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RESEARCH

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Efficacy of platelet-rich plasma use as an adjunctive treatment in autologous osteochondral transplantation for patients with osteochondral lesions of the talus accompanied by chronic lateral ankle instability

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Abstract

Background Autologous osteochondral transplantation (AOT) combined with biological agents is an advanced technique for treating osteochondral lesions. Therefore, this study aimed to explore the effect of combining platelet-rich plasma (PRP) treatment with AOT on postoperative functional and magnetic resonance imaging (MRI) outcomes in patients with osteochondral lesions of the talus (OLTs) accompanied by chronic lateral ankle instability (CLAI).

Methods This retrospective study had a minimum follow-up period of 1 year. Thiry-nine patients with CLAI who underwent AOT between 2019 and 2023 were included in this study. Of these, 21 and 18 received AOT combined with PRP treatment (AOT + PRP group) and AOT alone (AOT-alone group), respectively. Preoperative and postoperative follow-up assessments were performed using the visual analog scale (VAS), American Orthopedic Foot and Ankle Society (AOFAS), and foot and ankle ability measure-sport scale (FAAM-sport scale). The final follow-up MRI was evaluated using the Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) 2.0 ankle scoring system.

Results Both groups showed a significant reduction in VAS scores and significant improvements in AOFAS and FAAM-sport scale scores at the final follow-up compared with the preoperative values. No significant differences were observed in the final follow-up VAS, AOFAS, FAAM-sport scale, and MOCART 2.0 ankle scores between the groups. However, significant between-group differences were found at postoperative months 1 ($P < 0.001$) and 3 ($P = 0.031$) for VAS scores and at postoperative month 3 for FAAM-sport scale scores ($P = 0.005$). The AOT + PRP group showed

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significantly better final follow-up scores for the "surface of the repair tissue" on the MOCART 2.0 ankle score system than the AOT-alone group ($P = 0.029$).

Conclusions PRP did not result in significantly superior outcomes when used as an adjunct to AOT compared to AOT alone in the setting of concomitant OLTs and CLAI.

Keywords Osteochondral lesions of the talus, Autologous osteochondral transplantation, Chronic lateral ankle instability, Platelet-rich plasma

Background

Osteochondral lesions of the talus (OLTs) are common injuries resulting from ankle sprains and fractures [1]. Approximately half of the patients with lateral ankle sprains experience some degree of osteochondral lesions [2]. In some cases, these patients progress to chronic lateral ankle instability (CLAI), where OLTs persist and may worsen owing to ongoing joint instability [3]. Consequently, surgically repairing the osteochondral lesions and lateral ankle ligaments simultaneously is necessary for patients with failed conservative treatment for OLTs accompanied by CLAI [4]. However, the surgical treatment of OLTs is currently contentious. Autologous osteochondral transplantation (AOT) was previously considered suitable for patients with failed marrow stimulation or subchondral cyst formation. Recent studies have shown that marrow stimulation is less effective for larger lesions, suggesting that AOT is suitable for treating such cases. The critical size of these lesions was previously reported as 150 mm²; however, recent studies reveal it may be closer to 100 mm² [5, 6]. Current guidelines recommend AOT for lesions exceeding 100 mm² [7]. However, the AOT technique is associated with some common donor site complications, such as pain, stiffness, and crepitation [8].

While previous studies have shown that AOT yields satisfactory clinical outcomes [9, 10], it faces issues as an alternative treatment, such as poor integration of transplanted cartilage plugs and formation of subchondral cysts, necessitating the development of adjunctive methods to enhance cartilage repair capacity. These methods include various treatments containing growth factors or stem cells [11]. Platelet-rich plasma (PRP) is widely used as a biological adjunct in the auxiliary treatment of OLTs. The abovementioned research includes efficacy studies of microfracture surgery combined with PRP treatment, comparisons of PRP with other biological agents for the conservative treatment of talar cartilage damage, and analyses of the efficacy of PRP-only treatment [12–14]. PRP contains numerous cytokines that promote cartilage repair [15], which is particularly required in AOT. However, combining PRP treatment with AOT is a novel approach that lacks current clinical research reports. Animal experiments have indicated that PRP use in AOT can improve graft integration at the cartilage interface and reduce graft degeneration [16, 17]. There are also reports of other orthobiologics used as adjuncts in AOT treatment. CBMA has been found to reduce subchondral cysts after AOT. In patients with OLTs undergoing AOT, the effects of CBMA alone are comparable to those of CBMA combined with extracellular matrix allografts (ECMA) [18].

Therefore, this study aimed to compare the efficacy of AOT with and without PRP use in treating OLTs among patients with CLAI. It was hypothesized that combining PRP treatment with AOT would enhance cartilage integration and improve clinical outcomes compared to AOT alone.

