CLINICAL ARTICLE

# Autologous Osteoperiosteal Transplantation for the Treatment of Large Cystic Talar Osteochondral Lesions

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**Objective:** The effectiveness of autologous osteoperiosteal transplantation (AOPT) for the treatment of large cystic talar osteochondral lesions (OCLs) should be further evaluated, and the postoperative cartilage coverage is questionable. The purpose of this retrospective observational study was to investigate the clinical outcomes of AOPT for the treatment of large cystic talar OCLs and to report second-look arthroscopic results.

**Methods:** From June 1, 2017, to June 1, 2021, all talar OCLs at our center were reviewed. Painful cystic lesions treated with AOPT were included in the study. The American Orthopaedic Foot and Ankle Society (AOFAS; 0–100 points) ankle-hindfoot score, Foot Function Index (FFI; 0–100 points), visual analog scale (VAS; 0–10 points) score, and Tegner score (0–10 points) were used to describe pain and functional outcomes. Furthermore, complications, patient-reported satisfaction degrees, imaging results (including computed tomography and magnetic resonance), and second-look arthroscopic evaluation data were also collected for analysis.

**Results:** A total of 29 cases were eligible for the study, and 26 responded to the latest follow-up request, with a mean follow-up duration of 30.2 (range, 12–57) months. The AOFAS score improved from $69.2 \pm 10.9$ preoperatively to $80.9 \pm 10.0$ at the latest follow-up ($p = 0.000$). The FFI score improved from $30.4 \pm 18.4$ preoperatively to $16.3 \pm 14.0$ at the latest follow-up ($p = 0.000$). The VAS pain score improved from $4.0 \pm 2.1$ preoperatively to $2.5 \pm 2.0$ at the latest follow-up ($p = 0.001$). No donor site morbidity was found. The mean postoperative MOCART score was $57.7 \pm 9.5$. Second-look arthroscopy showed a fibrillated cartilage-like surface at the lesion site in most cases, while two cases exhibited a nearly normal surface.

**Conclusion:** The transplantation of osteoperiosteal cylinder autografts taken from the iliac crest for the treatment of large cystic talar OCLs yielded acceptable clinical results. Good integration of the bony part was observed, but cartilage regeneration remained uncertain.

**Key words:** Autologous Osteoperiosteal Transplantation; Depth; Osteochondral Lesion; Talus

## Introduction

Talar osteochondral lesions (OCLs) refer to talar dome cartilage defects involving subchondral bone.[1] Up to 50% of ankle sprains and 65%–73% of ankle fractures will reportedly lead to talar OCLs.[2–4] Young and sports-active individuals are more likely to be affected.[5] The average age

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Received 10 July 2022; accepted 17 October 2022

**Orthopaedic Surgery** 2023;15:103–110 • DOI: 10.1111/os.13586




Orthopaedic Surgery

of onset is 20 to 30 years.[1] The main symptom is weight-bearing-associated ankle pain, which is often obscure and difficult to accurately locate. Other possible symptoms include ankle swelling, limited range of motion, stiffness, and giving way.[6] These symptoms are mostly atypical, leading to the requirement of imaging tests for the final diagnosis. Magnetic resonance imaging (MRI) is considered to be the gold-standard diagnostic method for talar OCLs, and the most commonly used five-stage classification system based on MRI was developed by Hepple.[7] Hepple stage V indicates cartilage defects accompanied by subchondral cyst formation.

Various new treatment protocols have been used to deal with Hepple stage V talar OCLs.[8] These include autologous chondrocyte implantation, juvenile cartilage allograft transplantation, and tissue engineering methods.[8] However, the high cost and technically demanding process have limited their application, and the outcomes remain unclear. Autologous osteochondral transplantation (AOCT) has been proven to be effective in treating large cystic talar OCLs and is often regarded as a standard protocol.[9–13] The autografts in AOCT are taken from the nonweightbearing area of the distal femoral joint surface. However, the main problem in AOCT is that donor site morbidity could be as high as 50%.[14] To reduce donor site morbidity, several studies have tried autologous osteoperiosteal transplantation (AOPT) instead of AOCT, and the autografts in AOPT are harvested from the iliac crest or ipsilateral tibia.[15–17] This kind of procedure is based on the observation that periosteal autografts have a strong ability to yield chondrogenesis because the periosteum contains chondrogenic precursor cells.[18–20] Comparable outcomes were found between AOPT and AOCT in one study.[21] However, the clinical outcomes and cartilage coverage after AOPT remain to be further investigated because few studies have reported clinical outcomes, and only two studies have reported second-look arthroscopic results.[15,21]

In our study, we hypothesized that AOPT was effective in treating large cystic talar OCLs. The aims of our retrospective study were as follows: (i) to report the clinical and imaging outcomes when transplanting a cylinder osteoperiosteal autograft taken from the ipsilateral iliac crest to treat large cystic talar OCLs; (ii) to report donor site morbidity after AOPT; (iii) to show the cartilage coverage of the talar dome after AOPT under second-look arthroscopy.

