Osteochondral Allograft Transplantation in Patients With Osteochondritis Dissecans of the Knee

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Background: Osteochondritis dissecans (OCD) of the knee can be difficult to treat. Cartilage restoration techniques are often indicated when the lesion or fragment cannot be salvaged and the patient remains symptomatic. Fresh osteochondral allograft (OCA) transplantation can restore both bone and cartilage defects characteristic of OCD.

Hypothesis: We hypothesized that osteochondral allografting is a successful method for treating OCD of the knee.

Study Design: Case series; Level of evidence, 4.

Methods: This study comprised 135 patients (149 knees) who underwent OCA for OCD of the knee (type III or IV) between 1997 and 2013 and had a minimum follow-up of 2 years. The median age was 21 years (range, 12-55 years) and 75.8% of the patients were male. The mean allograft size was 7.3 cm² (range, 2.2-25 cm²). Evaluation included the following: frequency and type of reoperations; modified Merle d’Aubigné and Postel (18-point) scale; International Knee Documentation Committee (IKDC) pain, function, and total scores; and Knee Society function (KS-F) and knee (KS-K) scores. Clinical failure was defined as revision OCA or conversion to arthroplasty. Graft survivorship was determined.

Results: The median follow-up time was 6.3 years (range, 1.9-16.8 years) and 62% of participants had more than 5-year follow-up. Thirty-four of 149 knees (23%) had reoperations, of which 12 (8%) were classified as allograft failures (7 OCA revisions, 3 unicompartmental knee arthroplasties, and 2 total knee arthroplasties). OCA survivorship was 95% at 5 years and 93% at 10 years. Of the 137 knees whose grafts were still in situ at the latest follow-up, the mean modified Merle d’Aubigné and Postel (18-point) score was 16.8; IKDC pain, function, and total scores were 2.1, 8.1, and 82.3; and KS-F and KS-K scores were 95.7 and 94.3, respectively. The majority of patients (95%) reported being satisfied with the outcome of their procedure.

Conclusion: OCA transplantation was an effective treatment for OCD of the knee, with a low rate of graft failure, significant improvement in pain and function scores, and high patient satisfaction.

Keywords: osteochondral allograft transplantation; osteochondritis dissecans; knee

Osteochondritis dissecans (OCD) affects a wide spectrum of patients but is most prevalent in adolescents and young adults. The incidence of OCD is suspected to be approximately 15 to 30 per 100,000 patients. A hypothesis for the origin of OCD is not universally accepted, because theories include possible repetitive microtrauma, vascular insufficiency, or abnormal endochondral ossification. This pathologic process involves the fragmentation of subchondral bone, which then becomes avascular and separates from the surrounding cartilage. The pathologic lesion can then manifest as pain or other symptoms, including catching and locking. Nonoperative treatment of OCD with activity modification and bracing has been reported to be successful in 50% to 94% of patients with open physes and stable lesions. Reparative techniques such as anterograde/retrograde drilling, internal fixation, bone grafting, or debridement/fragment excision have demonstrated variable outcomes.
For lesions that are not salvageable, cartilage restoration techniques such as microfracture,11 osteochondral autologous transfer,13,15,27 autologous chondrocyte implantation,29 and osteochondral allografting2,24 have been utilized with varying degrees of success. Fresh osteochondral allograft (OCA) transplantation is theoretically an attractive option because it can restore both the osseous and chondral components caused by the OCD lesion. The purpose of this study was to determine the clinical outcome of a large cohort of patients (juvenile and adult) who received fresh OCA transplantation for the surgical management of OCD after failure of other treatments. We hypothesized that OCA transplantation was a successful and durable option for treating OCD of the knee.

METHODS

Since 1983, more than 950 OCA transplantations have been included in the Scripps Health institutional review board–approved database. A review of this database identified 165 knees in 150 patients who had undergone OCA transplantation for OCD (type III or IV) between 1997 and 2013. All OCA transplantations were performed by a single surgeon. Of the 150 patients, 15 (10%) did not have a minimum follow-up of 2 years and were excluded. This study included 149 knees (135 patients) that had a minimum follow-up of 2 years. The median age at the time of surgery was 21 years (range, 12-55 years); 75.8% of patients were male and 24.2% were female. The majority of lesions involved the medial femoral condyle (62%) and the lateral femoral condyle (29%), with the remaining lesions on the trochlea (6%), patella (1%), or 2 anatomic locations (2%). Eighty-one percent of knees had a median of 1 surgery (range, 1-7) before the OCA transplantation, which included chondral debridement (67%), loose body removal (51%), subchondral marrow stimulation (42%), open reduction internal fixation (10%), osteotomy (3%), hardware removal (3%), osteochondral autograft transplantation (3%), previous OCA transplantation (2%), and extensor mechanism repair (1%). The mean allograft size was 7.3 cm² (range, 2.2-25 cm²).

