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Comparison of arthroscopic autologous cancellous bone grafting combined with PRP injection versus autologous osteochondral transplantation for large medial cystic osteochondral lesions of the talus

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Research Article

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Abstract

Objective

Osteochondral lesions of the talus (OLTs) with large subchondral cysts have inferior clinical outcomes after reparative techniques. Alternative techniques such as autologous cancellous bone grafting (ACBG) and autologous osteochondral transplantation (AOCT) are substitutable for larger lesions. The purpose of this study is to compare the short-term clinical and imaging outcomes of patients undergoing arthroscopic ACBG with Platelet-Rich Plasma (PRP) injection and AOCT for large cystic osteochondral lesions of the talus (OLTs).

Methods

A retrospective analysis of data from patients who underwent surgical treatment for medial large cystic OLTs was conducted between October 2021 and December 2022. For comparability, a 1:1 matching was performed based on the patients', age, sex, body mass index (BMI), injury side, and lesion characteristics in both groups, resulting in complete data for 44 patients with OLTs. Clinical outcomes of the two groups were compared using the American Orthopaedic Foot & Ankle Society (AOFAS) Ankle-Hindfoot Score, Visual Analogue Scale (VAS), and Foot and Ankle Ability Measure (FAAM). Ankle Activity Score (AAS), satisfaction rate, subjective evaluation results, and complications were also collected. Donor-site morbidity was recorded according to the symptoms, including pain, stiffness, swelling, locking, giving way, and discomfort. The integrity of the subchondral bone and the quality of the repaired cartilage were assessed using the Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) 2.0 score at 12 months postoperatively.

Results.

There were no significant differences in patient demographic and lesion characteristics between groups. Intra-group comparisons showed that both groups of patients had significant improvements in pain severity and ankle function postoperatively compared to preoperatively. At 3 months postoperatively, the AOFAS and FAAM-S score in ACBG were significantly higher than those in AOCT ($P < 0.05$), while there was no statistically significant difference in the VAS score between the two groups ($P > 0.05$). There were no significant statistical differences between groups in any variables of clinical and radiological outcomes at 1 year postoperatively. Although there was no statistically significant difference in the overall complication rate and donor site morbidity between the two groups, the proportion in ACBG was lower than that in AOCT, which requires further validation.

Conclusion

Arthroscopic autologous cancellous bone grafting (ACBG) combined with platelet-rich plasma (PRP) injection and medial malleolar osteotomy combined with autologous osteochondral transplantation (AOCT) have similar effects in treating large medial cystic osteochondral lesions of the talus (OLT). Both procedures show significant improvement in efficacy at 1 year postoperatively with no significant differences, while arthroscopic ACBG demonstrates superior early functional recovery at 3 months postoperatively.

Level of evidence

III, retrospective comparative study.

Introduction

Osteochondral Lesion of the Talus (OLTs) is defined as injury to the talar articular cartilage and adjacent subchondral bone [1, 2], which is a common cause of chronic ankle pain, swelling, and dysfunction[3, 4], with etiologies often associated with trauma, chronic sprains, and genetic factors [1, 5, 6]. Although articular cartilage exhibits superior load absorption and stress distribution properties, its intrinsic self-repair capacity is extremely limited [4, 7]. Therefore, patients often experience chronic symptoms and treatment becomes more challenging. Especially when the injury extends to the subchondral bone (such as Hepple stage IV-V), nonoperative treatment is often not ideal and surgical treatment becomes the main option [7, 8].

In the literature, the surgical treatment strategies for OLTs are diverse, which selection depends on the characteristics of the injury, such as size, depth, location, and stability [9, 10], including arthroscopic microfracture surgery (MF), retrograde or anterograde drilling and filling of the defect, autologous or allogeneic osteochondral transplantation, autologous chondrocyte implantation (ACI), and autologous Matrix-induced chondrogenesis (AMIC)[8–14]. The arthroscopic bone marrow stimulation techniques (such as microfracture) are classic first-line treatment methods for superficial and small area injuries [15, 16]. However, for lesions that are larger (usually > 1.5 cm^2), deeper (> 5mm), or cystic, the mechanical properties of fibrocartilage regenerated by bone marrow stimulation (BMS) techniques are insufficient, resulting in a significant decline in clinical efficacy [17]. Autologous osteochondral transplantation (AOCT) has been widely adopted for larger and deeper defects, providing sufficient structural support and adequately filling the defects [18, 19].

For larger medial OLTs, medial malleolar osteotomy combined with autologous osteochondral transplantation is a commonly used surgical approach. This method is used to achieve sufficient intra-articular exposure for autologous cartilage transplantation surgery [20, 21], but it involves significant trauma and carries risks such as nonunion of the osteotomy, issues related to internal fixation, and prolonged postoperative rehabilitation periods [22]. Arthroscopic bone grafting is performed through the arthroscopic approach to complete lesion debridement and bone grafting procedures without requiring medial malleolus osteotomy, and has potential advantages of minimal trauma, avoidance of osteotomy

complications, and accelerated postoperative recovery [23, 24]. However, the cartilage generated by pine bone grafts consists primarily of fibrocartilage, which has inferior elasticity and mechanical properties compared to hyaline cartilage[25]. PRP is platelet-rich plasma extracted from the patient's own blood, which is rich in various growth factors and cytokines that promote tissue repair and regeneration, with anti-inflammatory, analgesic, and healing properties [26]. To our knowledge, there is currently a lack of studies directly comparing the clinical efficacy of the two techniques in treating OLTs. This study aims to retrospectively compare the clinical efficacy of arthroscopic autologous cancellous bone grafting (ACBG) combined with PRP injection versus medial malleolus osteotomy combined with autologous osteochondral transplantation in the treatment of large, medial cystic OLTs.

Materials and methods

This study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Xuzhou Renci Hospital (No: XZRCLL-KT-202511001), and all participants voluntarily signed the informed consent form. This is a retrospective cohort study, which provides Level III evidence according to the Oxford Centre for Evidence-Based Medicine (OCEBM) criteria.

Inclusion criteria: (1) Patients diagnosed with large medial cystic OLTs through clinical and imaging examinations; (2) Conservative treatment for at least three months was ineffective; (3) the diameter of the subchondral cyst was larger than 10 mm; (4) Complete clinical and imaging data, with a follow-up period of at least 12 months. Exclusion criteria: (1) History of previous surgery on the affected ankle; (2) systemic diseases, such as rheumatoid arthritis, gouty arthritis or active infection; (3) Surgical or anesthetic contraindications preventing surgery; (4) Inability to cooperate with follow-up.

Patients with symptomatic OLTs who underwent arthroscopic ACBG or AOCT at our ankle sports medicine Center between October 2021 and December 2024 were reviewed with a minimum follow-up period of 12 months. According to the surgical methods received, the patients were divided into two groups. ACBG (n = 35) underwent arthroscopic autologous cancellous bone grafting combined with PRP injection, and this technique involved lesion debridement, microfracture, and bone grafting through a standard ankle arthroscopy approach, without the need for medial malleolus osteotomy. AOCT (n = 26) underwent medial malleolus osteotomy combined with autologous osteochondral transplantation, using open surgery to fully expose the medial lesion of the talus. All surgeries were performed by the same experienced orthopedic surgeon. To control the baseline conditions between the two groups and minimize the influence of potential confounding factors, a 1:1 propensity score matching was conducted based on the patients' characteristics (including sex, age, BMI, injury side, lesion characteristics). A caliper of 0.1 was used in the match, and replacement of patients in the algorithm was not allowed. Of those, 12 patients who underwent arthroscopic AOCT and 5 patients who underwent AOCT did not complete the final follow-up and were excluded from the study. Finally, 23 patients in the ACBG and 21 patients in the AOCT were enrolled (Fig. 1).

