Double-Plug Autologous Osteochondral Transplantation Shows Equal Functional Outcomes Compared With Single-Plug Procedures in Lesions of the Talar Dome: A Minimum 5-Year Clinical Follow-up

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Double-Plug Autologous Osteochondral Transplantation Shows Equal Functional Outcomes Compared With Single-Plug Procedures in Lesions of the Talar Dome

A Minimum 5-Year Clinical Follow-up

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Background: Autologous osteochondral transplantation (AOT) is used for large (>100-150 mm²) or cystic osteochondral lesions (OCLs) of the talus. Larger lesions may require using more than 1 graft to fill the defect. While patients with larger OCLs treated with microfracture exhibit inferior clinical outcomes, there is little evidence regarding the effect of lesion size and number of grafts required on clinical and radiological outcomes after AOT.

Hypothesis: Larger OCLs of the talar dome treated by double-plug AOT (dp-AOT) have inferior clinical and radiological MRI outcomes compared with smaller OCLs requiring single-plug AOT (sp-AOT).

Study Design: Cohort study; Level of evidence, 3.

Methods: Fourteen consecutive patients with a large OCL (mean, 208 ± 54 mm²) treated using dp-AOT with a minimum 5-year follow-up were matched by age and sex to a control cohort of 28 patients who underwent sp-AOT for a smaller OCL (mean, 74 ± 26 mm²) over the same period. Functional outcomes were assessed both pre- and postoperatively using the Foot and Ankle Outcome Score (FAOS) and Short Form–12 (SF-12) general health questionnaire. Mean follow-up was 85 months (range, 65-118 months). Latest postoperative MRI was evaluated with modified magnetic resonance observation of cartilage repair tissue (MOCART) score.

Results: There was no significant difference between groups demographically (P > .05). All patients with dp-AOT and sp-AOT showed a significant pre- to postoperative increase in FAOS and SF-12 scores (P < .001). When comparing preoperative scores for both groups, there was no statistical significance between sp-AOT and dp-AOT scores (FAOS, P = .719; SF-12, P = .947). There was no significant difference in functional scores between the 2 groups postoperatively for both FAOS (P = .883) and SF-12 (P = .246). Mean MOCART scores did not exhibit any statistically significant difference between groups (P = .475). Two patients complained of knee donor site stiffness (4.8%), which later resolved.

Conclusion: Patients with large OCLs treated using a dp-AOT procedure did not show inferior clinical or radiological outcomes compared with those treated with sp-AOT at a minimum 5-year follow-up. The dp-AOT procedure is as effective as sp-AOT in treating larger OCLs of the talar dome in the intermediate term, with similar high postoperative clinical and radiological outcomes.

Keywords: autologous osteochondral transplantation; double plug; functional scores; MRI; outcomes

Cartilage damage of the talus is common and may occur in up to 50% of ankle sprains, potentially leading to an osteochondral lesion (OCL).5,25,41 Smaller OCLs (100-150 mm²) have been demonstrated to be adequately treated with arthroscopic bone marrow stimulation, showing good short- to medium-term outcomes.1,7,9,15,31,47 However, concerns regarding long-term outcomes of marrow stimulation techniques remain due to the formation of biomechanically inferior fibrocartilage.3,12,20,21,32 As a result, a variety of other treatment strategies, each with inherent advantages and disadvantages, have been used as alternative treatment strategies for larger lesions.11,13,14,18,37 Autologous chondrocyte implantation (ACI) may result in repair tissue similar to normal hyaline cartilage, but it is an expensive 2-stage procedure with clinical scores that can decline after 48 months.15-18 Osteochondral allograft can be effective for large-volume and cystic lesions, but high rates of poor incorporation and graft collapse have been reported.11,18

Autologous osteochondral transplantation (AOT) is a surgical treatment modality in which an OCL is replaced with a viable cylindrical osteochondral graft, usually from
the ipsilateral knee. An advantage of this cartilage replacement strategy over reparative techniques is that the damaged cartilage is replaced with hyaline cartilage rather than fibrocartilage.

Autologous osteochondral transplantation in the ankle has been generally indicated for large OCLs not amenable to—or after failed—marrow stimulation techniques, as well as for cystic and large-volume (>100-150 mm²) lesions.