Preoperative and postoperative clinical assessment included the modified Merle d’Aubigné and Postel (18-point) scale; International Knee Documentation Committee (IKDC) pain, function, and total scores; and Knee Society function (KS-F) and knee (KS-K) scores. Routine demographic and surgical data were collected. The number and type of reoperations after the OCA transplantation were documented. For survivorship calculations, failure of the allograft was defined as any procedure that included removal of the allograft, such as revision of the allograft, unicompartmental knee arthroplasty (UKA), or total knee arthroplasty (TKA). Satisfaction with the allograft surgery was determined using a 5-category Likert scale, with responses ranging from “extremely satisfied” to “dissatisfied.” Patients who could not return for clinical examination were sent questionnaires via mail.

Statistical Methods

Patient demographics (eg, age, sex, and weight) and surgical details (eg, location, number, and size of the allograft) were described using means and frequencies. Survivorship of the OCA was calculated using the Kaplan-Meier method. Preoperative and postoperative modified Merle d’Aubigné and Postel (18-point) scores; IKDC pain, function, and total scores; and KS-F and KS-K scores were analyzed using the paired-samples t test. To assess variables that predicted OCA failure, knees were stratified into 2 groups (OCA failure and OCA nonfailure) and compared in univariate analyses using Mann-Whitney U tests and chi-square tests on select variables: age category (<30 years vs ≥30 years), sex (male vs female), total graft area (in square centimeters), previous surgery (<2 previous surgeries vs ≥2 previous surgeries), anatomic location (medial femoral condyle vs all other locations), and preoperative modified Merle d’Aubigné and Postel (18-point) score. Data were analyzed using SPSS software (version 13.0; SPSS Inc). Statistical significance was set at P < .05 and all tests were 2-tailed.

Surgical Technique

Preoperatively, the donor and recipient were matched solely on the basis of size using standard anteroposterior radiographs with a correction for magnification. Immunologic human leukocyte antigen matching or blood type matching was not performed; immunosuppressive therapy was not used postoperatively. Fresh allograft donor tissue was obtained from healthy donors between the ages of 16 and 40 years who met the American Association of Tissue Banks criteria. Donor tissue was recovered within 24 hours of death and maintained at 4°C in nutritive culture media until the time of implantation, between 7 and 28 days. Before October 2002, allografts were obtained from the University of California, San Diego tissue bank. Since October 2002, allografts have been acquired from AlloSource.

Surgery was performed through a midline skin incision and a small arthroteny. After exposure of the lesion, subchondral bone loss and the size and depth of the lesion were analyzed and either a shell technique or plug allograft technique was used. The area to be grafted was modified into a geometric shape and the defect was prepared down to a depth of 2 to 10 mm. A dowel technique was used for small and medium-sized lesions, and a shell allograft technique or a multiple dowel technique was used for larger lesions22 (127 knees had a dowel, 19 knees had a shell, and 3 knees had both a dowel and shell). Once the recipient site was prepared, the allograft plug was tailored into a shape matching the lesion. To decrease the immunogenicity of the graft, pulsatile lavage of the osseous surface was used to remove marrow elements. After the graft had been properly positioned, fixation was achieved with either a press-fit without additional fixation or with the use of absorbable polydioxanone pins (Johnson & Johnson) or chondral darts (Arthrex). No metal screws were used.

Postoperative care included full active range of motion and protected weightbearing for a period of 4 to 12 weeks, depending on the size of the lesion and extent of the allograft reconstruction. Closed-chain exercises began at 4 weeks postoperatively and unrestricted activities of daily living began at 2 to 4 months. The patient was allowed to

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return to recreational and athletic activities between 4 and 6 months after surgery if the knee limb demonstrated full functional recovery. Radiographs were obtained at 4 to 6 weeks, 3 months, and 1 year postoperatively to confirm allograft incorporation.

RESULTS

Of 149 knees, 34 (23%) underwent reoperation after the OCA transplantation. Of these, 22 knees (15%) had a procedure not requiring allograft removal or unrelated to the allograft (Table 1). Twelve knees (8%) were classified as OCA failures with revision or removal of the allograft (7 revision OCA transplantations, 3 UKAs, and 2 TKAs) (Table 2). The mean time to failure was 6.1 ± 1.3 years. OCA survivorship was 95% at 5 years and 93% at 10 years (Figure 1).