Surgical techniques

The surgical operations for both groups of patients were performed by the same group of surgeons. After successful anesthesia, the patient was placed in a supine position, and the affected limbs underwent routine disinfected and draped. The patient's foot is pulled at a certain angle towards the outer edge of the operating table to fully allow for the plantar flexion and dorsiflexion of the ankle joint.

ACBG

The standard approach to the ankle joint was adopted to directly reach the joint cavity, using a 4.0 mm, 30°arthroscope for systematic diagnosis and treatment of the ankle joint. The probe was used to assess the osteochondral lesions on the talus surface. The damaged cartilage and subchondral tissue were debrided with an arthroscopic curette until reaching healthy margins. Debridement of the base and margins of the lesion with a curette. Reassess the lesion margins with a probe and perform three-dimensional measurements of the osteochondral defect. Microfracture cones were used to perform bone marrow stimulation procedures by drilling holes into the talar bed at a depth of 5 mm and a spacing of 2–3 mm. A curette was performed to harvest the subjacent autologous cancellous bone at the Gerdy's tubercle after removal of the cylindrical bone. After obtaining the graft, all fluids in the joints were suctioned out using a curettage aspirator, and then dry arthroscopy technique was applied. The prepared cancellous bone graft was placed on the delivery guide which is accurately pushed into the defect area [27]. According to the system instruction, PRP was prepared using a platelet separator. A total of 500 ml of blood was centrifuged at 3000 rpm for 10 minutes at 4°C. At the end of the procedure, 50 ml PRP was obtained. During the surgical procedure, 10 ml of PRP was activated with thrombin by mixing 1 ml of normal saline with 1000 units of thrombin, which was injected into the lesion site after the PRP solidified into a gel-like form. We recommend that patients perform ankle flexion and extension exercises to ensure the even distribution of PRP gel on the defect surface. The remaining PRP was administered as a 10 ml outpatient injection monthly. (Fig. 2).

AOCT

Diagnostic ankle arthroscopy was performed to confirm the location, size, and presence of subchondral cystic lesions of the medial OLTs. To adequately expose the lesion and facilitate subsequent procedures, medial malleolar osteotomy was performed in all patients. After the osteotomy was completed, fully expose the lesion area. The separated cartilage was debrided, and then a 2.0 mm K-wire was vertically drilled from the center of the lesion to confirm and enter the subchondral cyst. A collection tube with a diameter matching the cartilage defect area (usually 8 mm or 10 mm) is used to create a cylindrical bone groove, taking care to avoid thermal damage to the surrounding normal cartilage. After thorough debridement of the cystic lesion, the sclerotic bone of the cyst wall was scraped with a curette until fresh bleeding occurred. The non-weight-bearing area of the ipsilateral distal femur as a donor site for osteochondral grafts. After trimming, the osteochondral graft is implanted into the talar socket using a “press-fit” technique with the cartilage surface facing the joint cavity, without additional fixation. The donor bone column should be flush with the surrounding native cartilage, and graft stability should be confirmed through passive ankle joint movement. Finally, 2 or 3 cannulated screws were used to fix the

medial malleolus, and anatomical reduction was confirmed by the C-arm machine. Suture the joint capsule, subcutaneous tissues, and skin in sequence, and applied sterile dressing with compression to the surgical area (Fig. 3).

Postoperative rehabilitation

Postoperatively, all patients followed a standardized rehabilitation protocol. Cold compress and elevation of the affected limb were used to prevent infections and deep vein thrombosis (DVT)., Active and passive range of motion training for the ankle joint would begin within a pain-free range to reduce swelling and prevent joint stiffness for the third day after surgery. For the first 6 weeks after surgery, the affected limb was immobilized with a short leg brace and kept non-weight-bearing. ACBG gradually transitioned from partial to full weight bearing under the protection of a walking boot at 6 weeks after surgery. AOCT patients also began to gradually engage in weight-bearing activities after confirming satisfactory osteotomy healing through follow-up X-ray measurements.

Clinical and Imaging Evaluation

Visual Analog Scale (VAS, 0–10 points) [28] was used to assess foot and ankle pain, American Orthopaedic Foot and Ankle Society (AOFAS, 0-100 points) ankle-hindfoot score [29, 30], Foot and Ankle Ability Measure (FAAM) [31], and Ankle Activity Score (AAS) [32] to evaluate ankle function at preoperative and at the last follow-up. A comprehensive subjective evaluation was conducted 12 months postoperatively. Patients were asked to classify the surgical outcomes as excellent (asymptomatic), good (slight discomfort), fair (improved but with residual disability), or poor (symptoms unchanged or worsened). Excellent and good results indicate patient satisfaction with the surgery. The assessment was conducted by two senior orthopedic surgeons who were not involved in the surgical procedure and was unaware of the surgical purpose. Complications such as wound infection, donor site morbidity, nonunion of osteotomy and wound numbness were evaluated and recorded during each follow-up visit.

The sizes of osteochondral lesions were measured on preoperative MRI scans by determining the maximum lesion diameter in the coronal or sagittal position. The area and volume of each OLTs was calculated using lesion length, width, and height on MRI scans. The quality of the cartilage repair tissue and its integration with surrounding structures were assessed using the Magnetic Resonance Observation of Cartilage Repair Tissue (MOCART) 2.0 ankle score [33, 34] on T2-weighted MRI at the last follow-up performed at 12 months postoperatively. This was determined by a senior radiologist who was not involved in the patient's treatment and was unaware of the study objectives. Donor-site morbidity was recorded according to symptoms, including pain, stiffness, swelling, and discomfort. In addition, the Lysholm score was used to assess the most common knee donor-site morbidity in the AOCT group.

Statistical analysis

Statistical analysis was performed using SPSS 24.0 software. Continuous data were expressed as mean ± standard deviation, and the Shapiro-Wilk test was used for normality testing. Intergroup comparisons were performed using the independent samples t-test or Mann-Whitney U test. Intragroup comparisons of pre- and postoperative indicators were conducted using the paired samples t-test or Wilcoxon signed-rank test. Comparisons between categorical data groups were made using the chi-square test or Fisher's exact test. A P value < 0.05 was considered statistically significant.

Results

(1) Patient Characteristics

A total of 44 patients with large cystic OLTs were retrospectively evaluated from October 2021 to December 2024. Among them, 23 patients underwent arthroscopic ACBG surgery after evaluation of inclusion and exclusion criteria, and 21 patients underwent AOCT. The characteristics of the 44 patients in the study are described in Table 1. The arthroscopy ACBG group was comprised 13 males and 10 females with a mean age of 38.26 ± 11.05 years and a mean BMI of 26.35 ± 2.84 at the time of surgery. The AOCT group was comprised 11 males and 10 females with a mean age of 39.43 ± 11.60 years and a mean BMI of 25.48 ± 3.49 at the time of surgery. There were no significant differences in patient characteristics and lesion volume between the arthroscopy group and the AOCT group.