Methods

Study design, patients, and setting

Patients with OLTs accompanied by CLAI who underwent AOT at the 900th Hospital of the Joint Logistics Support Force between 2019 and 2023 were enrolled in this retrospective study. The inclusion criteria were as follows: (1) OLTs with concomitant CLAI; (2) ineffective conservative treatment for over 3 months; (3) magnetic resonance imaging (MRI) findings indicating subchondral cystic changes in the talus, failure of previous bone marrow stimulation surgery, or lesion area > 100 mm^2; (4) Hepple MRI classification [19] stage III or above; (5) age > 18 years; and (6) follow-up period ≥ 1 year. In contrast, the exclusion criteria were (1) a history of lateral ankle ligament repair or reconstructive surgery; (2) lesion size > 250 mm^2; (3) history of ankle joint infection; (4) coagulation dysfunction; and (5) anemia.

Data collection

All outpatient, inpatient, and follow-up visit information was extracted for the study participants. Demographic data and conservative treatment duration were recorded. Anterior talofibular ligament (ATFL) injury-induced CLAI was diagnosed based on a history of recurrent ankle sprains, a positive anterior drawer stress test, and musculoskeletal ultrasonographic findings. Hepple classification was performed using preoperative MRI. OLT locations were recorded using 9-zone method [20]. The lesion area (calculated as long axis radius × short axis radius × π) and depth were measured and calculated using the MRI data. Intraoperatively, the number of transplanted bone plugs and surgical techniques for the lateral ankle ligaments were recorded. Talar cartilage repair was evaluated using the Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) 2.0 ankle scoring system [21] based on the final follow-up MRI. Pain and function were assessed using the visual analog scale (VAS), American Orthopedic Foot and Ankle Society (AOFAS) scoring system, and foot and ankle ability measure-sport scale (FAAM-sport scale). These scores were recorded preoperatively, at 3 and 6 months postoperatively, and at the final follow-up (VAS scores were further recorded at 1 month postoperatively). Finally, the follow-up duration, adverse outcomes, and donor-site complications were also documented.

A single senior orthopedic surgeon performed all surgeries, and MRI scoring was performed by the same physician (Dr. YZ), who was blinded to the group allocation. The attending resident physicians recorded pain and functional scores during hospitalization or follow-up visits. Dr. SL retrieved the medical records and accurately documented the data.

Surgical procedure

Following spinal anesthesia, patients were positioned supine with a tourniquet applied to the proximal thigh. The surgical site was routinely disinfected and draped. Standard anteromedial and anterolateral portals were established for all patients, followed by arthroscopic examination to reconfirm the location of the talar cartilage lesions and debride the lesion surface. The decision to perform medial or lateral malleolar osteotomy was based on the lesion exposure after traction. Ligament repair or reconstruction was performed based on the condition of the ATFL remnant and ligament quality. A comprehensive intra-articular examination was performed to address soft tissue or bony impingement and remove intra-articular debris or loose cartilage.

Fig. 1 After performing intramedial malleolar osteotomy and adequately exposing the ankle joint in an everted position, two transplanted osteochondral columns were interlocked in an "8-shaped" configuration and implanted into the target area. The displayed grafts were well-matched with the host

AOT was performed using a cartilage transplantation system (Arthrex, AR-1981–08 S, Naples, FL, USA). Osteotomy was not required if the lesion was located anteriorly and well exposed through plantar flexion; otherwise, it was necessary. A circular harvester was aligned with the lesion, and complete coverage was ensured for single osteochondral plug transplantation. For two-plug transplantation, the harvester positions were carefully designed to implement the "nesting" technique while covering the lesion. With the knee in semi-flexion, a lateral parapatellar approach was established on the affected knee. The required number of osteochondral plugs was harvested from the non-weight-bearing area of the lateral femoral condyle. An osteochondral plug was slowly inserted using an inserter parallel to the prepared cylindrical tunnel in the talus to avoid angulation and graft osteochondral fracture during impaction. The osteotomy block was fixed with 2–3 cannulated screws of 3.5 mm after completing cartilage transplantation.

ATFL repair was performed using a modified Broström procedure. Two 2.3-mm suture anchors were implanted at the fibular attachment site, one for ATFL suturing and repair and the other for extensor retinaculum reinforcement. An autologous gracilis tendon graft was used for ATFL reconstruction. A bone groove was created and fixed with 2 suture anchors on the fibular side, whereas an interference screw was used for fixation on the talar side. Calcaneofibular ligament (CFL) reconstruction was based on the ATFL reconstruction technique, where the braided tendon graft was folded back on the fibular side and guided anteriorly and posteriorly to the talar and calcaneal attachment sites, respectively, with each end fixed using 1 interference screw.(Fig. 1)