## Methods

### *Study Design and Participants*

This retrospective observational study was approved by the institutional ethics committee (approval number: 2022-Lunshen-014). From June 1, 2017, to June 1, 2021, the medical records of patients who were admitted to our hospital with a diagnosis of talar OCL were reviewed for eligibility. According to the literature, talar OCLs are defined as chondral defects of the talar dome combined with subchondral bone lesions.[1] The inclusion criteria were as follows: painful talar OCLs with subchondral cyst formation, with or without ankle lateral collateral ligament tears; failed conservative treatment for at least 6 months; operative methods of AOPT, with or without ankle lateral collateral ligament repair; regular follow-up for at least 12 months. The exclusion criteria were as follows: combined with hip or knee arthropathy, lower limb deformity, or new fractures during the follow-up period; and obvious ipsilateral ankle arthritis with joint space narrowing. Eligible patients were asked to participate in the latest follow-up and sign an informed consent form.

### *Surgical Techniques*

The operations were performed by two well-trained foot and ankle surgeons. Patients underwent operations in the supine position with spinal-epidural anesthesia, and a tourniquet was routinely used. The AOPT technique was described in detail by Hu *et al.*[15] Briefly, arthroscopic exploration was performed to confirm the location and size of the lesion. Anteromedial or anterolateral lesions were accessed *via* arthrotomy, while posterior medial lesions were exposed by medial malleolar chevron osteotomy. The cartilage lesion on the surface was debrided, and then a remover tube (Smith & Nephew) with an appropriate outer diameter was used to roughly remove the subchondral cyst and create a bone socket, which was further thoroughly debrided by a curette. The sclerotic wall was freshened by multiple drilling. An incision was made along the anterior iliac crest. At the time of exposure, special attention should be given not to damage the periosteum of the iliac crest. A cylindrical osteoperiosteal autograft was obtained by a harvester tube (Smith & Nephew) with an inner diameter equal to the outer diameter of the remover tube. Some small pieces of cancellous bone, which were used to fill the peripheral space of the bone socket in the talus, were further harvested by a curette at the donor site and mixed with several pills of recombinant human bone morphogenetic protein 2 (1 mg, Hangzhou Jiuyuan Gene Engineering Co., Ltd.). The cylinder osteoperiosteal autograft was tapped into the bone socket with the periosteum on the surface, which sat flush with the surrounding normal cartilage (Figure 1). If osteotomy was performed, the medial malleolus was reduced with reduction forceps and fixed with three half-threaded cannulated screws (Depuy Synthes).

If the OCLs were combined with definite chronic lateral ankle mechanical instability (meeting the minimum inclusion criteria of chronic ankle instability suggested by the International Ankle Consortium[22] with a positive anterior drawer test and imaging-confirmed ATFL tear), arthroscopic assisted Brostrom surgery was performed at the same time.

### *Postoperative Management*

Patients were asked to visit the doctor regularly 1, 2, 3, 6, and 12 months after surgery. Passive range of motion was allowed immediately after surgery, followed by active range