Table 1
Comparison of patient demographics and lesion characteristics between the two groups

Age, years	**ACBG**	**AOCT**	**P Value[a]**
	(n = 23)	**(n = 21)**	
	38.26 ± 11.05	**39.43 ± 11.60**	**0.734**
Sex, male/female	13/10	11/10	0.783
BMI, kg/m^2	26.35 ± 2.84	25.48 ± 3.49	0.371
Side, left/right	12/11	9/12	0.537
Duration of symptoms, months	20.70 ± 6.48	22.71 ± 5.57	0.277
Tanaka osteoarthritis stage, 0/I	16/7	13/8	0.592
Lesion size			
Diameter, mm	11.98 ± 2.02	12.66 ± 2.19	0.291
Area, mm^2	163.91 ± 37.26	147.43 ± 31.91	0.124
Depth, mm	9.23 ± 1.54	9.74 ± 1.79	0.313
Volume, mm^3	1418.76 ± 289.53	1542.91 ± 362.19	0.214

ACBG: Arthroscopic autologous cancellous bone grafting combined with PRP injection; AOCT: Medial malleolus osteotomy combined with autologous osteochondral grafting. Data are reported as mean ± SD or n. BMI: body mass index. [a]: Independent t test or chi-square test. The P values shown are for intergroup comparisons. Significance was accepted for $P < 0.05$

(2) Clinical Outcomes

At 3 months postoperatively and last follow-up, both groups demonstrated significant improvement in VAS, AOFAS and FAAM scores compared to preoperatively ($P < 0.001$). At 3 months postoperatively, the AOFAS score (89.83 ± 4.19 vs. 80.76 ± 6.38) and FAAM-S (77.04 ± 7.46 vs. 70.29 ± 5.53) in ACBG were significantly higher than those in AOCT ($P < 0.05$). At 1 year postoperatively, there were no statistically significant differences in VAS scores, AOFAS scores, and FAAM between the two groups ($P > 0.05$). In both groups, AAS scores showed a significant decrease from before the injury to after the injury, followed by a notable increase at the last follow-up ($P < 0.001$), with comparable scores between groups. No statistically significant differences were observed in intergroup of AAS ($P > 0.05$) (Table 3). In the arthroscopy ACBG group, 22 patients were rated as excellent to good, while 21 patients in the AOCT group were graded as excellent to good. The satisfaction rate was 100% for both groups of patients. The incidence of complications in the arthroscopy group was 8.70% (2/23), while the AOCT group was 33.33% (7/21), with no statistically significant difference ($P = 0.064$) (Table 3).

Table 2
Comparison of clinical outcomes between the two groups

VAS,	ACBG (n = 23)	AOCT (n = 21)	P Value[a]
Preoperative	6.91 ± 1.04	6.76 ± 1.13	0.647
3 months postoperative	1.43 ± 0.73	1.62 ± 1.02	0.492
1 year postoperative	1.13 ± 0.63	1.10 ± 0.54	0.843
AOFAS			
Preoperative	51.83 ± 7.49	51.49 ± 6.64	0.276
3 months postoperative	89.83 ± 4.19	80.76 ± 6.38	< 0.001
1 year postoperative	91.83 ± 4.67	90.43 ± 4.24	0.306
FAAM-ADL			
Preoperative	43.13 ± 10.14	44.10 ± 8.35	0.734
3 months postoperative	78.65 ± 7.62	76.90 ± 8.71	0.482
1 year postoperative	92.65 ± 5.69	90.24 ± 6.10	0.181
FAAM-S			
Preoperative	44.09 ± 7.45	41.86 ± 6.24	0.290
3 months postoperative	77.04 ± 7.46	70.29 ± 5.53	0.002
1 year postoperative	88.57 ± 8.55	90.67 ± 6.87	0.377
AAS			
Pre-symptom	8.13 ± 1.01	8.05 ± 0.97	0.784
Preoperative	1.09 ± 0.52	1.24 ± 0.63	0.384
1 year postoperative	7.65 ± 0.89	7.33 ± 0.97	0.260

ACBG: Arthroscopic autologous cancellous bone grafting combined with PRP injection; AOCT: Medial malleolus osteotomy combined with autologous osteochondral grafting. Data are reported as mean ± SD or n; a: Independent t test or chi-square test. The P values shown are for intergroup comparisons. Significance was accepted for $P < 0.05$; VAS Visual Analogue Scale; AOFAS: American Orthopedic Foot and Ankle Society; FAAM-ADL: Foot and Ankle Ability Measure- Activity of Daily Living; FAAM-S: Foot and Ankle Ability Measure -Sports; AAS: Ankle Activity Score.

Table 3
Comparison of complications and efficacy evaluation between the two groups

Complication, n (%)	**ACBG (n = 23)**	**AOCT (n = 21)**	***P* Value[a]**
	2(8.70%)	**7(33.33%)**	**0.064**
wound infection	0(0%)	1(4.76%)	0.477
donor site morbidity	1(4.35%)	5(23.81%)	0.088
nonunion of osteotomy	0(0%)	1(4.76%)	0.477
wound numbness	1(4.35%)	0(0%)	1.000
Satisfaction rate (%)	100%	100%	1.000
Subjective evaluation, n (%)			0.241
Excellent	17(73.91%)	12(57.14%)	
Good	6(26.09%)	9(42.86%)	
Fair	0(0%)	0(0%)	
Poor	0(0%)	0(0%)	

ACBG: Arthroscopic autologous cancellous bone grafting combined with PRP injection; AOCT: Medial malleolus osteotomy combined with autologous osteochondral grafting. a: Independent t test or chi-square test. The P values shown are for intergroup comparisons. Significance was accepted for $P < 0.05$

(3) Radiologic Outcomes

The mean preoperative osteochondral lesion volume in the arthroscopic ACBG group was 1418.76 ± 289.53 mm^3, with a mean postoperative MOCART score of 68.26 ± 4.42 (Table 1). CT and MRI data in the arthroscopic ACBG with PRP group are shown in Fig. 4 and Fig. 5, respectively. The mean preoperative osteochondral lesion volume in the AOCT group was 1542.91 ± 362.19 mm^3, with a mean postoperative MOCART score of 69.52 ± 4.72 (Table 4). CT and MRI images in the AOCT group are shown in Fig. 6 and Fig. 7, respectively. Although compared with the AOCT group, the arthroscopy group had higher MOCART scores, the difference between the two groups was not statistically significant (P = 0.365).

Table 4
Comparison of MOCART 2.0 ankle score at 12 months postoperatively between the two groups.

Volume fill of (osteo)chondral defect	**ACBG**	**AOCT**	**P Value**
	14.13 ± 3.89	**12.38 ± 4.36**	**0.167**
Integration into adjacent cartilage and bone	11.09 ± 4.99	12.62 ± 4.90	0.311
Surface of the repair tissue	4.57 ± 1.44	4.05 ± 2.01	0.329
Signal intensity of the repair tissue	12.39 ± 3.65	11.19 ± 4.45	0.331
Bony defect or bony overgrowth	11.30 ± 5.27	13.33 ± 5.77	0.230
Presence of edema-like marrow signal	8.26 ± 2.44	8.57 ± 2.32	0.667
Presence of subchondral cysts	5.87 ± 4.17	6.90 ± 3.35	0.372
Total	68.26 ± 4.42	69.52 ± 4.72	0.365

ACBG: Arthroscopic autologous cancellous bone grafting combined with PRP injection; AOCT: Medial malleolus osteotomy combined with autologous osteochondral grafting. MOCART: Magnetic Resonance Observation of Cartilage Repair Tissue. Data are reported as mean ± SD or n. [a]: Independent t test or chi-square test. The P values shown are for intergroup comparisons. Significance was accepted for $P < 0.05$.

Discussion

This study showed that in the treatment of large medial cystic osteochondral lesions of the talus (OLTs), patients who underwent arthroscopic autologous cancellous bone grafting (ACBG) combined with PRP injection had early advantages in functional recovery compared to those who underwent medial malleolar osteotomy combined with autologous osteochondral transplantation (AOCT) at the 3-month postoperatively. At the 12-month postoperative final follow-up, there was no significant difference in clinical outcomes between patients with large cystic OLTs who underwent arthroscopic ACBG and those who underwent AOCT. Similarly, there were no significant differences in radiological outcomes between the ACBG group and the AOCT group. In addition, compared to the AOCT group, the complication incidence and donor morbidity in the ACBG group were both lower, although the difference was not statistically significant, the rate of complication incidence and donor morbidity in the arthroscopic ACBG group were both lower. To our knowledge, no study has compared the outcomes of the arthroscopic ACBG combined PRP group and the AOCT group as surgical options for large cystic OLTs. The results of this study confirmed that arthroscopic minimally invasive surgery is comparable in efficacy to open osteotomy, with faster early functional recovery, providing more evidence for the clinical choice of minimally invasive approaches in treating large cystic OLTs.