Larger OCLs, however, may require the use of more than 1 graft to fill the defect site. This raises concerns of long-term durability and clinical outcomes due to fibrocartilage formation between individual grafts creating devitalized cartilage islands with poor durability. A number of studies have reported postoperative cyst formation after AOT, which has been postulated to be a consequence of the graft-fibrocartilage interface.

The relationship between the number of grafts and postoperative cyst formation remains to be investigated. While patients with larger talar OCLs treated with bone marrow stimulation procedures have been shown to exhibit poor clinical outcomes, there is little evidence regarding lesion size, number of grafts required, and clinical outcomes after AOT. No prior studies have specifically compared outcomes of single-plug AOT (sp-AOT) with double-plug AOT (dp-AOT). The aim of the current study was to evaluate and compare clinical outcome scores and magnetic resonance imaging (MRI) of patients treated with sp-AOT and dp-AOT. Our hypothesis was that large OCLs requiring dp-AOT would have inferior clinical outcomes compared with smaller OCLs requiring sp-AOT.

MATERIALS AND METHODS

Study Design

Between 2003 and 2007, a total of 14 consecutive patients (7 males and 7 females) with large OCLs were treated with dp-AOT under the care of the senior surgeon (J.G.K.). The 14-patient study group was age and sex matched to a control cohort of 28 patients (17 males and 11 females) who underwent a sp-AOT procedure for smaller OCLs over the same period.

This retrospective study was approved by our institutional review board (IRB) under the Foot and Ankle Department Registry. Medical records were reviewed for identification of all study patients of the senior surgeon. Inclusion criteria were age between 18 and 60 years, who had undergone an AOT procedure of the talar dome. Exclusion criteria were patients with rheumatoid arthritis, patients with insulin-dependent diabetes mellitus, and patients who had undergone concomitant surgical procedures. Patient sex, age at the time of surgery, lesion size (mm²), number of AOT plugs (2 plugs for the dp-AOT group vs 1 plug for the sp-AOT group), and follow-up time were documented.

Clinical and MRI Data

Preoperative care consisted of gathering a history, performing a physical examination, obtaining plain radiographs (anterior-posterior, lateral, and mortise views), and MRI. Nonoperative treatment consisted of nonweight-bearing immobilization in a controlled ankle movement (CAM) boot for 3 to 4 weeks. For the subsequent 4 weeks, patients performed dorsiflexion and planter flexion range-of-motion exercises and progressed weightbearing by 10% each day. If symptoms had not improved or had worsened, patients were regarded to have failed nonoperative therapy. All patients were routinely assessed using the Foot and Ankle Outcome Score (FAOS) and Short Form–12 (SF-12) general health questionnaire at each patient office visit before surgery and at the latest follow-up visit or by e-mail. Identical questionnaires were used in all instances. Data were kept in office records and our institution’s registry and were later retrospectively collected upon IRB approval was granted for the current study. Routine preoperative workup also included physical examination, standard weightbearing radiographs in multiple planes, and preoperative MRI.

In addition, postoperative MRIs performed on a 3-T imaging system (GE Healthcare, Milwaukee, Wisconsin, USA) were reviewed and graded by 2 board-certified musculoskeletal radiologists (G.L.D. and T.W.D.) using a modification of the magnetic resonance observation of cartilage repair tissue (MOCART) score (Figure 1). Both radiologists reviewed all images and came to a consensus on the MOCART score. In contrast to the original MOCART score described by Marlovits et al, the modified MOCART score uses point allocation to each MRI parameter with a total score of 100 points. All data collection was performed by research fellows to reduce any potential bias on behalf of the senior surgeon.