PRP preparation and treatment

Leukocyte-poor PRP (LP-PRP) was prepared using a PRP preparation kit (Weigao Group Co., Shandong, China). First, 40–50 mL of venous blood was drawn from the patient and centrifuged (WG-YLj-II model) to separate it into 3 layers as follows: the upper layer containing plasma with platelets and a small number of leukocytes, middle buffy coat layer, and lower layer containing red blood cells. The superficial portions of the upper and middle layers were aspirated using a syringe and transferred into another centrifuge tube for a second centrifugation step. After removing the supernatant, 3–4 mL of LP-PRP was obtained, with a platelet concentration 5–6 times higher than the baseline value. The centrifugal force was set at 200 g for the first centrifugation and 1500 g for the second, both performed at 2000 rpm for 10 min each. No drainage tubes were placed during the surgery in any patient. After adequate hemostasis and irrigation fluid removal, the incision was closed, and a single PRP injection was administered into the joint cavity. Subsequent injections were administered every 2–3 weeks, with 3 injections constituting a complete treatment cycle. The preparation and administration of PRP adhered to the MIBO guidelines [22, 23].(Fig. 2)

Postoperative treatment

In the first 48 to 72 h postoperatively, ice therapy should be used to control swelling. When the patient is awake, ice packing or cryotherapy should be applied for 20 min every hour. After that, ice therapy should be performed at least 3 times a day, each session lasting 20 min. Regarding pain management, intravenous flurbiprofen axetil (80 mg) was administered daily for 3–5 days, followed by daily administration of oral etoricoxib (0.2 g). Upon discharge, the patient was administered sufficient oral medication for 1 week. Postoperatively, the ankle is immobilized in a cast for 3 weeks, with a non-weight-bearing status. During this period, straight leg raises, and toe movement exercises are performed. After the cast is removed, non-weight-bearing ankle pumps and ankle flexion-extension exercises are performed. Gradual weight-bearing is introduced using a CAM boot and crutches, with full weight-bearing achieved by 8 weeks postoperatively. After achieving full weight-bearing, the protective boot is removed, and proprioception, strength, and joint resistance training for inversion and eversion are conducted. Typically, normal daily and strenuous sports activities resumed at weeks 12 and 24, respectively.

Statistical analysis

The Shapiro–Wilk test was used to assess the normality of continuous variable data. Normally distributed data were expressed as the mean (standard deviation), and between-group comparisons were performed using the *t*-test. Paired *t*-tests were used to compare the preoperative and postoperative data. Non-normally distributed data were expressed as median (lower quartile, upper quartile), and between-group comparisons were performed using the Mann–Whitney *U* test. Categorical variables were expressed as frequencies and numbers, and group differences were compared using the chi-square test. All statistical analyses were performed using IBM SPSS Statistics version 27.0, and a significant difference was set at $P < 0.05$. Cohen's d was used to measure the effect size of the normally distributed continuous variables between the groups.

Results

Patient demographics

A total of 53 patients with OLTs accompanied by CLAI met the inclusion criteria. Of these, 5 were not followed up within the required timeframe during the first year postoperatively, 3 had their last MRI scan within 1 year, 4 had missing follow-up scores, and 2 who underwent AOT combined with PRP treatment did not complete the planned 3 injections. Therefore, these patients were excluded from the study. Ultimately, 39 patients were included in the study, among whom 21 underwent AOT combined with PRP treatment (AOT + PRP group) and 18 received AOT alone (AOT-alone group). All patients underwent ATFL repair or reconstruction. The median age in the AOT + PRP group was 28 years, compared to 24 years in the AOT-alone group ($P = 0.702$). The average BMI in the AOT + PRP group was 25.5 kg/m^2, compared to 24.57 kg/m^2 in the AOT-alone group ($P = 0.165$). The proportion of males in the AOT + PRP group was 90.5%, while in the AOT-alone group, it was 83.3% ($P = 0.647$). The proportion of left ankles in the AOT + PRP group