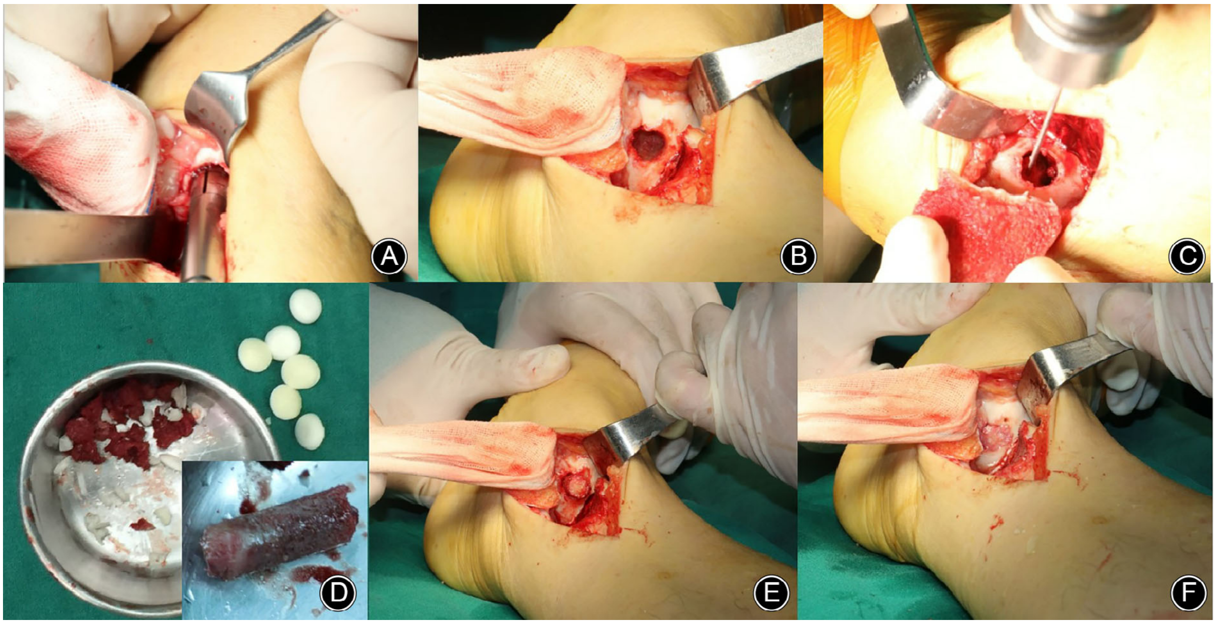

**Fig. 1** Surgical process of autologous osteoperiosteal transplantation. (A) The subchondral cyst was removed by a remover tube and further debrided by a curette. (B) A bone socket was created. (C) The sclerotic wall was freshened by multiple drilling. (D) A cylinder osteoperiosteal autograft and some small pieces of cancellous bone were obtained from the iliac crest. The white pills are recombinant human bone morphogenetic protein 2 (Hangzhou Jiuyuan Gene Engineering Co., Ltd.) used to promote bone healing. (E) The cylinder autograft was tapped into the bone socket with the periosteum on the surface. (F) The surface of the autograft sat flush with the surrounding normal cartilage

of motion and muscle strength training according to the individual's pain level. Non-weight bearing was maintained for 6 weeks, followed by partial weight bearing for 2 weeks and full weight bearing thereafter. Jogging was allowed 3 months after surgery. Returning to sports was suggested at more than 6 months after surgery (Figure 2). If Brostrom surgery was performed, a U-shaped ankle support was applied for 6 weeks, followed by ankle tape protection for 4 weeks. Furthermore, ankle and hindfoot varus was not allowed in the first 6 weeks.

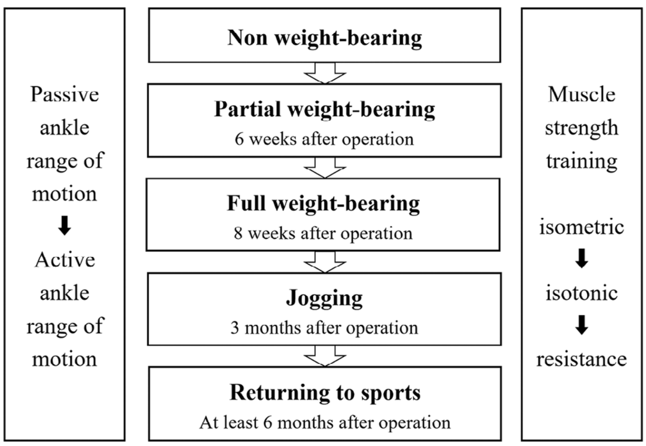


**Fig. 2** A flow chart showing the postoperative management protocol

### *Evaluation*

Basic information on the enrolled patients, including age, sex, BMI, affected side, comorbidity, imaging and previous follow-up data, was collected through chart review. Small amounts of missing data were obtained by telephone interview. Outcome measures included the visual analog scale (VAS; 0–10 points), American Orthopaedic Foot and Ankle Society (AOFAS; 0–100 points) ankle-hindfoot score, Tegner score (0–10 points), Foot Function Index (FFI; 0–100 points), complications, patient-reported satisfaction degrees (1–5 points; 1—very unsatisfied; 2—unsatisfied; 3—fair; 4—satisfied; 5—very satisfied), computed tomography (CT) evaluation, and magnetic resonance observation of cartilage repair tissue (MOCART; 0–100 points) score.