Arthroscopic bone marrow stimulation (BMS) is generally the most widely used treatment for small to medium-sized symptomatic osteochondral lesions of the talus (OLTs) [8, 11]. For patients with large cystic OLTs, debridement and drilling alone are insufficient to restore the structure of the bone defect and

subchondral scaffold; osteochondral or bone grafting is recommended [8, 35, 36]. In this study, we performed 1:1 propensity score matching to control for baseline conditions, including gender, age, BMI, symptom duration, injured side, arthritis stage, and lesion size between the two groups. Although there were differences between the two groups, no statistically significant difference was founded, the two groups were comparable. Autologous bone grafting serves as a natural scaffold for local growth factors in the treatment of large cystic OLTs [37]. A study reported the outcomes of autologous bone grafting with preservation of articular cartilage for the treatment of talar osteochondral lesions associated with large subchondral cysts [35]. Sawa et al. treated 12 cystic OLTs using autologous bone grafting from the distal tibia, with an average follow-up of 25.3 months. The mean AOFAS score improved from 65.7 (range 47 to 81) preoperatively to 92 (range 90 to 100) at the final follow-up, with 100% patient satisfaction. Further arthroscopic examination revealed that the average arthroscopic score according to the International Cartilage Repair Society (ICRS) represented nearly normal cartilage. By comparing VAS, AOFAS, FAAM, and AAS scores, we found that at 3 months postoperatively, ACBG patients demonstrated significantly higher AOFAS and FAAM-S scores than AOCT (Table 2), while at 1 year postoperatively, there was no significant difference in patient□reported outcome measurements (PROMs) between the two groups. This reflects that arthroscopic technique demonstrates early advantages in functional recovery during the 3-month follow-up, no medial malleolar osteotomy is needed and risks of iatrogenic injury are minimized. In this study, the postoperative clinical and radiological outcomes of patients in both groups were examined in detail at the final follow-up of approximately 12 months. In the arthroscopic ACBG with PRP group, the AOFAS score significantly improved from a mean of 51.83 to 91.83, the VAS score significantly improved from a mean of 6.91 to 1.13, the AAS score significantly improved from a mean of 1.09 to 7.65, the FAAM-ADL score significantly improved from a mean of 43.13 to 92.65, the FAAM-S score significantly improved from a mean of 44.09 to 88.57, and the mean postoperative MOCART score was 68.26. In the AOCT group, the AOFAS score significantly improved from a mean of 51.49 to 90.43, the VAS score significantly improved from a mean of 6.76 to 1.10, the AAS score significantly improved from a mean of 1.24 to 7.33, the FAAM-ADL score significantly improved from a mean of 44.10 to 90.24, the FAAM-S score significantly improved from a mean of 41.86 to 90.67, and the mean postoperative MOCART score was 69.52. These results indicate that both techniques achieved good clinical and imaging outcomes in the treatment of osteochondral lesions of the talus (OLTs) combined with large subchondral cysts, which is consistent with previous studies [25, 38].

During open autologous osteochondral transplantation (AOCT) surgery, surgeons typically harvest autologous bone grafts from non-weight-bearing areas, implant them into the damaged site, and replace the damaged cartilage [20, 21]. Traditional treatment for medial OLTs typically involves medial malleolar osteotomy to adequately expose the defect site due to the unique anatomical structure of the ankle joint, which disrupts the normal bone anatomy and leads to impaired blood supply around the talus. Lee et al. reported that during secondary arthroscopic-look and MRI investigation for cartilage recovery, 1 patient (1/36, 2.78%) experienced nonunion at the osteotomy site, 2 patients (2/36, 5.56%) had delayed-unions, and 9 patients (9/31, 29%) sustained medial malleolar cartilage damage due to osteotomy [39]. Arthroscopic autologous cancellous bone grafting (ACBG) can reduce surgical trauma, protect local

tissue blood supply, thereby decreasing postoperative pain and inflammatory response, and promoting early mobilization and functional recovery. Yokoe et al.[40] proposed percutaneous retrograde autologous talar cancellous bone grafting technique which involved drilling through the talar neck to obtain autogenous bone and retrograde filling of the lesion, eliminating the need for osteotomy or harvesting grafts from the knee or iliac bone. In our study, the AOFAS and FAAM-S scores at 3 months postoperatively were superior in the arthroscopic ACBG group compared to the AOCT group, which is consistent with previous study findings. The donor-site morbidity is a concerning shortcoming of bone grafting procedures, as graft harvesting can release pro-inflammatory cytokines within the joint, which may lead to postoperative pain. Previous studies have reported that the incidence of donor site complications for AOCT between 2% and 50% [41–43]. A meta-analysis reported that the proportion of patients with donor site morbidity after AOCT ranged from 6.7% to 10.8% [22]. At the final follow-up, 5 patients (23.81%) in the AOCT group experienced donor site morbidity. Compared to the results of the aforementioned meta-analysis, the proportion of patients with total donor site morbidity in our study was higher, possibly because we defined pain and various forms of discomfort, such as pain, stiffness, swelling, locking, giving way, and discomfort related to cold or rainy weather, as donor complications.

Current research indicates that bone grafting alone is used to treat OLT, with fibrocartilage forming at the lesion site rather than hyaline cartilage, so researchers are considering covering it with a stent to restore cartilage integrity [44].The fibrocartilage layer generated by microfracture lacks the durability of hyaline articular cartilage, which leads to premature deterioration of the repair and recurrence of symptoms [45]. Platelet-rich plasma (PRP) is an autologous whole blood derivative with a higher platelet concentration than natural blood, which may possess biological functions that promote healing [46]. A meta-analysis [47] compared the short- and medium-term efficacy of PRP combined with microfracture versus MF alone in the treatment of knee cartilage lesions which included 6 randomized controlled trials (RCTs) and 5 cohort studies, involving a total of 664 patients. The analysis found that, compared to MF alone, PRP + MF showed superior outcomes in functional results and pain control. In a prospective randomized clinical trial by Jormeil et al. [48] the clinical effects of PRP and hyaluronic acid (HA) as adjunctive therapies after arthroscopic microfracture in OLTs were evaluated. Although both injections improved pain scores and led to functional improvements for at least one year, PRP demonstrated significantly superior efficacy compared to HA. Therefore, in light of these results, we conclude that PRP may demonstrate promising efficacy in the repair of cartilage injuries. In our study, similar clinical outcomes were achieved with application of PRP gel to the cancellous bone surface following arthroscopic ACBG.

This study has some limitations that need to be noted. The follow-up period was limited to a specific timeframe, and the long-term effects of arthroscopic ACBG versus AOCT treatment were not assessed. The number of patients included in this study is limited, which may reduce the statistical power of the results. In addition, although we performed 1:1 propensity score matching (PSM) on patient demographics and lesion characteristics, this study is retrospective and non-randomized. Patients were not randomly assigned to each treatment group, which may lead to potential selection bias. Finally, a histological evaluation and secondary arthroscopy were not performed due to ethical constraints and the need to avoid iatrogenic injury. Future large-sample, prospective multicenter studies with longer follow-

up periods are needed to provide more comprehensive insights for comparing the efficacy of these two treatment approaches, with a focus on tracking clinical and radiological outcomes at multiple time points.

Conclusion

In summary, arthroscopic autologous cancellous bone grafting combined with PRP injection shows superior early functional recovery at 3 months postoperatively compared to medial malleolar osteotomy combined with autologous osteochondral transplantation. Both surgical approaches can alleviate patient pain, restore function, and improve cartilage repair. At the final follow-up, the postoperative clinical and imaging outcomes were comparable between the two groups. This arthroscopic procedure may represent a safe and effective alternative with a lower incidence of morbidity at the normal knee donor site.