Surgical Technique

All procedures were performed using a previously described technique, and surgical approach was based on lesion location. The OATS instrumentation (Arthrex Inc, Naples, Florida, USA) was used for all cases. Lesions...
located anteriorly were accessed with standard open arthrotomy and ankle plantar flexion. Lesions that could not be accessed in this manner or that were located in the central or posterior aspects of the talus required osteotomy. Lesion location and surgical approach were based on preoperative MRI. A chevron-type medial malleolar osteotomy was performed for centro- and posteromedial lesions, and a lateral tibial osteotomy was performed for lateral lesions as previously described.26 Titanium screws were used to achieve fixation, which minimized obstruction of postoperative MRI due to hardware artifact. Osteochondral grafts were taken via mini-open arthrotomy from a nonweightbearing, nonarticulating aspect of the ipsilateral lateral femoral condyle and ranged from 6, 8, and 10 mm in diameter. Care was taken to ensure that the harvest trephine was placed perpendicular to the articular surface and that a small gap of native tissue was left between harvest sites when 2 grafts were required. This prevented harvest sites from fracturing into each other. Donor sites were also back-filled with TruFit synthetic bone void filler (Smith & Nephew, Andover, Massachusetts, USA) to provide an osteoconductive scaffold and promote bone and fibrocartilage infill. Lesions larger than 10 mm required 2 grafts placed side by side in a figure-of-8 formation or “nested,” which minimized fibrocartilage fill in adjacent graft space (Figures 2 and 3). Lesion size and number of grafts required were confirmed with a sizing guide upon visualization of the OCL. Graft sites were drilled using an acorn-shaped drill tip to a depth of 12 mm to provide adequate stability and articular congruity.26,28 The graft was rotated in the host site until proper alignment was achieved and then gently tapped into position so that it was neither proud nor counter sunk.26

Postoperative Protocol

Postoperative protocol was uniform for all patients, regardless of surgical approach or number of grafts transplanted. Patients were placed in an ankle splint for 2 weeks postoperatively and were nonweightbearing throughout this time. The operated knee was allowed to move freely in an Ace bandage immediately after surgery. Two weeks postoperatively, the patients were placed in a CAM boot and instructed to perform dorsiflexion and plantar flexion exercises daily. At 4 weeks, the patients began to bear 10% of their body weight and gradually increase by 10% daily until reaching full weightbearing at 6 weeks. At this point, patients began a formal physiotherapy program focused on balance and joint proprioception, in addition to strength and range of motion.26

Statistical Analysis

The senior statistician (H.T.D.) performed all analysis. For statistical analyses, the Fisher exact test was used to compare categorical variables between study and control groups. Due to the small sample size, the nonparametric Wilcoxon rank sum test was used to determine differences between study and control groups in the noncategorical (continuous) variables, which included age and follow-up months after surgery as well as postoperative FAOS, SF-12, and modified MOCART scores. In addition, a paired t test was used to compare pre- and postoperative FAOS and SF-12 scores in dp-AOT and sp-AOT groups. Significance was set at \( P < .05 \). All analyses were performed using SAS software version 9.1 (SAS Institute Inc, Cary, North Carolina, USA).

RESULTS

Patient Demographics

For the dp-AOT, the mean patient age at the time of surgery was 42.79 ± 11.9 years. The mean size of the OCL was 208 ± 54 mm\(^2\). The minimum follow-up time was 5 years after surgery, with a mean follow-up period of 93.04 ± 15.08 months (range, 65-118 months). The mean time until last follow-up MRI was 19.1 ± 8.43 months (range, 12-36 months). Mean preoperative duration of symptoms was 30.3 months (range, 6-60 months). Eight patients (57%) specifically reported a traumatic injury. For the sp-AOT group, the mean patient age at the time of surgery was 44.14 ± 11 years, and the mean size of the OCL was 74 ± 26 mm\(^2\). The minimum follow-up time was 5 years after surgery, with a mean follow-up period of 85.29 ± 17.55 months (range, 66-113 months). The mean time until the last follow-up MRI was 19.2 ± 8.59 months (range, 12-37 months). Mean preoperative duration of symptoms was 30.3 months (range, 6-60 months). Eight patients (57%) specifically reported a traumatic injury.

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When comparing demographics of both groups, there was no statistical significance between dp-AOT and sp-AOT groups regarding age (P = .566), sex (P = .530), or follow-up period (P = .132). The OCL size did show a statistically significant difference between dp-AOT (208 ± 54 mm²) and sp-AOT (74 ± 26 mm²) (P < .001). There was no statistically significant difference in symptom duration between groups (P > .05). All lesions were circumferentially contained by a stable rim of normal cartilage. Two patients in the sp-AOT and 3 patients in the dp-AOT groups underwent previous microfracture at an outside institution that had failed to relieve all the patients’ symptoms.