Approximately two-thirds of the patients asked for screw removal 1 year after the initial surgery. Second-look arthroscopy was performed during the screw-removing surgery with the patient's agreement. The International Cartilage Repair Society (ICRS; 0–12 points) score was acquired for these patients.

### *Statistical Analysis*

The SPSS 19.0 statistical software was used for data analysis. The quantitative data are presented as the mean ± standard deviation. All hypothesis tests were bilateral, and $p < 0.05$ was considered statistically significant. The paired-samples $t$ test was used to analyze the difference between preoperative and postoperative scores. The correlation between patient satisfaction and other factors was assessed using the Pearson correlation coefficient.

## Results

Twenty-nine patients were eligible for follow-up, while three did not respond. A total of 26 patients were included in the study. The mean follow-up duration was 30.2 (range, 12–57) months. Table 1 shows detailed demographic information, and Figure 3 shows the distribution of the lesions according to Steven's anatomical grid scheme.[23] Fifteen of 26 cases had combined arthroscopic assisted Brostrom surgery. The mean diameter of the chondral lesion was 13.6 ± 4.0 mm, and the mean depth of the subchondral cysts was 10.7 ± 3.5 mm.

### *Clinical Outcomes*

The AOFAS score improved from 69.2 ± 10.9 preoperatively to 80.9 ± 10.0 at the latest follow-up ($p = 0.000$). The FFI score improved from 30.4 ± 18.4 preoperatively to 16.3 ± 14.0 at the latest follow-up ($p = 0.000$). The VAS pain score improved from 4.0 ± 2.1 preoperatively to 2.5 ± 2.0 at the latest follow-up ($p = 0.001$). With regard to the VAS pain score, 17 cases improved, three cases slightly worsened, and six cases remained unchanged. With regard to activity levels (Tegner score), 16 cases improved, six cases slightly worsened, and four cases remained unchanged (Table 2, Figure 4). Donor-site morbidity was not observed, and the only complication was residual ankle pain.

### *Imaging Outcomes*

Bone union between the cylinder autograft and the surrounding tissue was confirmed by CT scan 3 months after the operation in all cases. The complete filling of the subchondral cyst was observed. Thirteen patients underwent magnetic resonance examination 1 year after the operation (Figure 5) and the mean MOCART score was 57.7 ± 9.5 (Table 2).

### *Second-Look Arthroscopy*

Seventeen patients underwent second-look arthroscopy. Fourteen cases showed fibrillated cartilage-like surfaces, which were slightly higher than the surrounding normal cartilage, one case showed a nearly bare bony surface, and two cases showed smooth cartilage-like surfaces, which were leveled to the surrounding normal cartilage (Figure 6). The mean ICRS score was 9.7 ± 2.0 (Table 3).

**TABLE 1 Demographic information (N = 26)**

| Items | Values |
|---|---|
| Number | 26 |
| Age (years) | 41.8 ± 12.9 |
| Sex (male: female) | 20:6 |
| Side (left: right) | 11:15 |
| BMI (kg/m$^2$) | 26.6 ± 3.9 |
| Defect size | |
| Depth (mm) | 10.7 ± 3.5 |
| Diameter (mm) | 13.6 ± 4.0 |
| Follow-up (months) | 30.2 ± 15.4 |

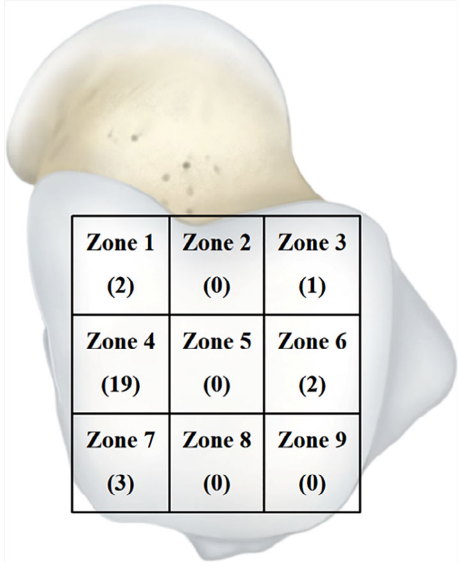


**Fig. 3** The distribution of talar osteochondral lesions included in the study (27 lesions from 26 cases were included)

### *Overall Satisfaction Degree*

The mean patient-reported satisfaction degree was 3.9 ± 1.1. The satisfaction degree did not seem to correlate with the MOCART score ($r = 0.145$, $p = 0.636$) or the ICRS score ($r = 0.136$, $p = 0.603$), but only correlate with pain and function outcomes (VAS, $r = 0.608$, $p = 0.001$; AOFAS, $r = 0.506$, $p = 0.008$; FFI, $r = 0.529$, $p = 0.006$).