Abbreviations

OLT
Osteochondral lesions of the talus
ACBG
autologous cancellous bone grafting
PRP
Platelet-Rich Plasma
BMI
body mass index
AOFAS
American Orthopaedic Foot & Ankle Society
VAS
Visual Analogue Scale
FAAM
Foot and Ankle Ability Measure
FAAM-ADL
FAAM-Activity of Daily Living
FAAM-S
FAAM-Sports
AAS
Ankle Activity Score
MOCART
Magnetic Resonance Observation of Cartilage Repair Tissue
MF
microfracture
OCEBM

Oxford Centre for Evidence-Based Medicine
ACI
autologous chondrocyte implantation
AMIC
autologous Matrix-induced chondrogenesis
DVT
deep vein thrombosis
ICRS
International Cartilage Repair Society
PROMs
patient□reported outcome measurements
PDGF
platelet-derived growth factor
TGF-β
transforming growth factorβ
VEGF
vascular endothelial growth factor
EFG
epidermal growth factor
IGF
insulin-like growth factor
FGF
fibroblast growth factor
HA
hyaluronic acid
PSM
propensity score matching

Declarations

Ethics approval and consent to participate:

This study has been approved by the Ethics Committee of Xuzhou Renci Hospital (ID: XZRCLL-KT-202511001) and complied with the requirements of the Declaration of Helsinki.

Consent for publication:

We declare that all authors of this manuscript have provided written informed consent for publication. All authors have reviewed and approved the final manuscript and consent to its publication.

Competing Interests:

The authors declare that they have no relevant financial or non-financial interests to disclose.

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Author Contribution

Hao Han, Qi Lu: Conceptualization and study design, statistical analysis and manuscript drafting; Long Yang, Fan Hu: Patient data follow-up and collectionYuehua Hui: Postoperative care guidelinesXiangjun Qin, Qinwei Guo: Surgical procedures instruction Jie Li: Funding supportGuangchao Cao, Ji Zhou: Manuscript review and research guidance

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Availability of data and material:

The datasets used and/or analyzed in this study are available from the corresponding author upon reasonable request.

Clinical trial number

Not applicable

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Figures

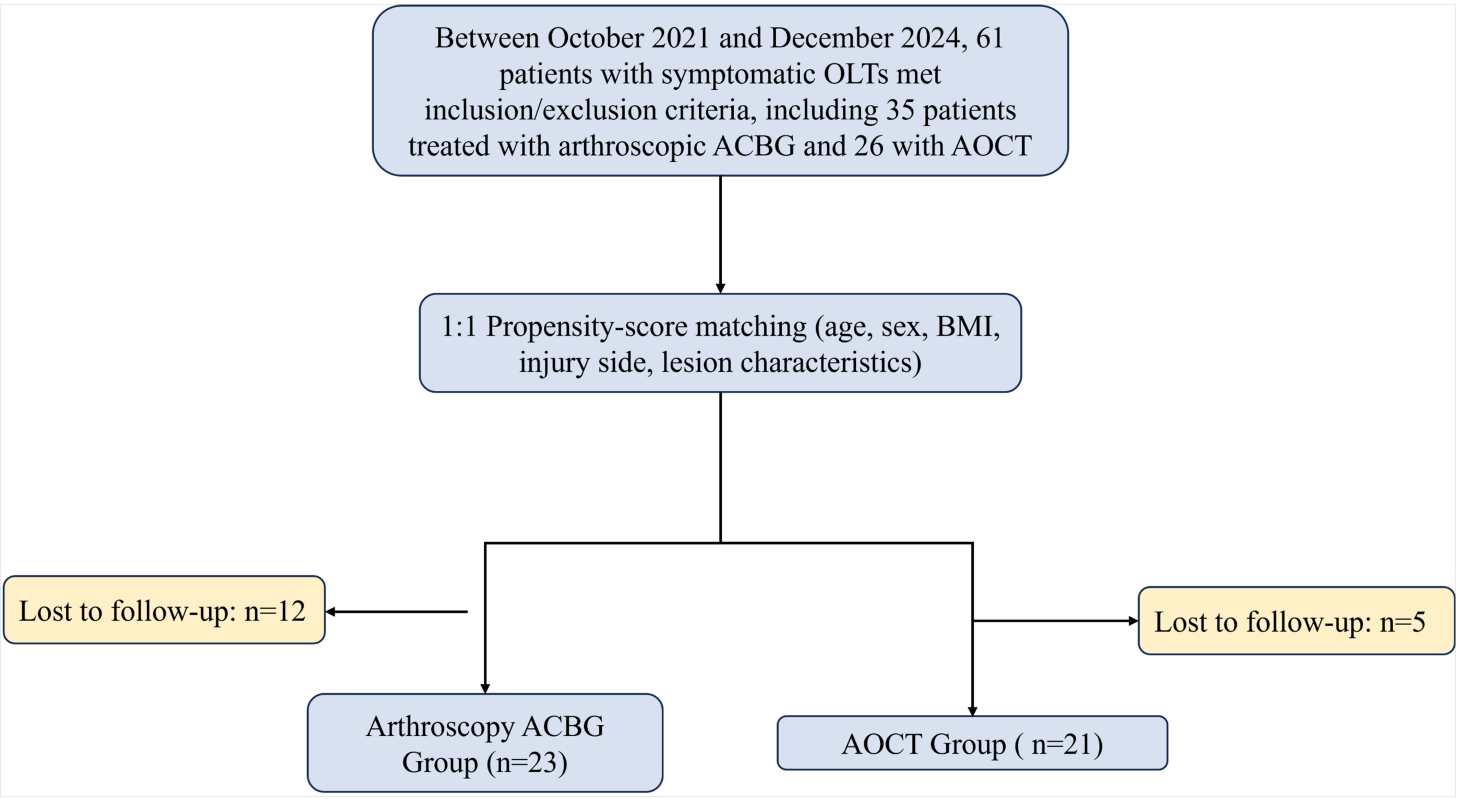


Figure 1

Flow chart of the patient inclusion process. ACBG: autologous cancellous bone grafting; AOCT: autologous osteochondral transplantation.