Clinical Outcomes

Patients in both groups showed a statistically significant increase in their postoperative scores at latest follow-up compared with preoperative scores. In the sp-AOT group, mean pre- and postoperative FAOS scores were 51.55 ± 10.19 and 87.06 ± 5.14, respectively (P < .001), and mean SF-12 scores were 57.78 ± 9.64 and 87.89 ± 5.69, respectively (P < .001). Similarly, patients in the dp-AOT group had a statistically significant increase in functional outcomes. Mean pre- and postoperative FAOS scores were 49.46 ± 12.06 and 86.19 ± 6.48, respectively (P < .001), and mean pre- and postoperative SF-12 scores were 56.60 ± 13.29 and 85.61 ± 5.69, respectively (P < .001) (Figure 4).

When comparing preoperative scores, there was no statistical significance between both groups. Mean preoperative FAOS score for the dp-AOT and sp-AOT were not statistically different (P = .719). The SF-12 scores also did not show any statistical difference (P = .947) (Figure 4). Similarly, there was no significant difference in functional scores between the 2 groups at latest follow-up. Mean postoperative FAOS scores for the dp-AOT and sp-AOT groups were not statistically different (P = .883). Likewise, SF-12 scores did not show any statistical difference (P = .246) (Figure 4).

Both pre- and postoperative scores of patients who underwent previous microfracture were not significantly different from the total cohort. In the sp-AOT group with prior microfracture, mean pre- and postoperative FAOS scores were 46.75 ± 3.80 and 84.34 ± 4.78, respectively, and mean SF-12 scores were 52.72 ± 5.26 and 91.55 ± 3.42, respectively. In the dp-AOT group with prior microfracture, mean pre- and postoperative FAOS scores were 57.40 ± 10.72 and 84.20 ± 1.80, respectively, and mean SF-12 scores were 57.34 ± 12.74 and 85.83 ± 4.40, respectively. Owing to their small numbers, further analysis to assess the difference between this group and those who did not have prior microfracture was not performed.
Magnetic Resonance Imaging

Postoperative modified MOCART scores showed no statistically significant difference in terms of total MOCART score or in each of its subcategories between treatment groups (Figure 5). Total modified MOCART score for sp-AOT was 75 ± 12.77 versus 69.29 ± 20.74 in the dp-AOT group (P = .4754). Although no statistically significant difference existed between groups in the subcategory of subchondral bone appearance on MRI (P = .3289), all 14 patients (100%) in the dp-AOT group showed abnormal subchondral bone signal (edema/cyst) compared with 26 of 28 patients (92.9%) in the sp-AOT group.

Postoperative Complications

No serious surgical complications were reported. Two cases of knee stiffness were identified, 1 case each in the sp-AOT and dp-AOT groups. One resolved after 8 months and the other resolved after 1 month. There was 1 case of saphenous nerve hypoesthesia. Postoperative radiograph and MRI indicated no cases of delayed or nonunion of medial malleolar or lateral tibial osteotomies.

DISCUSSION

Our study demonstrates that patients with larger OCLs treated with dp-AOT did not have inferior functional scores preoperatively than those with smaller OCLs requiring sp-AOT. Similarly, dp-AOT had equivalent scores to sp-AOT at a minimum of 5 years postoperatively. The larger OCLs requiring a dp-AOT did not yield inferior functional scores postoperatively compared with smaller OCLs managed by sp-AOT.

Despite an abundant volume of literature suggesting that critical size OCLs (>80-150 mm²) fail after marrow stimulation techniques, few data exist to validate whether the same applies to AOT.7,9,27 While larger OCLs managed
by AOT may potentially require more than 1 plug, this theoretically might place the AOT reconstruction at risk due to fibrocartilage formation between the plugs. Fibrocartilage is known to dedifferentiate from type II to type I collagen at 1 year and further degrade over time. The "nesting technique" employed in the current study, and popularized by Scranton et al., limits the gap formation between the osteochondral plugs, hence decreasing discrepancies between the circular peripheries of the grafts and increasing congruency. This has the theoretical advantage of limiting the fibrocartilage interface, which might have an implication in the mid- to long-term survivorship of the double plugs and attaining comparable results to the sp-AOT.