## Discussion

Overall, we found that the clinical and imaging outcomes of AOPT for the treatment of large cystic talar OCLs were acceptable, but the 1-year cartilage coverage was not ideal under second-look arthroscopy.

Various surgical techniques have been used to treat OCLs,[8,9,15,24,25] but the outcomes are not always satisfactory. Autologous osteoperiosteal cylinder grafts taken from the iliac crest to treat large cystic medial talar OCLs were first reported in 2013 by Hu *et al.*[15] They advocated that periosteal autografts have a strong ability to yield chondrogenesis because the periosteum contains chondrogenic precursor cells.[15,18–20] Its advantage over osteochondral transplantation is less donor-site morbidity.[15,21] In Hu's study, 16 patients were involved, the mean VAS score improved from 5.51 to 0.98, the mean AOFAS score improved from 75.00 to 90.00, the mean MOCART score and ICRS score were 60.00 and 9.00, respectively, after surgery.[15] However, few subsequent

**TABLE 2 Clinical and imaging outcomes (N = 26)**

| Score | Pre-operation | 1 year | Latest follow-up | p* | t |
|---|---|---|---|---|---|
| VAS score | 4.0 ± 2.1 | 2.6 ± 1.9 | 2.5 ± 2.0 | 0.001 | −3.893 |
| AOFAS score | 69.2 ± 10.9 | 80.9 ± 10.2 | 80.9 ± 10.0 | 0.000 | 4.817 |
| FFI score | 30.4 ± 18.4 | 16.4 ± 14.1 | 16.3 ± 14.0 | 0.000 | −4.303 |
| Tegner score | 2.4 ± 1.7 | 4.0 ± 1.9 | 3.9 ± 1.9 | 0.005 | 3.040 |
| Satisfaction degree | \ | \ | 3.9 ± 1.1 | \ | \ |
| MOCART score (n = 13) | \ | 57.7 ± 9.5 | \ | \ | \ |

Abbreviations: AOFAS, American Orthopaedic Foot and Ankle Society; AOPT, autologous osteoperiosteal transplantation; FFI, foot function index; MOCART, magnetic resonance observation of cartilage repair tissue; VAS, visual analog scale.; * Comparison between preoperative scores and latest follow-up scores.