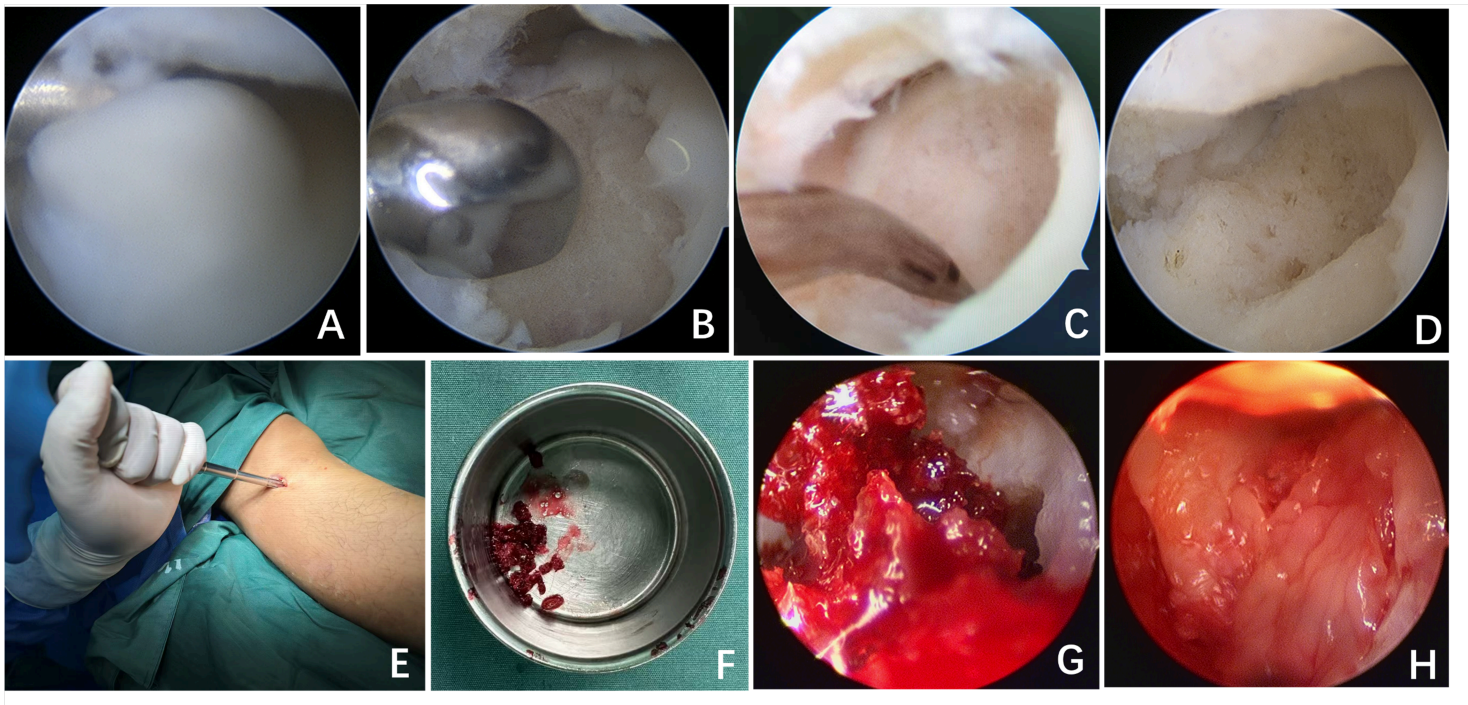


Figure 2

Arthroscopic autologous cancellous one grafting (ACBG) combined with PRP injection procedure. (A) Arthroscopic visualization of the cartilage defect area; (B) a curette and shaver are used to thoroughly debride the defect area, including degenerated cartilage, cystic components, and necrotic bone; (C) The subchondral channels are created on the bottom and lateral walls of the defect area with a microfractures awl; (D) Overall appearance of the subchondral channel within the lesion after microfracture; (E) Autologous cancellous bone was harvested from the Gerdy's tubercle in right knee; after removal of the cylindrical bone using a harvesting tube, the underlying autologous cancellous bone graft is harvested with a curette; (F) Gross morphology of harvested cancellous bone; (G) Autologous cancellous bone is placed into the defect area; (H) The prepared PRP gel is delivered to the defect area.

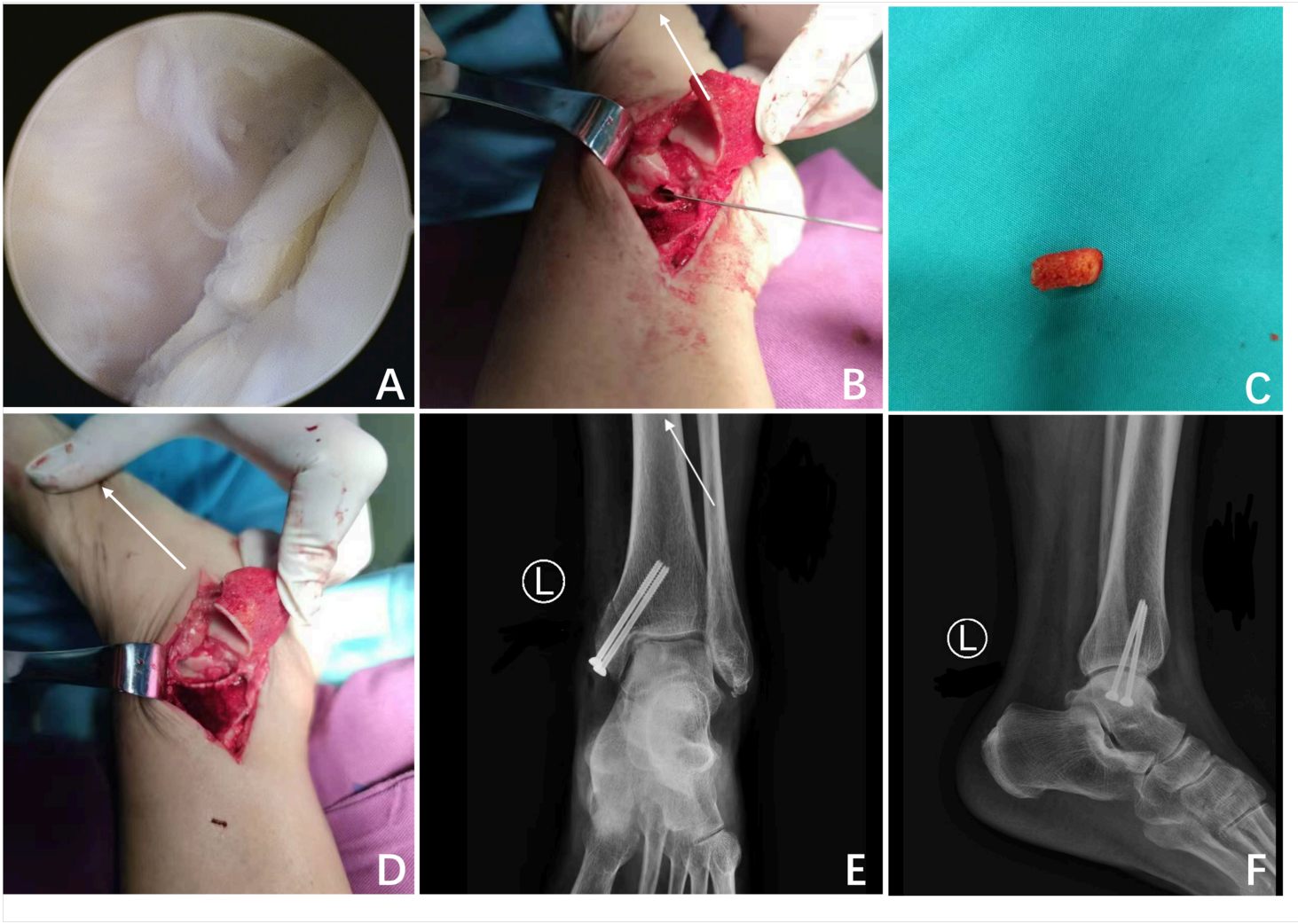


Figure 3

Autologous osteochondral transplantation procedure. (A) Osteochondral lesions of the talus have been confirmed via arthroscopy; (B) Medial malleolar osteotomy to expose the area of cartilage damage (the white arrow indicates the foot); (C) The gross appearance of the osteochondral graft harvested from the non-weight-bearing area of the ipsilateral distal femur; (D) Autologous osteochondral grafts were filled in

the talar cartilage defect area (white arrow indicates the foot); (E-F) Anatomical reduction was confirmed using a C-arm machine to take anteroposterior and lateral X-rays of the ankle joint.