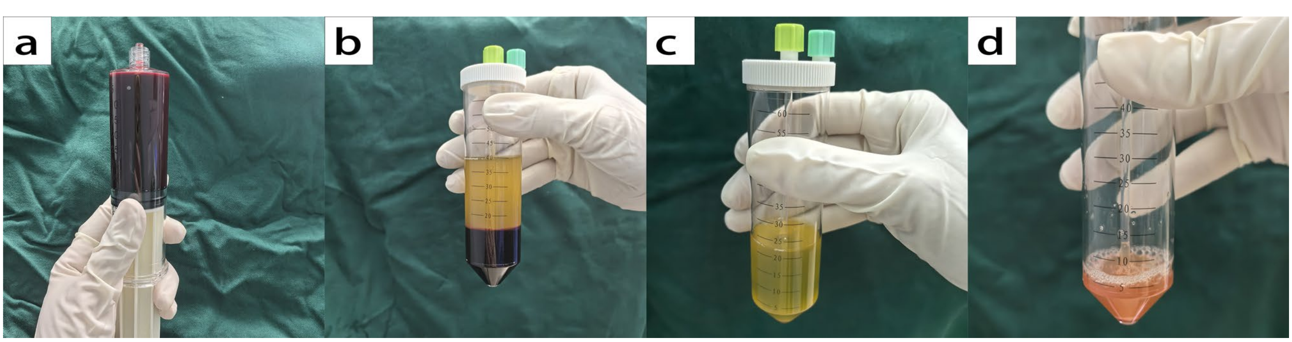

Fig. 2 LP-PRP preparation process. (**a**) Forty milliliters of venous blood is drawn. (**b**) The first centrifugation is performed, separating the blood into three layers: the top layer containing plasma with platelets and a small number of white blood cells, the middle buffy coat layer, and the bottom layer consisting of red blood cells. (**c**) The superficial portions of the top and middle layers are aspirated and transferred into another centrifuge tube. (**d**) A second centrifugation is performed to remove the supernatant and obtain the final LP-PRP. LP-PRP, leukocyte-poor platelet-rich plasma

Table 1 Baseline characteristics of the two groups

Characteristic	AOT + PRP (n = 21)	AOT alone (n = 18)	p -value
Male (n, %)	19 (90.5%)	15 (83.3%)	0.647
Left ankle (n, %)	9 (42.9%)	9 (50%)	0.752
Age (yr)	28 (22,34)	24 (22,31.25)	0.702
BMI (kg/m^2)	25.52 ± 2.26	24.57 ± 1.86	0.165
Symptom duration (mo)	18 (10.5, 43)	13 (7.75, 36)	0.271
Duration of follow-up (mo)	35 (26, 41)	26.5 (15.5, 42)	0.397
Lesion surface area (mm^2)	129.36 (106.53, 183.19)	124.48 (110.55, 194.78)	0.935
Lesion depth (mm)	8.35 (6.68, 11.94)	7.96 (6.07, 10.3)	0.624
Lesion location			0.775
Medial	14 (66.7%)	13 (72.2%)	
Middle	0	1 (5.6%)	
Lateral	7 (33.3%)	4 (22.2%)	
Number of transplanted osteochondral plugs	1 (1, 2)	1 (1, 2)	0.778
Surgical method for ATFL			1.000
ATFL repair (n, %)	12 (57.1%)	10 (55.6%)	
ATFL reconstruction (n, %)	9 (42.9%)	8 (44.4%)	
Complications (n, %)	0	1 ankle stiffness (5.6%)	0.462
Hepple stage (n, %)			0.803
I, II	0	0	
III	4 (19%)	5 (27.8%)	
IV	7 (33.3%)	5 (27.8%)	
V	10 (47.6%)	8 (44.4%)	
Osteotomy (n, %)			0.679
No osteotomy	14 (66.6%)	10 (55.6%)	
Medial osteotomy	6 (28.6%)	6 (33.3%)	
Lateral osteotomy	1 (4.8%)	2 (11.1%)	

Note: The BMI in continuous variables follows a normal distribution and is expressed as means ± standard deviation. Other continuous variables that do not follow a normal distribution are expressed as medians (lower quartile, upper quartile). Categorical variables were presented as counts and percentages

BMI, body mass index; ATFL, anterior talofibular ligament; mo, months; yr, years; AOT, autologous osteochondral transplantation; PRP, platelet-rich plasma

Table 2 Distribution of OLTs locations (9-zone method)

	Medial	Middle	Lateral
Anterior	2 (5.1%)	1 (2.6%)	3 (7.7%)
Middle	24 (61.5%)	0	7(17.9%)
Posterior	1 (2.6%)	0	1 (2.6%)

Note: Categorical variables were presented as counts and percentages. OLTs, osteochondral lesions of the talus

was 42.9%, and 50% in the AOT-alone group (P = 0.752). The median follow-up time was 35 months (range, 13–48 months) in the AOT + PRP group and 26.5 months (range, 12–46 months) in the AOT-alone group (P = 0.397). No statistically significant between-group differences were found in baseline characteristics (Table 1). Two patients underwent reconstruction for concomitant CFL and ATFL injuries. The average time to internal fixation removal was 8 months for patients who underwent medial and lateral malleolar osteotomies.