When comparing OCA failures (n = 12) with nonfailures (n = 137), no statistically significant differences were found between groups with regard to age, sex, previous surgery, total graft area, anatomic location, and preoperative modified Merle d’Aubigné and Postel (18-point) score.

Of the 149 knees, 137 (92%) had the OCA in situ at the latest follow-up. The median follow-up duration was 6.3 years (range, 1.9-16.8 years), and 62% of patients had more than 5 years of follow-up and 23% had more than 10 years of follow-up. Pain and function improved from preoperatively to the latest follow-up as assessed using the modified Merle d’Aubigné and Postel (18-point), IKDC, and KS scales (Table 3). The majority of patients were satisfied with the outcome of the OCA transplantation (78% extremely satisfied, 17% satisfied, 3% somewhat satisfied, 1% somewhat dissatisfied, and 1% dissatisfied).

DISCUSSION

OCD can be a challenging clinical problem, particularly in skeletally mature patients with large or unstable lesions that have failed to respond to nonsurgical treatment.

Although an extensive body of literature exists regarding the treatment of OCD, there is still no clear consensus.2,6 Patient age, skeletal maturity, and size, location, and stability of the lesion are some of the important variables that are considered in published treatment algorithms.4 Large unstable or unsalvageable lesions in skeletally mature patients often require intervention, but little consensus on the specific type of surgical intervention is available. Published literature on OCD treatment includes few comparative trials to help guide decision making; comparisons must be made between individual case series of specific treatments that may not have comparable patient populations. In addition, many cartilage repair studies report on the outcome of treatment of knee cartilage lesions based on anatomic location rather than diagnosis, preventing critical analysis of disease-related outcomes.
This study sought to investigate the clinical outcome of a large group of patients who were treated with fresh osteochondral allograft transplantation for OCD of the knee. These patients represented the “worst case” scenario in the spectrum of OCD lesions and presented for consideration of OCA as a potential salvage procedure because of a number of factors such as relatively large size, stage III or IV lesions, and/or failure of previous treatment. The study population included patients aged older than 12 years (median age 21 years); thus, nearly all patients were skeletally mature with relatively large symptomatic lesions (average size 7.3 cm²), 81% of whom had a failed previous surgery. Our hypothesis was that OCA would be an excellent treatment for these patients with OCD with large defects because, unlike other cartilage procedures, OCA transplantation allows for immediate reconstitution of both the hyaline cartilage and subchondral bone defects characteristic of large OCD lesions. Thus, the osteochondral allograft procedure is uniquely suited to restore the entire diseased or deficient osteochondral unit with anatomically similar tissue. The results of this study support our hypothesis. OCA reconstruction resulted in substantial and significant reductions in pain and improvements in function in the majority of patients, with postoperative IKDC pain, function, and total scores that were better than any other OCA cohort we have studied to date. In addition, long-term allograft survival was excellent (93% at 10 years). The 23% reoperation rate in this population is significant but not dissimilar to the reoperation rate with other cartilage repair procedures. Although any reoperation should be considered an adverse event, the concept that subsequent interventions are either unrelated or directly related to the OCD disease or the allograft implant is valid and better defines the natural history of the knee with OCD and an implanted allograft. We sought to determine whether further operations were directly related to the allograft. Two types of operations were defined: those that resulted in removal of the allograft (revision or arthroplasty) or those that were not directly related to allograft failure. Of 149 knees, 22 (15%) had a reoperation that did not involve removal of the allograft. This is not surprising for a young active population in which further knee injury (eg, meniscus tear/anterior cruciate ligament tear) or onset of new knee symptoms requiring further surgical intervention is common. Twelve knees (8%) had revision or removal of the allograft. Most often, this involved repeating the allograft procedure. Horton et al recently reported on the long-term outcome of revision allografting, with 61% survivorship at 10 years, suggesting that revising a failed allograft is an appropriate intervention. Other authors have reported reoperation rates after cartilage repair procedures. Zaslav et al reported on 126 patients undergoing autologous chondrocyte implantation after failed chondroplasty or microfracture. At 48 months of follow-up, 49% underwent further surgery. The relatively low graft failure rate prevented us from performing a logistic regression analysis to identify variables that contribute to graft failure. We did perform a univariate analysis to gain some insight into what clinical variables might be important. Age, sex, previous surgery, graft size, anatomic location, and preoperative modified Merle d’Aubigné and Postel (18-point) scores were not statistically different between groups.