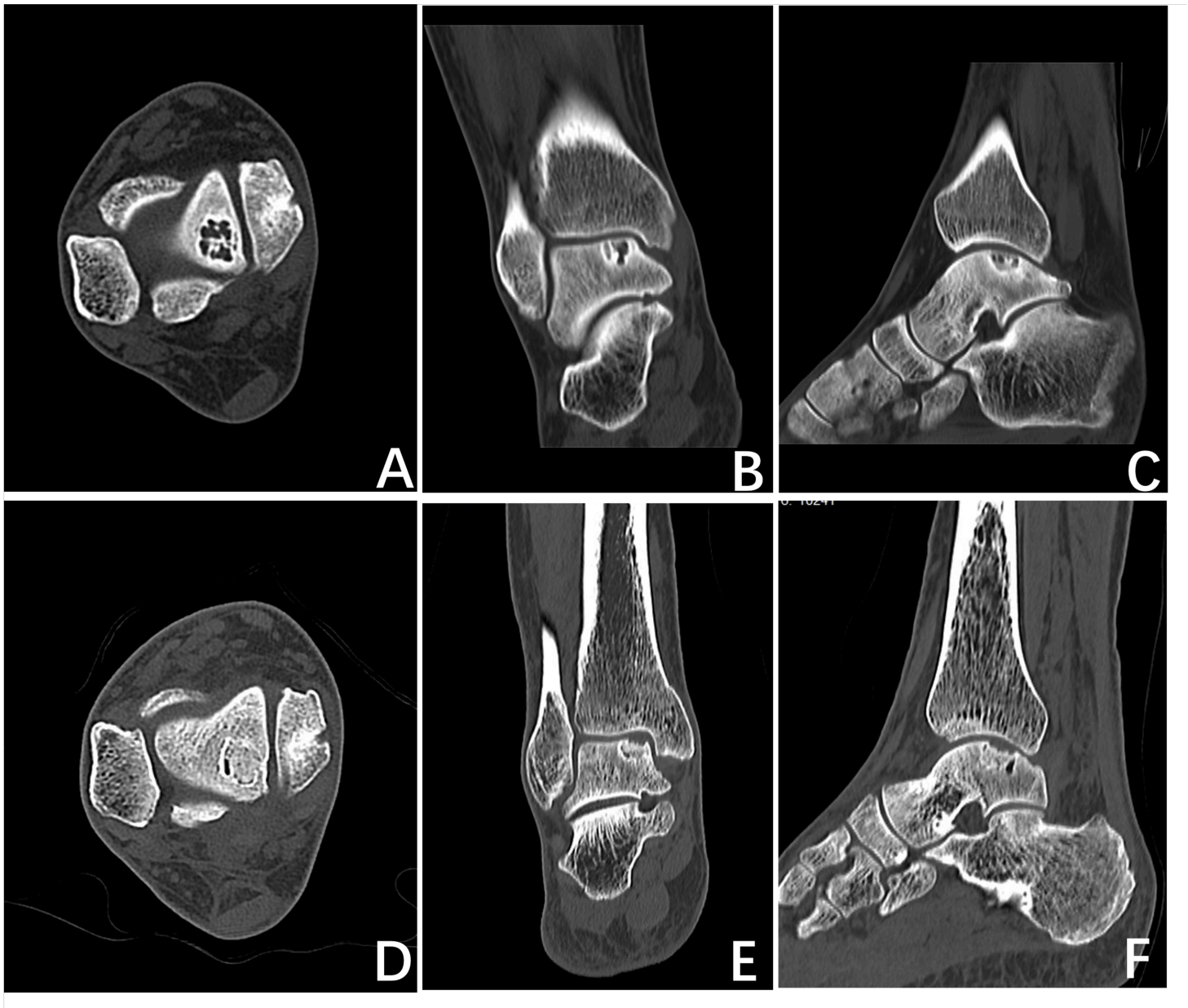


Figure 4

Comparison of (A-C) preoperative and (D-F) postoperative osteochondral lesions of the talus (OLTs) on computed tomography (CT) images in the arthroscopic autologous cancellous one grafting (ACBG) combined with PRP injection procedure group.

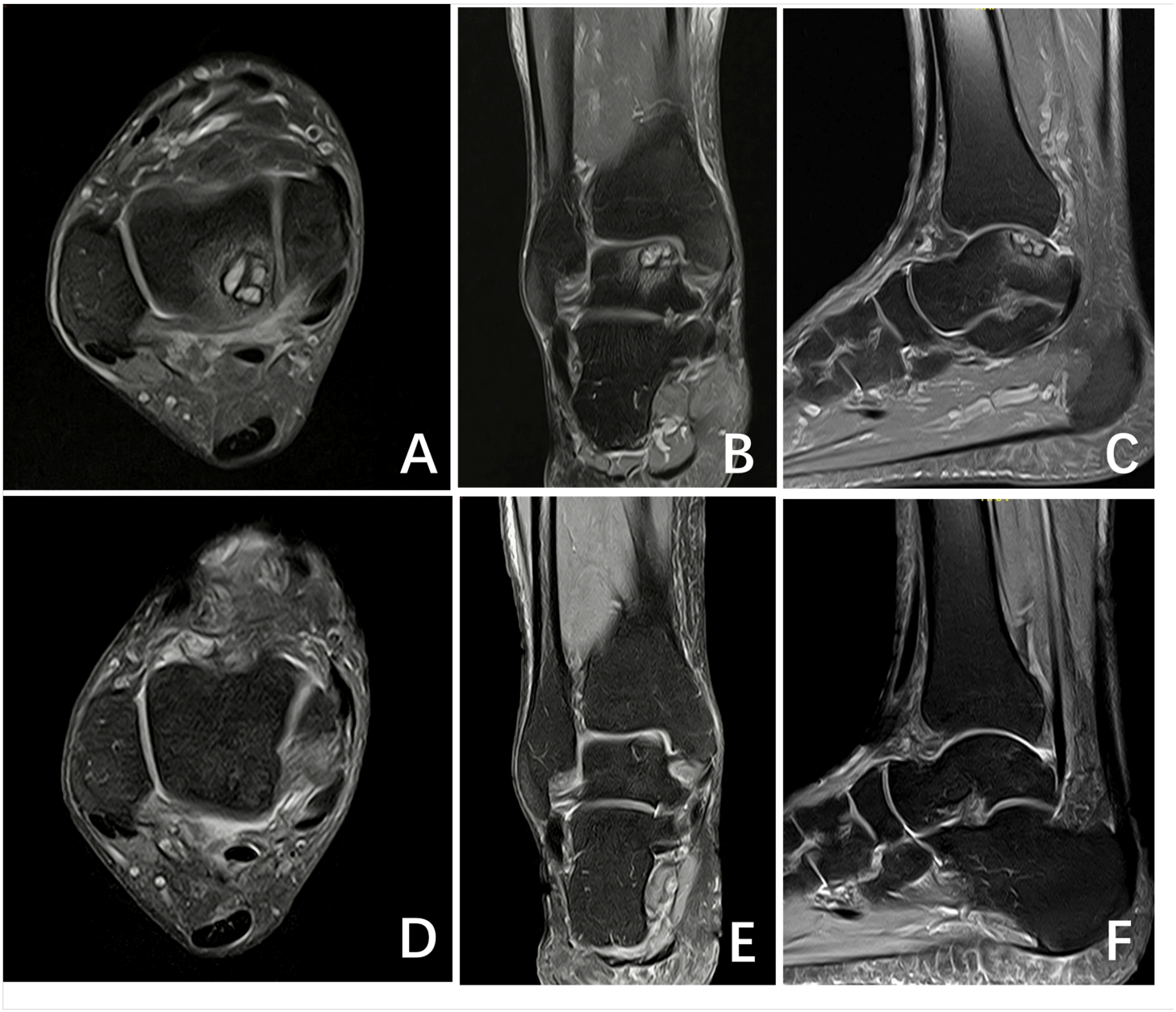


Figure 5

Comparison of (A-C) preoperative and (D-F) postoperative osteochondral lesions of the talus (OLTs) on magnetic resonance images (MRI) in the arthroscopic autologous cancellous one grafting (ACBG) combined with PRP injection procedure group.