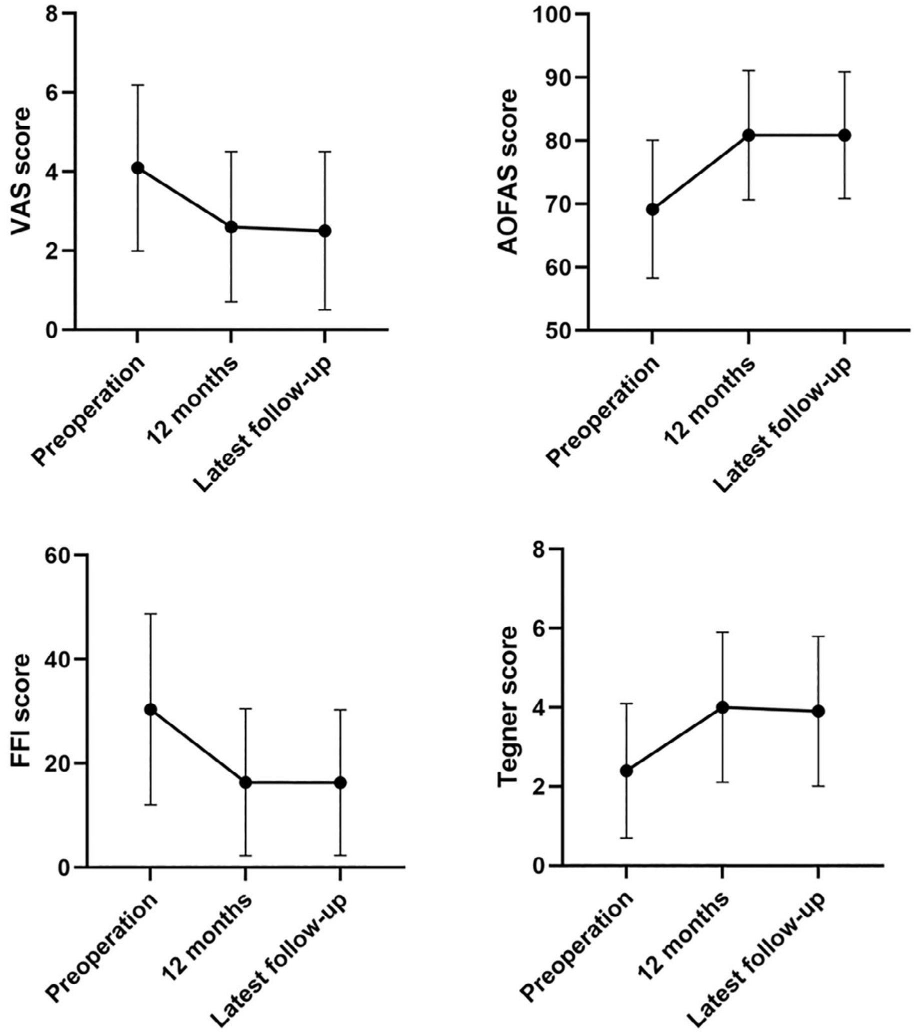


**Fig. 4** Pain and function outcomes (N = 26). VAS, visual analog scale; AOFAS, American Orthopaedic Foot and Ankle Society; FFI, foot function index

studies further confirmed the effectiveness of this approach. Chen *et al.*[16] also reported the clinical outcomes of AOPT for the treatment of large cystic medial talar OCLs in 15 patients, but the autografts were taken from the medial tibia instead of the iliac crest. The mean VAS score improved from 5.40 to 1.00, the mean AOFAS score improved from 49.00 to 89.00, and the mean MOCART score was 64.00.[16] Second-look arthroscopy was not performed in Chen's study.[16]

We used AOPT to treat large cyst talar OCLs, regardless of lesion location (medial or lateral), and the autografts were taken from the ipsilateral iliac crest. No donor-site