Previous studies that utilized logistic regression reported increasing odds ratios with increasing graft size, patient age older than 30 years, medial femoral graft location, and multiply operated knees. Minas et al reported a 26% failure rate for autologous chondrocyte implantation in patients who had undergone prior marrow stimulation procedures. This failure rate was 3 times higher than that of their patients who had not had previous marrow stimulation. In this study and 2 of our recent studies, we did not find an association between previous knee surgery and adverse outcomes among patients who had undergone OCA transplantation. We postulate that the allograft surgery, by its nature of replacing both bone and cartilage, is less affected by perturbations of the subchondral bone caused by marrow stimulation.

The utilization of OCA for the treatment of OCD has been previously described. Garrett reported success in 16 of 17 grafts in patients with OCD lesions with a follow-up of 2 to 9 years. Emmerson et al previously reported on the use of OCA in 64 patients with OCD, in which 47 (72%) were rated excellent, 7 (11%) were rated fair, and 1 (2%) was rated poor. Kaplan-Meier survival analysis demonstrated 91% survivorship at 5 years and 76% at 10 years. Lyon et al recently reported on 11 patients with a mean age of 15.2 years and an average lesion size of 5.1 cm between 12 and 41 months of follow-up. All patients demonstrated clinical improvement, with reduced pain, improved function, and return to

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### TABLE 3

<table>
<thead>
<tr>
<th>Measure</th>
<th>Preoperative Score</th>
<th>Postoperative Score</th>
<th>P Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>Modified Merle d’Aubigné and Postel (18-point) scale</td>
<td>13.6 ± 2.0</td>
<td>16.8 ± 1.5</td>
<td>&lt;.001</td>
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<tr>
<td>International Knee Documentation Committee score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Pain</td>
<td>5.3 ± 2.5</td>
<td>2.1 ± 2.2</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Function</td>
<td>3.5 ± 1.8</td>
<td>8.1 ± 2.0</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Total score</td>
<td>44.2 ± 17.5</td>
<td>82.3 ± 15.8</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Knee Society score</td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Function</td>
<td>72.3 ± 18.6</td>
<td>95.7 ± 9.6</td>
<td>&lt;.001</td>
</tr>
<tr>
<td>Knee</td>
<td>81.1 ± 14.8</td>
<td>94.3 ± 8.8</td>
<td>&lt;.001</td>
</tr>
</tbody>
</table>

Data are presented as mean ± SD.
sports. All grafts showed radiographic healing. No revision or complications were reported in early follow-up.

Although other treatment options such as fragment excision, microfracture, mosaicplasty, and autologous chondrocyte transplantation have been reported in the treatment of OCD, it is difficult to directly compare these treatments to fresh osteochondral allografting because of the differences in patient populations (eg, skeletal age and lesion size) and the inclusion of other diagnoses in the treatment groups. Wright et al reported a 65% failure rate to treat 169 patients with chondral lesions of the femur (including OCD) with an autologous chondrocyte implantation to treat OCD. Minas used autologous chondrocyte implantation to treat 169 patients with chondral lesions of the femur (including OCD) with an 87% success rate. Peterson et al treated 58 patients with an average lesion size of 5.7 cm² and a mean defect depth of 7.8 mm using autologous chondrocyte implantation, with a 90% success rate at 5.6 years. Peterson et al also reported long-term results of autologous chondrocyte implantation for OCD in 26 patients; 81% of patients improved and 96% would have the operation again.

Our study had several limitations. First, because this was a retrospective case series, no control group was available and we could not assess the success of this treatment compared with other potential treatment modalities. Second, 1 of our outcome measures, the modified Merle d'Aubigné and Postel score, has not been validated for use in knees; however, it has been used in our allograft program since 1983 and predates the advent of other validated outcome measures. Third, we obtained follow-up via telephone or mail for some of our patients. Patient examination in person would have been ideal, but this is not often possible because our institution is a national referral center (the majority of patients do not live locally). Fourth, we lacked radiographic follow-up. Although all patients were followed radiographically until healing of the allograft was documented, long-term radiographic follow-up on this cohort of patients was not available. In addition, we were not aware of any validated radiographic outcome measures useful in follow-up of osteochondral allograft transplantation or other cartilage repair procedures.

Fresh OCA transplantation for unsalvageable OCD lesions of the knee resulted in significant improvements in pain and function in the majority of patients with surviving grafts. Postoperative pain and function scores were better than any other patient cohort we have studied to date. Allografts also demonstrated good long-term durability with excellent survivorship. Failure of the allograft did not preclude revision allografting. We conclude that OCA transplantation is a valuable treatment option for surgical management of OCD of the knee.

REFERENCES