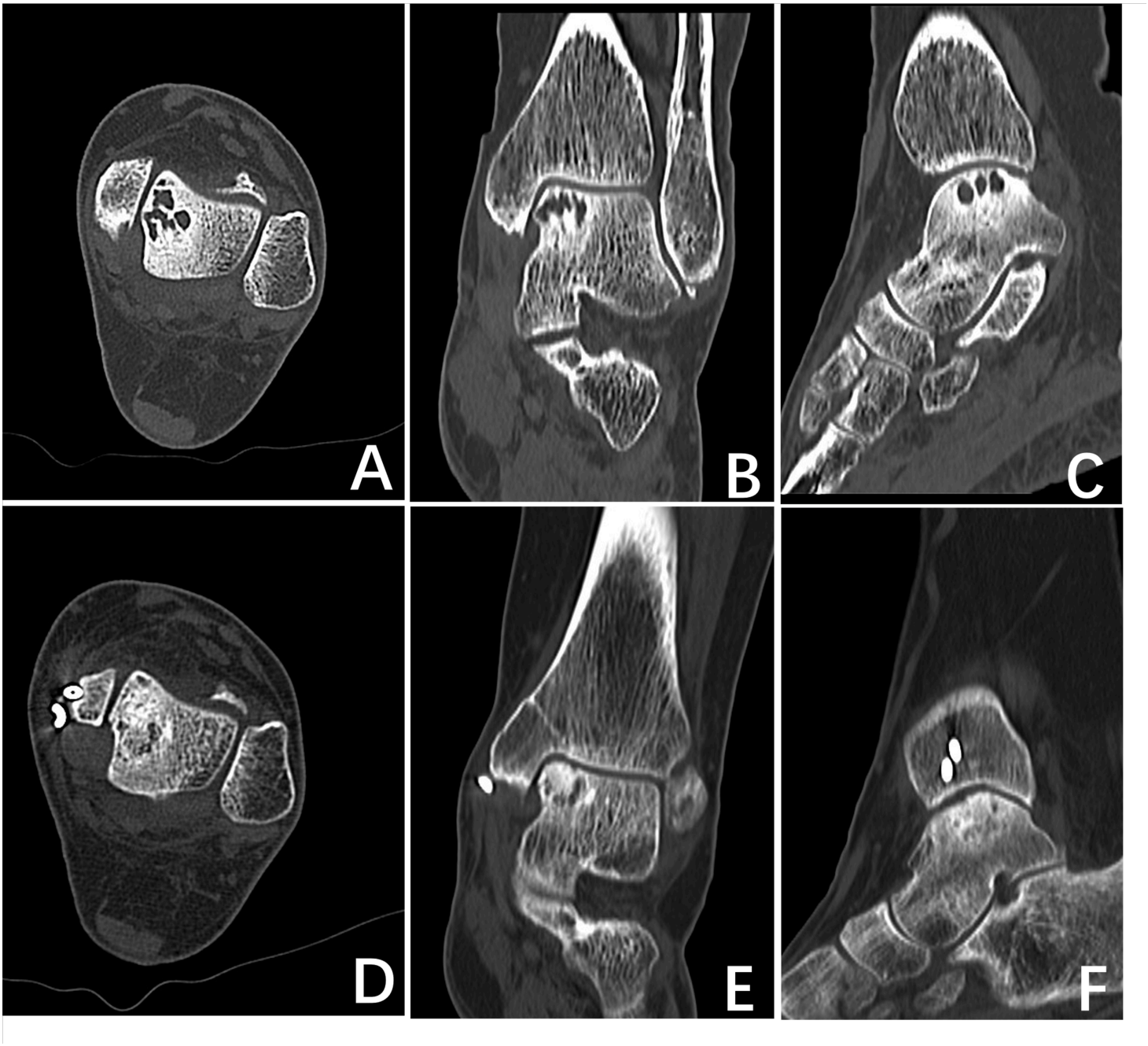


Figure 6

Comparison of (A-C) preoperative and (D-F) postoperative osteochondral lesions of the talus on computed tomography (CT) imaging scans in the autologous osteochondral transplantation (AOCT) group.

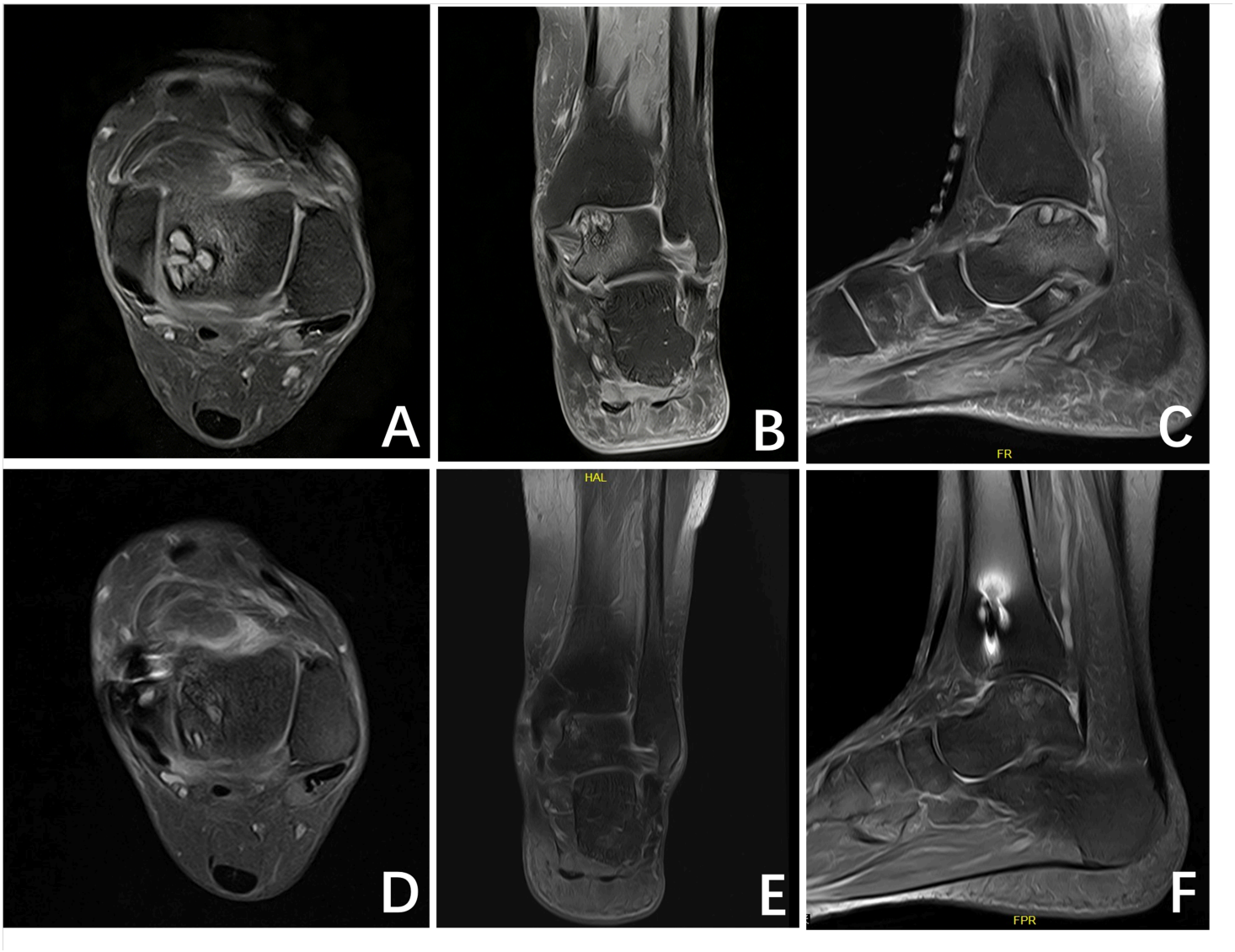


Figure 7

Comparison of (A-C) preoperative and (D-F) postoperative osteochondral lesions of the talus on magnetic resonance images (MRI) in the autologous osteochondral transplantation (AOCT) group.