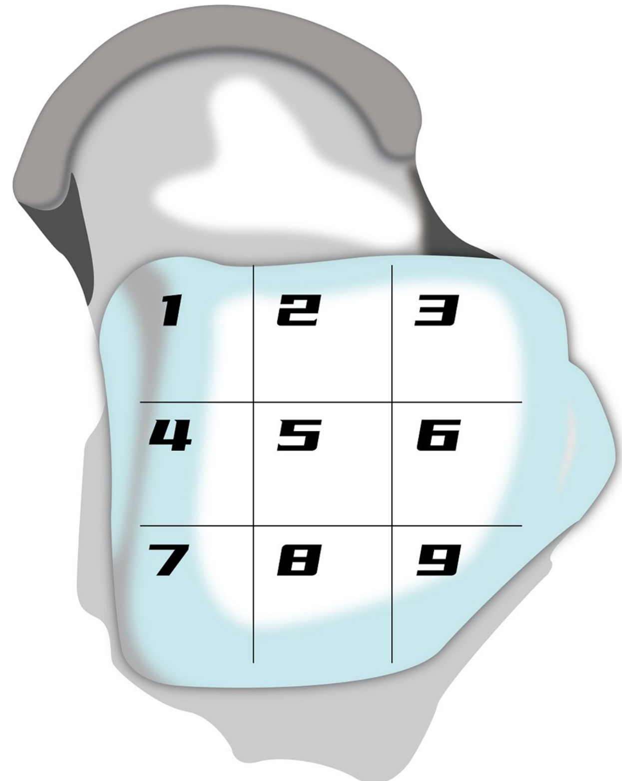

Fig. 3 Nine-zone method

Lesion characteristics

Table 2 shows a distribution of the OLTs. Twenty-seven (69.2%), 11 (28.2%), and 1 (2.6%) cases were in the medial dome, lateral, and central regions, respectively. The most commonly affected regions were zones 4 (61.5%) and 6 (17.9%), with other regions showing lower frequencies. No lesions were observed in zone 5 or 8. (Fig. 3)

Clinical and functional outcomes

Significant between-group differences in VAS scores were observed at postoperative months 1 (P < 0.001) and 3 (P = 0.031). Cohen's d values were 1.424 and 0.719, both > 0.8, indicating large effect sizes. This suggests that the AOT + PRP group had significantly lower VAS scores than the AOT-alone group at postoperative months 1 and 3. No statistically significant between-group differences were observed in the AOFAS scores at any time point. However, the FAAM-sport scale scores significantly differed between the groups at postoperative month 3 (P = 0.005). Cohen's d value was 0.964, indicating a large effect size, with the AOT + PRP group showing significantly better FAAM-sport scale scores than the AOT-alone group at postoperative month 3. Table 3

Table 3 Comparison of pain and functional scores between the two groups

Variables	AOT + PRP (n = 21)	AOT alone (n = 18)	p -value
VAS (mm)			
Preoperative	70.52 ± 6.83	68.55 ± 8.22	0.419
Postoperative			
1 month	40.47 ± 6.32	51.05 ± 8.54	<0.001
3 months	29.52 ± 5.92	34.44 ± 7.79	0.031
6 months	23.28 ± 6.47	24.44 ± 6.89	0.591
Last follow-up	22.85 ± 6.36	25.61 ± 9.24	0.280
AOFAS			
Preoperative	49.76 ± 10.85	51.22 ± 12.64	0.700
Postoperative			
3 months	70 ± 12.85	61.89 ± 14.07	0.091
6 months	87.05 ± 6.24	88.83 ± 7.95	0.437
Last follow-up	88.01 ± 6.7	89.11 ± 8.19	0.644
FAAM-sport scale			
Preoperative	10.14 ± 2.3	9.83 ± 2.6	0.696
Postoperative			
3 months	20.47 ± 5.10	15.44 ± 5.35	0.005
6 months	24.48 ± 4.62	22.05 ± 5.89	0.159
Last follow-up	26.42 ± 4.34	26.56 ± 4.68	0.930

Note: The FAAM-sport scale has a total score of 32 and consists of eight items assessing athletic ability. Each item is rated on a 5-point Likert scale (4 to 0) ranging from "no difficulty" to "unable to perform." Continuous variables follow a normal distribution and is expressed as means ± standard deviation

AOT, autologous osteochondral transplantation; PRP, platelet-rich plasma; FAAM, foot and ankle ability measure; AOFAS, American Orthopedic Foot and Ankle Society; VAS, visual analog scale

Table 4 Comparison of preoperative and final follow-up pain and functional scores within the group

Variables		Preoperative	Last follow-up	p -value
AOT + PRP	VAS (mm)	70.52 ± 6.83	22.85 ± 6.36	<0.001
	AOFAS	49.76 ± 10.85	88.01 ± 6.7	<0.001
	FAAM-sport scale	10.14 ± 2.3	26.42 ± 4.34	<0.001
AOT alone	VAS (mm)	68.55 ± 8.22	25.61 ± 9.24	<0.001
	AOFAS	51.22 ± 12.64	89.11 ± 8.19	<0.001
	FAAM-sport scale	9.83 ± 2.6	26.56 ± 4.68	<0.001

Notes: Continuous variables follow a normal distribution and is expressed as means ± standard deviation

AOT, autologous osteochondral transplantation; PRP, platelet-rich plasma; FAAM, foot and ankle ability measure; AOFAS, American Orthopedic Foot and Ankle Society; VAS, visual analog scale

presents the detailed between-group comparisons of pain and functional scores at different time points. (Fig. 4)

Table 4 shows the summary of the comparison of pain and functional scores between the preoperative and final follow-up time points. All differences were significant ($P < 0.001$). Both the AOT + PRP and AOT-alone groups showed good therapeutic outcomes postoperatively, including pain reduction and improved ankle joint function.