Postoperative MRI findings did not show any difference in modified MOCART scores between dp-AOT and sp-AOT in terms of total score and in each individual subcategory of the modified MOCART score. An interesting finding was the persistence of abnormal subchondral bone signal from pre- to postoperative MRI in all patients of the dp-AOT group. This, however, did not affect their final functional outcome scores compared with the sp-AOT group, which is in agreement with other studies. Similar subchondral bone abnormalities and cyst formation on MRI have been reported in a number of studies and ranged from 15% to 50% in patients undergoing AOT. In most of the aforementioned studies, clinical and MR findings were not well correlated, where MRIs revealed a wide range of appearances that did not result in adverse clinical outcome. It has been recently suggested that MRI should not be a routine evaluation for AOT and is indicated only when clinical symptoms persist after AOT. A recent meta-analysis to evaluate the correlation between MRI and clinical outcome after cartilage repair showed that for most MRI parameters, limited or no correlation was found and that only 28% of the analyzed studies found a correlation between clinical outcome and the MOCART score. Another study using single-photon emission computed tomography (SPECT)–CT showed 100% of AOT cases had subchondral bone cyst formation. Whether this phenomenon is due to the postoperative influx of synovial fluid through the AOT plug–native cartilage fibrous interface versus residual subchondral bone injury from the initial OCL lesion is not yet known and yet to be further investigated. What is clear, based on the current study and prior literature, is that the presence of subchondral change or a subchondral cyst does not appear to result in poorer clinical outcomes.

Size of the OCL has not been shown to be a predictor of outcome in the current study. Despite this, Bultzer and Arnold reported a case series of 43 patients undergoing AOT for talar OCLs and found that the smaller the diameter of the transplants and the fewer the number of transplants used, the better were the results in pain reduction and postoperative range of motion. In a randomized controlled study, Gobbi et al compared chondroplasty, microfracture, and AOT of the talus in 53 patients with a mean follow-up of 53 months. They found no difference between chondroplasty, microfracture, and AOT. Magnetic resonance imaging revealed incomplete fill and edema after chondroplasty or microfracture and chondral gaps after AOT. Better outcomes were associated with smaller lesions for both microfracture and AOT. In a more recent study, Kim et al reported prognostic factors affecting outcomes of talar AOT in a series of 52 patients. The authors found that patient age, sex, body mass index, duration of symptoms, location of talar OCL, and the existence of a subchondral cyst did not significantly influence clinical outcomes of AOT. They also found, in agreement with our results, that lesion size did not significantly influence clinical outcome. The relation of functional outcome to lesion size in these studies may vary, in part, due to technical variables. Larger lesions in the current study were treated with 2 AOT plugs. By comparison, previous AOT studies reporting size as a prognostic indicator used only a single plug, did not report the number of plugs used, and/or did not specifically investigate the effect of number of plugs on clinical outcome. A critical size for AOT single plug may be implicated, but further investigation is still warranted. In addition, variation in plug length and depth alignment, which is a technical variable not frequently reported, could have been another technical confounding variable among these clinical studies. Kock et al, in a cadaveric biomechanical loading study of knee AOTs, reported that short-bottomed plugs—which were exactly matched to the depth of the recipient site—were more stable than long-bottomed and long-unbottomed plugs.

Knee donor site morbidity was present in 2 cases (4.8%) in the current study. This is comparable with prior rates in the literature. The 2 cases of morbidity were restricted to complaints of stiffness and were later resolved. Still, surgeons must consider the risks of donor site morbidity during preoperative planning. The effect of harvesting multiple grafts on donor site morbidity has yet to be determined. Further study is required to determine how the risks and benefits of using multiple grafts compare with other surgical treatment strategies.

There are a number of limitations to this study. First, this is a retrospective study. However, matching the study group in terms of age, sex, and mean follow-up time from surgery provided unbiased data for this retrospective case-control study. While patients of a wide age range were included, age matching the study group also helped to control this issue. Second, the number of patients in this study is limited because they were extracted from a single surgeon’s database. However, this precludes any confounding variables related to surgical technique that might have been introduced with patients being pooled from multiple surgeons’ databases. Third, the short-term follow-up MRI did not coincide with the 5-year follow-up functional scores. This is due to the retrospective nature of the study and the fact that it is not customary in the senior surgeon’s practice to obtain an MRI after 2 years of follow-up if the patients are doing well clinically secondary to insurance provider restrictions. Last, due to the retrospective nature of the study, we were only able to report outcome scores at final follow-up. More studies with larger number of patients and mid- to long-term follow-up MRIs are required to further validate the results of the current study. Future studies should focus on tracking clinical and radiological outcomes at multiple time points.
Therefore, dp-AOT may be as effective as sp-AOT in treating talar OCLs in the mid-term follow-up.

REFERENCES