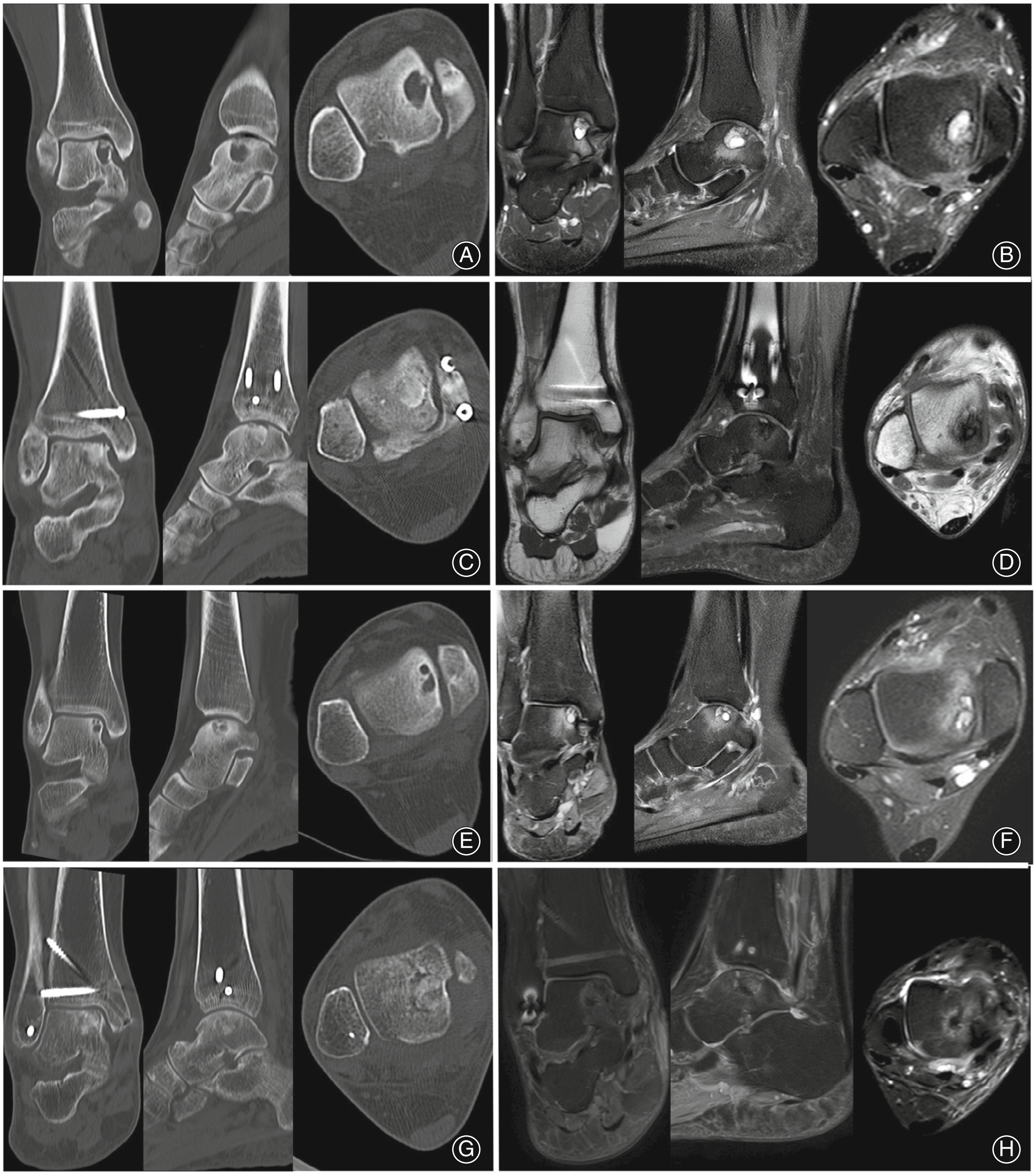


**Fig. 5** Imaging of two typical cases. (A, B) Preoperative imaging from a 58-year-old male patient. (C, D) Computed tomography imaging 3 months after surgery and magnetic resonance imaging 1 year after surgery from the same patient. (E, F) Preoperative imaging from a 60-year-old female patient. (G, H) Computed tomography imaging 3 months after surgery and magnetic resonance imaging 1 year after surgery from the same patient

morbidity was found. Although the MOCART score and ICRS score were similar to those in previous studies, our second-look arthroscopy showed fibrillated tissue coverage in most AOPT cases (82%), and the surface of the fibrillated tissue was slightly higher than the surrounding normal cartilage. We do not think this was a nearly normal appearance

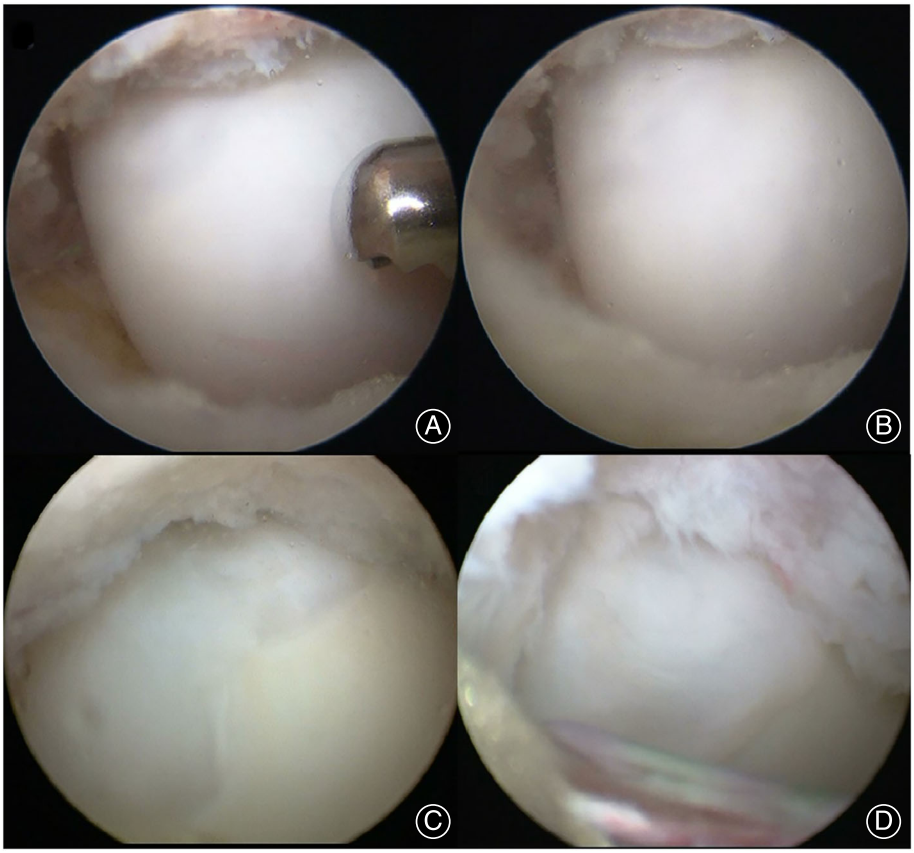


**Fig. 6** Typical appearance of the cartilage under second-look arthroscopy after autologous osteoperiosteal transplantation. (A, B) Smooth cartilage-like tissue coverage in two cases. (C, D) Fibrillated cartilage-like tissue coverage in most cases