MRI outcomes

The follow-up times for the AOT + PRP and AOT-alone groups were 35 (26–41) and 26.5 (15.5, 42) months, respectively. Table 5 shows a comparison of the total MOCART 2.0 ankle scores and individual item scores at the last follow-up between the groups. The "surface of the repair tissue" score significantly differed between the groups ($P = 0.029$), with the AOT + PRP group performing better than the AOT- alone group. No statistically significant differences were found in the total score or scores of the other sub-items between the groups. (Fig. 5)

Complications, failures and secondary surgical procedures

Regarding complications, one patient (2.6%) experienced postoperative ankle stiffness due to inadequate rehabilitation. However, no nonunion, malunion, implant failure, or infection were observed. Five patients (12.8%) reported donor site pain at the last follow-up. There were no cases of failure or subsequent surgeries.

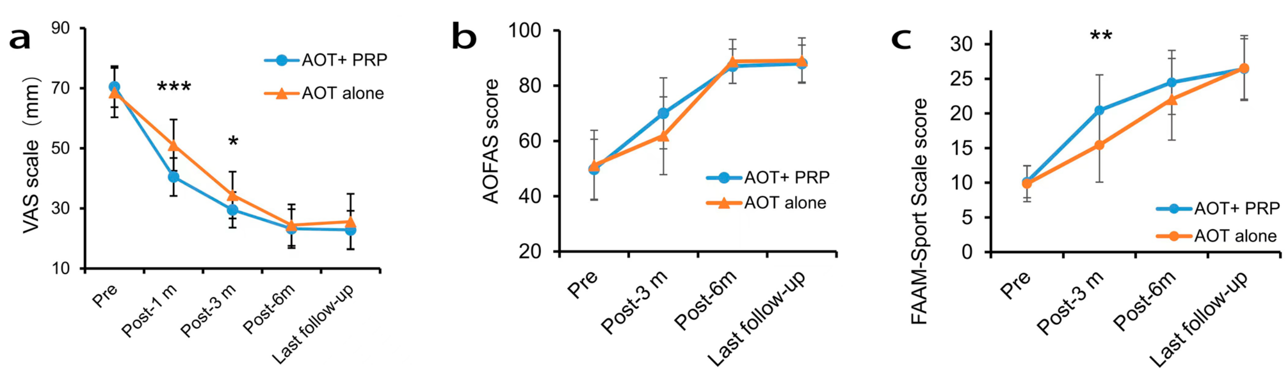

Fig. 4 Line graph comparing VAS (**a**), AOFAS (**b**), and FAAM-sport scale scores (**c**) between the two groups. *, $P < 0.05$, **, $P < 0.01$, ***, $P < 0.001$. Pre = Preoperative, Post-1 m = Post-operative 1 month, Post-3 m = Post-operative 3 months, Post-6 m = Post-operative 6 months. VAS, visual analog scale; FAAM, foot and ankle ability measure; AOFAS, American Orthopedic Foot and Ankle Society

Table 5 Comparison of the MOCART 2.0 ankle scores at the final follow-up between the two groups

Variables	AOT + PRP (*n* = 21)	AOT alone (*n* = 18)	*p* -value
Volume fill of (osteo)chondral defect (20)	15 (10, 15)	15 (10, 20)	0.903
Integration into adjacent cartilage and bone (20)	20 (15, 20)	20 (15, 20)	0.870
Surface of the repair tissue (5)	5 (0, 5)	0 (0, 1.25)	0.029
Signal intensity of the repair tissue (15)	10 (10, 15)	10 (10, 15)	0.330
Bony defect or bony overgrowth (20)	10 (10, 15)	10 (10, 12.5)	0.908
Presence of edema-like marrow signal (10)	5 (2.5, 10)	5 (0, 10)	0.590
Presence of subchondral cysts (10)	10 (5, 10)	5 (5, 10)	0.059
MOCART 2.0 ankle score (100)	70 (65, 80)	65 (50, 75)	0.129

Note: The total score is 100, and the weight of each subitem is indicated after each item. Continuous variables that do not follow a normal distribution are expressed as medians (lower quartile, upper quartile)

AOT, autologous osteochondral transplantation; PRP, platelet-rich plasma; MOCART, Magnetic Resonance Observation of Cartilage Repair Tissue

