy addresses the limitations of conventional treatment approaches, particularly with regard to long-term vascular patency maintenance and wound healing facilitation in patients with diabetic foot ulcers complicated by lower extremity ischemic disease.

Our investigation also explored recurrence risk factors within the one-year postoperative period following ASO surgical intervention. Multivariate logistic regression analysis identified critical predictive variables, including low ABI measurements, elevated TNF-α concentrations, increased BMI, extended diabetic disease duration, and specific treatment modality selection.

The ABI is a fundamental diagnostic tool for assessing lower extremity vascular perfusion. Diminished ABI values indicate severe peripheral arterial disease, characterized by compromised blood flow capacity, which can potentially impede circulation maintenance after vascular reconstruction procedures [26]. Our findings showed that patients with lower pretreatment ABI measurements had significantly higher recurrence risks, presumably due to inadequate postoperative blood flow recovery.

Chronic low-grade inflammatory states, particularly elevated TNF-α levels, actively promote atherosclerotic progression and intimal hyperplasia development, hampering vascular recanalization and blood flow restoration [27]. Patients with higher pretreatment TNF-α concentrations had a higher recurrence probability, as persistent inflammation delays wound healing and accelerates endothelial damage and restenosis.

Obesity often exacerbates atherosclerotic processes, elevating thrombotic risk and complicating postoperative blood flow restoration [28]. Obese patients typically exhibit compromised blood rheological properties, limiting posttreatment circulation improvement and leading to higher recurrence rates. Additionally, patients with prolonged diabetic histories tend to present more severe peripheral vascular disease and diabetic neuropathy, both of which contribute to higher postoperative recurrence likelihood.

This investigation provides preliminary evidence that Rotarex mechanical thrombectomy combined with DCB intervention effectively

reduces recurrence risk, suggesting superior efficacy in preventing intimal hyperplasia and minimizing restenosis. The therapeutic advantage is primarily attributed to the Rotarex system's efficient thrombus removal, which restores vascular patency, reduces obstruction, and enhances blood flow, creating optimal conditions for vascular repair.

Furthermore, DCB technology delivers antiproliferative agents such as paclitaxel, which inhibit intimal hyperplasia and prevent restenosis caused by excessive vascular intimal proliferation [29, 30]. The synergistic interaction between these therapeutic modalities enhances vascular intervention efficacy while reducing postoperative restenosis. Additionally, the combined approach mitigates chronic low-grade inflammation, further minimizing vascular wall damage and hyperplastic responses. Through hemodynamic optimization, intimal hyperplasia inhibition, and inflammatory response reduction, this combined strategy reduces recurrence risk and significantly enhances long-term clinical outcomes.

Identifying risk factors facilitates early recognition of high-risk populations, enabling the development of personalized therapeutic protocols. Patients with diminished ABI and elevated TNF-α concentrations can benefit from aggressive vascular reconstruction, integrated with rigorous diabetic management and inflammation control strategies. Weight management and considerations of diabetic disease duration should be systematically incorporated into comprehensive treatment plans.

Our investigation demonstrates that Rotarex mechanical thrombectomy combined with DCB technology significantly improves multiple clinical parameters in ASO patients with DFU. This includes enhanced hemodynamic outcomes, improved glycemic control, reduced inflammatory markers, and accelerated functional recovery. Beyond improving clinical efficacy, this combined strategy reduces ulcer recurrence rates and optimizes diabetes management through enhanced circulation and inflammation modulation.

Future research should focus on expanding sample sizes and extending follow-up durations to comprehensively assess the impact of this combined therapy across various ASO pathological subtypes. Given the influence of obesity and diabetes duration on treatment outcomes, individualized therapeutic strategies will likely become a key focus. The evolving understanding of inflammation's role in vascular pathology suggests that combination therapies targeting both mechanical and biological aspects of disease progression, including biomarker-guided therapy selection and risk stratification, may offer promising avenues for future treatment protocols. In conclusion, the combined AngioJet-DCB approach demonstrates enhanced clinical efficacy in ASO-DFU management through improved hemodynamic outcomes and reduced recurrence risk.

Disclosure of conflict of interest

None.

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Table S1. Comparison of the baseline data of the patients with recurrence

Variable	Total (n=198)	Recurrence group (n=62)	Non-relapse group (n=136)	t/χ^2 Value	*P* Value
Age					
≥65 years	119	44	75	4.445	0.035
<65 years	79	18	61		
Sex					
Male	106	35	71	0.309	0.579
Female	92	27	65		
BMI					
≥25 kg/m^2	83	36	47	9.664	0.002
<25 kg/m^2	115	26	89		
Duration of Diabetes					
≥10 years	132	49	83	6.211	0.013
<10 years	66	13	53		
Smoking History					
Yes	124	40	84	0.138	0.711
No	74	22	52		
Drinking History					
Yes	24	8	16	0.052	0.820
No	174	54	120		
Marital Status					
Married	181	55	126	0.841	0.359
Other	17	7	10		
Therapeutic regimen					
Conventional Group	94	40	54	10.512	0.001
Coated Group	104	22	82		
Length of Affected Vessels (mm)	156.70±51.36	154.77±57.49	157.58±48.52	0.356	0.722
Pre-Treatment PI	7.87±0.77	7.74±0.65	7.93±0.82	1.642	0.102
Pre-Treatment RI	1.12±0.13	1.11±0.16	1.12±0.12	0.343	0.732
Pre-Treatment FPG	8.61±0.46	8.60±0.54	8.61±0.42	0.179	0.858
Pre-Treatment PPG	15.20±1.23	14.97±1.22	15.31±1.22	1.796	0.074
Pre-Treatment HbA1c	8.88 (1.59)	8.80 (0.96)	9.03 (1.99)	0.758	0.448
Pre-Treatment CRP	26.34±6.40	25.53±6.46	26.71±6.36	1.205	0.230
Pre-Treatment TNF-α	48.34±8.44	50.23±8.92	47.48±8.10	2.148	0.033
Pre-Treatment IL-6	2.91±0.50	2.95±0.51	2.89±0.50	0.716	0.475
Pre-Treatment ABI	0.23 (0.15)	0.16 (0.14)	0.25 (0.12)	4.399	<0.001
Pre-Treatment Rutherford Grading	4.59±0.51	4.69±0.52	4.55±0.50	1.883	0.061
Pre-Treatment Wagner Grading	2.87±0.58	2.90±0.56	2.86±0.59	0.386	0.700
Pre-Treatment Claudication Distance	213.66±34.57	211.10±36.77	214.82±33.60	0.703	0.483