**TABLE 3 Second-look arthroscopic assessment and its relation with imaging results (N = 17)**

| Case No. | ICRS score | ICRS overall repair assessment | MOCART score |
|---|---|---|---|
| 1 | 10 | Nearly normal | 65 |
| 2 | 10 | Nearly normal | 55 |
| 3 | 10 | Nearly normal | \ |
| 4 | 9 | Nearly normal | \ |
| 5 | 11 | Nearly normal | \ |
| 6 | 3 | Severely abnormal | 55 |
| 7 | 11 | Nearly normal | \ |
| 8 | 10 | Nearly normal | 55 |
| 9 | 9 | Nearly normal | 55 |
| 10 | 10 | Nearly normal | \ |
| 11 | 10 | Nearly normal | 65 |
| 12 | 12 | Normal | 65 |
| 13 | 9 | Nearly normal | 60 |
| 14 | 12 | Normal | 65 |
| 15 | 10 | Nearly normal | \ |
| 16 | 10 | Nearly normal | \ |
| 17 | 9 | Nearly normal | 35 |

Abbreviations: ICRS, International Cartilage Repair Society; MOCART, magnetic resonance observation of cartilage repair tissue.

despite the ICRS score being rated “nearly normal.” The arthroscopic outcomes were different from those in Hu’s study, in which most cases showed a nearly normal cartilage appearance.[15] The clinical outcomes were also slightly different from those in Hu’s and Chen’s study, in which more satisfactory functional outcomes were reported.[15,16] In our study, the overall pain and function scores did improve at a mean of 30.2 months after AOPT, but the degree of improvement was relatively limited, with several individuals’ pain and function levels remaining unchanged, and a few even reported slightly worsened pain and function. The differences in outcomes may be due to some differences in surgical details or postoperative management. However, only a few studies have reported the outcomes of AOPT, and the total number of cases in the literature is limited. Selection bias may also exist in each study.

We found that satisfactory clinical outcomes were sometimes combined with a relatively poor imaging manifestation, on the contrary, poorer clinical outcomes were sometimes combined with nice imaging results. Patient satisfaction levels were only correlated with pain and functional outcomes and were not correlated with imaging or arthroscopic appearance. This phenomenon, which is difficult to explain, suggests that the treatment of large cystic talar OCLs still needs considerable improvement. The actual mechanisms of chondrogenesis induced by the periosteum should be further intensively investigated, so as to take appropriate measures to promote the chondrogenesis process after AOPT.

### *Limitations and Strengths*

Our study has several limitations. First, the sample size (26 cases) is relatively small; however, in comparison with previous studies, the number of AOPT patients included in our study is the greatest. Second, although we had attempted to take a biopsy and identify it as hyaline or fibrous cartilage, regretfully, we did not obtain results since the tissue we removed was too small to obtain histological results because we wanted to preserve cartilage integrity. In addition, the actual mechanism of chondrogenesis and cartilage remodeling within AOPT surgeries should be further studied.

Our study also has several strengths. Since few studies have reported the outcomes of AOPT and few patients were included in previous studies, our study added more mid-term follow-up data of AOPT for the treatment of Hepple stage V talar OCLs to the literature. Patient-reported outcomes, MRI, and second-look arthroscopic evaluations are all useful information for the surgeons to make a judgment about this surgical technique and make appropriate surgical decisions.

## Conclusion

In conclusion, Hepple stage V talar osteochondral lesions are intractable clinical problems. The transplantation of osteoperiosteal cylinder autografts taken from the iliac crest for the treatment of large cystic lesions yielded acceptable pain and functional results. Integration of the bony part was observed, but cartilage regeneration remained uncertain.

## Conflicts of Interest

The authors declare that there is no conflict of interest.

## Ethics Statement

This study protocol was reviewed and approved by the Ethics Committee for Clinical Trials, The Third Affiliated Hospital of Southern Medical University, approval number [2022-Lunshen-014]. Written informed consent was obtained from participants.

## Funding Information

This research did not receive any specific grant from funding agencies in the public, commercial, or not-for-profit sectors.

## Author Contributions

HG and ZC conceived the study. CZ and YL initiated the study design. All coauthors contributed to the implementation of the study and to the refinement of the study protocol. HG and ZC drafted the manuscript. All authors have reviewed and given their final approval of the submitted version.

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