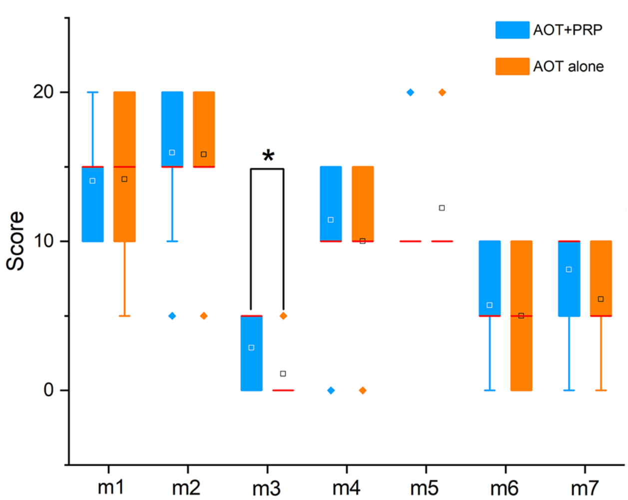

Fig. 5 Box plot comparing each MOCART 2.0 ankle sub-item score between the two groups. *, $P < 0.05$. m1 = Volume fill of (osteo)chondral defect, m2 = Integration into adjacent cartilage and bone, m3 = Surface of the repair tissue, m4 = Signal intensity of the repair tissue, m5 = Bony defect or bony overgrowth, m6 = Presence of edema-like marrow signal, m7 = Presence of subchondral cysts. MOCART, Magnetic Resonance Observation of Cartilage Repair Tissue

Discussion

Our main finding was that no statistically significant between-group differences were found in pain, functional scores, or MOCART 2.0 ankle scores among patients with OLTs accompanied by CLAI, with a mean follow-up period > 2 years. Both groups showed significant improvement in their final follow-up results compared to preoperative values, achieving good outcomes. The AOT + PRP group had significantly lower VAS scores at postoperative months 1 and 3 than the AOT-alone group. Additionally, the FAAM-Sport scores at 3 months postoperatively were better in the combined group than in the AOT-alone group. The between-group differences in individual sub-items of the MOCART 2.0 ankle scoring system were recorded; it was found that the "surface of the repair tissue" score in the combined group was significantly better than in the AOT-alone group.

PRP, a blood concentrate with at least twice the baseline concentration, contains growth factors beneficial for tissue repair [24]. Among these, transforming growth factor-β (TGF-β) is considered a crucial factor in cartilage anabolic metabolism [25]. PRP-alone treatment has shown greater efficacy than hyaluronic acid and saline treatment for OLTs and is considered safe [26]. Research on surgical treatment combined with PRP is limited and currently focuses on PRP use in conjunction with microfracture surgery. Most studies have indicated that PRP treatment combined with microfracture surgery yields better functional scores than microfracture surgery alone [27, 28]. Interestingly, the positive effects of PRP treatment, both alone and in combination with microfracture surgery, on cartilage injuries have sparked interest in its application in AOT. However, studies on PRP treatment combined with AOT are scarce and have mostly focused on animal experiments. Altan et al. [17] and Smyth et al. [16] used rabbit osteochondral defect models. They found that PRP treatment combined with AOT improved graft integration with the original cartilage interface and reduced graft degeneration. Similarly, Boakye et al. [29] noted enhanced TGF-β expression and chondrogenesis. Li et al. [30] reported the safety and efficacy of AOT combined with PRP for treating full-thickness cartilage defects of the femoral condyle in the knee joint. This study is the first to compare AOT with and without PRP for treating OLTs.

This study monitored postoperative VAS, AOFAS, and FAAM-sport scale scores, finding that the AOT + PRP group had significantly lower VAS scores at months 1 and 3, suggesting better early postoperative inflammation control and pain reduction due to PRP's anti-inflammatory effects [14]. Although no significant differences were observed in pain scores between the groups after postoperative month 6 and at the final follow-up, the AOT + PRP group showed a quicker return to near-normal pain levels than the AOT-alone group. A reduction in postoperative pain theoretically aids in rehabilitation and functional recovery. However, in practice, only the FAAM-sport scale score at postoperative month 3 showed a significant difference, with the AOT + PRP group demonstrating better athletic performance than the AOT-alone group. This advantage gradually diminished and eventually disappeared in subsequent follow-up visits. No statistically significant between-group differences were observed in the AOFAS scores at any time point. The excellent final AOFAS score rate (92.3%) aligns with previous studies [31, 32]. Functional improvement with PRP treatment was limited, as the AOT-alone group already demonstrated high rates of excellent functional outcomes. Shimozono et al. [31] reported 87% good or excellent outcomes after AOT, and an approximately 10-year follow-up study by Shim et al. [33] confirmed that AOT resulted in better clinical outcomes and survival rates for patients with large cystic lesions.

There was a significant difference in the subitem "Surface of the repair tissue" of the MOCART 2.0 ankle scoring system between the two groups. No significant difference was observed in the "integration into adjacent cartilage and bone" score, indicating that both groups did not show significant differences in osteochondral integration on the radiological level. However, the AOT + PRP group showed an advantage in terms of cartilage surface repair. The impact the graft undergoes during impaction and the subsequent joint activity-related degeneration may destroy surface chondrocytes [34]. PRP treatment enhances the repair of surface cartilage by promoting chondrocyte proliferation and inducing the formation of cartilage matrix [35]. This is similar to the functional and radiological outcomes reported by Shimozono et al. [36], who used concentrated bone marrow aspirate (CBMA) combined with AOT. CBMA contains hematopoietic and mesenchymal stem cells, which are beneficial for cartilage formation, and it shares similar growth factor concentrations with PRP [37]. Migliorini et al. [38] reported that a higher total MOCART score is achievable after AOT surgery. However, the "surface of the repair tissue" score accounts for only 5 points out of the total 100, and this difference is insufficient to cause a significant difference in the overall MOCART 2.0. Rizzo et al. [39] and Puddu et al. [40] found that the postoperative clinical outcomes of patients with OLTs were not linearly correlated with MRI results.

The widespread application of PRP is limited by the heterogeneity in its preparation methods, concentrations, and usage across current studies [41]. Additionally, the inflammatory cells or factors obtained during PRP preparation can affect its efficacy, particularly reactive oxygen species, inflammatory factors, and matrix metalloproteinases released by leukocytes, which can damage cartilage [42]. To avoid cartilage damage by inflammatory factors, this study prepared LP-PRP, which has been shown to provide better pain relief and functional improvement in knee cartilage injuries [43]. Although the optimal PRP concentration for use has not been definitively established, current recommendations for PRP treatment of OLT suggest a platelet concentration of 4–6 times the baseline concentration [12, 44]. Akpancar et al. [45] reported the use of PRP as a conservative treatment for OLT, with a volume of 4 mL per injection, administered in 3 injections at 3-week intervals, yielding good therapeutic outcomes. When microfracture surgery is combined with PRP treatment, the recommended injection volume is 3–4 mL; if necessary, repeat injections may be performed 2–3 weeks later, with a typical treatment course of up to 3 sessions [44]. This study referred to these treatment protocols for local injection therapy.

This study has some limitations. First, it was a retrospective study with a relatively small sample size. Second, although AOT provides good OLT treatment outcomes, graft degeneration remains a long-term issue. This study had a short follow-up period; therefore, the potential effects of PRP could not be observed. Third, this study was a single-center investigation, which may introduce selection bias, such as a higher proportion of males, compared with other studies on OLTs. Fourth, this study attempted to standardize the use of PRP; however, preventing heterogeneity in PRP preparation and usage remains challenging owing to the lack of high-quality, evidence-based guidelines. Moreover, the postoperative use of NSAIDs may have reduced the efficacy of PRP [46], which could be one of the reasons why the combination group did not show significant superiority over the AOT alone group. Lastly, due to incomplete FAOS score data collection, we were unable to utilize this sole validated PROM scoring tool for OLTs [47]. We plan to address this issue in our future research.

Conclusions

This study showed that PRP treatment reduced pain levels within 3 months postoperatively, improved athletic performance at 3 months postoperatively, and enhanced graft surface cartilage repair (as observed on MRI) in patients with OLTs accompanied by CLAI treated with AOT. However, it did not result in significant between-group differences in pain, functional outcomes, or total MOCART 2.0 score at the final follow-up. Therefore, large-scale, prospective randomized controlled trials are required to validate our findings.

Abbreviations

AOT	Autologous Osteochondral Transplantation
PRP	Platelet-Rich Plasma
OLTs	Osteochondral Lesions of the Talus
CLAI	Chronic Lateral Ankle Instability
VAS	Visual Analog Scale
AOFAS	American Orthopedic Foot and Ankle Society
FAAM	Foot and Ankle Ability Measure
ATFL	Anterior Talofibular Ligament
CFL	Calcaneofibular Ligament
CBMA	Concentrated Bone Marrow Aspirate
LP-PRP	Leukocyte-Poor PRP
MOCART	Magnetic Resonance Observation of Cartilage Repair Tissue
TGF-β	Transforming Growth Factor-β

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Author contributions
JX: Data curation, data analysis, and writing. XY and YZ: Data curation, data analysis. SL: Data collection，Methodology. XH: Ideas, funding acquisition and writing - review & editing. All authors reviewed the manuscript.

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Data availability
No datasets were generated or analysed during the current study.

Declarations

Ethics approval and consent to participate
This study was approved by the ethic committee of the 900th Hospital of the Joint Logistics Team, PLA (IRB No. 2024-028). All participants provided written informed consent.

Consent for publication
Not applicable.

Competing interests
The authors declare no competing interests.

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